CITY OF LEAVENWORTH STORMWATER INFRASTRUCTURE PRELIMINARY HYDROLOGY/HYDRAULIC ANALYSIS

For

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EXECUTIVE SUMMARY

The City of Leavenworth owns four (4) distinct storm drainage systems which drain the majority of storm water and other surface water runoff from the upland areas of the City and unincorporated Chelan County through the City and into the Wenatchee River. The area which these systems drain is approximately 2,189 acres.

From west to east, these drainage basins and their associated drainage networks have been labeled Ski Hill, Downtown West, Downtown East, and Alpensee Strasse. Below noted model capacity and flooding issues can be resolved by capital improvements as well as reductions of tributary flows into each of the networks.

Ski Hill basin is the largest of the four at 1,579 acres due to its proximity with tributary areas on Tumwater Mt. and Ski Hill ridge. Capacity issues with this drainage system were evident following simulation of a 25 year design storm in the existing condition and the 10 year design storm in the future condition and all others storms thereafter. In the existing and future condition, flooding began at the 100 year storm simulation with flooding occurring at increased locations in the future condition.

Alpensee Strasse basin is the second largest of the four at 457 acres due to its proximity with Ski Hill ridge. Capacity issues with this drainage system were evident following simulation of a 10 year design storm (existing conditions) and 2 year design storm (future conditions) and all other storms thereafter. Flooding at various locations began occurring when modeling the 10 year design storm.

Downtown West basin is the third largest of the four at 129 acres. Minor capacity issues with this drainage system were evident following simulation of a 100 year design storm. No flooding was evident. These limitations were observed under existing and future conditions.

Downtown East basin is the smallest of the four at 24 acres. No capacity issues or flooding was evident.

SECTION 1: INTRODUCTION

The City of Leavenworth is in receipt of a grant from the Washington State Department of Ecology (Ecology). The grant shall be used for preparing an inventory, map, and analysis of existing stormwater infrastructure and wetlands within the City, Urban Growth Area (UGA) and associated unincorporated areas of Chelan County. This research will be used to support the preparation of a Green Infrastructure Master Plan.

Purpose

This report focuses on stormwater, i.e. specifically the hydrology and storm drainage network hydraulics within the study area. This report will review the existing and future network capacity to convey stormwater from areas upland of the City as well as through the City to the Wenatchee River. Specific local regulatory requirements will be presented for both runoff control and water quality treatment. Appropriate Best Management Practices (BMPs) that have potential to meet local regulatory requirements will be reviewed and ranked.

Study Limits

The study limits are generally described as the Wenatchee River (south), Tumwater Mt. (west), Ski Hill ridge crest (north) and Chumstick Creek (east).

The North Road/Chumstick Road intersection, and upland tributary areas to Chumstick Road-to the north, are not included in this study, as this section of Chumstick Road storm drainage infrastructure is owned by Chelan County.

Regulatory References

The Leavenworth municipal code addresses stormwater performance requirements in Title 14. Title 14 requires adherence to the Storm Water Management Manual for Eastern Washington (SWMMEW). This 715 page extensive guidance manual was developed by Ecology in conjunction with local governments, including Chelan County, in 2004.

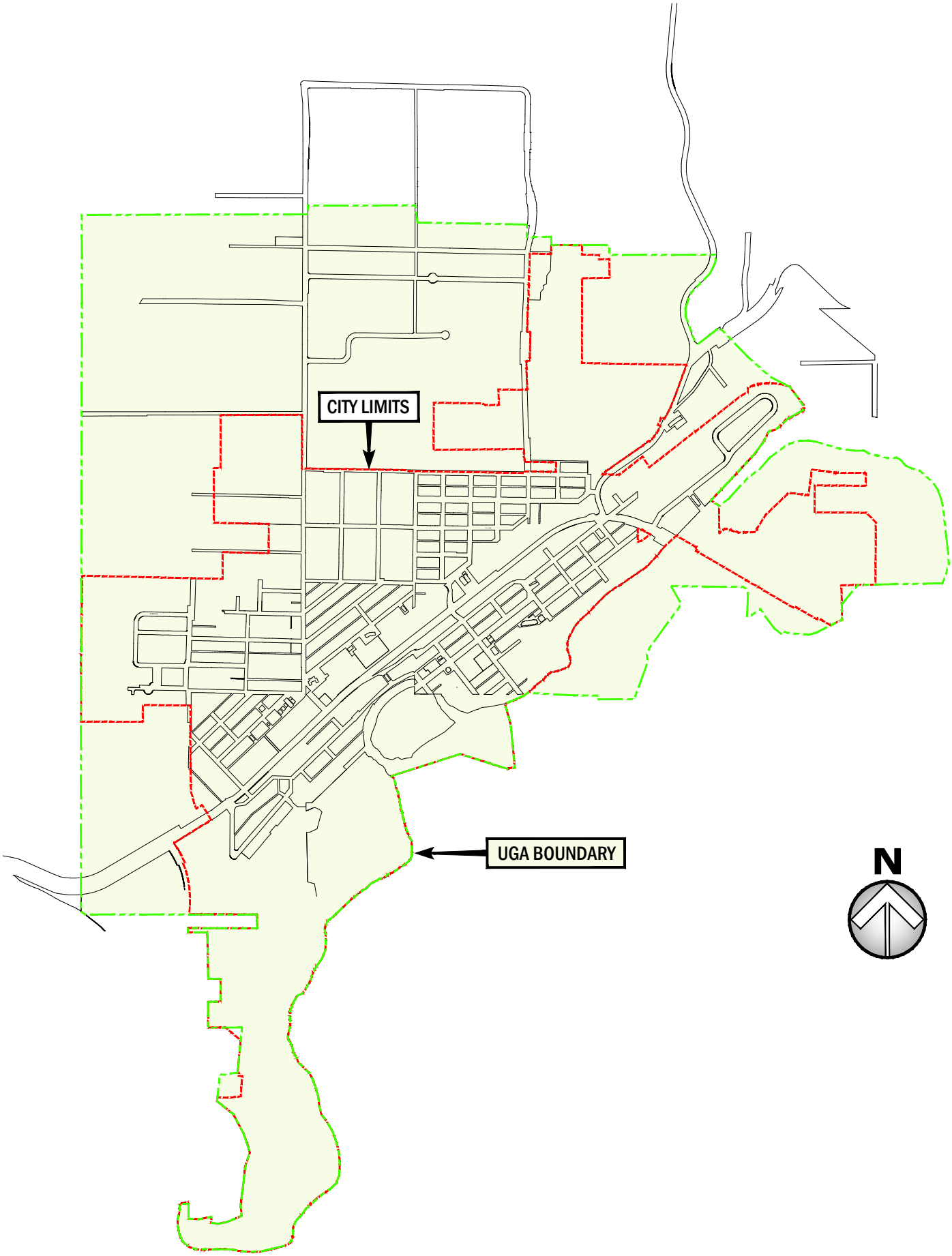
The WSDOT Highway Runoff Manual (HRM) addresses linear projects and is referenced in this report. As of this date, the HRM has not been adopted by the City.

Methodology

The general approach to complete this study:

- Basemap
    - Evaluate readily available public storm drainage records and as-built drawings.
    - Prepare a draft basemap.
    - Complete a follow-up field review.
    - Selectively field survey critical portions of the existing pipe network.
    - Complete the basemap.
- Existing Conditions
    - Delineate drainage basin areas, evaluate soil types, and determine ground cover conditions.
- Design Storm & Precipitation
    - Present required design storms and associated precipitation depths.
- Performance Standards
    - Describe local performance standards requirements for water quality treatment and runoff control.
- Modeling

    - A 3D software model of each individual existing storm drainage network will be developed.
    - Hydrographs will be developed utilizing Soils Conservation Service (SCS) methodology.
    - Hydraulics analysis will be simulated via a backwater analysis.
    - Route locally accepted design storm hydrographs through the models.
    - Analyze the hydraulic results of the design storm routing.
- Water Quality Requirements
    - Describe project specific procedures for determining the required type(s) of water quality treatment.
- Best Management Practices
    - Analyze and rank appropriate local BMPs.



CITY OF LEAVENWORTH
VICINITY MAP

City of Leavenworth and Region Zoning

1:4,000

0 0.1 0.2 0.3 Miles

N

November 2014

Legend

- City Limits
- Urban Growth Area

City of Leavenworth Zoning

- Central Commercial Zone
- General Commercial Zone
- Tourist Commercial Zone
- Light Industrial Zone
- RL-6 Zone
- RL-10 Zone
- RL-12 Zone
- Residential Multi-family Zone
- Planned Development Zone
- Recreation Public Zone
- Recreation Zone

Chelan County Zoning

- Commercial Agriculture
- Commercial Forest
- Rural Residential 2.5
- Rural Residential 5
- Rural Residential 10
- Rural Residential 20
- Rural Public
- Rural Recreation
- Rural Village
- Rural Waterfront
- Water

CITY OF LEAVENWORTH THE BAVARIAN VILLAGE WA

SECTION 2: BASEMAP

Resources

Resources review included readily available paper and electronic records related to storm drainage infrastructure. These records were requested of and obtained from the City, Chelan County, and the Washington State Department of Transportation (WSDOT). Over 1,600 electronic files were reviewed and evaluated. A total of 39 relevant paper records, from 1932 to 2014, were determined applicable for incorporation into the project basemap.

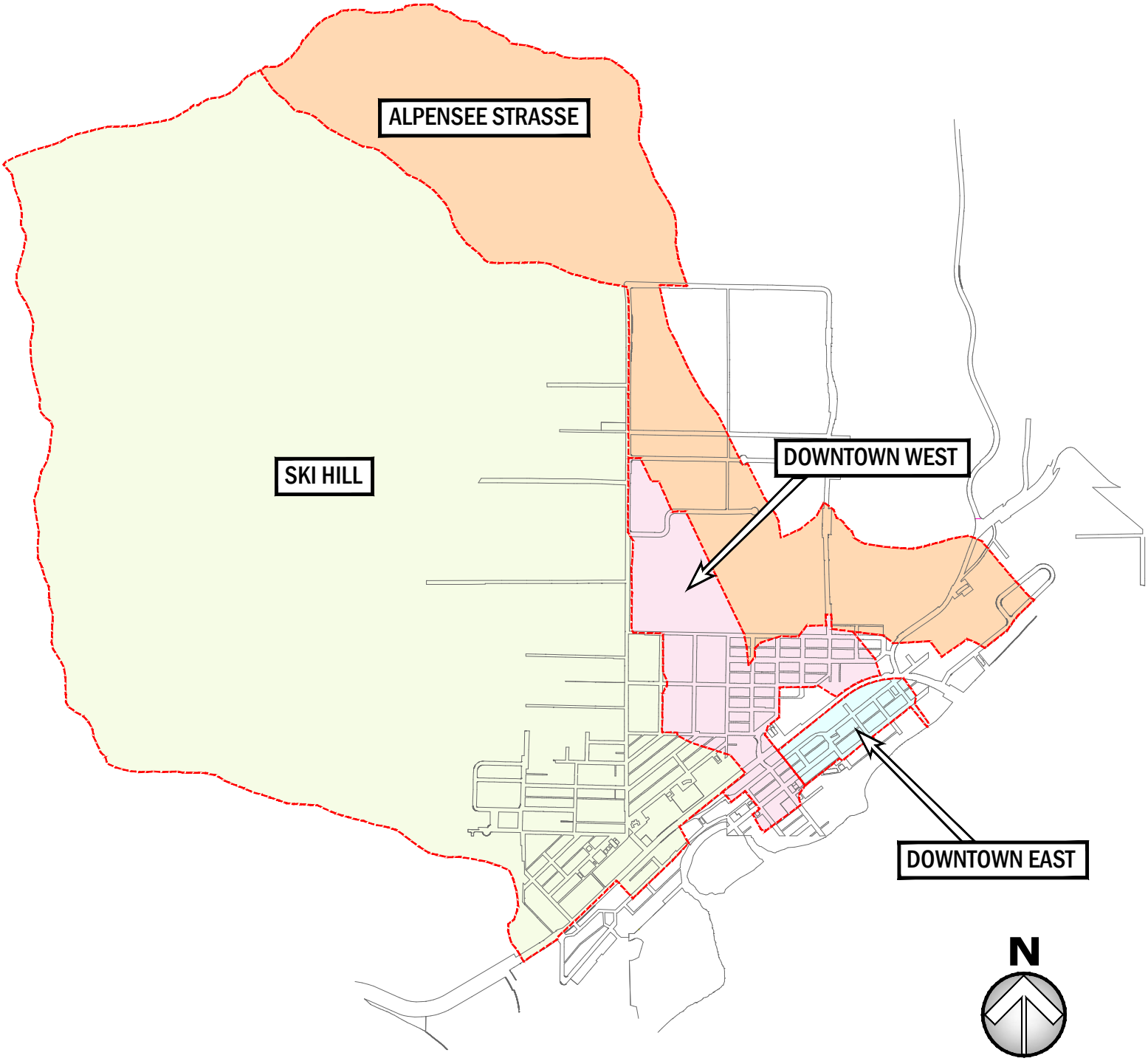
The foundation of the basemap is the Chelan County GIS including but not limited to, parcels, right-of-way, soils, contours, zoning, streams, and aerial photography. Once the foundation was prepared, the relevant paper and electronic records were added. Highly accurate LIDAR topography (contours) was later incorporated into a portion of the basemap after receipt of an electronic file from the Bureau of Reclamation.

Field Work

The basemap was visually field checked for accuracy and revised as needed. City staff was also given the opportunity to review the basemap for accuracy. All applicable review comments were incorporated into the basemap.

A topographic field survey was conducted. The survey was needed to increase map accuracy at critical locations of the storm drainage physical network. The survey was limited to select ditches, pipe inlets, pipe outfalls, catch basins, and storm drain manholes. The survey mapped approximately 90 catch basins and storm drain manholes. The limited survey was due to project budget constraints.

Additional topographical field survey work may be very useful to further raise confidence in the mapping of the existing network and output results from subsequent hydraulic and hydrologic modeling.



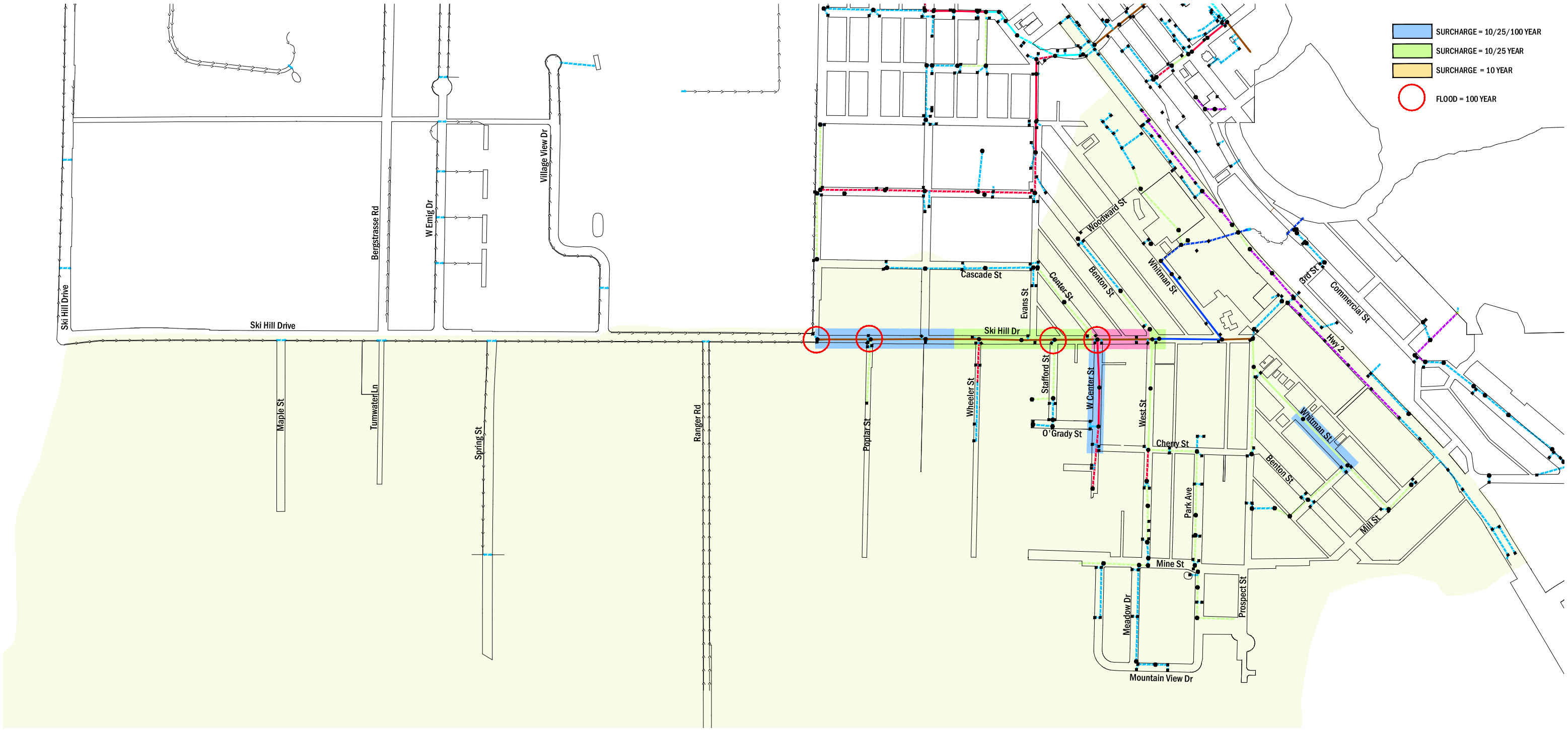
LEGEND

PIPE DIAMETERS

- 12" OR LESS
- 15"
- 18"
- 24"
- 30"
- 36"
- 42"
- 48"

- SDMH / CB TYPE II
- CB TYPE 1
- PIPE: FIELD SURVEY CONFIRMED
- PIPE NOT FIELD SURVEYED
- DITCH

DRAINAGE BASIN KEY MAP



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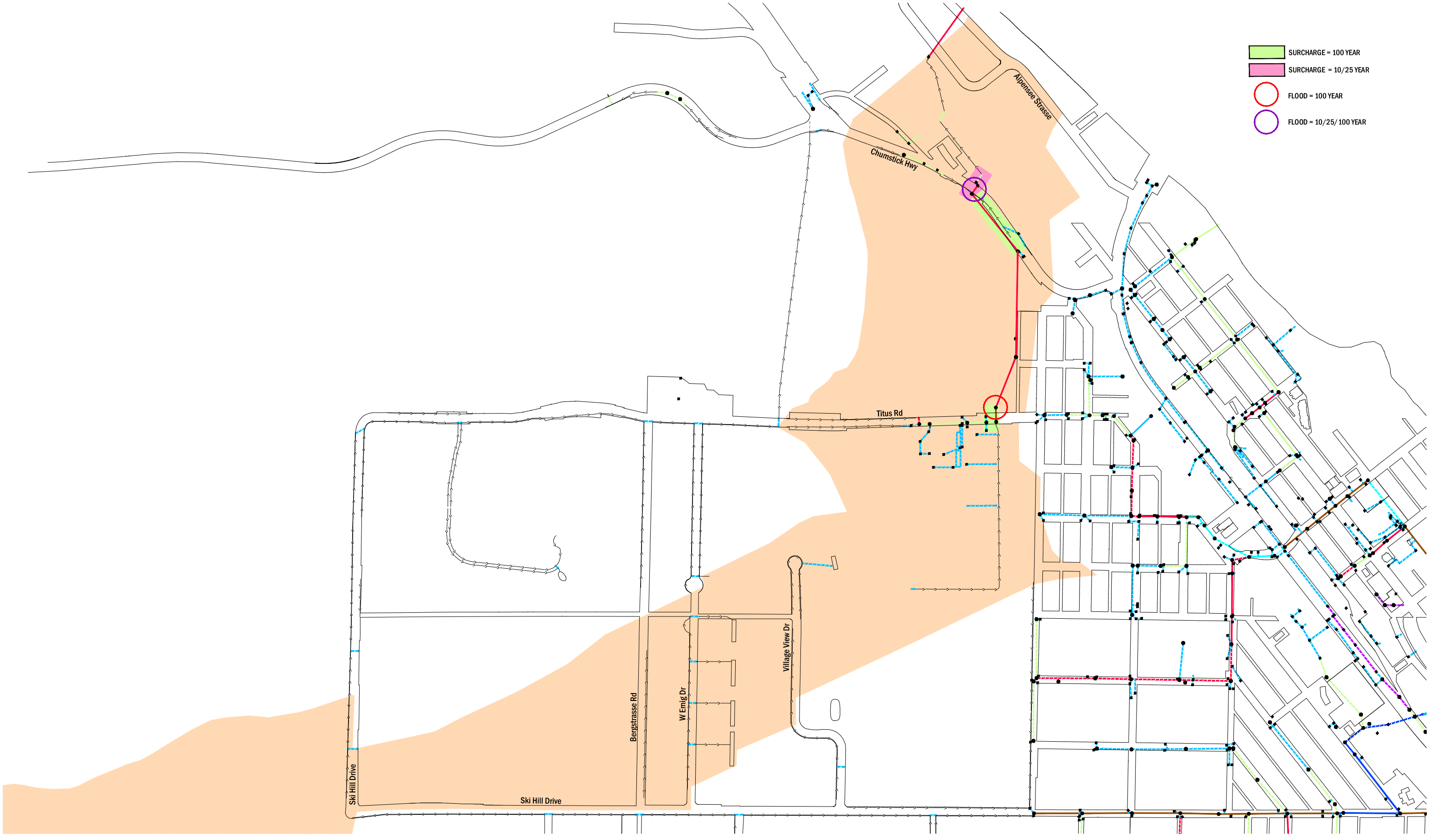
SKI HILL STORM NETWORK



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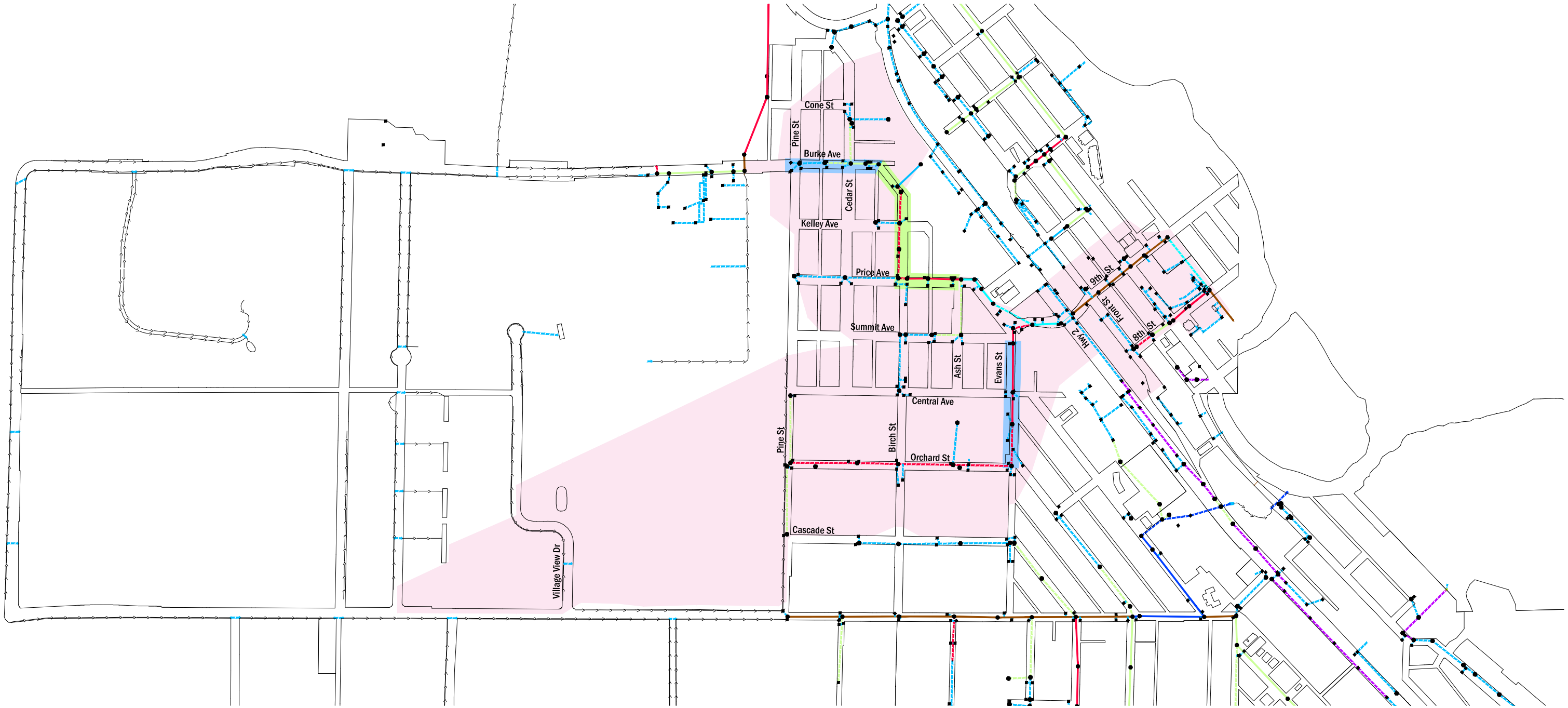
ALPENSEE STRASSE
STORM NETWORK



SURCHARGE = 25 YEAR

SURCHARGE = 25/100 YEAR

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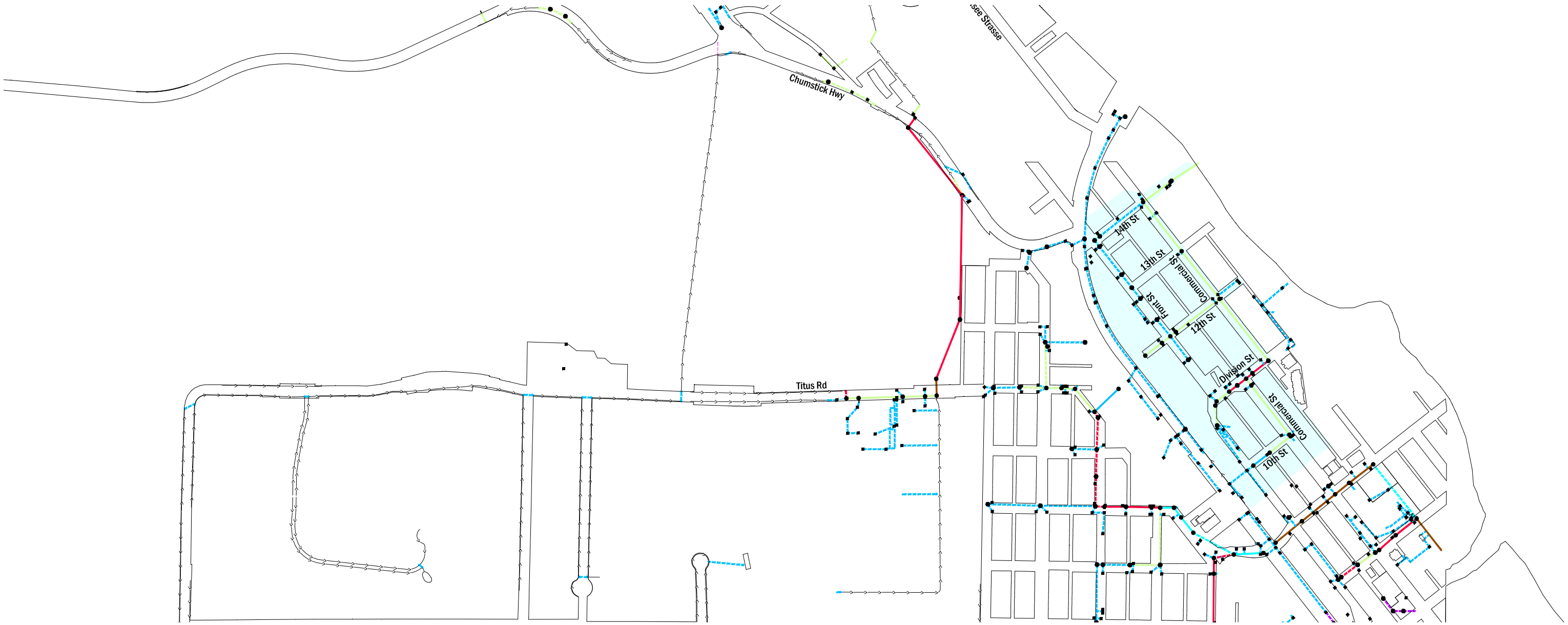
DOWNTOWN WEST STORM NETWORK



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DOWNTOWN EAST
STORM NETWORK

SECTION 3: SITE CONDITIONS

Drainage Basins

The existing storm drainage infrastructure consists of four (4) major independent networks which convey runoff from upland areas, through downtown to the Wenatchee River. These four (4) networks are labeled from west to east: Ski Hill, Downtown West, Downtown East, and Alpensee Strasse. The remainder of this report is limited to these 4 networks. Several other minor systems do exist within the City limits but will not be addressed further.

Soil Types

The existing soil types were determined from the online Web Soil Survey, USDA NRCS. This survey is the accepted standard for determining a soil type and its associated Hydrologic Soil Group (HSG). The HSG is critical to modeling as it characterizes the runoff potential of each soil type, e.g. an “A” soil has a much lower runoff potential than a “D” soil.

The buildable area of the study is approximately 828 acres. This area includes the portions of the City limits, Urban Growth Area (UGA), and unincorporated areas of Chelan County. An HSG summary of this area is B (566 acres), C (64 acres), D (183 acres), and 15 acres of rock and terrace escarpments.

The non-buildable area of the study is approximately 1,587 acres. This area generally encompasses Tumwater Mt and Ski Hill ridge. An HSG summary of this area is B (766 acres), C (360 acres), D (384 acres), and 78 acres of rock outcrops.

Ground Cover

The existing ground cover types were characterized via guidance from the reference Urban Hydrology for Small Drainage Basins, USDA NRCS. This manual is the accepted standard for identifying the use of a specific area and its associated Runoff Curve Number (RCN). The RCN is also critical to modeling as it characterizes the runoff potential of a given area based on soil HSG (previously determined) and ground cover type, e.g. pavement, lawn, woods, etc. An RCN of 98 (impervious surfaces such as pavements) has a much higher runoff potential than a RCN of 60 (woods with fair cover within HSG B soils).

Future Ground Cover / Zoning

An analysis of the zoning codes of Leavenworth and Chelan County was used to determine the maximum allowable building foot print as a percentage of gross parcel area. Where applicable, those percentages shown below are used to assist in estimating the future groundcover conditions. It should also be noted that future groundcover conditions are also impacted by off street parking and landscaping requirements within the CC, GC, TC, LI, and RM zones.

City limits and UGA

- Central Commercial (CC): 100%
- General Commercial (GC): 75%
- Tourist Commercial (TC): 50%
- Light Industrial (LI): 100%
- Residential Low Density (RL-6, RL-10, RL-12): 35%
- Multifamily Residential (RM): 40%

Unincorporated Chelan County

- Rural Resource (RR5, RR10, RR20): 35%

Hydrogeology

The Leavenworth Water Problems Study, Final Report, Feb 1999 was prepared in response to water problems in the Ski Hill area. The study included a hydrogeology section prepared by Alan Wald, Hydrogeologist, and WA Dept. of Ecology. Select excerpts, summarized by this author, which relate to stormwater runoff follow:

- *Spring runoff from snowmelt on Tumwater Mt. infiltrates into the ground but reappears as…..surface water…..near the base of the mountain. This discharge flows down shallow streams and roadside ditches while infiltrating the alluvial and glacial deposits. This infiltration in turn flows beneath the ground.*
- *The water in wetlands….is only a transitional phase of surface to subsurface flow.*
- *A review of the lithologic descriptions in 30 well logs….and research on the hydrogeology of nearby areas….suggest there are 3…..aquifers in the area, 1. Perched Season Water…at depths less than 15 to 20 feet. 2. Middle Aquifer….at depths of 20 to 60 feet, 3. Deep Aquifer at depths of 100 to 150 feet. These aquifers are not distinct separate units. There is a likely hydraulic connection between them. A steep groundwater gradient and proximity to the Wenatchee River suggests aquifer discharge to the river controls groundwater levels in the area.*
- *Most well logs and pump tests in the area show upward hydrostatic pressure or groundwater discharge from a large up-gradient contributing area.*
- *The stormwater outflow pipes at 8th St and Commercial St flowed all summer and varied from 0.2 and 4 cfs (Apr '98) to 0.02 and 3 cfs (Aug '99), respectively.*

It is evident from the study that runoff from the surrounding mountains manifests itself in the form of both groundwater and surface water flow within the Ski Hill area.

Ski Hill Basin Description

- Area: Includes City, Urban Growth Area (UGA), and unincorporated areas of Chelan County.
- Topography
    - Slopes from the NW to the SE.
    - Tumwater Mt. (east) and Ski Hill ridge (north) are mountainous.
- Ground Cover
    - Rural undeveloped land and farms; Urban single family residential, multifamily, and commercial.
    - Tumwater Mt. and Ski Hill ridge are generally forested with rock outcrops. Lower slopes are open in places with brush and grasses.
- Natural Conveyance
    - Tumwater Mt. and Ski Hill ridge have numerous steep natural drainages split by ridges and sub-ridges.
    - Varied locations of sheet flow and shallow concentrated flow.
- Manmade Conveyance
    - Surface: ditches, curb and gutter.
    - Subsurface: ±19,000 LF of pipe 6" to 42" diameter, catch basins, manholes, and one outfall within the putting course.

- Sanitary Sewer
    - The Ski Hill network includes a partial combined system of sanitary sewer and storm water. Each conveys its flows by separate pipe but utilize the same structures, i.e. sanitary sewer manholes, for pipe connections. Separation of flows within these structures is achieved via a vertical concrete separation wall with metal bolt down panels. The intent of the panels is to physically limit the storm flow hydraulic grade line to the elevation of the panels. This physical restriction may reduce network capacity to convey stormwater.

Alpensee Strasse Basin Description

- Area: Includes City, UGA, and County unincorporated areas.
- Topography
    - Slopes from the NW to the SE.
- Ground Cover
    - Rural undeveloped land and farms; Urban single family residential, multifamily, and commercial.
    - Ski Hill is generally forested with rock outcrops. Lower slopes are open in places with brush and grasses.
- Natural Conveyance
    - Ski Hill has numerous natural drainage features split by ridges and sub-ridges.
    - Varied locations of sheet flow and shallow concentrated flow.
- Manmade Conveyance
    - Surface: ditches, curb and gutter.
    - Subsurface: pipe, catch basins, manholes, and one outfall at the east end of Alpensee Strasse Rd.

Downtown West Basin Description

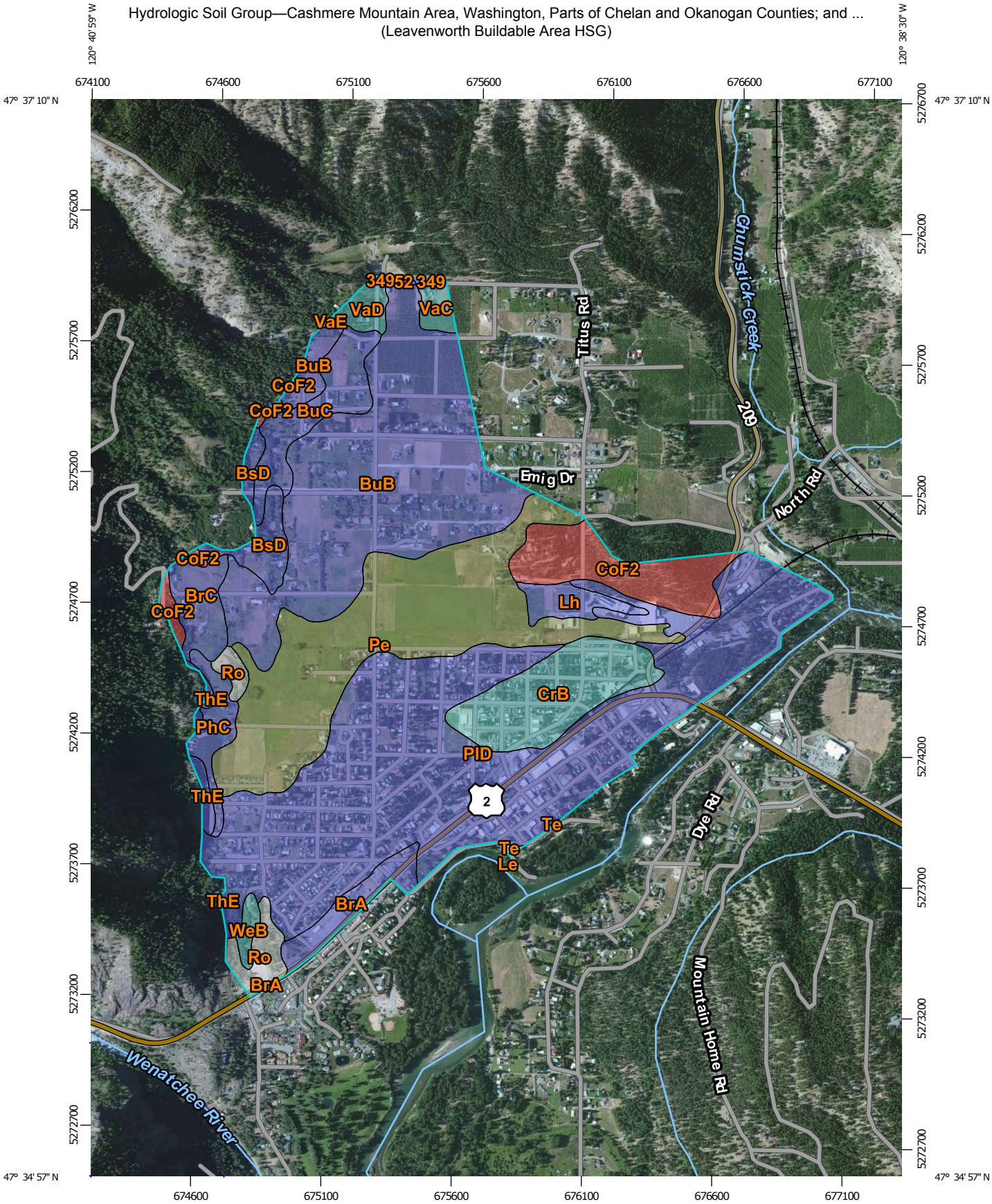
- Area: Within the City limits.
- Topography
    - Slopes from the NW to the SE.
- Ground Cover
    - Rural undeveloped land and farms; Urban single family residential, multifamily, and commercial.
- Natural Conveyance
    - Varied locations of sheet flow and shallow concentrated flow.
- Manmade Conveyance
    - Surface: ditches, curb and gutter.
    - Subsurface: pipe, catch basins, manholes, and one outfall near the Main St. / 8th St. intersection.

Downtown East Basin Description

- Area: Within the City limits
- Topography
    - Slopes from the NW to the SE.
- Ground Cover
    - Urban single family residential, multifamily, and commercial.

- Natural Conveyance
    - None.
- Manmade Conveyance
    - Surface: curb and gutter.
    - Subsurface: pipe, catch basins, manholes, and one outfall at 14th St.

Hydrologic Soil Group—Cashmere Mountain Area, Washington, Parts of Chelan and Okanogan Counties; and ...
(Leavenworth Buildable Area HSG)



Map Scale: 1:20,000 if printed on A portrait (8.5" x 11") sheet.

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Meters: 0 250 500 1000 1500

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cashmere Mountain Area, Washington, Parts of Chelan and Okanogan Counties
Survey Area Data: Version 13, Sep 3, 2014

Soil Survey Area: Chelan County Area, Washington (Parts of Chelan and Kittitas Counties)
Survey Area Data: Version 10, Sep 3, 2014

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 25, 2010—Oct 17, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Cashmere Mountain Area, Washington, Parts of Chelan and Okanogan Counties (WA608)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
52	Burch loam, 3 to 8 percent slopes	B	0.6	0.1%
349	Varelum loam, 8 to 15 percent slopes	B	1.1	0.1%
Subtotals for Soil Survey Area			**1.7**	**0.2%**
Totals for Area of Interest			**828.3**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — Chelan County Area, Washington (Parts of Chelan and Kittitas Counties) (WA607)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BrA	Brief gravelly sandy loam, 0 to 3 percent slopes	B	15.2	1.8%
BrC	Brief gravelly sandy loam, 8 to 15 percent slopes	B	16.6	2.0%
BsD	Brief stony sandy loam, 0 to 25 percent slopes	B	15.7	1.9%
BuB	Burch fine sandy loam, 3 to 8 percent slopes	B	178.1	21.5%
BuC	Burch fine sandy loam, 8 to 15 percent slopes	B	26.9	3.3%
CoF2	Cle Elum-Rock outcrop complex, 25 to 65 percent slopes	D	43.4	5.2%
CrB	Colockum silt loam, 3 to 8 percent slopes	C	47.9	5.8%
Le	Leavenworth loamy sand	A	0.0	0.0%
Lh	Leavenworth fine sandy loam	B	10.6	1.3%
Pe	Peoh silt loam	C/D	140.0	16.9%
PhC	Peshastin loam, 8 to 15 percent slopes	B	12.6	1.5%
PlD	Peshastin stony loam, 0 to 25 percent slopes	B	283.8	34.3%
Ro	Rock outcrop		14.2	1.7%
Te	Terrace escarpments		0.7	0.1%
ThE	Thow gravelly fine sandy loam, 25 to 45 percent slopes	B	4.6	0.6%

Hydrologic Soil Group— Summary by Map Unit — Chelan County Area, Washington (Parts of Chelan and Kittitas Counties) (WA607)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
VaC	Varelum silt loam, 3 to 15 percent slopes	C	5.3	0.6%
VaD	Varelum silt loam, 15 to 25 percent slopes	C	6.6	0.8%
VaE	Varelum silt loam, 25 to 45 percent slopes	C	0.3	0.0%
WeB	Wenatchee silt loam, 3 to 8 percent slopes	C	4.0	0.5%
Subtotals for Soil Survey Area			**826.6**	**99.8%**
Totals for Area of Interest			**828.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

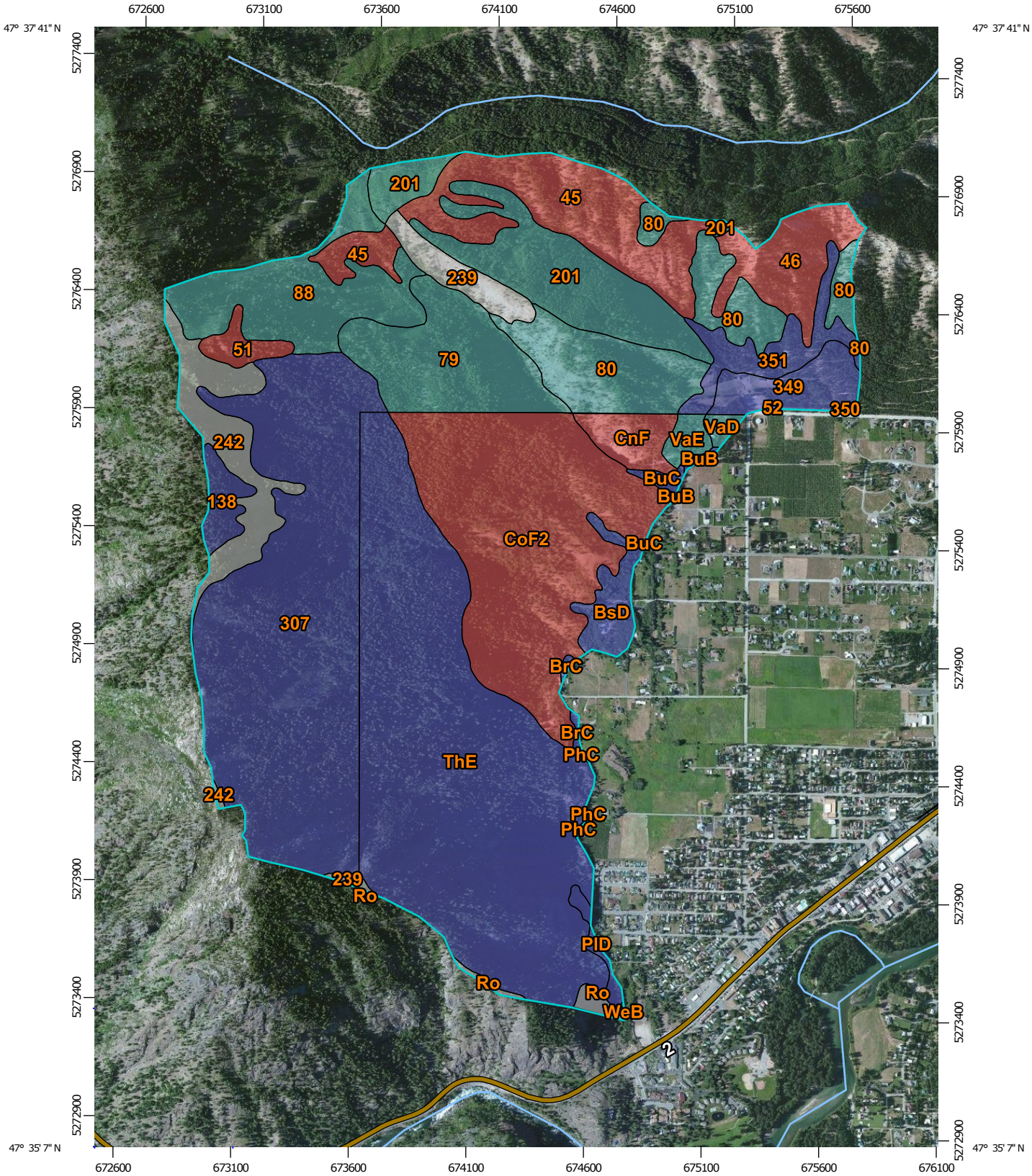
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Hydrologic Soil Group—Cashmere Mountain Area, Washington, Parts of Chelan and Okanogan Counties; and ...
(Leavenworth Non-Buildable Area HSG)



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Meters: 0 300 600 1200 1800

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Cashmere Mountain Area, Washington, Parts of Chelan and Okanogan Counties (WA608)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
45	Blag-Cle Elum-Rock outcrop complex, 30 to 75 percent slopes	D	99.6	6.3%
46	Blag-Rock outcrop complex, 30 to 80 percent slopes	D	42.9	2.7%
51	Brisky-Rock outcrop complex, 30 to 60 percent slopes	D	10.7	0.7%
52	Burch loam, 3 to 8 percent slopes	B	0.2	0.0%
79	Cle Elum loam, 30 to 60 percent slopes	C	79.8	5.0%
80	Cle Elum loam, 30 to 60 percent south slopes	C	93.5	5.9%
88	Culving-Rock outcrop complex, 30 to 60 percent slopes	C	81.7	5.1%
138	Icicle very bouldery sandy loam, 30 to 75 percent slopes	B	13.7	0.9%
201	Nard sandy loam, 30 to 60 percent slopes	C	93.5	5.9%
239	Rock outcrop		21.7	1.4%
242	Rock outcrop-Chumstick-Icicle complex, 45 to 90 percent slopes		49.5	3.1%
307	Thow cindery fine sandy loam, 30 to 60 percent slopes	B	296.2	18.7%
349	Varelum loam, 8 to 15 percent slopes	B	29.0	1.8%
350	Varelum loam, 15 to 30 percent slopes	B	0.4	0.0%
351	Varelum loam, 30 to 60 percent slopes	B	30.3	1.9%
Subtotals for Soil Survey Area			**942.7**	**59.4%**
Totals for Area of Interest			**1,587.7**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — Chelan County Area, Washington (Parts of Chelan and Kittitas Counties) (WA607)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BrC	Brief gravelly sandy loam, 8 to 15 percent slopes	B	1.9	0.1%
BsD	Brief stony sandy loam, 0 to 25 percent slopes	B	20.6	1.3%
BuB	Burch fine sandy loam, 3 to 8 percent slopes	B	1.6	0.1%
BuC	Burch fine sandy loam, 8 to 15 percent slopes	B	3.3	0.2%
CnF	Cle Elum silt loam, 45 to 65 percent slopes	D	19.1	1.2%
CoF2	Cle Elum-Rock outcrop complex, 25 to 65 percent slopes	D	211.2	13.3%
PhC	Peshastin loam, 8 to 15 percent slopes	B	0.5	0.0%
PlD	Peshastin stony loam, 0 to 25 percent slopes	B	5.4	0.3%
Ro	Rock outcrop		6.3	0.4%
ThE	Thow gravelly fine sandy loam, 25 to 45 percent slopes	B	363.6	22.9%
VaD	Varelum silt loam, 15 to 25 percent slopes	C	3.7	0.2%
VaE	Varelum silt loam, 25 to 45 percent slopes	C	7.7	0.5%
WeB	Wenatchee silt loam, 3 to 8 percent slopes	C	0.1	0.0%
Subtotals for Soil Survey Area			**645.0**	**40.6%**
Totals for Area of Interest			**1,587.7**	**100.0%**

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
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

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

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

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

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	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
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

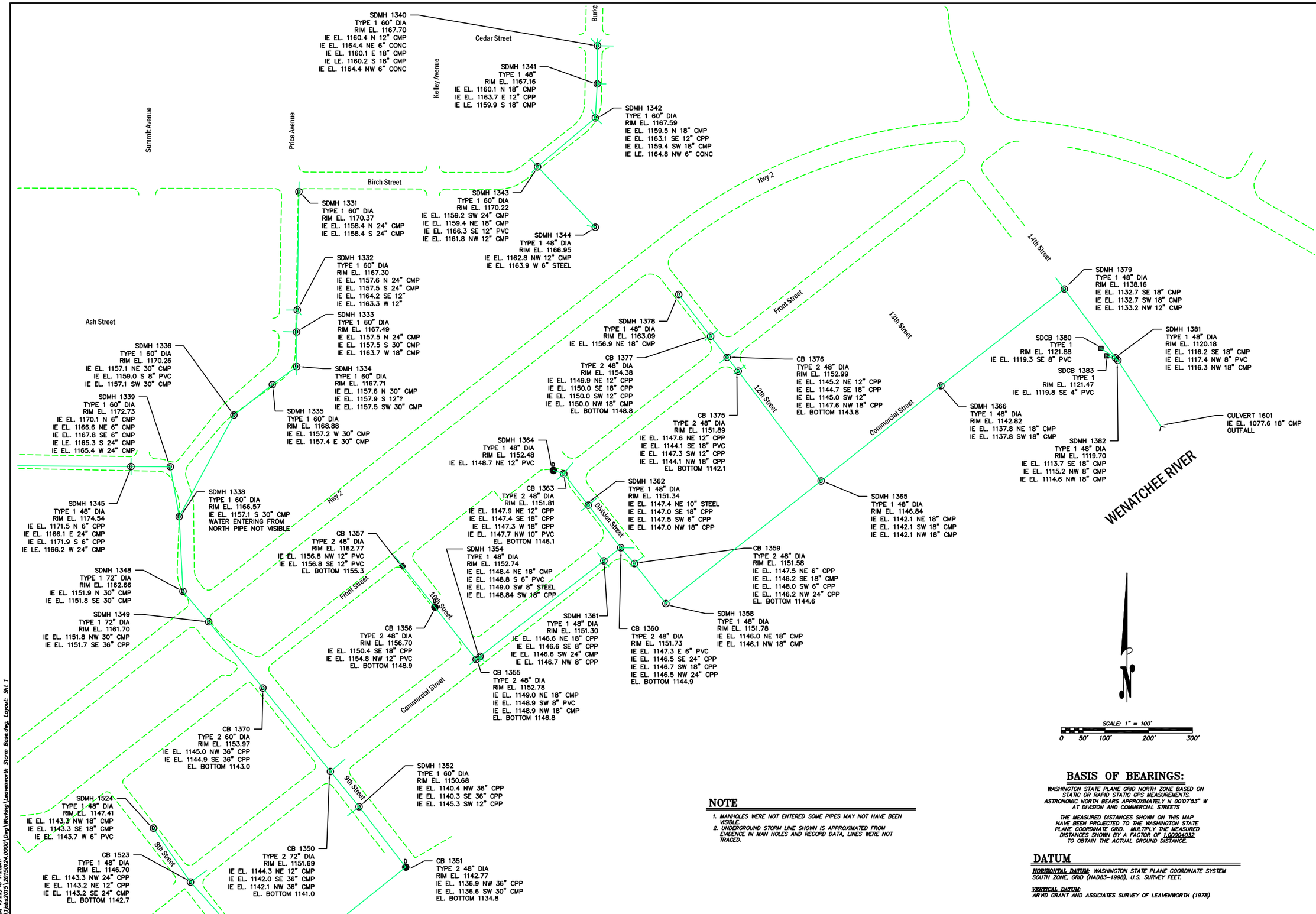
1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor*: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2]	A [3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

PACIFIC ENGINNING
STORM STRUCTURE SURVEY
CITY OF LEAVENWORTH



NOTE

1. MANHOLES WERE NOT ENTERED SOME PIPES MAY NOT HAVE BEEN VISIBLE.
2. UNDERGROUND STORM LINE SHOWN IS APPROXIMATED FROM EVIDENCE IN MAN HOLES AND RECORD DATA, LINES WERE NOT TRACED.

BASIS OF BEARINGS:

WASHINGTON STATE PLANE GRID NORTH ZONE BASED ON STATIC OR RAPID STATIC GPS MEASUREMENTS.
ASTRONOMIC NORTH BEARS APPROXIMATELY N 00°07'53" W AT DIVISION AND COMMERCIAL STREETS

THE MEASURED DISTANCES SHOWN ON THIS MAP HAVE BEEN PROJECTED TO THE WASHINGTON STATE PLANE COORDINATE GRID. MULTIPLY THE MEASURED DISTANCES SHOWN BY A FACTOR OF 1.00004032 TO OBTAIN THE ACTUAL GROUND DISTANCE.

DATUM

HORIZONTAL DATUM: WASHINGTON STATE PLANE COORDINATE SYSTEM SOUTH ZONE, GRID (NAD83–1998), U.S. SURVEY FEET.

VERTICAL DATUM:
ARVID GRANT AND ASSICIATES SURVEY OF LEAVENWORTH (1978)

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LAYOUT: SHT 1
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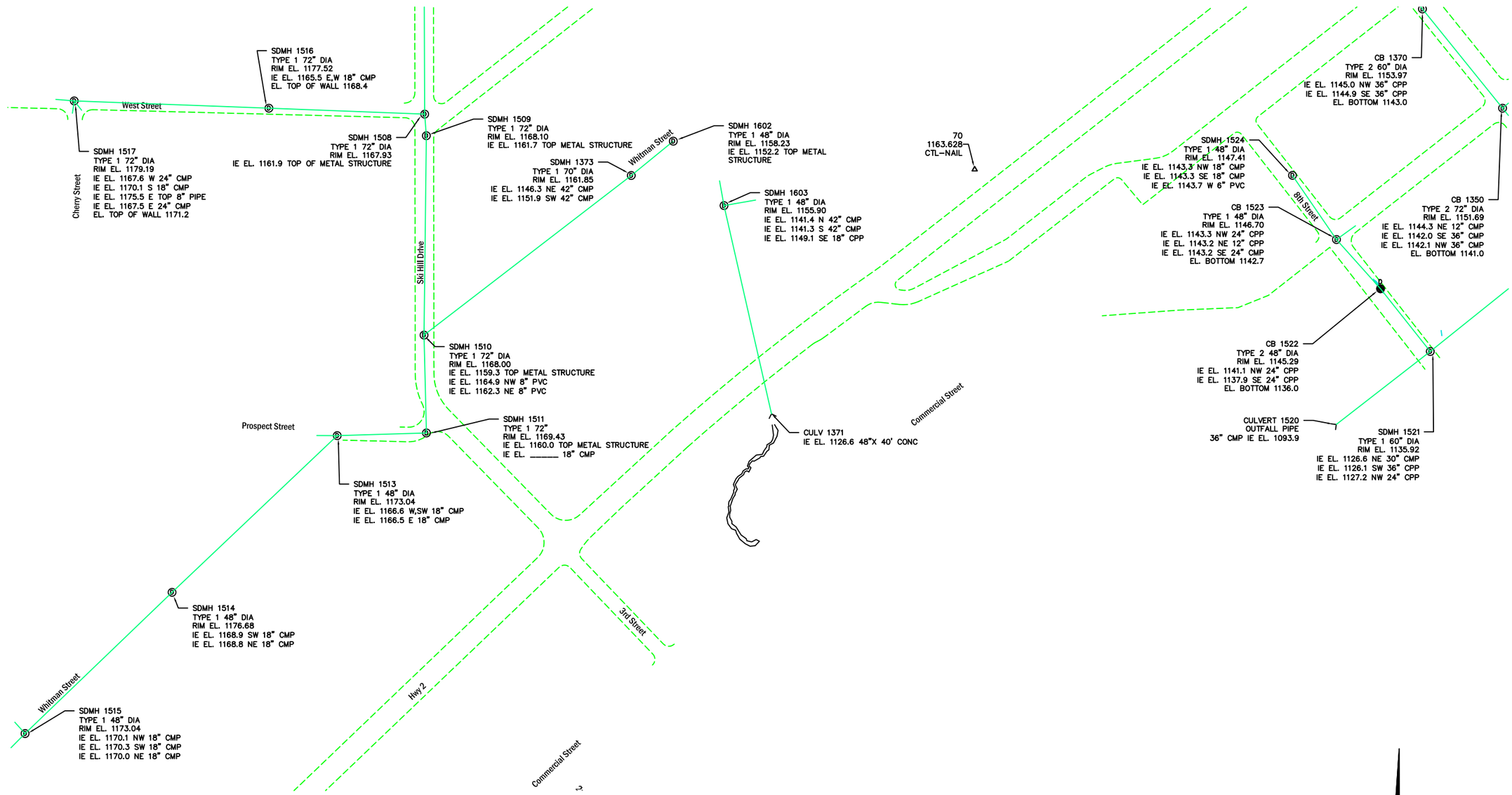

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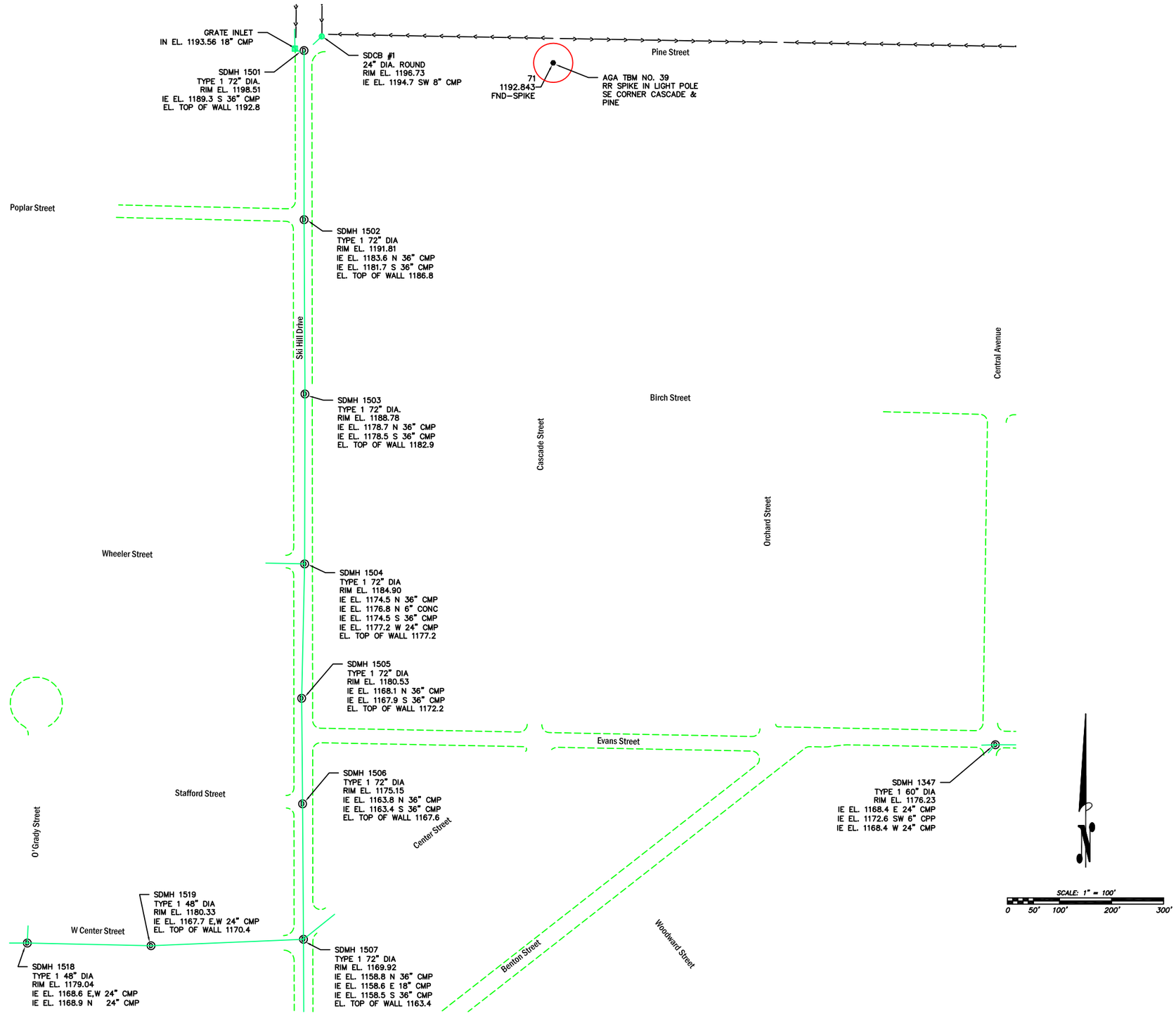

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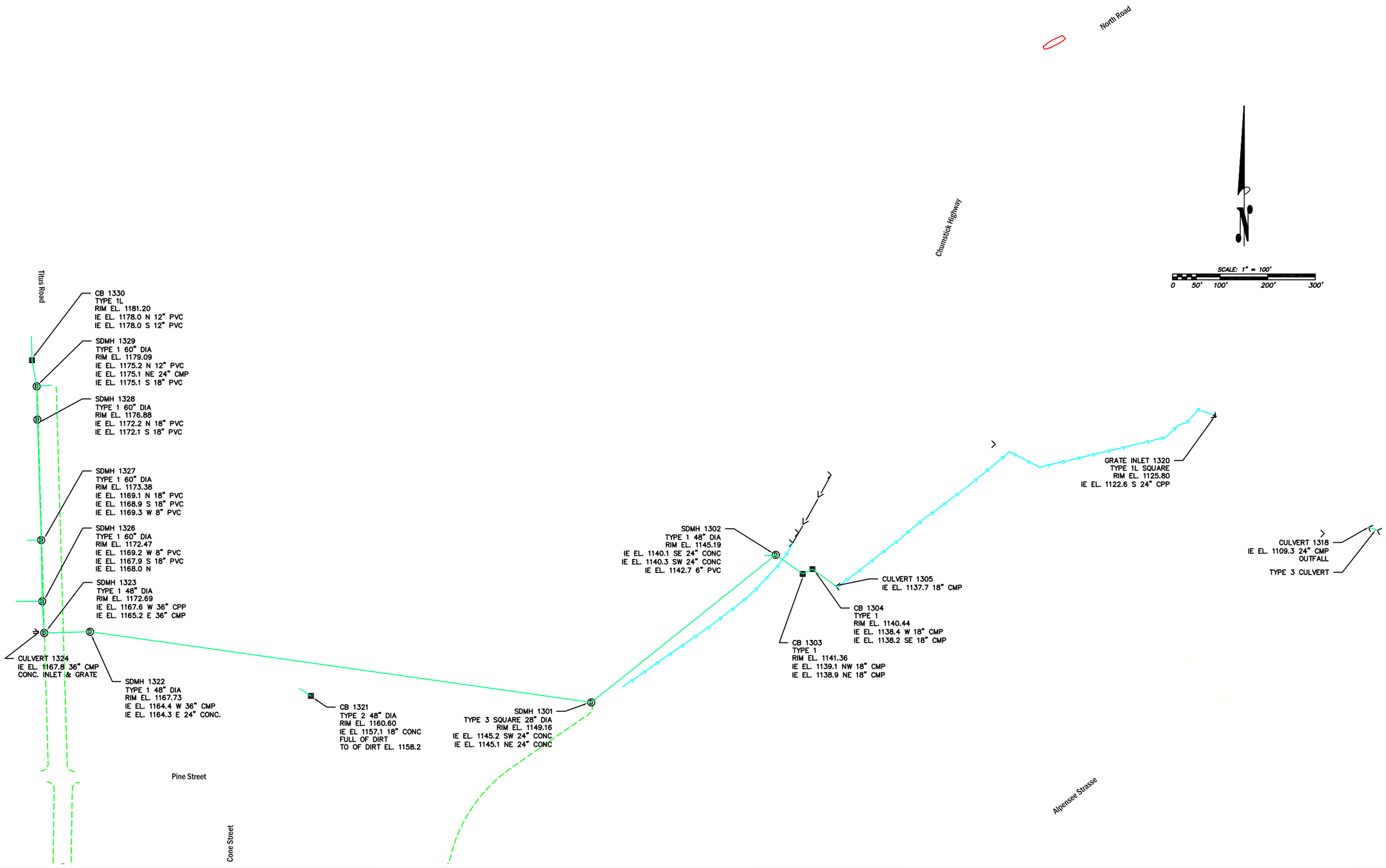

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SECTION 4: PERFORMANCE STANDARDS

The SWMMEW locates Leavenworth in Region 1, i.e. areas on the east slopes of the Cascade Mountains with more than 16 inches of annual precipitation.

To date, Leavenworth has not yet adopted a preferred stormwater facility sizing approach, i.e. performance standard. The SWMMEW default approach is designated Method 1. An engineer has the option of choosing whether to use a volume or rate approach. No project is required to meet both standards. The Method 1 standards are summarized in the tables below.

Water Quality

Table 4a: Water Quality Performance Standards

	Water Quality Treatment (volume)	**Water Quality Treatment Upstream of Runoff Control (flow)	**Water Quality Treatment Downstream of Runoff Control (flow)
Rainfall Distribution	*Regional Storm	Short Duration Storm	Short Duration Storm
Design Storm	6 month 24 hour	2 year 2 hour	2 year 2 hour

**alternatively, the modified type 1A may be used.*
***"upstream" and "downstream" are intended to describe treatment relative to the location of a detention facility*

Runoff Control

Table 4b**:** Runoff Control Performance Standards

	Runoff Control (volume)	Runoff Control (flow)
Rainfall Distribution	Regional Storm	Regional Storm
Design Storm	*TBD	*TBD

**currently not codified*

The Wenatchee River, downstream of its confluence with Icicle Creek, is listed as an "exempt surface water". In general, that means that runoff control is not required for any of the subject four (4) storm drainage networks prior to their discharges to the river. That does not preclude the City from adopting a requirement of runoff control prior to connection to any of the networks.

Non-Exempt Streams

SWMMEW standards address the relationship of runoff control of stormwater and nonexempt streams. The following is a summary of those standards.

Projects shall limit the peak rate of discharge to a non-exempt stream to 1) 50% of the pre-developed or existing 2-year peak flow <u>and</u> 2) the pre-developed or existing 25-year peak flow.

Wetlands and Water Quality Treatment

SWMMEW standards address the relationship of water quality treatment of stormwater and wetlands. The wetland categories used below are based on the Eastern Washington Wetland Rating System. The following is a summary of those standards.

Stormwater treatment facilities are not allowed within a wetland or its natural vegetated buffer except for:

- *Necessary conveyance systems approved by the local government; <u>or</u>*
- *As allowed in a wetland mitigation plan; <u>or</u>*

- *When the following requirements are met:*
  - *The wetland meets the criteria for the "Hydrologic Modification of a Wetland" <u>and either</u>;*
    - *Is a Category 4 wetland;*
      <u>or</u>:
    - *Is a Category 3 wetland <u>and</u> has been previously disturbed by human activity, as evidenced by agriculture, fill areas, ditches <u>or</u> the wetland is dominated by introduced or invasive weedy plant species.*

Basic treatment is required prior to discharge to Category 3 wetlands. A Category 3 wetland that meets the above requirements may be used to meet metals treatment requirements. Oil treatment is required for all discharges to wetlands from high use sites.

Wetlands and Runoff Control

SWMMEW standards address the relationship of runoff control of stormwater and wetlands. The following is a summary of those standards.

- *If the wetland 1) does not have an outlet to a stream, or 2) does not have a direct outlet to an exempt river or lake, or 3) has an outlet to a non-exempt stream, the project shall maintain the pre-developed or existing 2-year and 25-year peak runoff rate.*
- *Category 3 or 4 wetlands may be excluded from this requirement and used as detention facilities if the criteria for "Hydrologic Modification of a Wetland" are met.*

<u>Hydrologic Modification of a Wetland:</u>
Hydrologic modification is not allowed in Category 1 or 2 wetlands unless it is demonstrated that preferred methods of stormwater disposal are not possible <u>and</u> that other options would result in damage to the wetland by limiting base flow.

Category 3 or 4 wetlands can be considered for hydrologic modification if:

- *There is good evidence that the natural hydrologic regime of the wetland can be restored by introducing stormwater runoff; <u>or</u> the wetland is under imminent threat and could receive greater protection if acquired for a stormwater management project rather than left in existing ownership;*
  <u>and</u>:
- *Introduced runoff is from the same natural drainage basin; the wetland lies in the natural path of the runoff; and provisions are made to locate runoff discharge at the natural location. Exceptions may be made for regional facilities planned by the local jurisdiction, but the wetland should receive water from sites in the same watershed.*

Road Projects

The HRM performance standards are introduced here as they are appropriate for typical City linear projects, i.e. road construction and reconstruction.

Table 4c: Roadway Performance Standards

	Water Quality (volume)	**Upstream Facility Water Quality (flow)**	***Downstream Facility Water Quality (flow)**	**Detention Runoff Control (flow)**	**Infiltration Runoff Control (flow)**
Rainfall Distribution	SCS 24 hour or Regional Storm	SCS 24 hour or Short Duration	SCS 24 hour or Short Duration or Regional	SCS 24 hour or Regional Storm	SCS 24 hour or Regional Storm
Design Storm	6 month post-developed	6 month or 2 year 2 hour post-developed	2 year release	50% of 2 year. 25 year 24 hour pre-developed	25 year 24 hour pre-developed

**whichever produces the largest flow*

SECTION 5: WATER QUALITY REQUIREMENTS

Procedures to determine the type(s) of water quality treatment required for a project is well defined in section 2.2.5 of the SWMMEW. Generally, four types of treatment may be required including basic, metals, oil, and phosphorus.

Specifically, a project is required to determine the area (sf) of pollution generating surfaces and average daily traffic (ADT). This data is then used to designate the project "use", which is then used to determine the required type(s) of water quality treatment. A summary of the definition of terms follows.

Pollutant Generating Impervious Surfaces (PGIS)

All curb, gutter, sidewalk, driveways, and roofs which drain onto roadway and parking impervious surfaces are defined as PGIS and subject to treatment. All other surfaces are generally understood to be designated as non-pollutant generating impervious surfaces (NPGIS). Should PGIS and NPGIS be combined, i.e. their surface runoff mingles, then the combined designation is PGIS.

Average Daily Traffic (ADT)

ADT is estimated via the "Trip Generation" manual published by the Institute of Transportation Engineers (ITE).

Use

Project ADT is applied to the table below in order to define whether a project is Low, Moderate, or High Use. A use definition is the final step required to prescribe the type of required treatment. The following table describes each use and the required type of treatment, i.e. Basic, Metals, and Oils. Exemptions are outlined on SWMMEW pages 2-20 and 2-21.

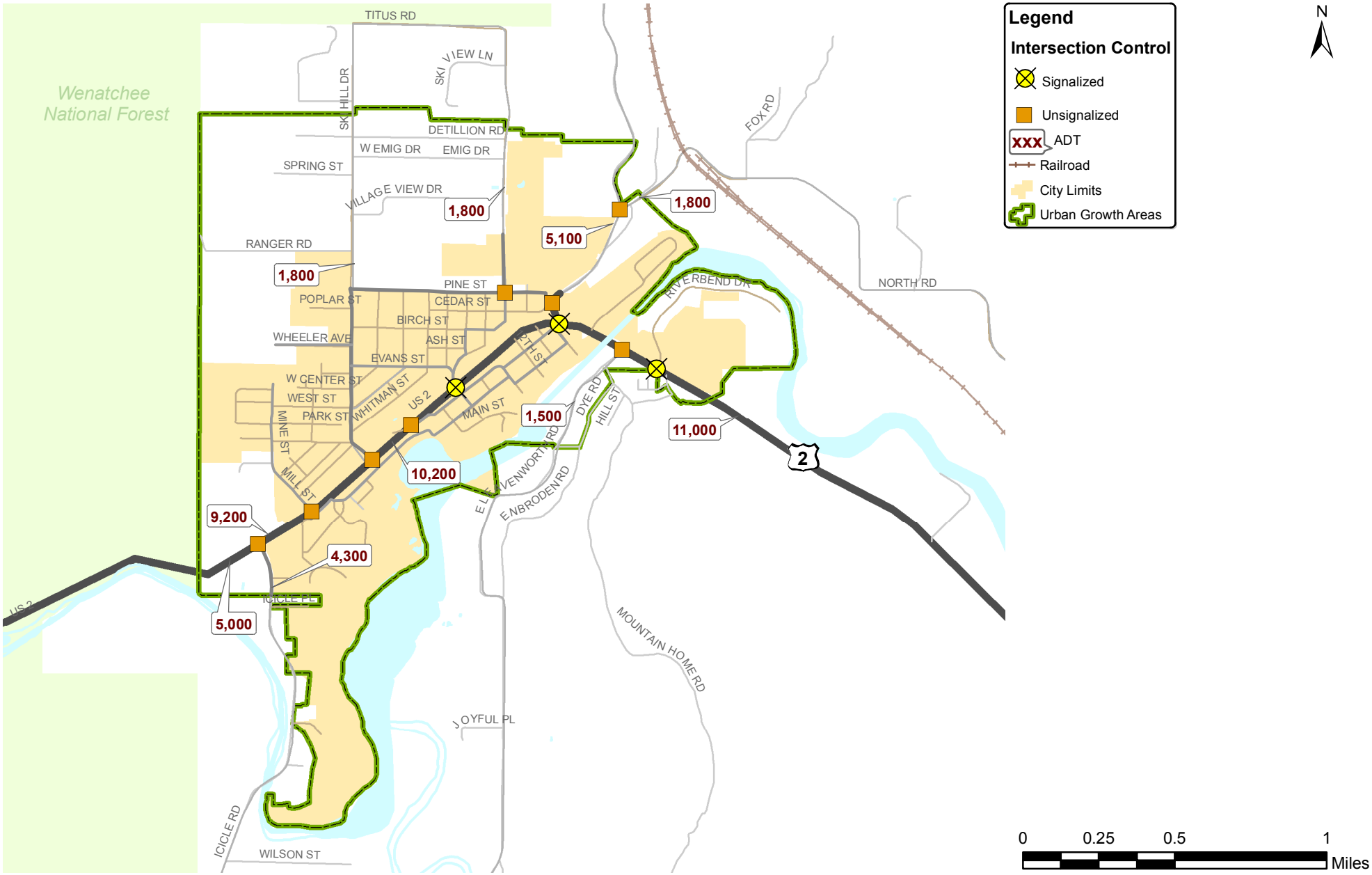
Table 5: Use Procedures

Use Definition	Urban Roads	Rural Roads	Parking Areas	
Low	< 7,500 Basic	< 15,000 Basic	< 40 trip ends per 1,000 sf of building Basic	< 100 trip ends Basic
Moderate	7,500 - 30,000 Basic, Metals	15,000 - 30,000 Basic, Metals	40 – 100 trip ends per 1,000 sf of building Basic, Metals	100 – 300 trip ends Basic, Metals
*High	> 30,000 Basic, Metals, Oils	> 30,000 Basic, Metals, Oils	> 100 trip ends per 1,000 sf of building Basic, Metals, Oils	> 300 trip ends Basic, Metals, Oils

*See pages 2-19 and 2-20 for additional High Use definitions

Total Maximum Daily Load's (TMDL)

Downstream of the City, the Wenatchee River has phosphorus levels which are negatively impacting the dissolved oxygen (DO) and pH levels in the river. Large reductions of point and nonpoint sources of phosphorus loading to the river are now required by Ecology.



2008 Average Weekday Traffic Volumes

Leavenworth Transportation Element

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transpoGROUP

FIGURE

4

SECTION 6: DESIGN STORMS / PRECIPITATION DEPTHS

Two design storms are used in the model simulations, i.e. The Regional Storm (36 hour) and Short Duration Storm (3 hour). The Regional storm simulates lower intensity and larger volumes events typical of a "general" storm. The Short Duration storm simulates high intensity and smaller volumes typical of a summer thunderstorm. Precipitation depths are specific to the Leavenworth locale.

Table 6: Precipitation Depths

Design Storm	*6 month	2 year	10 year	25 year	100 year
**Regional	1.17"	1.74"	2.61"	2.90"	3.77"

*Multiply 2 year precipitation by 0.67
**Multiple 24-hour precipitation by 1.16

The Short Duration storm precipitation depth is 0.58", i.e. 0.55" times 1.06 for Region 1.

The local average annual precipitation total is 24.22 inches.

LEAVENWORTH 3 S, WASHINGTON (454572)

Period of Record Monthly Climate Summary

Period of Record : 05/01/1914 to 01/09/2015

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	33.4	41.9	52.5	62.9	72.1	78.8	87.8	87.2	78.0	63.1	44.2	33.9	61.3
Average Min. Temperature (F)	17.3	21.4	27.8	33.9	40.3	46.3	50.8	50.0	42.7	34.6	28.0	20.4	34.5
Average Total Precipitation (in.)	4.35	2.77	2.07	1.01	0.85	0.85	0.34	0.44	0.71	2.01	4.01	4.82	24.22
Average Total SnowFall (in.)	30.4	14.4	6.4	0.3	0.0	0.0	0.0	0.0	0.0	0.5	11.7	31.3	94.9
Average Snow Depth (in.)	18	18	7	0	0	0	0	0	0	0	2	10	5

Percent of possible observations for period of record.
Max. Temp.: 84.6% Min. Temp.: 84.5% Precipitation: 88.5% Snowfall: 86.5% Snow Depth: 84.9%
Check Station Metadata or Metadata graphics for more detail about data completenes

SECTION 7: MODELING RESULTS

Ski Hill Basin Results
Drainage area: 1,579 acres.

Table 7a: Ski Hill Basin Existing Conditions

Storm	6 month	2 year	10 year	25 year	100 year
Maximum Runoff (cfs)	1.9	10.5	32.0	44.0	103.2
Total Runoff (cf)	100,562	594,020	2,141,026	2,831,959	5,304,002
Surcharge (pipe #)	-	-	-	*6-8	**1-8, 14, 18-19, 21
Flood (structure #)	-	-	-	-	**1501-1502, 1507, 1515

*Ski Hill Rd
**Ski Hill Rd, Pine St., Poplar St., Center St., and Whitman St.

Table 7b: Ski Hill Basin Future Conditions

Storm	6 month	2 year	10 year	25 year	100 year
Maximum Runoff (cfs)	2.72	12.13	36.53	52.22	115.96
Total Runoff (cf)	131,593	709,383	2,394,972	3,131,399	5,732,467
Surcharge (pipe #)	-	-	*7	*5-8	**1-8, 14, 18-19, 21
Flood (structure #)	-	-			**1501-1502, 1507, 1515, 1517

*Ski Hill Rd
**Ski Hill Rd, Pine St., Poplar St., Center St., Whitman St., and West St.

Alpensee Strasse Basin Results
Drainage area: 457 acres.

Table 7c: Alpensee Strasse Basin Existing Conditions

Storm	6 month	2 year	10 year	25 year	100 year
Maximum Runoff (cfs)	1.5	5.4	17.1	23.6	46.4
Total Runoff (cf)	73,813	329,531	978,433	1,244,263	2,147,143
Surcharge (pipe #)	-	-	*10-11	*9-11	**4-11
Flood (structure #)	-	-	*1302-1304	*1302-1304	**1301-1304, 1322, 1326

*Chumstick Rd crossing
**Chumstick Rd crossing and Titus Rd

Table 7d: Alpensee Strasse Basin Future Conditions

Storm	6 month	2 year	10 year	25 year	100 year
Maximum Runoff (cfs)	3.4	8.6	28.6	36.7	63.6
Total Runoff (cf)	202,019	576,000	1,385,222	1,698,664	2,728,432
Surcharge (pipe #)	-	*11	*9-11	**5-11	**4-11
Flood (structure #)	-	-	*1301-1304	*1301-1304	**1301-1304, 1322, 1326

*Chumstick Rd crossing
**Chumstick Rd crossing and Titus Rd

Downtown West Basin Results

Drainage area: 129 acres.

Table 7e: Downtown West Basin Existing Conditions

Storm	6 month	2 year	10 year	25 year	100 year
Maximum Runoff (cfs)	1.6	3.9	9.8	12.3	20.2
Total Runoff (cf)	73,751	187,668	424,651	515,127	809,954
*Surcharge (pipe #)	-	-	-	-	1-2, 30-34, 15-17
Flood (structure #)	-	-	-	-	-

Table 7f: Downtown West Basin Future Conditions

Storm	6 month	2 year	10 year	25 year	100 year
Maximum Runoff (cfs)	2.2	4.6	9.4	11.6	19.0
Total Runoff (cf)	89,943	197,767	422,507	508,711	791,190
*Surcharge (pipe #)	-	-	-	-	1-2, 30-34, 15-17
Flood (structure #)	-	-	-	-	-

*Price Ave, Birch St, and Burke Ave

Downtown East Basin Results

Drainage area: 24 acres

Table 7g: Downtown East Basin Existing & Future Conditions

Storm	6 month	2 year	10 year	25 year	100 year
Maximum Runoff (cfs)	1.5	2.7	4.7	5.4	7.4
Total Runoff (cf)	52,093	93,648	162,387	186,085	258,524
Surcharge (pipe #)	-	-	-	-	-
Flood (structure #)	-	-	-	-	-

ATTACHMENT A
1999 WATER QUALITY PROBLEMS STUDY EXCERPTS

Stormwater

Stormwater in the study area includes surface and subsurface natural flows and runoff from curtain drains, ditches, roadways, and structures. The City of Leavenworth has no stormwater treatment system in place. Stormwater is collected at grated culverts and piped underground. The existing City stormwater system consists of 29,389 lineal feet of storm sewer pipe, 90 storm sewer manholes, 27 shared access manholes where sanitary sewer pipe is located above the storm sewer pipe, and seven discharge points into the Wenatchee River. At this time, no periodic monitoring of the discharge points is done to determine the impact of stormwater on the water quality of the Wenatchee River.

At several locations, the storm sewer is connected directly to the sanitary sewer because storm sewer was not available at time of construction. The City is not aware of any storm sewer connections to the sanitary sewer in the Ski Hill area. Where connections exist, it is problematic during storm events. Stormwater can overload the sewage treatment plant, causing partly treated sewage to discharge into the Wenatchee River.

The Chelan County Public Works Department maintains a system of grassed ditches, culverts, and buried pipe that serve to channel runoff in the UGA. Grass growing in the ditches serves to filter sediments out of the runoff. Year-round, County staff checks the ditches regularly to look for excessive sod buildup. Sod buildup is partially caused by winter sand that is washed by rain and snowmelt into ditches. Too much sod impedes the flow of water so the County removes it by excavation. In the summer of 1998, the County ditch paralleling Wheeler Street was deepened, but work was delayed due to excessive sogginess of the soil. The stormwater from the Ski Hill Basin enters the City stormwater system at grated culverts. The City of Leavenworth is responsible for checking and cleaning these intake culverts. The City's routine practice during spring runoff and all major runoff events is to monitor all stormwater intakes.

Flooding Issues

Landowners in the area west of Ski Hill Drive and south of Maple Street have reported longer periods of increased wetness on their land since 1994. Landowners inside the City limits west of Ski Hill Drive have reported recent seasonal problems with high groundwater table, seasonal flooding, and sheet flow.

The City of Leavenworth stormwater drainage system is servicing both City and Chelan County stormwater from the Ski Hill Basin. During storms and spring run-off, the capacity of the intakes is not adequate. Ponding and sheet flow sometimes occur at the entry points into the City stormwater drainage system at Ski Hill Drive and Pine Street and at Poplar Street. This sheet flow has impacted adjacent private properties.

Installation of curtain drains and French drains on private parcels has resulted in concentrated flow down gradient onto adjacent properties.

Ski Hill Drive, from Pine Street to West Street, has stormwater entry road drains at a higher elevation than the adjacent properties. Thus, water sometimes sheet flows onto property west of Ski Hill Drive instead of entering the drains.

Surface Hydrology

A field indicator for the hydrology criteria is "the visual observation of inundation during the growing season. Photos recorded the presence of water on the ground surface (inundation) or flowing water over time at 44 parcels. The largest field indicator is found in the western part of the Ski Hill Basin, south of Spring Street to the Wheeler Road area. Other field indicators characterize the region adjoining Highway 2 at Icicle Road, the lands north of Pine Street, the land adjoining the west side of Chumstick Highway, and the land adjoining lower Titus Road near the Club West facility.

Surface Hydrology Implications

The hydrology results identify several areas within the study boundary that will need to be re-examined to determine whether or not urban densities are appropriate and feasible:

1. The block of land south of Maple Street, west of Ski Hill Drive, extending south to the Wheeler Street vicinity;
2. The block of land north of Hwy. 2 at Icicle Road containing a 2-acre emergent pond and a smaller Scrub-shrub wetland, both identified on the NWI maps and during the study's fieldwork;
3. Lands adjoining the west side of Chumstick Road, where a series of seeps were observed in the roadcuts;
4. Lands containing a riparian corridor of Chumstick Creek;
5. Lands bordering Pine Street; and
6. Lands adjoining lower Titus Road near the Club West facility. Wetlands were present at the base of the hill bisected by Titus Road, and are connected as an east-to-west drainage corridor draining into Chumstick Creek.

Hydrogeology Implications

The study results suggest that some Ski Hill Basin lands contain wetlands and/or water problems that could impact property owners and adjacent lands. The county and City should consider these findings when designating UGA densities for the Ski Hill Basin. When making adjustments to the UGA, appropriate densities should be developed for two categories of Ski Hill Basin lands:

- Parcels categorized as likely wetlands or likely filled or drained wetlands
- Parcels categorized as unknown or parcels adjacent to or surrounded by parcels categorized as likely wetlands.

The largest cluster of parcels is found in the western part of the Ski Hill Basin, south of Spring Street and extending to the Wheeler Road area. Other clusters characterize the region adjoining Highway 2 at Icicle Road, the lands north of Pine Street, the land adjoining the west side of Chumstick Highway, and the land adjoining lower Titus Road near the Club West facility.

The hydrogeology report and the field findings together explain the nature of the wetlands present in this large region and why current landowners are experiencing water problems. The aquifer underlying the basin is recharged from a large geographic area to the north and west, and responds to annual and multi-year precipitation patterns. Recent years have seen the recharge of groundwater tables with saturation from the surface down over 150 feet to bedrock, reflected in the increased water visible on the land surface from early spring into summer. This type of wetland hydrology fluctuates seasonally and in response to general climate patterns that determine recharge of groundwater.

Overall, water table levels are lower in series of years where the October to March precipitation is below normal. The climate patterns of a series of drought years resulted in a lowered groundwater table for a period of years. Several Ranger Road landowners reported increased wetness on their land in recent years due to the 1994 fires on Tumwater Mountain. They believe that the fires removed forest cover and this resulted in higher than normal spring runoff to the basin. Precipitation data, however, suggests instead a climatic explanation for land being wetter. From 1983 to 1994, the March to October precipitation levels were below normal, but rose to above normal levels in 1995 through 1998. Increased precipitation allowed gradual recharge of the aquifer after an elevenyear drought cycle, unrelated to the 1994 fires, but occurring at the same time.

A second factor contributing to the increased wetness of this land is the 25-year process of conversion from agricultural land use to single family residential land use in the areas south of Maple Street and north of Wheeler Street, west of Ski Hill Drive. The hydrogeology results note that the increasing amount of impervious surfaces in the basin over time has decreased the capacity of the ground to uptake spring runoff. Thus, during the spring, runoff from the upper basin is ponding in the lower part of the Ski Hill Basin. These are the lands identified in the landowner surveys and in the study results as having water problems.

Many residents who have built homes and on-site septic systems in the Ski Hill Basin use French and curtain drains to shift water off their land. The hydrogeology results demonstrate that natural processes will replace any water

artificially drained off a parcel. Realistically, a parcel in this region is "not drainable" when water tables are high due to the interconnected nature of the three wetland systems. Artificial drainage off one parcel impacts parcels located at a lower gradient. One example of this is the increased duration of flooding reported in the surveys by the landowners in the Wheeler/Poplar Streets area, all located at the lowest gradient before water enters the City stormwater drainage system. Included in this area is the home that required special engineering and $30,000 to build a floating foundation, and the farmer who has experienced increased duration and spread of water on farm fields, making them unusable.

Parcels already inside the City limits in this region are predominantly categorized as "likely wet" in the study results. The City land is situated at the lowest gradient for the Ski Hill Basin and thus is most impacted by upgradient changes in land use that alter hydrology.

Flooding Issues

Ehancement and restoration of wetlands on open space lands would increase spring runoff storage capacity in the lower Ski Hill Basin. This would slow runoff entry into the City's stormwater drainage system and decrease ponding on City parcels which are currently most affected by spring runoff.

Water Quality Issues

The water quality for the Ski Hill Basin stormwater should be improved before it is piped untreated into the Wenatchee River. Enhancement and restoration of wetlands on open space lands would increase water quality filtering capacity of County stormwater before it enters the City's stormwater system.

SOILS REPORT

Authored by Ron Myhrum, Resource Soil Specialist, Natural Resource Conservation Service, after examination of soil pits in the study area on April 16-17, 1998.

At the request of the U.S. Army Corps of Engineers, Seattle District, Andrea Mann-Lower of the Wenatchee NRCS and I provided technical assistance to a groundwater study of the Ski Hill Area of Leavenworth, Washington, on April 16 and 17. I was asked to provide assistance in the identification of hydric soils and Andrea Mann-Lower provided valuable knowledge of the past practices and conditions of the area, as well as gaining experience in hydric soil identification.

During the the course of our visit, we examined soil pits at sites from the bottom to the top of Ski Hill Drive, mainly west of the road. It is apparent that groundwater flow is greatly influenced by the soil type on the site and the location of the site, as well as past drainage modifications. The field work revealed that at the top of Ski Hill Drive, the soils are well drained, moderately permeable and contained no identifiable hydric indicators and no water table within the upper 20 inches of the profile. These soils are identified in the soil survey as Burch soils and Brief soils. In most cases, this area is the conduit for runoff from the canyons above. Because of the slope and the nature of the soils, the water either moves as surface flow along drainageways or is absorbed into the soil and moves horizontally and then laterally, to emerge downslope on the flatter areas. In the lower, flatter areas, the soil pits showed consistent hydric soil indicators, i.e., dark surface layers on top of gleyed or gray subsoil layers. In some pits, the water table was at the surface or within 12 inches, while in other pits, no water table was apparent although the soils did show hydric conditions. Information provided on some of these sites indicated that some drainage modifications had occurred in the past but complete records are unavailable to make accurate predictions. The soil in this area is identified in the soil survey as the Peoh soil and is listed as a hydric soil on the Chelan County hydric soils list.

Finally, it is emphasized that the Soil Survey of Chelan County Area is a good reference for soils information. However, as it is at a scale of 1:20000, it should not be used to identify the soil on a specific site. This requires a site visit. It can be used to compare soils on a site with soils described in the report and contains valuable information to make specific land use interpretations.

HYDROGEOLOGY REPORT

Authored by Alan Wald, Hydrogeologist, WA Dept. of Ecology

Introduction

Hydrogeology is the study of water movement through rocks and soil. It combines hydrology (study of precipitation, evaporation, streamflow, and groundwater) and geology (study of the origin, movement, and weathering of rocks and soil). Hydrology defines the flow of water. Geology defines the physical setting in which that flow occurs. The following discussion considers both.

Little distinction is made between surface water and groundwater for purposes of this report. Spring runoff from snowmelt on Tumwater Mountain infiltrates the ground but reappears as spring flow (surface water discharge) near the base of the mountain. This discharge flows down shallow streams and roadside ditches while infiltrating the alluvial and glacial deposits from Ski Hill to Leavenworth. This infiltration in turn flows beneath the ground beyond the City of Leavenworth and discharges to the Wenatchee River as surface water again. The water in wetlands in the Ski Hill Basin is only a transitional phase of surface and subsurface flow in the watershed from Tumwater Mountain to the Columbia River, and eventually to the sea.

Geology of Ski Hill Basin

The Chumstick Formation, northeast of the Leavenworth Fault and the Ingalls Tectonic Complex to the southwest characterize the Pre-Pleistocene bedrock geology of the Chiwaukum Graben. The Chumstick Formation is typically gray sandstone and siltstone of early Cenozoic Age. The Ingalls Complex is typically darker schist and conglomerates of the same age. Depth to bedrock below land surface varies from less than 40 feet to greater than 250 feet in places, but is typically 100 to 150 feet. The Leavenworth Fault on the western boundary of the Chiwaukum Graben is extensively fractured and conveys perennial groundwater discharge to springs at the base of Tumwater Mountain. Surficial geology is predominantly unconsolidated glacial and glaciofluvial sediments in valley fill and terrace deposits. The glacial sediments are frequently compacted and dense where overridden by advancing ice sheets while glaciofluvial sediments typically have a higher permeability due to sorting by fluvial processes. Sediments underlying the study area include water-bearing gravel and occasional granite boulders interbedded with finegrained lacustrine silts and clays.

Aquifers of Ski Hill Basin

Bedrock in the study area is not considered an aquifer for purposes of this study. Although wells have been drilled into the sandstone and schist to depths of 200 feet or more below the surface, none have produced significant quantities of water. A review of lithologic descriptions in 30 well logs from the study area and research on the hydrogeology of nearby areas suggest there are three water-bearing zones or aquifers in the study area:

1. A perched, seasonal water table at depths of less than 15 to 20 feet,
2. A middle aquifer of water bearing strata of sufficient permeability to yield water to wells at depths of 20 to 60 feet, and
3. A deep aquifer of sands and gravel overlying bedrock at depths of 100 to 150 feet.

These aquifers are not distinct, separate units across the study area. There is likely hydraulic connection between them even though they may be separated by fine-grained outwash and occasionally dense till of insufficient porosity to yield water to wells. A steep groundwater gradient and proximity to the Wenatchee River suggest aquifer discharge to the river controls groundwater levels in the study area.

A local well log (Bradshaw: Section 2, Township 24 N, Range 17E, Parcel ID # 33) describes interbedded silty clays and gravel, with numerous granite boulders to a depth of 111 feet. The well is finished in water-bearing sands and gravel at a depth of 80 to 111 feet. The static water level after drilling was 17 feet below the top of the well. Another local well log (ID#ACE382: Section 1, Township 24 North, Range 17 E) to the east includes interbedded clay and silty sand to a depth of 110 feet. The well is finished in water-bearing sands and gravel at a depth of 94 to 110 feet. The static

water level after drilling was 33.5 feet below the top of the well. As shown in these and other well logs from the study area, the deep aquifer is generally 100 to 120 feet thick, of which 90 feet or more may be saturated. Groundwater levels in the Bradshaw well declined from 6.19 feet below land surface (April, 1998) to 10.60 feet below land surface (September, 1998), as shown in Figure 2.

Groundwater discharge is the upward movement of groundwater in these aquifers under conditions of increasing hydraulic head with depth. Groundwater recharge is the downward movement of groundwater under conditions of decreasing hydraulic head with depth. Most well logs and pump tests in the study area show upward hydrostatic pressure or groundwater discharge from large, upgradient contributing areas. Contributing areas include the Leavenworth Fault and extensive glacial moraines and drift deposits. Some wells have low-pressure, artesian flows at the land surface which may cause wetlands to form in low-lying areas. When recharge areas are large, these groundwater discharge wetlands persist through the summer in most years. Both surface and shallow subsurface flows follow the local topography and drain southeasterly from the foothills of Tumwater Mountain (elevation 3800 feet mean sea level) to the Wenatchee River (elevation 1100 feet mean sea level). Small streams in the area drain numerous hillside springs and flow generally less than 1 cfs (449 gpm) through the summer months.

Annual precipitation of more than 31.8 inches or less than 16.2 inches has a probability of 10% (or recurrence interval of 1 year in 10). Snow accumulates from December through March with snowmelt during April and May in the lower elevations. Average seasonal snowfall from October through April for the period 1931 – 1965 was 94.1 inches (about 10 inches water equivalent). The greatest seasonal snowfall was 154.8 inches. The area lies within the Washington Department of Natural Resources "Rain-On-Snow Zone" and rapid snowmelt may occur with rainfall in the early spring in some years. Accumulated precipitation from October through March averages 20.71 inches but varies from less than 9 inches to more than 36 inches per year. Accumulated precipitation from October – March has been above average to average for 1996 – 1998. Spring runoff, particularly during rain-on-snow events, recharges soil moisture deficits by early April. Infiltration and deep percolation of runoff also contribute to groundwater recharge and a rise in the water table. Soil moisture depletion by evapo-transpiration and drainage during summer months causes a soil moisture deficit until recharge by early rains in the fall.

Soil moisture storage capacity varies with organic matter content and the porosity of rock fragments in the soil. Actual storage capacity is determined by experimental methods but, lacking such data, may be assumed to be 6 inches for most soils derived from glacial or glaciofluvial sediments in eastern Washington. Estimated evapo-transpiration for a 6-inch water-storage capacity soil averages 12.5 inches per year (WSU, 1973). Soil moisture recharge occurs in late fall before freeze-up and again in late spring during snowmelt and runoff. Precipitation exceeds evapo-traspiration by greater than 10 inches in average years, with a significant water surplus available for runoff, surface storage, and groundwater recharge. Measurements taken in 1998 show maximum water levels in springs, ditches, wetlands, and shallow groundwater during snowmelt followed by gradual declines into the summer.

Wetlands of Ski Hill Basin

The City of Leavenworth stormwater drainage system collects runoff and subsurface drainage from many of these wetlands and discharges it to the Wenatchee River. The stormwater outfall pipes at 8th Street and below Commercial Street flowed all summer and varied from .2 and 4 cfs in April, 1998, to .02 and 3 cfs, respectively, in August, 1999. Additional development and drainage of wetlands in the Ski Hill Basin will increase the magnitude and duration of this stormwater drainage.

ATTACHMENT B
WATER QUALITY BMPS

BMP	A) Region 1 Suitability	B) Cold Region Suitability	Ability to Remove Key Pollutants					H) Capital Costs	I) O & M Costs	J) Effective Life (years)	K) Runoff Control
			C) Total Suspended Solids (TSS)	D) Metals	E) Phosphorus	F) Pesticides / Fungacides	G) Hydrocarbons				
Sand Filter Basic T5.80	Preferred	Poor	Significant	Less	Less		Less	Low	Low to Moderate	5 - 20	
Sand Filter Large T5.81	Preferred	Poor	Significant	Less	Less		Less	Low	Low to Moderate	5 - 20	
Sand Filter Vault T5.82	Preferred	Good	Significant	Less	Less		Less	Low	Low to Moderate	5 - 20	
Sand Filter Linear T5.83	Preferred	Fair to Poor	Significant	Less	Less		Less	Low	Low to Moderate	5 - 20	
Bio-infiltration Swale T5.30	Preferred	Fair	Significant	Significant	Less	Significant	Significant	Low to Moderate	Low	5 - 20	
Infiltration - Surface T5.10, T5.21	Acceptable with Limitations	Fair / Fair	Significant	Less		Less	Less	Moderate	Moderate	5 - 10	X
Infiltration - Subsurface T5.20	Acceptable with Limitations	Fair	Significant	Less		Less	Less	Moderate to High	Moderate	10 - 15	X
Wet Pond Basic T5.70	Limited Use	Fair	Significant	Less	Less		Less	Moderate to High	Low to Moderate	20 -50	X
Wet Pond Extended T5.71	Limited Use	Good	Significant	Less	Less		Less	Moderate to High	Low to Moderate	20 -50	X
Wet Vault T5.72	Limited Use	Good	Significant					Moderate to High	High	50 - 100	X
Wetland Extended T5.73	Limited Use	Good	Significant	Significant	Less	Significant	Significant	Low to Moderate	Moderate	20 - 50	X
Biofiltration Swale T5.40	Limited Use	Fair	Significant	Less	Less		Less	Low to Moderate	Low to Moderate	5 - 20	
Vegetated Filter Strip T5.50	Limited Use	Fair	Significant	Less	Less		Less	Low	Low	20 - 50	
Oil Water Separator T5.100, T5.110		Fair to Poor					Significant				
Leaf Compost Filter			Significant	Less		Significant	Significant				

Table 5.2.4 Suggested Stormwater Treatment Options Based on Average Annual Rainfall

Stormwater Practice	Arid Watersheds < 16 in. rainfall	Semi-Arid Watersheds 16 in. to 35 in. rainfall
Sand filters	Preferred: ▪ Requires greater pretreatment ▪ Sensitive to sediment loadings	Preferred
Bio-infiltration Swales	Acceptable with Limitations: ▪ Use dryland grass	Preferred: ▪ Use dryland or irrigated grass
Extended detention dry ponds	Preferred: ▪ Multiple storm extended detention ▪ Stable pilot channels ▪ "Dry" forebay	Acceptable: ▪ Dry or wet forebay needed
Infiltration	Acceptable with Limitations: ▪ See Table 5.6.3 ▪ Minimize erodable soils that reduce infiltration ▪ Pretreatment ▪ Soil limitations	Acceptable with Limitations: ▪ See Table 5.6.3 ▪ Minimize erodable soils that reduce infiltration ▪ Pretreatment
Wet ponds	Not Recommended: ▪ Evaporation rates are too high to maintain a normal pond without extensive use of scarce water	Limited Use: ▪ Liners to prevent water loss require water balance analysis design for a variable rather than permanent normal pool ▪ Use water sources such as AC condensate for pool ▪ Aeration unit to prevent stagnation
Stormwater wetlands	Not Recommended: ▪ Evaporation rates too great to maintain wetlands plants	Limited Use: ▪ Require supplemental water ▪ Submerged gravel wetlands can help reduce water loss
Biofiltration Swales	Not Recommended: ▪ Not recommended for pollutant removal, but rock berms and grade control needed for open channels to prevent channel erosion	Limited Use: ▪ Limited use unless irrigated or use dryland grasses ▪ Rock berms and grade control essential to prevent erosion in open channels

Adapted from: *Stormwater Strategies for Arid and Semi-Arid Watersheds*, Watershed Protection Techniques, Vol. 3, No. 3, March 2000

Table 5.2.6 Summary of BMP Applicability in Cold Regions

Section ---- BMP #	BMP Category or Type	Applica-bility	Notes
5.4	***Infiltration and Bio-infiltration***		
T5.10	Infiltration Pond	fair	Can be effective but may be restricted by groundwater quality concerns related to infiltration of chlorides. Frozen ground may inhibit the infiltration capacity of ground.
T5.20	Infiltration Trench	fair	Same concerns as for Infiltration Pond
T5.21	Infiltration Swale	fair	Same concerns as for Infiltration Pond
T5.30	Bio-infiltration Swale	fair	Same concerns as for Infiltration Pond
5.5	***Biofiltration***		
T5.40	Biofiltration Swale	fair	Reduced effectiveness in the winter because of dormant vegetation. Very valuable for snow storage and meltwater infiltration.
T5.50	Vegetated Filter Strip	fair	Reduced effectiveness in the winter because of dormant vegetation. Very valuable for snow storage and meltwater infiltration.
5.6	***Subsurface Infiltration***	fair to good	Infiltration surface below frost line.
	Drywell	fair to good	Infiltration surface below frost line.
5.7	***Wetpools and Dry Ponds***		
T5.70	Basic Wetpond	fair	Can be effective but needs modifications to prevent freezing of outlet pipes. Limited by reduced treatment volume and biological activity during ice cover.
T5.71	Large Extended Detention (ED) Wetpond	good	Some modifications needed to conveyance structures. Extended detention storage provides treatment during winter season.

Table 5.2.6 Summary of BMP Applicability in Cold Regions

Section ---- BMP #	BMP Category or Type	Applica-bility	Notes
See section 5.7.3	Large Extended Detention (ED) Dry Ponds	fair	Few modifications needed to adapt to cold climates. Not highly recommended because of relatively poor warm season performance.
T5.72	Wet Vault	good	Design pool elevation below frost line or per manufacturer specs. Some modifications needed to conveyance structures.
T5.73	Extended Detention (ED) Wetland	good	Extended detention storage provides treatment during winter season. Modifications needed to wetland plant species. Some modifications needed to conveyance structures.
5.8	***Sand Filtration***		
T5.80	Basic Sand Filter	poor	Frozen ground considerations, combined with frost heave, make this ineffective in cold climates.
T5.81	Large Sand Filter	poor	Same concerns as for Basic Sand Filter.
T5.82	Sand Filter Vault	good	Design filter elevation below frost line or per manufacturer specs
T5.83	Linear Sand Filter	poor to fair	Design filter elevation below frost line or per manufacturer specs. Cold conditions may plug surface inlet and impact performance.
5.9	***Evaporation Ponds***	fair to good	Evaporation not expected to result in significant water losses during cold weather; hence must size to provide adequate storage.
5.10	***Oil and Water Separator***		
T5.100	API Separator Bay	poor to fair	Check with the manufacturer for cold weather applicability.
T5.110	Coalescing Plate Bay	poor to fair	Check with the manufacturer for cold weather applicability.

Table 5.2.2[4] Ability of Treatment Facilities to Remove Key Pollutants[1] [3]

Treatment Facility	TSS	Dissolved Metals incl. Cu, Zn	Total Phosphorus	Pesticides/ Fungicides	Hydro-carbons incl. O&G, PAH
Wet Pond	■	+	+		+
Wet Vault	■				
Biofiltration	■	+	+	+	+
Sand Filter	■	+	+		+
Constructed Wetland	■	■	+	■	■
Leaf Compost Filters	■	+		■	■
Infiltration[2]	■	+		+	+
Oil/Water Separator					■
Bio-infiltration	■	■	+	■	■

Footnotes:

■ *Significant Process*

+ Lesser Process

(1) Adapted from Kulzer, King Co. Additional BMPs not included in the table, but that have metals treatment benefit, are amended sand filter, and two facility treatment trains; for phosphorus treatment are large sand filter, two facility treatment trains, and amended sand filter.

(2) Assumes loamy sand, sandy loam, or loam soils

(3) If a cell is blank, then the treatment facility is not particularly effective at treating the identified pollutant

Table 5-1 Relative rankings of cost elements and effective life of BMP options.

BMP	Capital Costs	O&M Costs	Effective Life[1]
Vegetated Filter Strip	Low	Low	20–50 years
Wet Biofiltration Swale	Low to Moderate	Low to Moderate	5–20 years
Continuous Inflow Biofiltration Swale	Low to Moderate	Low	5–20 years
Media Filter Drain	Low	Low to Moderate	5–20 years[2]
Compost-Amended Vegetated Filter Strip	Low	Low	5–20 years[2]
Wet Pond	Moderate to High	Low to Moderate	20–50 years
Combined Wet/Detention Pond	Moderate	Low to Moderate	20–50 years
Constructed Stormwater Treatment Wetland	Moderate to High	Moderate	20–50 years
Combined Stormwater Wetland/Detention Pond	Low to Moderate	Moderate	20–50 years
Wet Vault (Category 1 BMP)	Moderate to High	High	50–100 years
Combined Wet/Detention Vault (Category 1 BMP)	Moderate to High	High	50–100 years
Bioinfiltration Pond	Low to Moderate	Low	5–20 years
Infiltration Pond	Moderate	Moderate	5–10 years before deep tilling required
Infiltration Trench	Moderate to High	Moderate	10–15 years
Infiltration Vault	Moderate	Moderate to High	5–10 years
Drywell	Low to Moderate	Low to Moderate	5–20 years
Engineered and Natural Dispersion	Low	Low	50–100 years
Detention Pond	Moderate	Low	20–50 years
Detention Vault (Category 1 BMP)	Moderate to High	High	50–100 years
Detention Tank (Category 1 BMP)	Moderate to High	High	50–100 years
Presettling Basin	Low to Moderate	Moderate	
Proprietary Presettling Devices	Moderate	Moderate	50–100 years
Bioretention	Moderate	Moderate	5–20 years

Sources: Adapted from Young et al. (1996); Claytor and Schueler (1996); U.S. EPA (1993); and others.

[1] Assumes regular maintenance, occasional removal of accumulated materials, and removal of any clogged media.

[2] Estimated based on best professional judgment.

Table 5.11.1 - Treatment trains for phosphorus removal

First Basic Treatment Facility	Second Treatment Facility
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault
Vegetated Filter Strip	Linear Sand Filter (no presettling needed)
Linear Sand Filter	Filter Strip
Basic Wetpond	Basic Sand Filter or Sand Filter Vault
Wetvault	Basic Sand Filter or Sand Filter Vault
Basic Combined Detention and Wetpool	Basic Sand Filter or Sand Filter Vault
NOTE: See Section 5.2.3 (or Table 5.2.6) for Cold Weather Considerations and Table 5.2.4 for Arid and Semi-Arid Climate Considerations.	

Table 5.11.2 -Treatment Trains for Dissolved Metals Removal

First Basic Treatment Facility	Second Treatment Facility
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault or Media Filter(1)
Filter Strip	Linear Sand Filter with no pre-settling cell needed
Linear Sand Filter	Filter Strip
Basic Wetpond	Basic Sand Filter or Sand Filter Vault or Media Filter(1)
Wetvault	Basic Sand Filter or Sand Filter Vault or Media Filter(1)
Basic Combined Detention/Wetpool	Basic Sand Filter or Sand Filter Vault or Media Filter(1)
Basic Sand Filter or Sand Filter Vault with a presettling cell if the filter isn't preceded by a detention facility	Media Filter(1)
(1) The media must be of a nature that has the capability to remove dissolved metals effectively based on at least limited data. Ecology includes Stormfilter's ™ leaf compost and zeolite media in this category.	

Table 5.2.3 Screening Treatment Facilities Based on Soil Type

Soil Type	Infiltration	Wet Pond*	Bio-Infiltration	Biofiltration* (Swale or Filter Strip)
Coarse Sand or Cobbles	-	-	-	-
Sand	■	-	-	-
Loamy Sand	■	-	■	■
Sandy Loam	■	-	■	■
Loam	-	-	■	■
Silt Loam	-	-	■	■
Sandy Clay Loam	-	■	-	■
Silty Clay Loam	-	■	-	-
Sandy Clay	-	■	-	-
Silty Clay	-	■	-	-
Clay	-	■	-	-

Notes:

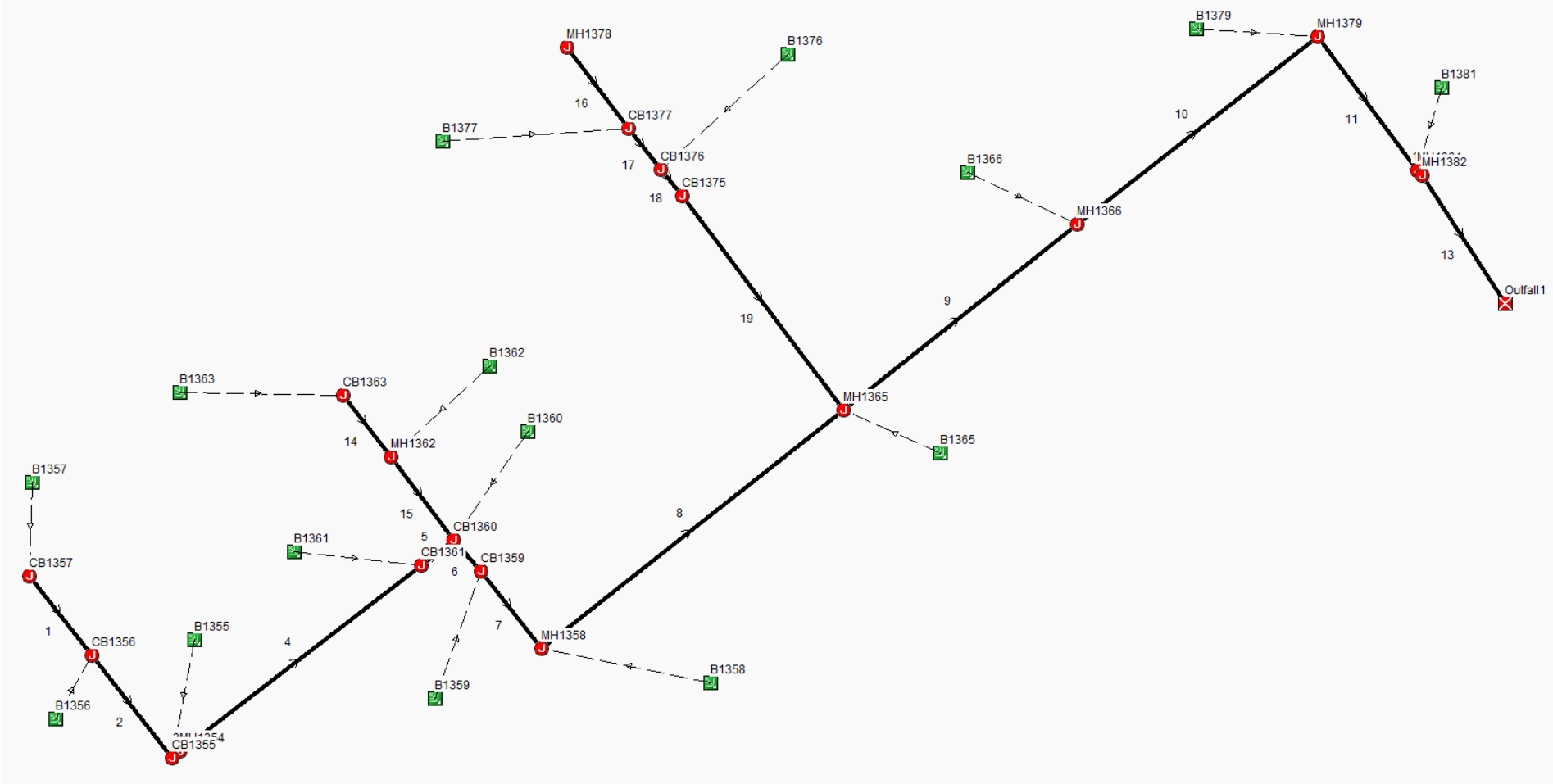
■ *Indicates that use of the technology is generally appropriate for this soil type.*

\- *Indicates that use of the technology is generally not appropriate for this soil type*

* *Coarser soils may be used for these facilities if a liner is installed to prevent infiltration, or if the soils are amended to reduce the infiltration rate.*

Note: *Sand filtration is not listed because its feasibility is not dependent on soil type.*

ATTACHMENT C
MODEL INPUT PARAMETERS



Model: Downtown East

Project Description

File Name	Leavenworth Storm Basin DE.SPF
Description	Downtown East Analysis

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	User-Defined
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Sep 16, 2015	00:00:00
End Analysis On	Sep 17, 2015	12:00:00
Start Reporting On	Sep 16, 2015	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	6
Subbasins	15
Nodes	20
Junctions	19
Outfalls	1
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	19
Channels	0
Pipes	19
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Junction Input

SN	Element ID	Ground/Rim (Max) Elevation (ft)	Invert Elevation (ft)
1	Structure - 1354	1152.90	1148.40
2	Structure - 1355	1152.78	1148.90
3	Structure - 1356	1156.70	1150.40
4	Structure - 1357	1162.77	1156.80
5	Structure - 1358	1151.78	1146.00
6	Structure - 1359	1151.58	1146.20
7	Structure - 1360	1151.73	1146.50
8	Structure - 1361	1151.30	1146.60
9	Structure - 1362	1151.34	1147.00
10	Structure - 1363	1151.81	1147.40
11	Structure - 1365	1146.84	1142.10
12	Structure - 1366	1142.82	1137.80
13	Structure - 1375	1151.89	1144.10
14	Structure - 1376	1152.99	1144.70
15	Structure - 1377	1154.38	1149.90
16	Structure - 1378	1163.09	1156.90
17	Structure - 1379	1138.16	1132.70
18	Structure - 1381	1120.18	1116.20
19	Structure - 1382	1119.70	1113.70

Pipe Input

SN	Element ID	Pipe Diameter or Height (in)	Pipe Shape	Length (ft)	Average Slope (%)	Manning's Roughness	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)
1	Pipe - (1)	12	CIRCULAR	119	5.4	0.0090	1156.80	1150.40
2	Pipe - (10)	18	CIRCULAR	358	1.4	0.0240	1137.80	1132.70
3	Pipe - (11)	18	CIRCULAR	196	8.4	0.0240	1132.70	1116.20
4	Pipe - (12)	18	CIRCULAR	8	19.8	0.0240	1116.20	1114.60
5	Pipe - (13)	18	CIRCULAR	180	20.1	0.0240	1113.70	1077.60
6	Pipe - (14)	18	CIRCULAR	91	0.4	0.0240	1147.40	1147.00
7	Pipe - (15)	18	CIRCULAR	122	0.4	0.0240	1147.00	1146.50
8	Pipe - (16)	18	CIRCULAR	120	5.8	0.0240	1156.90	1149.90
9	Pipe - (17)	18	CIRCULAR	61	8.5	0.0240	1149.90	1144.70
10	Pipe - (18)	18	CIRCULAR	40	1.5	0.0240	1144.70	1144.10
11	Pipe - (19)	18	CIRCULAR	314	0.6	0.0240	1144.10	1142.10
12	Pipe - (2)	18	CIRCULAR	152	1.0	0.0240	1150.40	1148.90
13	Pipe - (3)	18	CIRCULAR	11	4.4	0.0240	1148.90	1148.40
14	Pipe - (4)	18	CIRCULAR	357	0.5	0.0240	1148.40	1146.60
15	Pipe - (5)	18	CIRCULAR	49	0.2	0.0240	1146.60	1146.50
16	Pipe - (6)	24	CIRCULAR	48	0.6	0.0240	1146.50	1146.20
17	Pipe - (7)	18	CIRCULAR	116	0.2	0.0240	1146.20	1146.00
18	Pipe - (8)	18	CIRCULAR	452	0.9	0.0240	1146.00	1142.10
19	Pipe - (9)	18	CIRCULAR	350	1.2	0.0240	1142.10	1137.80

Subbasin : Sub-Structure - 1355

Soil/Surface Description	(acres)	Group	Number
Urban industrial, 72% imp	0.24	B	88.00
Composite Area & Weighted CN	0.24		88.00
Time of Concentration (days hh:mm:ss) 0 00:12:00			

Subbasin : Sub-Structure - 1356

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.19	B	98.00
Composite Area & Weighted CN	0.19		98.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1357

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.77	B	98.00
Composite Area & Weighted CN	0.77		98.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1358

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	0.30	B	75.00
1/8 acre lots, 65% impervious	0.30	B	85.00
Composite Area & Weighted CN	0.60		80.00
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1359

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	0.09	B	75.00
1/8 acre lots, 65% impervious	0.09	B	85.00
Composite Area & Weighted CN	0.18		80.00
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1360

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.46	B	92.00
1/4 acre lots, 38% impervious	0.06	B	75.00
1/8 acre lots, 65% impervious	0.06	B	85.00
Composite Area & Weighted CN	0.58		89.60
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1361

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	1.65	B	92.00
Composite Area & Weighted CN	1.65		92.00
Time of Concentration (days hh:mm:ss) 0 00:12:00			

Subbasin : Sub-Structure - 1362

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.51	B	92.00
Composite Area & Weighted CN	0.51		92.00
Time of Concentration (days hh:mm:ss) 0 00:12:00			

Subbasin : Sub-Structure - 1363

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	2.83	B	98.00
> 75% grass cover, Good	0.31	B	61.00
Composite Area & Weighted CN	3.14		94.30
Time of Concentration (days hh:mm:ss) 0 00:40:00			

Subbasin : Sub-Structure - 1365

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	1.29	B	75.00
1/8 acre lots, 65% impervious	1.29	B	85.00
Urban commercial, 85% imp	0.64	B	92.00
Composite Area & Weighted CN	3.22		82.40
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1366

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	0.92	B	75.00
1/8 acre lots, 65% impervious	0.92	B	85.00
Composite Area & Weighted CN	1.84		80.00
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1376

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	1.28	B	92.00
> 75% grass cover, Good	0.70	B	61.00
1/8 acre lots, 65% impervious	0.17	B	85.00
1/4 acre lots, 38% impervious	0.17	B	75.00
Composite Area & Weighted CN	2.32		80.90
Time of Concentration (days hh:mm:ss) 0 00:40:00			

Subbasin : Sub-Structure - 1355

Soil/Surface Description	(acres)	Group	Number
Urban industrial, 72% imp	0.24	B	88.00
Composite Area & Weighted CN	0.24		88.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1356

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.19	B	98.00
Composite Area & Weighted CN	0.19		98.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1357

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.77	B	98.00
Composite Area & Weighted CN	0.77		98.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1358

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.59	B	85.00
Composite Area & Weighted CN	0.59		85.00
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1359

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.19	B	85.00
Composite Area & Weighted CN	0.19		85.00
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1360

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.34	B	98.00
1/8 acre lots, 65% impervious	0.23	B	85.00
Composite Area & Weighted CN	0.57		92.80
Time of Concentration (days hh:mm:ss) 0 00:12:00			

Subbasin : Sub-Structure - 1361

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	1.65	B	98.00
Composite Area & Weighted CN	1.65		98.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1362

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.51	B	98.00
Composite Area & Weighted CN	0.51		98.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1363

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	3.14	B	98.00
Composite Area & Weighted CN	3.14		98.00
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1365

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	1.12	B	98.00
1/8 acre lots, 65% impervious	2.09	B	85.00
Composite Area & Weighted CN	3.21		89.55
Time of Concentration (days hh:mm:ss) 0 00:18:00			

Subbasin : Sub-Structure - 1366

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.37	B	98.00
1/8 acre lots, 65% impervious	1.47	B	85.00
Composite Area & Weighted CN	1.84		87.60
Time of Concentration (days hh:mm:ss) 0 00:20:00			

Subbasin : Sub-Structure - 1376

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	1.97	B	98.00
Urban commercial, 85% imp	0.35	B	92.00
Composite Area & Weighted CN	2.32		97.10
Time of Concentration (days hh:mm:ss) 0 00:06:00			

Subbasin : Sub-Structure - 1377

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.23	B	92.00
Composite Area & Weighted CN	0.23		92.00

Time of Concentration (days hh:mm:ss) 0 00:12:00

Subbasin : Sub-Structure - 1379

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	3.48	B	98.00
1/4 acre lots, 38% impervious	1.04	B	75.00
1/8 acre lots, 65% impervious	1.04	B	85.00
Urban industrial, 72% imp	1.39	B	88.00
Composite Area & Weighted CN	6.95		90.60

Time of Concentration (days hh:mm:ss) 0 00:20:00

Subbasin : Sub-Structure - 1381

Soil/Surface Description	(acres)	Group	Number
Urban industrial, 72% imp	0.24	B	88.00
Composite Area & Weighted CN	0.24		88.00

Time of Concentration (days hh:mm:ss) 0 00:18:00

Subbasin : Sub-Structure - 1377

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.15	B	92.00
Paved parking & roofs	0.08	B	98.00
Composite Area & Weighted CN	0.23		94.10

Time of Concentration (days hh:mm:ss) 0 00:09:00

Subbasin : Sub-Structure - 1379

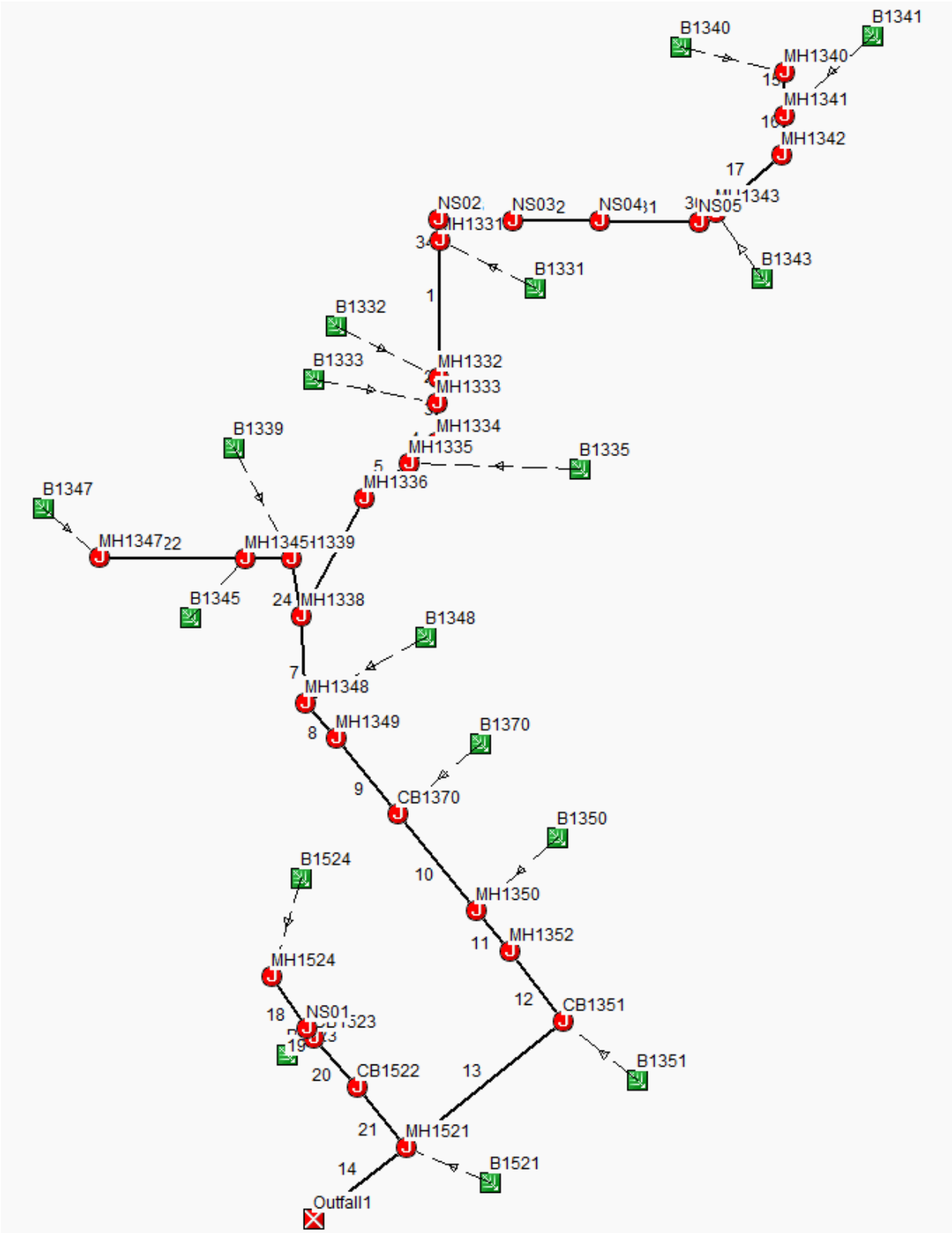
Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	4.17	B	92.00
1/8 acre lots, 65% impervious	1.39	B	85.00
Urban industrial, 72% imp	1.39	B	88.00
Composite Area & Weighted CN	6.95		89.80

Time of Concentration (days hh:mm:ss) 0 00:20:00

Subbasin : Sub-Structure - 1381

Soil/Surface Description	(acres)	Group	Number
Urban industrial, 72% imp	0.24	B	88.00
Composite Area & Weighted CN	0.24		88.00

Time of Concentration (days hh:mm:ss) 0 00:20:00



Model: Downtown West

Project Description

File Name	Leavenworth Storm Basin DW Future.SPF
Description	Downtown West Analysis

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	User-Defined
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Sep 16, 2015	00:00:00
End Analysis On	Sep 17, 2015	12:00:00
Start Reporting On	Sep 16, 2015	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	6
Subbasins	17
Nodes	30
Junctions	29
Outfalls	1
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	29
Channels	0
Pipes	29
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Junction Input

SN	Element ID	Ground/Rim (Max) Elevation (ft)	Invert Elevation (ft)
1	Structure - 1331	1170.37	1158.40
2	Structure - 1332	1167.30	1157.50
3	Structure - 1333	1167.49	1157.50
4	Structure - 1334	1167.71	1157.50
5	Structure - 1335	1168.88	1157.20
6	Structure - 1336	1170.26	1157.10
7	Structure - 1338	1166.57	1157.10
8	Structure - 1339	1172.73	1165.30
9	Structure - 1340	1167.70	1160.10
10	Structure - 1341	1167.16	1159.90
11	Structure - 1342	1167.59	1159.40
12	Structure - 1343	1170.22	1159.20
13	Structure - 1345	1174.54	1166.10
14	Structure - 1347	1176.23	1168.40
15	Structure - 1348	1162.66	1151.80
16	Structure - 1349	1161.70	1151.70
17	Structure - 1350	1151.69	1142.00
18	Structure - 1351	1142.77	1136.60
19	Structure - 1352	1150.68	1140.30
20	Structure - 1370	1153.97	1144.90
21	Structure - 1521	1135.92	1126.10
22	Structure - 1522	1145.29	1137.90
23	Structure - 1523	1146.70	1143.20
24	Structure - 1524	1147.41	1143.30
25	Structure - NS01	1147.00	1143.20
26	Structure - NS02	1171.00	1158.56
27	Structure - NS03	1172.25	1158.72
28	Structure - NS04	1172.66	1158.88
29	Structure - NS05	1170.90	1159.04

Pipe Input

SN	Element ID	Pipe Diameter or Height (in)	Pipe Shape	Length (ft)	Average Slope (%)	Manning's Roughness	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)
1	Pipe - (1)	24	CIRCULAR	270	0.3	0.0240	1158.40	1157.50
2	Pipe - (10)	36	CIRCULAR	245	1.2	0.0240	1144.90	1142.00
3	Pipe - (11)	36	CIRCULAR	104	1.6	0.0120	1142.00	1140.30
4	Pipe - (12)	36	CIRCULAR	174	2.1	0.0120	1140.30	1136.60
5	Pipe - (13)	30	CIRCULAR	399	2.6	0.0240	1136.60	1126.10
6	Pipe - (14)	36	CIRCULAR	229	14.1	0.0120	1126.10	1093.90
7	Pipe - (15)	18	CIRCULAR	87	0.2	0.0240	1160.10	1159.90
8	Pipe - (16)	18	CIRCULAR	78	0.6	0.0240	1159.90	1159.40
9	Pipe - (17)	18	CIRCULAR	173	0.1	0.0240	1159.40	1159.20
10	Pipe - (18)	18	CIRCULAR	123	0.1	0.0240	1143.30	1143.20
11	Pipe - (19)	24	CIRCULAR	26	0.0	0.0120	1143.20	1143.20
12	Pipe - (2)	24	CIRCULAR	50	0.0	0.0240	1157.50	1157.50
13	Pipe - (20)	24	CIRCULAR	127	4.2	0.0120	1143.20	1137.90
14	Pipe - (21)	24	CIRCULAR	154	7.7	0.0120	1137.90	1126.10
15	Pipe - (22)	24	CIRCULAR	290	0.8	0.0240	1168.40	1166.10
16	Pipe - (23)	24	CIRCULAR	90	0.9	0.0240	1166.10	1165.30
17	Pipe - (24)	24	CIRCULAR	116	7.1	0.0240	1165.30	1157.10
18	Pipe - (3)	30	CIRCULAR	79	0.0	0.0240	1157.50	1157.50
19	Pipe - (30)	24	CIRCULAR	38	0.4	0.0240	1159.20	1159.04
20	Pipe - (31)	24	CIRCULAR	196	0.1	0.0240	1159.04	1158.88
21	Pipe - (32)	24	CIRCULAR	171	0.1	0.0240	1158.88	1158.72
22	Pipe - (33)	24	CIRCULAR	147	0.1	0.0240	1158.72	1158.56
23	Pipe - (34)	24	CIRCULAR	41	0.4	0.0240	1158.56	1158.40
24	Pipe - (4)	30	CIRCULAR	69	0.4	0.0240	1157.50	1157.20
25	Pipe - (5)	30	CIRCULAR	112	0.1	0.0240	1157.20	1157.10
26	Pipe - (6)	30	CIRCULAR	263	0.0	0.0240	1157.10	1157.10
27	Pipe - (7)	30	CIRCULAR	171	3.1	0.0240	1157.10	1151.80
28	Pipe - (8)	30	CIRCULAR	91	0.1	0.0240	1151.80	1151.70
29	Pipe - (9)	36	CIRCULAR	195	3.5	0.0240	1151.70	1144.90

Subbasin : Pre- 1331

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.37	C	94.00
1/8 acre lots, 65% impervious	2.81	C	90.00
1/4 acre lots, 38% impervious	2.81	C	83.00
1/8 acre lots, 65% impervious	0.75	B	85.00
1/4 acre lots, 38% impervious	0.75	B	75.00
Composite Area & Weighted CN	**7.49**		**85.58**
Time of Concentration (min)	24		

Subbasin : Pre - 1332

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	1.35	C	90.00
1/4 acre lots, 38% impervious	1.35	C	83.00
Composite Area & Weighted CN	**2.70**		**86.50**
Time of Concentration (min)	18		

Subbasin : Pre - 1333

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.76	C	94.00
1/8 acre lots, 65% impervious	2.67	C	90.00
1/4 acre lots, 38% impervious	2.67	C	83.00
1/8 acre lots, 65% impervious	0.76	B	85.00
1/4 acre lots, 38% impervious	0.76	B	75.00
Composite Area & Weighted CN	**7.62**		**85.95**
Time of Concentration (min)	24		

Subbasin : Pre - 1335

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.22	C	90.00
1/4 acre lots, 38% impervious	0.22	C	83.00
Composite Area & Weighted CN	**0.44**		**86.50**
Time of Concentration (min)	18		

Subbasin : Pre - 1339

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.09	B	92.00
1/8 acre lots, 65% impervious	0.04	B	85.00
1/4 acre lots, 38% impervious	0.04	B	75.00
1/8 acre lots, 65% impervious	0.77	C	90.00
1/4 acre lots, 38% impervious	0.77	C	83.00
Composite Area & Weighted CN	**1.71**		**86.45**
Time of Concentration (min)	18		

Subbasin : Pre - 1340

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	3.32	C	94.00
1/8 acre lots, 65% impervious	3.98	C	90.00
1/4 acre lots, 38% impervious	3.98	C	83.00
1/8 acre lots, 65% impervious	0.66	B	85.00
1/4 acre lots, 38% impervious	0.66	B	75.00
1/8 acre lots, 65% impervious	0.33	D	92.00
1/4 acre lots, 38% impervious	0.33	D	87.00
Composite Area & Weighted CN	**13.26**		**87.88**
Time of Concentration (min)	24		

Subbasin : Pre - 1341

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	1.29	C	90.00
1/4 acre lots, 38% impervious	1.29	C	83.00
Composite Area & Weighted CN	**2.58**		**86.50**
Time of Concentration (min)	18		

Subbasin : Pre - 1343

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.35	C	90.00
Urban commercial, 85% imp	1.30	C	94.00
1/4 acre lots, 38% impervious	0.35	C	83.00
Composite Area & Weighted CN	**2.00**		**91.38**
Time of Concentration (min)	12		

Subbasin : Pre - 1345

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.50	B	85.00
1/8 acre lots, 65% impervious	0.34	C	90.00
1/4 acre lots, 38% impervious	0.50	B	75.00
1/4 acre lots, 38% impervious	0.34	C	83.00
Composite Area & Weighted CN	**1.68**		**82.60**
Time of Concentration (min)	24		

Subbasin : Post - 1331

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.37	C	94.00
1/8 acre lots, 65% impervious	2.81	C	90.00
1/4 acre lots, 38% impervious	2.81	C	83.00
1/8 acre lots, 65% impervious	0.75	B	85.00
1/4 acre lots, 38% impervious	0.75	B	75.00
Composite Area & Weighted CN	**7.49**		**85.58**
Time of Concentration (min)	24		

Subbasin : Post - 1332

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	1.35	C	90.00
1/4 acre lots, 38% impervious	1.35	C	83.00
Composite Area & Weighted CN	**2.70**		**86.50**
Time of Concentration (min)	18		

Subbasin : Post - 1333

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.76	C	90.00
1/8 acre lots, 65% impervious	2.67	C	90.00
1/4 acre lots, 38% impervious	2.67	C	83.00
1/8 acre lots, 65% impervious	0.76	B	85.00
1/4 acre lots, 38% impervious	0.76	B	75.00
Composite Area & Weighted CN	**7.62**		**85.55**
Time of Concentration (min)	24		

Subbasin : Post - 1335

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.22	C	90.00
1/4 acre lots, 38% impervious	0.22	C	83.00
Composite Area & Weighted CN	**0.44**		**86.50**
Time of Concentration (min)	18		

Subbasin : Post - 1339

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.09	B	98.00
1/8 acre lots, 65% impervious	0.04	B	85.00
1/4 acre lots, 38% impervious	0.04	B	75.00
1/8 acre lots, 65% impervious	0.77	C	90.00
1/4 acre lots, 38% impervious	0.77	C	83.00
Composite Area & Weighted CN	**1.71**		**86.75**
Time of Concentration (min)	18		

Subbasin : Post - 1340

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	1.99	C	94.00
1/8 acre lots, 65% impervious	4.64	C	90.00
1/4 acre lots, 38% impervious	4.64	C	83.00
1/8 acre lots, 65% impervious	0.66	B	85.00
1/4 acre lots, 38% impervious	0.66	B	75.00
1/8 acre lots, 65% impervious	0.33	D	92.00
1/4 acre lots, 38% impervious	0.33	D	87.00
Composite Area & Weighted CN	**13.25**		**87.12**
Time of Concentration (min)	24		

Subbasin : Post - 1341

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	1.29	C	90.00
1/4 acre lots, 38% impervious	1.29	C	83.00
Composite Area & Weighted CN	**2.58**		**86.50**
Time of Concentration (min)	18		

Subbasin : Post - 1343

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.35	C	90.00
Urban commercial, 85% imp	1.30	C	94.00
1/4 acre lots, 38% impervious	0.35	C	83.00
Composite Area & Weighted CN	**2.00**		**91.38**
Time of Concentration (min)	12		

Subbasin : Post - 1345

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.50	B	85.00
1/8 acre lots, 65% impervious	0.34	C	90.00
1/4 acre lots, 38% impervious	0.50	B	75.00
1/4 acre lots, 38% impervious	0.34	C	83.00
Composite Area & Weighted CN	**1.68**		**82.60**
Time of Concentration (min)	24		

Subbasin : Pre - 1347

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.76	D	92.00
1/8 acre lots, 65% impervious	7.61	B	85.00
1 acre lots, 20% impervious	7.61	B	68.00
Pasture, grassland, or range, Good	22.84	D	80.00
Pasture, grassland, or range, Good	3.81	B	61.00
1/4 acre lots, 38% impervious	0.76	D	87.00
1/4 acre lots, 38% impervious	7.61	B	75.00
Urban commercial, 85% imp	0.76	B	92.00
> 75% grass cover, Good	2.28	B	61.00
1/2 acre lots, 25% impervious	8.37	B	70.00
Urban commercial, 85% imp	4.57	C	94.00
> 75% grass cover, Good	3.05	C	74.00
Wetlands	6.09	D	3.00
Composite Area & Weighted CN	**76.12**		**70.93**
Time of Concentration (min)	55		

Subbasin : Post - 1347

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	7.61	B	85.00
1 acre lots, 20% impervious	11.42	B	68.00
1/8 acre lots, 65% impervious	19.03	D	92.00
Pasture, grassland, or range, Good	3.81	B	61.00
1/4 acre lots, 38% impervious	7.61	B	75.00
1/2 acre lots, 25% impervious	11.42	B	70.00
1/8 acre lots, 65% impervious	3.81	C	90.00
Wetlands	11.42	D	3.00
Composite Area & Weighted CN	**76.13**		**67.70**
Time of Concentration (min)	55		

Subbasin : Pre - 1348

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.12	B	85.00
Urban commercial, 85% imp	0.99	B	92.00
1/4 acre lots, 38% impervious	0.12	B	75.00
Composite Area & Weighted CN	**1.23**		**89.60**
Time of Concentration (min)	12		

Subbasin : Post - 1348

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	0.12	B	85.00
Paved parking & roofs	0.99	B	98.00
1/4 acre lots, 38% impervious	0.12	B	75.00
Composite Area & Weighted CN	**1.23**		**94.40**
Time of Concentration (min)	12		

Subbasin : Pre - 1350

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	1.82	B	92.00
Composite Area & Weighted CN	**1.82**		**92.00**
Time of Concentration (min)	12		

Subbasin : Post - 1350

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	1.82	B	98.00
Composite Area & Weighted CN	**1.82**		**98.00**
Time of Concentration (min)	6		

Subbasin : Pre - 1351

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.84	B	92.00
Composite Area & Weighted CN	**0.84**		**92.00**
Time of Concentration (min)	12		

Subbasin : Post - 1351

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	0.84	B	98.00
Composite Area & Weighted CN	**0.84**		**98.00**
Time of Concentration (min)	6		

Subbasin : Pre - 1370

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	1.21	B	92.00
Composite Area & Weighted CN	**1.21**		**92.00**
Time of Concentration (min)	12		

Subbasin : Post - 1370

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	1.21	B	98.00
Composite Area & Weighted CN	**1.21**		**98.00**
Time of Concentration (min)	6		

Subbasin : Pre - 1521

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	2.48	B	92.00
Composite Area & Weighted CN	**2.48**		**92.00**
Time of Concentration (min)	12		

Subbasin : Post - 1521

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	2.48	B	98.00
Composite Area & Weighted CN	**2.48**		**98.00**
Time of Concentration (min)	6		

Subbasin : Pre - 1523

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	1.65	B	92.00
Composite Area & Weighted CN	**1.65**		**92.00**
Time of Concentration (min)	12		

Subbasin : Post - 1523

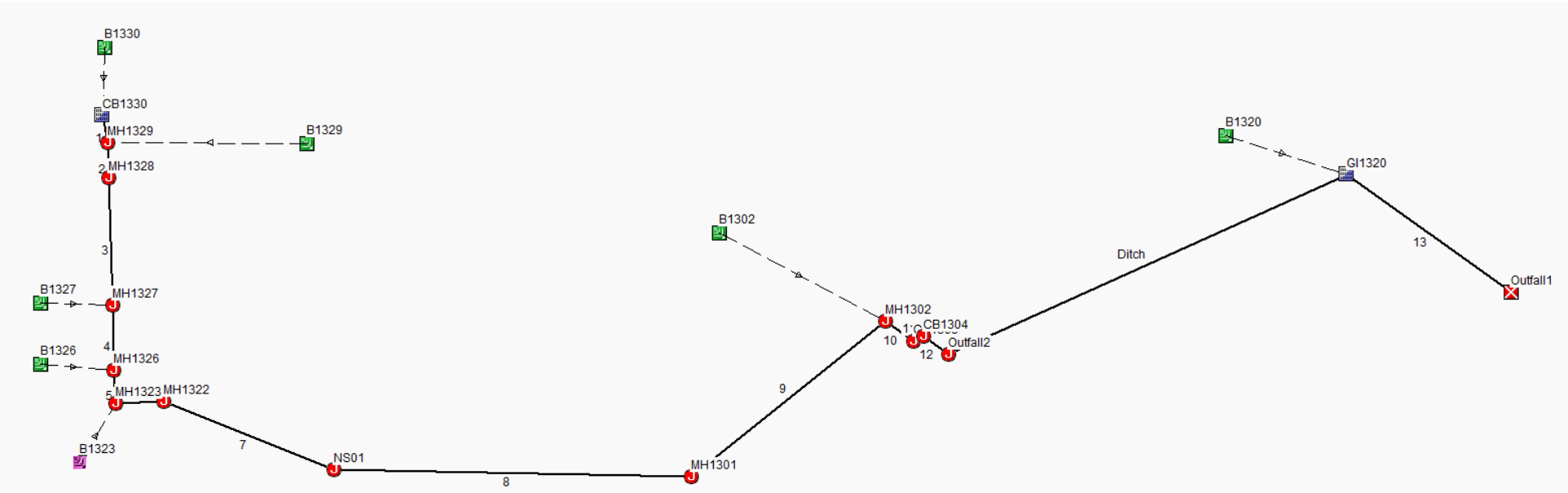
Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	1.65	B	98.00
Composite Area & Weighted CN	**1.65**		**98.00**
Time of Concentration (min)	6		

Subbasin : Pre- 1524

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	3.02	B	92.00
> 75% grass cover, Good	0.75	B	61.00
Composite Area & Weighted CN	**3.77**		**85.80**
Time of Concentration (min)	18		

Subbasin : Post - 1524

Soil/Surface Description	(acres)	Group	Number
Paved parking & roofs	3.77	B	98.00
Composite Area & Weighted CN	**3.77**		**98.00**
Time of Concentration (min)	6		



Model: Aplensee Strasse

Project Description

File Name	Leavenworth Storm Basin AS Future.SPF
Description	Alpensee Strasse Analysis

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	User-Defined
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Sep 16, 2015	00:00:00
End Analysis On	Sep 17, 2015	12:00:00
Start Reporting On	Sep 16, 2015	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	6
Subbasins	7
Nodes	15
Junctions	14
Outfalls	1
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	14
Channels	1
Pipes	13
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Junction Input

SN	Element ID	Ground/Rim (Max) Elevation (ft)	Invert Elevation (ft)
1	CB 1303	1141.82	1138.90
2	CB 1304	1140.44	1138.20
3	CB 1330	1181.20	1178.00
4	DUMMY	1167.00	1158.50
5	GI 1320	1125.80	1122.60
6	Outfall 2	1143.70	1137.70
7	SDMH 1301	1149.16	1145.10
8	SDMH 1302	1145.19	1140.10
9	SDMH 1322	1169.05	1164.30
10	SDMH 1323	1172.69	1165.20
11	SDMH 1326	1172.47	1167.90
12	SDMH 1327	1173.38	1168.90
13	SDMH 1328	1176.88	1172.10
14	SDMH1329	1179.09	1175.10

Channel Input

SN	Element ID	Length (ft)	Average Slope (%)	Shape	Manning's Roughness	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)
1	Ditch	930	1	Trapezoidal	0.0800	1137.70	1125.80

Pipe Input

SN	Element ID	Pipe Diameter or Height (in)	Pipe Shape	Length (ft)	Average Slope (%)	Manning's Roughness	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)
1	1	12	CIRCULAR	56	5.2	0.0090	1178.00	1175.10
2	2	18	CIRCULAR	70	4.3	0.0090	1175.10	1172.10
3	3	18	CIRCULAR	253	1.3	0.0090	1172.10	1168.90
4	4	18	CIRCULAR	129	0.8	0.0090	1168.90	1167.90
5	5	18	CIRCULAR	67	4.1	0.0090	1167.90	1165.20
6	6	36	CIRCULAR	96	0.9	0.0240	1165.20	1164.30
7	7	24	CIRCULAR	366	1.6	0.0130	1164.30	1158.50
8	8	24	CIRCULAR	714	1.9	0.0130	1158.50	1145.10
9	9	24	CIRCULAR	496	1.0	0.0130	1145.10	1140.10
10	10	24	CIRCULAR	69	1.7	0.0240	1140.10	1138.90
11	11	18	CIRCULAR	23	3.1	0.0240	1138.90	1138.20
12	12	18	CIRCULAR	61	0.8	0.0240	1138.20	1137.70
13	13	24	CIRCULAR	404	3.3	0.0240	1122.60	1109.30

Subbasin : Pre - 1302

Soil/Surface Description	(acres)	Group	Number
Woods, Good	21.48	D	77.00
> 75% grass cover, Good	2.15	D	80.00
Urban commercial, 85% imp	8.59	B	92.00
Urban commercial, 85% imp	4.30	D	95.00
Woods, Good	2.15	B	55.00
1/8 acre lots, 65% impervious	4.30	D	92.00
Composite Area & Weighted CN	**42.97**		**82.35**

Time of Concentration (days hh:mm:ss) 0 01:15:15

Subbasin : Post - 1302

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	21.48	D	92.00
> 75% grass cover, Good	2.15	D	80.00
Urban commercial, 85% imp	8.59	B	92.00
Urban commercial, 85% imp	4.30	D	95.00
1/8 acre lots, 65% impervious	2.15	B	85.00
1/8 acre lots, 65% impervious	4.30	C	90.00
Composite Area & Weighted CN	**42.97**		**91.15**

Time of Concentration (days hh:mm:ss) 0 01:15:15

Subbasin : Pre - 1320

Soil/Surface Description	(acres)	Group	Number
Woods, Good	7.21	B	55.00
Urban commercial, 85% imp	9.01	B	92.00
1/4 acre lots, 38% impervious	0.90	B	75.00
Urban commercial, 85% imp	0.90	D	95.00
Composite Area & Weighted CN	**18.02**		**76.50**

Time of Concentration (days hh:mm:ss) 0 00:27:20

Subbasin : Post - 1320

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	14.42	B	92.00
Urban commercial, 85% imp	0.90	D	95.00
1/8 acre lots, 65% impervious	2.70	B	85.00
Composite Area & Weighted CN	**18.02**		**91.10**

Time of Concentration (days hh:mm:ss) 0 00:27:20

Subbasin : Pre - 1323

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	5.64	B	85.00
Woods & grass combination, Good(orchards)	52.68	B	58.00
Woods, Good	75.25	D	77.00
Pasture, grassland, or range, Good	30.10	B	61.00
Pasture, grassland, or range, Good	15.05	D	80.00
> 75% grass cover, Good	7.53	D	80.00
> 75% grass cover, Good	13.17	B	61.00
1 acre lots, 20% impervious	63.96	B	68.00
1 acre lots, 20% impervious	18.81	D	84.00
> 75% grass cover, Good	18.81	C	74.00
Woods, Good	75.25	C	70.00
Composite Area & Weighted CN	**376.25**		**70.07**

Time of Concentration (days hh:mm:ss) 0 01:16:00

Subbasin : Post - 1323

Soil/Surface Description	(acres)	Group	Number
Woods, Good	75.25	D	77.00
1/8 acre lots, 65% impervious	22.58	D	92.00
> 75% grass cover, Good	26.34	D	80.00
> 75% grass cover, Good	11.29	B	61.00
1 acre lots, 20% impervious	94.06	B	68.00
1 acre lots, 20% impervious	37.63	D	84.00
> 75% grass cover, Good	18.81	C	74.00
Woods, Good	75.25	C	70.00
> 75% grass cover, Good	11.29	B	61.00
> 75% grass cover, Good	3.76	D	80.00
Composite Area & Weighted CN	**376.26**		**74.08**

Time of Concentration (days hh:mm:ss) 0 01:16:00

Subbasin : Pre - 1326

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.27	D	95.00
Pasture, grassland, or range, Good	0.19	D	80.00
Urban commercial, 85% imp	0.08	B	92.00
Composite Area & Weighted CN	**0.54**		**89.30**

Time of Concentration (days hh:mm:ss) 0 00:06:00

Subbasin : Post - 1326

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	0.27	D	95.00
Urban commercial, 85% imp	0.27	B	92.00
Composite Area & Weighted CN	**0.54**		**93.50**

Time of Concentration (days hh:mm:ss) 0 00:06:00

Subbasin : Pre - 1327

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	2.15	B	92.00
> 75% grass cover, Good	1.07	B	61.00
1 acre lots, 20% impervious	5.91	D	84.00
1 acre lots, 20% impervious	0.54	B	68.00
Pasture, grassland, or range, Good	1.07	B	61.00
Composite Area & Weighted CN	**10.74**		**80.20**

Time of Concentration (days hh:mm:ss) 0 01:02:28

Subbasin : Post - 1327

Soil/Surface Description	(acres)	Group	Number
Urban commercial, 85% imp	3.22	B	92.00
> 75% grass cover, Good	1.07	B	61.00
1 acre lots, 20% impervious	5.91	D	84.00
1 acre lots, 20% impervious	0.54	B	68.00
Composite Area & Weighted CN	**10.74**		**83.30**

Time of Concentration (days hh:mm:ss) 0 01:02:28

Subbasin : Pre - 1329

Soil/Surface Description	(acres)	Group	Number
Woods, Good	3.47	D	77.00
1 acre lots, 20% impervious	0.99	D	84.00
Woods, Good	0.40	B	55.00
1 acre lots, 20% impervious	0.10	B	68.00
Composite Area & Weighted CN	**4.96**		**76.46**

Time of Concentration (days hh:mm:ss) 0 00:20:32

Subbasin : Post - 1329

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	3.47	D	92.00
1 acre lots, 20% impervious	0.99	D	84.00
1/8 acre lots, 65% impervious	0.40	B	85.00
1 acre lots, 20% impervious	0.10	B	68.00
Composite Area & Weighted CN	**4.96**		**89.36**

Time of Concentration (days hh:mm:ss) 0 00:20:32

Subbasin : Pre - 1330

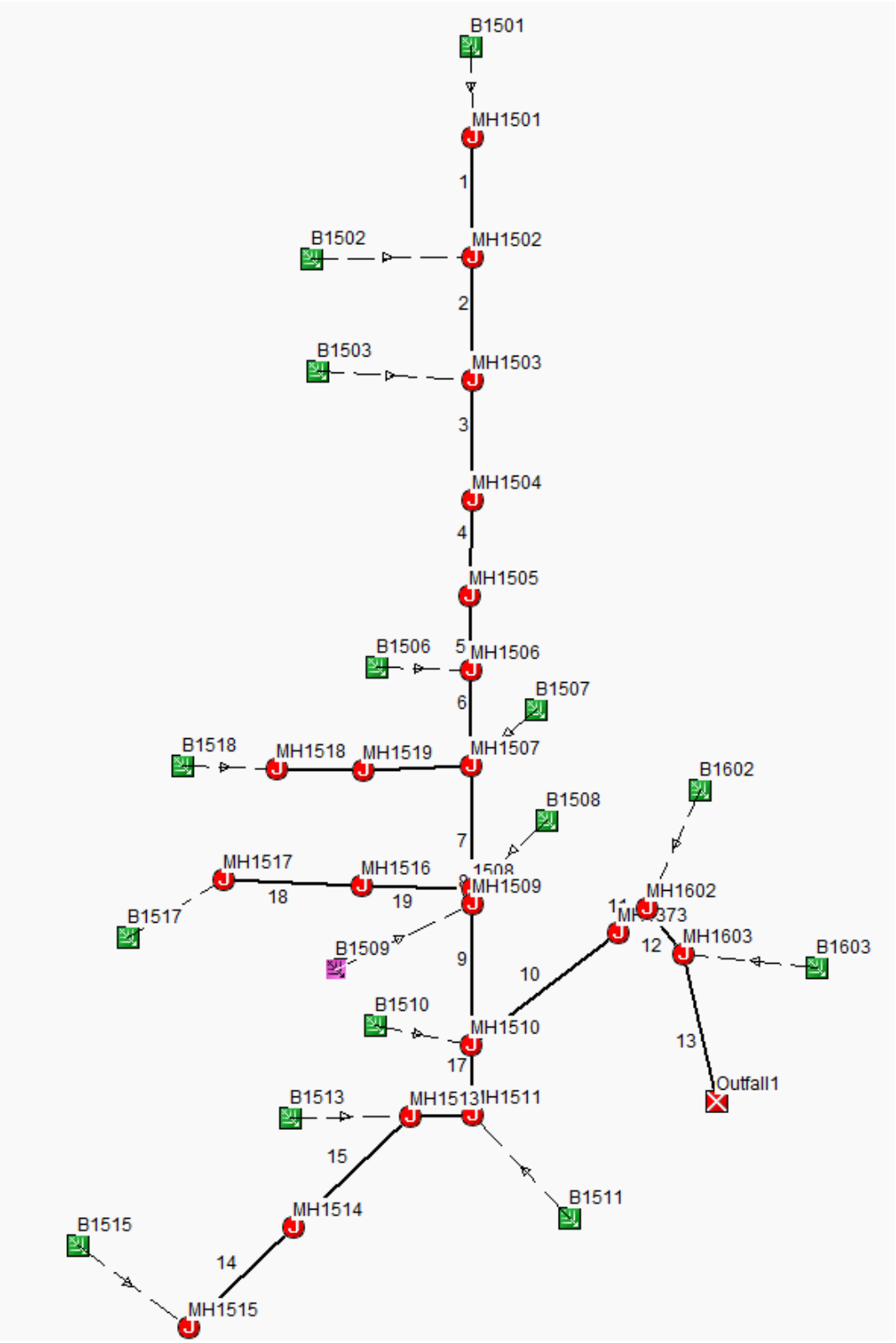
Soil/Surface Description	(acres)	Group	Number
1 acre lots, 20% impervious	3.77	D	84.00
1 acre lots, 20% impervious	0.20	B	68.00
Composite Area & Weighted CN	**3.97**		**83.20**

Time of Concentration (days hh:mm:ss) 0 00:21:05

Subbasin : Post - 1330

Soil/Surface Description	(acres)	Group	Number
1 acre lots, 20% impervious	3.77	D	84.00
1 acre lots, 20% impervious	0.20	B	68.00
Composite Area & Weighted CN	**3.97**		**83.20**

Time of Concentration (days hh:mm:ss) 0 00:21:05



Model: Ski Hill

Project Description

File Name	Leavenworth Storm Basin SH Future.SPF
Description	Ski Hill Analysis

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	User-Defined
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Sep 16, 2015	00:00:00
End Analysis On	Sep 17, 2015	12:00:00
Start Reporting On	Sep 16, 2015	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	6
Subbasins	16
Nodes	22
Junctions	21
Outfalls	1
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	21
Channels	0
Pipes	21
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Junction Input

SN	Element ID	Ground/Rim (Max) Elevation (ft)	Invert Elevation (ft)
1	1508	1167.93	1156.90
2	MH1373	1161.85	1146.30
3	MH1501	1198.51	1189.30
4	MH1502	1191.81	1181.70
5	MH1503	1188.78	1178.50
6	MH1504	1184.90	1174.50
7	MH1505	1180.53	1167.90
8	MH1506	1175.15	1163.40
9	MH1507	1169.92	1158.50
10	MH1509	1168.10	1156.70
11	MH1510	1168.00	1154.00
12	MH1511	1169.43	1160.00
13	MH1513	1173.04	1166.50
14	MH1514	1176.68	1168.80
15	MH1515	1173.04	1170.00
16	MH1516	1177.52	1165.50
17	MH1517	1179.19	1167.50
18	MH1518	1179.04	1168.60
19	MH1519	1180.33	1167.70
20	MH1602	1158.23	1144.70
21	MH1603	1155.90	1141.30

Pipe Input

SN	Element ID	Pipe Diameter or Height (in)	Pipe Shape	Length (ft)	Average Slope (%)	Manning's Roughness	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)
1	1	36	CIRCULAR	325	2.3	0.0240	1189.30	1181.70
2	2	36	CIRCULAR	335	1.0	0.0240	1181.70	1178.50
3	3	36	CIRCULAR	327	1.2	0.0240	1178.50	1174.50
4	4	36	CIRCULAR	258	2.6	0.0240	1174.50	1167.90
5	5	36	CIRCULAR	203	2.2	0.0240	1167.90	1163.40
6	6	36	CIRCULAR	260	1.9	0.0240	1163.40	1158.50
7	7	36	CIRCULAR	336	0.5	0.0240	1158.50	1156.90
8	8	36	CIRCULAR	42	0.5	0.0240	1156.90	1156.70
9	9	36	CIRCULAR	383	0.7	0.0240	1156.70	1154.00
10	10	42	CIRCULAR	503	1.5	0.0240	1154.00	1146.30
11	11	42	CIRCULAR	104	1.5	0.0240	1146.30	1144.70
12	12	42	CIRCULAR	158	2.2	0.0240	1144.70	1141.30
13	13	42	CIRCULAR	410	3.6	0.0240	1141.30	1126.60
14	14	18	CIRCULAR	392	0.3	0.0240	1170.00	1168.80
15	15	18	CIRCULAR	438	0.5	0.0240	1168.80	1166.50
16	16	18	CIRCULAR	172	3.8	0.0240	1166.50	1160.00
17	17	36	CIRCULAR	188	3.2	0.0240	1160.00	1154.00
18	18	18	CIRCULAR	375	0.5	0.0240	1167.50	1165.50
19	19	18	CIRCULAR	300	2.9	0.0240	1165.50	1156.90
20	20	24	CIRCULAR	238	0.4	0.0240	1168.60	1167.70
21	21	24	CIRCULAR	293	3.1	0.0240	1167.70	1158.50

Subbasin : Pre - 1501

Soil/Surface Description	(acres)	Group	Number
Sagebrush range, Good	50.50	D	55.00
Woods, Good	40.00	C	70.00
Woods, Good	187.50	B	55.00
Woods, Fair	187.50	B	60.00
Woods, Fair	40.00	C	73.00
Woods, Good	190.00	D	77.00
Woods, Fair	190.00	D	79.00
Pasture, grassland, or range, Good	33.00	B	61.00
2 acre lots, 12% impervious	97.50	B	65.00
2 acre lots, 12% impervious	10.00	C	77.00
2 acre lots, 12% impervious	10.00	D	82.00
Wetland	2.50	D	3.00
Composite Area & Weighted CN	**1038.50**		**67.07**
Time of Concentration (days hh:mm:ss)	0 00:52:19		

Subbasin : Post - 1501

Soil/Surface Description	(acres)	Group	Number
Sagebrush range, Good	42.50	D	55.00
Woods, Good	40.00	C	70.00
Woods, Good	175.50	B	55.00
Woods, Fair	187.50	B	60.00
Woods, Fair	40.00	C	73.00
Woods, Good	120.00	D	77.00
Woods, Fair	190.00	D	79.00
Pasture, grassland, or range, Good	1.00	B	61.00
2 acre lots, 12% impervious	116.17	B	65.00
2 acre lots, 12% impervious	10.00	C	77.00
2 acre lots, 12% impervious	68.00	D	82.00
Wetland	2.50	D	3.00
1/4 acre lots, 38% impervious	25.33	B	75.00
1/4 acre lots, 38% impervious	20.00	D	87.00
Composite Area & Weighted CN	**1038.50**		**68.19**
Time of Concentration (days hh:mm:ss)	0 00:52:19		

Subbasin : Pre - 1502

Soil/Surface Description	(acres)	Group	Number
Pasture, grassland, or range, Good	0.86	B	61.00
Wetland	3.85	B	30.00
Wetland	9.00	D	30.00
1/4 acre lots, 38% impervious	1.34	B	75.00
1/4 acre lots, 38% impervious	1.60	D	87.00
2 acre lots, 12% impervious	1.00	B	65.00
2 acre lots, 12% impervious	2.06	D	82.00
Composite Area & Weighted CN	**19.71**		**46.25**
Time of Concentration (days hh:mm:ss)	0 00:53:14		

Subbasin : Post - 1502

Soil/Surface Description	(acres)	Group	Number
Pasture, grassland, or range, Good	0.86	B	61.00
Wetland	3.85	B	30.00
Wetland	9.00	D	30.00
1/4 acre lots, 38% impervious	1.34	B	75.00
1/4 acre lots, 38% impervious	1.60	D	87.00
2 acre lots, 12% impervious	1.00	B	65.00
2 acre lots, 12% impervious	2.06	D	82.00
Composite Area & Weighted CN	**19.71**		**46.25**
Time of Concentration (days hh:mm:ss)	0 00:53:14		

Subbasin : Pre - 1503

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	2.83	B	75.00
Composite Area & Weighted CN	**2.83**		**75.00**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1503

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	2.83	B	75.00
Composite Area & Weighted CN	**2.83**		**75.00**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1504

Soil/Surface Description	(acres)	Group	Number
Pasture, grassland, or range, Good	1.70	D	80.00
Pasture, grassland, or range, Good	5.69	B	61.00
1 acre lots, 20% impervious	4.59	B	68.00
Woods, Good	106.91	B	55.00
2 acre lots, 12% impervious	13.48	B	65.00
2 acre lots, 12% impervious	9.00	D	82.00
1/4 acre lots, 38% impervious	2.76	B	75.00
Wetland	21.00	D	3.00
Wetland	6.75	B	3.00
Composite Area & Weighted CN	**171.88**		**49.92**
Time of Concentration (days hh:mm:ss)	0 01:09:55		

Subbasin : Post - 1504

Soil/Surface Description	(acres)	Group	Number
Pasture, grassland, or range, Good	1.20	D	80.00
Pasture, grassland, or range, Good	3.19	B	61.00
1 acre lots, 20% impervious	4.59	B	68.00
Woods, Good	100.91	B	55.00
2 acre lots, 12% impervious	13.48	B	65.00
2 acre lots, 12% impervious	9.00	D	82.00
1/4 acre lots, 38% impervious	11.26	B	75.00
Wetland	21.00	D	3.00
Wetland	6.75	B	3.00
1/4 acre lots, 38% impervious	0.50	D	87.00
Composite Area & Weighted CN	**171.88**		**50.84**
Time of Concentration (days hh:mm:ss)	0 01:09:55		

Subbasin : Pre - 1506

Soil/Surface Description	(acres)	Group	Number
1 acre lots, 20% impervious	2.00	B	68.00
1 acre lots, 20% impervious	0.26	D	84.00
Woods, Good	88.93	B	55.00
Pasture, grassland, or range, Good	5.21	D	80.00
1/4 acre lots, 38% impervious	2.33	B	75.00
1/4 acre lots, 38% impervious	1.00	D	87.00
Woods & grass combination, Good(orchard)	0.49	B	58.00
1/2 acre lots, 25% impervious	3.13	B	70.00
Urban commercial, 85% imp	1.00	B	92.00
Urban commercial, 85% imp	0.92	D	95.00
Wetland	3.50	D	3.00
Composite Area & Weighted CN	**108.77**		**56.68**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1506

Soil/Surface Description	(acres)	Group	Number
1 acre lots, 20% impervious	2.00	B	68.00
1 acre lots, 20% impervious	0.26	D	84.00
Woods, Good	86.93	B	55.00
Pasture, grassland, or range, Good	3.21	D	80.00
1/4 acre lots, 38% impervious	4.82	B	75.00
1/4 acre lots, 38% impervious	3.00	D	87.00
1/2 acre lots, 25% impervious	3.13	B	70.00
Urban commercial, 85% imp	1.00	B	92.00
Urban commercial, 85% imp	0.92	D	95.00
Wetland	3.50	D	3.00
Composite Area & Weighted CN	**108.77**		**57.25**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1507

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	9.51	B	75.00
Pasture, grassland, or range, Good	0.45	B	61.00
1/2 acre lots, 25% impervious	2.69	B	70.00
1/4 acre lots, 38% impervious	1.00	D	87.00
1/8 acre lots, 65% impervious	2.02	B	85.00
Composite Area & Weighted CN	**15.67**		**75.79**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1507

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	9.96	B	75.00
1/2 acre lots, 25% impervious	2.69	B	70.00
1/4 acre lots, 38% impervious	1.00	D	87.00
1/8 acre lots, 65% impervious	2.02	B	85.00
Composite Area & Weighted CN	**15.67**		**76.20**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1508

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	9.91	B	75.00
1/8 acre lots, 65% impervious	0.70	B	85.00
Composite Area & Weighted CN	**10.61**		**75.66**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1508

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	9.91	B	75.00
1/8 acre lots, 65% impervious	0.70	B	85.00
Composite Area & Weighted CN	**10.61**		**75.66**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1509

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	1.20	B	75.00
1/8 acre lots, 65% impervious	1.15	B	85.00
Composite Area & Weighted CN	**2.35**		**79.89**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1510

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	1.55	B	85.00
Urban commercial, 85% imp	2.05	B	92.00
Composite Area & Weighted CN	**3.60**		**88.99**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1511

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	3.81	B	85.00
Urban commercial, 85% imp	9.70	B	92.00
Composite Area & Weighted CN	**13.51**		**90.03**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1513

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	4.14	B	85.00
Composite Area & Weighted CN	**4.14**		**85.00**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1515

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	15.50	B	85.00
1/4 acre lots, 38% impervious	4.83	B	75.00
Woods, Good	3.45	B	55.00
Pasture, grassland, or range, Good	3.21	B	61.00
Pasture, grassland, or range, Good	1.62	D	80.00
1/4 acre lots, 38% impervious	2.55	D	87.00
Urban commercial, 85% imp	0.29	B	92.00
Composite Area & Weighted CN	**31.45**		**77.69**
Time of Concentration (days hh:mm:ss)	0 00:19:35		

Subbasin : Pre - 1517

Soil/Surface Description	(acres)	Group	Number
Woods, Good	87.08	B	55.00
Pasture, grassland, or range, Good	2.79	D	80.00
1 acre lots, 20% impervious	0.76	B	68.00
Woods & grass combination, Good(orchard)	2.00	B	58.00
Woods & grass combination, Good(orchard)	0.52	D	79.00
Pasture, grassland, or range, Good	0.66	B	61.00
1/4 acre lots, 38% impervious	1.20	B	75.00
1/4 acre lots, 38% impervious	0.36	D	87.00
1/8 acre lots, 65% impervious	26.50	B	85.00
1/8 acre lots, 65% impervious	3.17	D	92.00
Wetland	0.51	B	3.00
Composite Area & Weighted CN	**125.55**		**63.15**
Time of Concentration (days hh:mm:ss)	0 01:10:44		

Subbasin : Pre - 1518

Soil/Surface Description	(acres)	Group	Number
Pasture, grassland, or range, Poor	4.45	D	89.00
Woods & grass combination, Good(orchard)	0.66	B	58.00
1/4 acre lots, 38% impervious	4.00	B	75.00
1/4 acre lots, 38% impervious	1.47	D	87.00
1/8 acre lots, 65% impervious	0.13	B	85.00
Wetland	0.12	D	3.00
Composite Area & Weighted CN	**10.83**		**80.67**
Time of Concentration (days hh:mm:ss)	0 01:09:56		

Subbasin : Pre - 1602

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	1.45	B	75.00
1/8 acre lots, 65% impervious	3.84	B	85.00
Composite Area & Weighted CN	**5.29**		**82.26**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Pre - 1603

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	4.59	B	85.00
Urban commercial, 85% imp	7.70	B	92.00
1/4 acre lots, 38% impervious	0.15	B	75.00
> 75% grass cover, Good	1.34	B	61.00
Composite Area & Weighted CN	**13.78**		**86.47**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1509

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	1.20	B	75.00
1/8 acre lots, 65% impervious	1.15	B	85.00
Composite Area & Weighted CN	**2.35**		**79.89**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1510

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	1.55	B	85.00
Urban commercial, 85% imp	2.05	B	92.00
Composite Area & Weighted CN	**3.60**		**88.99**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1511

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	3.81	B	85.00
Urban commercial, 85% imp	9.70	B	92.00
Composite Area & Weighted CN	**13.51**		**90.03**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1513

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	4.14	B	85.00
Composite Area & Weighted CN	**4.14**		**85.00**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1515

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	17.31	B	85.00
1/4 acre lots, 38% impervious	4.83	B	75.00
Woods, Good	3.45	B	55.00
1/4 acre lots, 38% impervious	2.55	D	87.00
Urban commercial, 85% imp	1.69	B	92.00
Urban commercial, 85% imp	1.00	D	95.00
1/8 acre lots, 65% impervious	0.62	D	92.00
Composite Area & Weighted CN	**31.45**		**81.17**
Time of Concentration (days hh:mm:ss)	0 00:19:35		

Subbasin : Post - 1517

Soil/Surface Description	(acres)	Group	Number
Woods, Good	68.08	B	55.00
Pasture, grassland, or range, Good	1.00	D	80.00
1 acre lots, 20% impervious	0.76	B	68.00
1/4 acre lots, 38% impervious	2.20	B	75.00
1/4 acre lots, 38% impervious	0.36	D	87.00
1/8 acre lots, 65% impervious	47.16	B	85.00
1/8 acre lots, 65% impervious	5.48	D	92.00
Wetland	0.51	B	3.00
Composite Area & Weighted CN	**125.55**		**68.39**
Time of Concentration (days hh:mm:ss)	0 01:10:44		

Subbasin : Post - 1518

Soil/Surface Description	(acres)	Group	Number
Pasture, grassland, or range, Poor	1.00	D	89.00
1/4 acre lots, 38% impervious	4.66	B	75.00
1/4 acre lots, 38% impervious	1.47	D	87.00
1/8 acre lots, 65% impervious	0.13	B	85.00
Wetland	0.12	D	3.00
1/8 acre lots, 65% impervious	3.45	D	92.00
Composite Area & Weighted CN	**10.83**		**82.66**
Time of Concentration (days hh:mm:ss)	0 01:09:56		

Subbasin : Post - 1602

Soil/Surface Description	(acres)	Group	Number
1/4 acre lots, 38% impervious	1.45	B	75.00
1/8 acre lots, 65% impervious	3.84	B	85.00
Composite Area & Weighted CN	**5.29**		**82.26**
Time of Concentration (days hh:mm:ss)	0 00:06:00		

Subbasin : Post - 1603

Soil/Surface Description	(acres)	Group	Number
1/8 acre lots, 65% impervious	4.59	B	85.00
Urban commercial, 85% imp	7.70	B	92.00
1/4 acre lots, 38% impervious	0.15	B	75.00
> 75% grass cover, Good	1.34	B	61.00
Composite Area & Weighted CN	**13.78**		**86.47**
Time of Concentration (days hh:mm:ss)	0 00:06:00		