Final Report

Fairview Creek Stormwater Master Plan Addendum

April 2019, Final

Prepared For
City of Fairview, Oregon

Contact Information

Cardno
6720 SW Macadam Ave, Suite #200
Portland, Oregon 97219
Telephone: 503.419.2500
Facsimile: 503.419.2600

Cedomir.Jesic@cardno.com
www.cardno.com

REGISTERED PROFESSIONAL ENGINEER
60175PE
OREGON
JUL. 15, 2003
CEDOMIR JESIC

RENEWS: 08/09/19

Document Information

Prepared for	City of Fairview, Oregon
Project Name	Final Report Fairview Creek Stormwater Master Plan Addendum
File Reference	1019-Fairview Model Development Report.docx
Job Reference	21510190
Date	April 2019, Final

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
1.0	03/14/2019	Draft	Daniel Child	Cedomir Jesic
2.0	04/08/2019	Final	Daniel Child	Cedomir Jesic

Executive Summary

Understanding existing stormwater infrastructure and watershed hydrology is a critical component to stormwater master planning. Hydraulic-hydrologic models provide an effective way to quantify the performance of a watershed and storm system. As a planning tool, one-dimensional modeling provides information on sewer capacity, velocities, and the presence of flooding. This information can be used by the City to identify and prioritize stormwater improvements, anticipate future infrastructure improvement costs, and increase public safety.

This report presents the methodology used to create and calibrate hydraulic-hydrologic models within the City of Fairview's city limits. A 1D hydraulic model was created to represent Fairview and No-Name Creek watersheds.

Specifically, the 1D model will be used to identify capital improvement projects.

The project entails characterizing Fairview's watersheds, which include Fairview Creek and No-Name Creek. This was completed by delineating basins for all areas within the City of Fairview. A total area of 1,183 acres was delineated and incorporated into the model. Boundary conditions were also established that considered additional acreage upstream of Fairview's city limits. The boundary conditions contribute flow to the modeled area. Additionally, hydrologic infiltration parameters were determined.

An assessment of the City's stormwater GIS data was reviewed for completeness and used in the development of the model. 477 nodes and 463 links were used to represent the City of Fairview storm system. The hydraulic model was calibrated and verified using data collected from 1 storm event that occurred February 28th, 2018.

A lack of historical gauged stream data for Fairview Creek and No-Name Creek within the study area limited available calibration parameters for the system. These limitations restricted available calibration storm events to the timeframe between February and May 2018. A stream gauge managed by U.S. Geological Survey (USGS) on Fairview Creek at NE Glisan Street (USGS 14211814) with a record starting in May 1992, allowed for the capture of a 25-year equivalent gauged storm at the upstream boundary of the study area. A low-intensity storm measured on February 28, 2018 was used to evaluate hydraulic/hydrologic accuracy within the model, and the 25-year equivalent storm measured December 7, 2015 was used to calibrate the upstream boundary condition at NE Glisan Street.

This model was used to conduct a full master plan evaluation of the existing Fairview Creek and No-Name Creek storm system in order to identify required capital improvement projects to meet the public's needs, according to the City's design standards. Additionally, once the existing system deficiencies were defined, the model was expanded to represent future build-out within the City of Fairview.

This report is organized into five sections. Section 1 provides an overview of the purpose for the 1D modeling, area modeled, and general description of how a 1D model is developed. Section 2 provides a description of the variables and parameters used to develop the model. Section 3 provides a description of the model calibration process and model results. Section 4 describes the conveyance evaluation criteria, known problem areas, model results and deficiencies. Section 5 describes the capital improvement project (CIP) development, design, cost estimates, and table that describes and scores CIP projects, then lists those projects in order of prioritization and ranking.

Table of Contents

Appendices

Tables

Figures

Acronyms and Abbreviations

CIP	Capital Improvement Project
CN	Curve Number
CSPM	City of Fairview Consolodated Stormwater Master Plan
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System
LiDAR	Light imaging, Detection, and Ranging
NRCS	Natural Resources Conservation Service
SCS	Soil Conservation Service
TBD	To Be Determined
UIC	Underground Injection Control
USDA	U,S Department of Agriculture
USGS	U.S. Geological Service

1 Introduction

This report describes the modeling process, Capital Improvement Project (CIP) evaluation process, and recommended CIP addendums for the City of Fairview Consolidated Stormwater Master Plan (CSMP). The primary purpose of this project is to address inconsistencies found concerning existing CIPs for the Fairview Creek and No-Name Creek basins.

1.1 Goals

The goals of this project are to conduct a comprehensive hydrologic/hydraulic (H/H) model update for the Fairview Creek and No-Name Creek basins with the intent to evaluate existing CIPs and identify potential additional CIPs needed to meet the City of Fairview's stormwater goals. The total project effort included the following tasks:

- Review the City's existing data including: existing XPSWMM models, Geographic Information System (GIS) data, and as-built data
- Conduct interviews with City staff to identify known stormwater issues within the study area
- Identify data gaps
- Conduct field investigations to fill identified data gaps
- Data preparation including: basin, sub-basin, land use, and soil mapping
- One-dimensional (1D) Hydraulic model development and calibration
- Model evaluation
- CIP development
- Engineering cost estimates
- CIP prioritization

1.2 Report Organization

This report is organized into five sections:

- **Section 1 – Introduction:** provides a general overview and the purpose for this project, the project study area, modeling software selection, and a general description of how a 1D model is developed.
- **Section 2 – Model Development:** provides a description of the variables and parameters used to develop the hydraulic model. This section covers model hydrology, hydraulics, and boundary conditions.
- **Section 3 – Calibration and Results:** provides a description of the model in detail, the model calibration process, basin maps, model results and inundation maps.
- **Section 4 – Storm System Capacity Evaluation:** describes the conveyance infrastructure evaluation criteria, known problem areas, model results, and identified deficiencies.
- **Section 5 – Capital Improvement Projects Update:** describes the CIP development process, design, and cost estimates.
- **Appendix A –** Model Development
- **Appendix B –** Reports and Studies

1.3 Computer Model Selection

The use of 1D models allows channelized flows such as creeks, rivers, and pipes to be analyzed using cross sectional data along the flow line. These cross sections give information about the topography of the channelized flows. The water depths and velocities are then calculated using one-dimensional governing equations which solve for the depth of flow at each model node. A 1D model uses governing equations to solve for depth of flow, which is the single dimension which gives the model its classification. When considering unsteady flows along structures – such as through culverts, around bridges, or over weirs – upstream and downstream boundary conditions are used in order to see the change in flow when water moves through them.

XPSWMM was the selected hydrologic and hydraulic computer model. XPSWMM is based on the EPA SWMM model developed in the 1970's as a comprehensive urban runoff model for continuous and event based simulation. XPSWMM was selected for its user friendly model development, report generation, ability to import and export GIS shapefiles, data management tools, and due to existing models of the study area having been developed previously in XPSWMM.

1.4 Study Area

Two creeks analyzed in this study area are: Fairview and No-Name Creek. Fairview Creek runs from the southern edge of the city limits meandering through the city. No-Name Creek is part of the Fairview Creek watershed and runs on the eastern side of the city before discharging to Fairview Creek. Fairview Creek drains into Fairview Lake which then drains into the Columbia Slough by means of a mechanical gate controlled structure.

Fairview Creek originates from the Wetlands on the northeast side of Grant Butte in the City of Gresham, travels northward running between the Salish Ponds and then discharging into Fairview Lake. The study area for this project limits the Fairview Creek basin between NE Glisan Street and Fairview Lake. No-Name Creek originates south of NE Glisan Street and discharges to Fairview Creek north of NE Sandy Blvd and east of NE Fairview Ave. The study area encompasses the entire No-Name Creek basin. A map showing each study area basin is shown in Figure 1-1 Fairview Creek Study Area and Figure 1-2 No-Name Creek Study Area.

The Fairview Creek and No-Name Creek basins were divided into 214 sub-basins. See Exhibits 5 and 6 in Appendix A for a listing of each sub-basin for Fairview Creek and No-Name Creek, respectively.

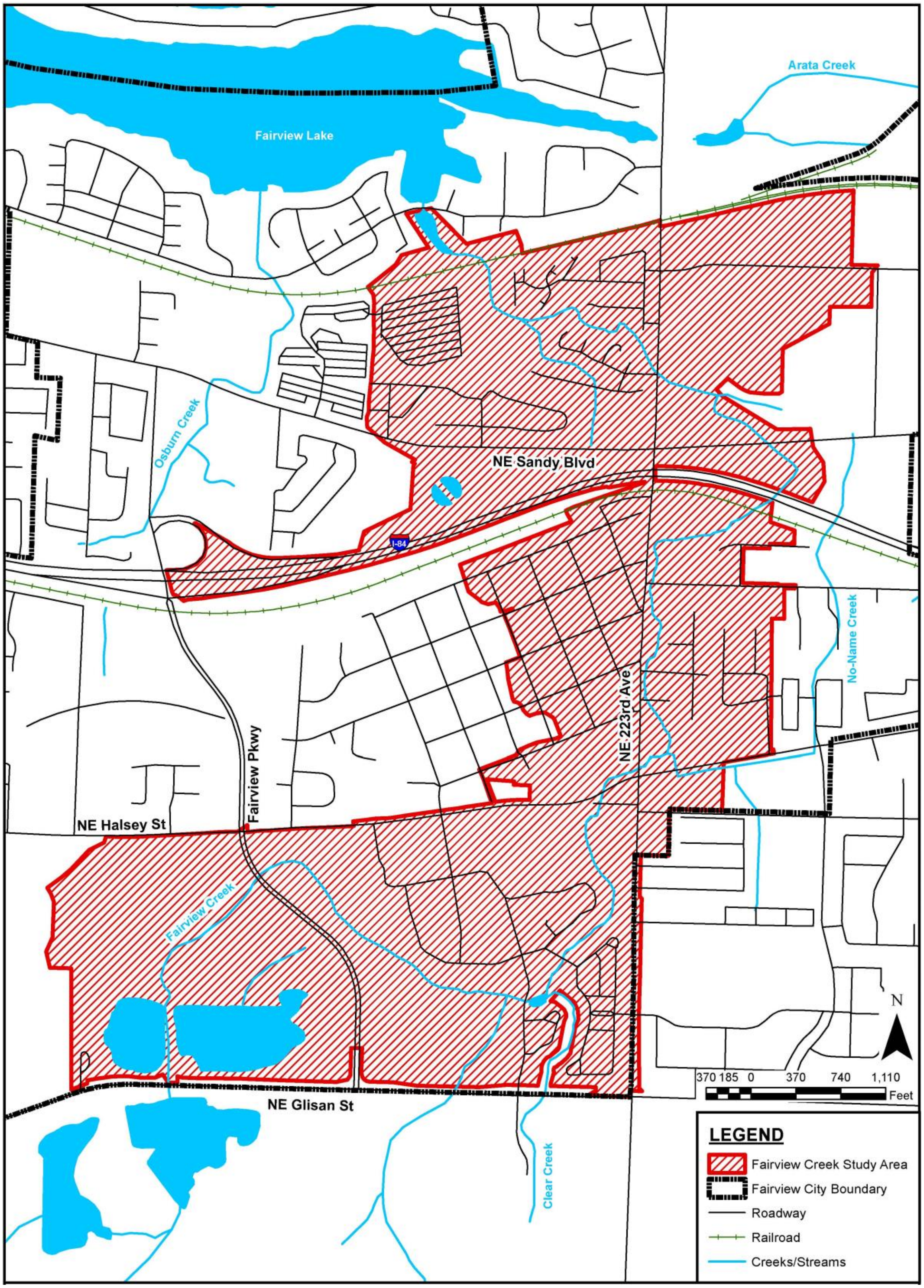


Figure 1-1 Fairview Creek Study Area

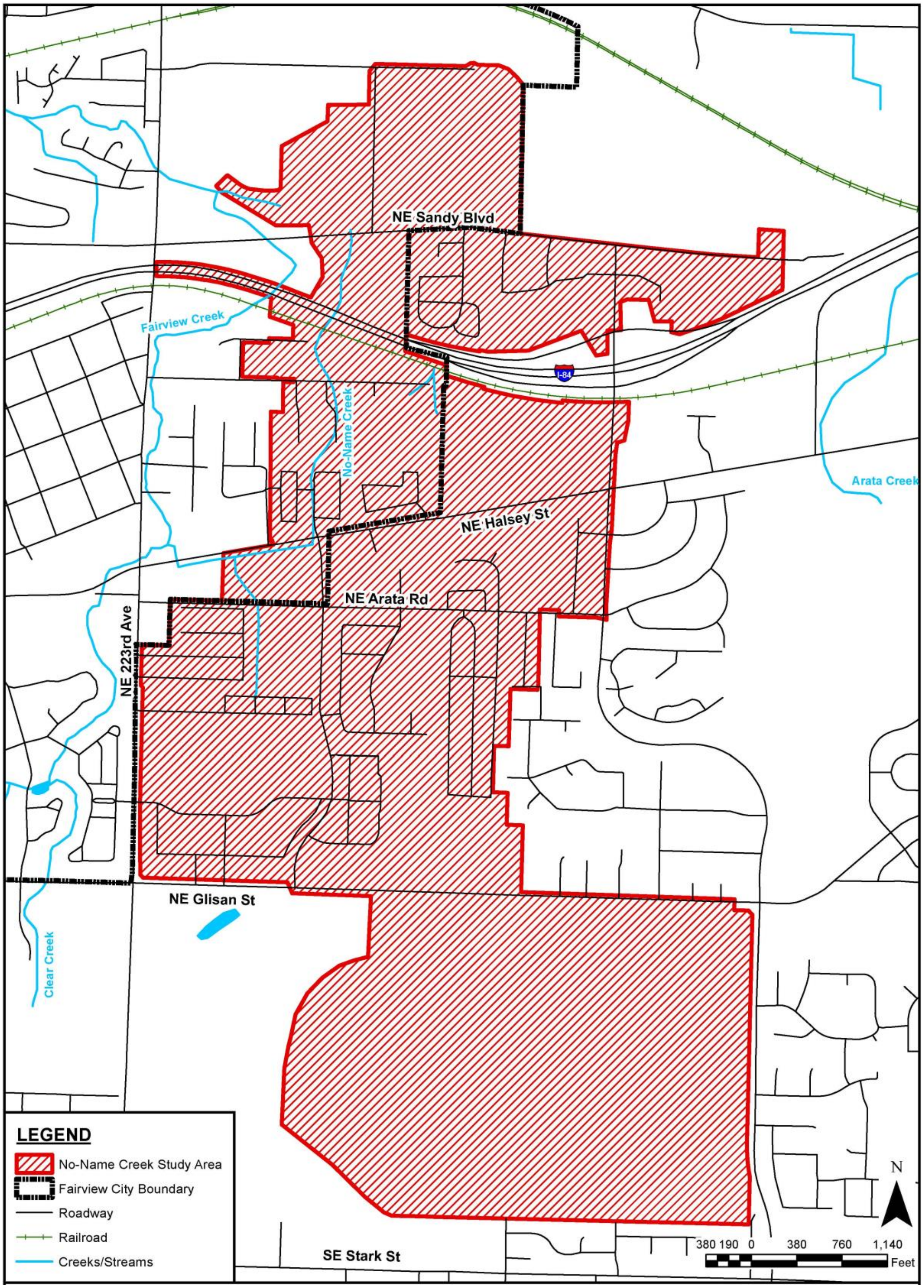


Figure 1-2 No-Name Creek Study Area

2 Model Development

This section presents the methodology used to develop the 1D hydrologic/hydraulic model. Model development has three primary components:

> Hydrology: The hydrologic analysis defines the amount of runoff generated within each watershed. Hydrologic parameters include basin area, soil infiltration, evaporation, and surface storage.

> Hydraulics: The hydraulic analysis defines how generated runoff moves through the watershed. Hydraulic model components include closed conduits, open channels, and storage facilities. Hydraulic parameters include system geometry, Manning's roughness coefficients, and entrance/exit losses.

> Boundary Conditions: Boundary conditions define the hydrologic/hydraulic conditions at the upstream and downstream limits of the model. Boundary conditions can be entered as either a flow, stage, or complex hydrologic parameters.

2.1 Model Description

The study area model includes Fairview Creek, No-Name Creek, and Clear Creek. Fairview Creek is the dominant creek within the study area and is modeled from NE Glisan Street to Fairview Lake. Fairview Lake is pump controlled and discharges to the Columbia Slough. No-Name Creek is located east of Fairview Creek and discharges to Fairview Creek north of NE Sandy Blvd. No-Name Creek was modeled from NE Arata Road to its confluence with Fairview Creek. Clear Creek is a minor tributary of Fairview Creek and the two connect north of NE Glisan Street between NE Market Drive and NE Park Lane. All Creeks flow south to north. The contributing basin contained in the model area is approximately 1,183 acres and was divided into 214 sub-basins.

An upstream contributing basin outside the modeled area was delineated for Fairview Creek and represented as an upstream boundary condition (see discussion in Section 2.4.1). The Fairview Creek watershed is highly developed and extends through the City of Gresham.

The hydraulic model includes 477 nodes and 463 links representing 8.2 miles of conduit and 4.4 miles of open channels. The model includes four weirs.

The following exhibits, included in Appendix A, provide additional information on the Fairview – No-Name Creek model: Exhibit 5 and Exhibit 6 identify each sub-basin used to develop the model. The Fairview Creek Summary Sheet and No-Name Creek Summary Sheet provide an overview of model conditions. The Fairview – No-Name Creek Area Table provides hydrologic parameters, such as impervious, pervious and total area, sub-basin width, sub-basin slope, and pervious curve number.

2.2 Hydrologic Data

The runoff function of XPSWMM generates surface runoff based on design or measured rainfall conditions, impervious cover, and soil groups. The SWMM Runoff Curve Number Method was selected for this analysis. This method was selected for its ability to combine losses and calculate excess runoff due to interception, depression storage, and infiltration.

2.2.1 Basin Delineation

Fairview Creek and its tributary No-Name Creek provide drainage to the main portion of the City of Fairview. The total acreage of the City of Fairview is 2,258 acres (3.53 square miles). Of the total drainage area of 3,738 acres, 693 acres lie within city limits. The total drainage area for each creek basin is summarized in Table 2-1.

Table 2-1 Watershed Area Summary

Creek	Watershed Area, acres	Study Area, acres
Fairview	3,107	552
No-Name	631	631
Total	3,738	1,183

37 acres of the study area drain away from the identified watersheds through Underground Injection Control's (UICs) or other means and are not accounted for in this analysis (See Section 0 Excluded Areas). Some basin boundaries extend beyond Fairview city limits, but are not a part of an upstream boundary condition (See Section 2.4.1 Upstream Boundary Conditions). These basins were delineated and included within the study area. Modeled basin drainage area totals are summarized in Table 2-2.

Table 2-2 Drainage Study Area Summary (Modeled Area)

Creek	Study Area Within City Limits, acres	Study Area Outside City Limits, acres	Total Study Area, acres
Fairview	552	0	552
No-Name	141	490	631
Total	693	490	1183

Basin information that contributes upstream of the study area is discussed within Section 2.4 Boundary Conditions, of this report. Each watershed within the study area was divided into several sub-basins based on ground topography and storm networks.

Sub-basin delineation was mapped manually using the City's stormwater infrastructure shapefiles and digital elevation data. Sub-basin parameters such as area, slope and basin flow length were also determined during the delineation process. Sub-basin flow length was used to calculate basin width.

Excluded Areas

Portions of the City of Fairview do not drain to one of the identified creeks modeled as part of this analysis. Five sub-basins were excluded. These areas were identified as draining to UIC systems, or draining away from the study area. Hydraulic models were not created for these areas (see Technical Appendix A: Exhibit 7 – Excluded Areas).

2.2.2 <u>Impervious Percentage</u>

Existing Conditions

The total impervious coverage for the study area is 46.3% of the total area. The city of Fairview is an urban area with some industrial areas as well as open spaces and recreational sites. Fairview is highly developed, and impervious coverage is generally homogeneous throughout the city with pockets of high and low impervious areas based on the zoning designations, such as industrial areas and city parks. Table 2-3 summarizes impervious, pervious, and total basin area in the existing conditions for the 1D model.

Table 2-3 1D Drainage Basin Area Summary

Creek	Impervious Area, acres	Pervious Area, acres	Impervious Percentage	Total Basin Drainage Area, acres
Fairview	263	289	47.6%	552
No-Name	285	346	45.2%	631
Total	548	635	46.3%	1183

Build-Out Conditions

Impervious coverage for the future build-out condition was developed based on the City of Fairview's comprehensive plan (See Figure 2-1). Impervious percentages for each basin were increased based on an assumed maximum build-out percentage for each zone in the comprehensive plan. Table 2-4 outlines the assumed maximum impervious percentages for each zone listed in Figure 2-1.

Table 2-4 Build-Out Impervious Cover By Zone

Comprehensive Plan Zone	Maximum Build-Out Impervious Percentage
Commercial	95
General Industrial	90
Light Industrial	90
Residential Light Density	80
Residential Medium Density	80
Village	95
Parks	By Basin
Public	By Basin
River Oriented	By Basin

Areas that are zoned Public, Parks, and River Oriented were looked at on a case by case basis, as these areas don't have a homogeneous impervious cover. Basins that contained above-ground stormwater facilities and greenways that were not likely to be covered by impervious area were considered to remain the same between existing and build-out conditions.

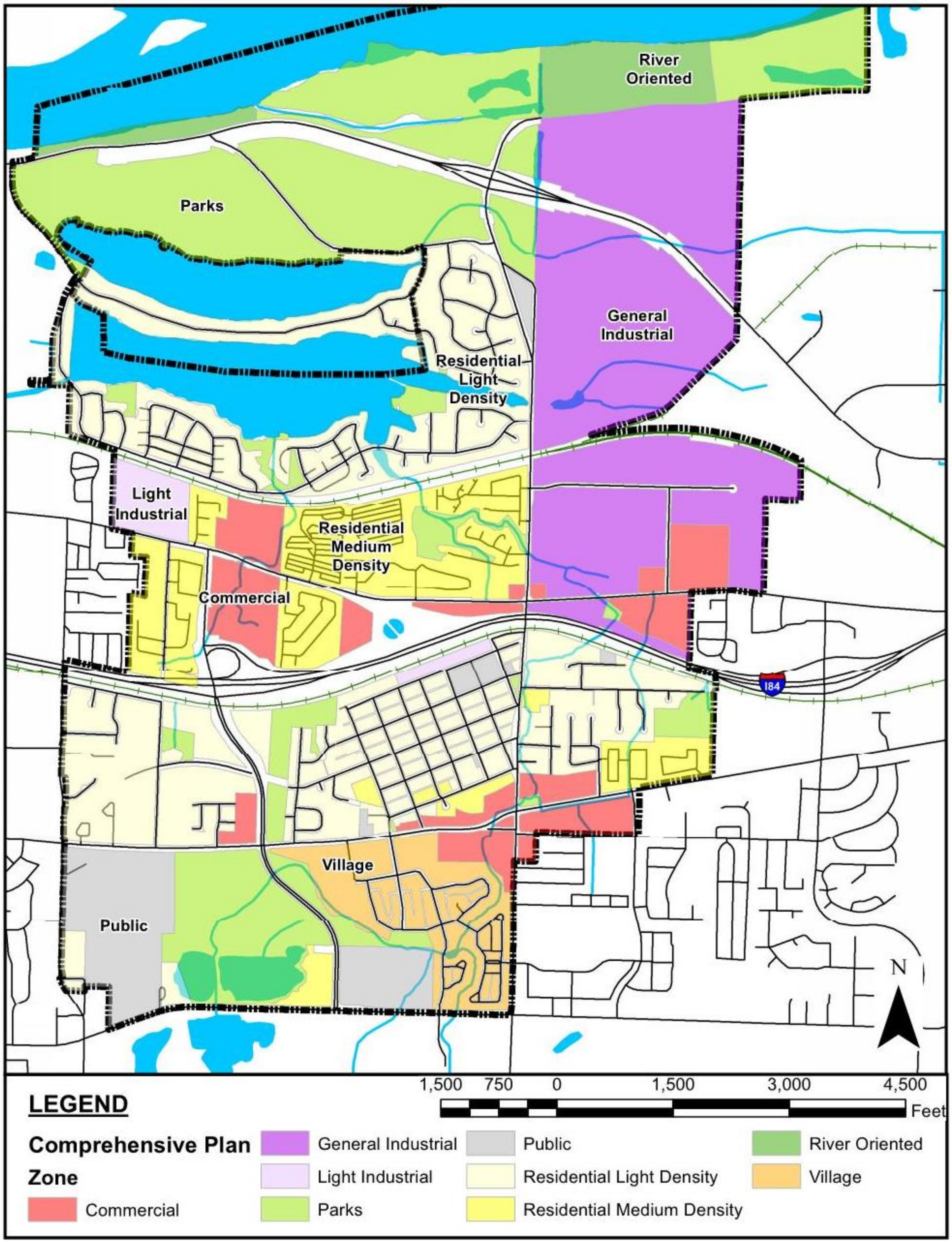


Figure 2-1 City of Fairview Comprehensive Plan

2.2.3 Width and Slope

The width parameter determines the lag time between the peak precipitation and the peak runoff. In other words, a smaller width will attenuate the flow while a larger width will have a quicker peak time for the same basin area. The width parameter is the distance perpendicular to flow path.

ArcMap version 10.4.1 was used to calculate basin flow length from Light imaging, Detection, and Ranging (LiDAR) elevation data. Statistics were generated for each sub-basin from the calculated flow length raster. A flow length of two standard deviations was used for each sub-basin, assuming a normal distribution, to capture 50% of the data. This was done to reduce the impact of outlier data that otherwise skewed the desired outcome beyond acceptable bounds.

The slope parameter also determines the lag time between the peak precipitation and peak runoff. A steep slope will have a shorter attenuation of flow while a flatter slope will have a longer response time.

The average basin slope used for the Fairview Creek study area was 1.27% and the average basin slope used for the No-Name Creek study area was 2.96%. See Technical Appendix A: Exhibits 5 and 6 Basin Delineation Summary Tables, for a listing of the width and slopes for Fairview Creek and No-Name Creek, respectively.

2.2.4 Infiltration and Surface Parameters

Hydrologic soil groups are based on estimates of infiltration rates. These infiltration rates are determined by soil types and then are categorized into four groups (A, B, C, and D), where Group A has a high infiltration rate and Group D has a very low infiltration rate. The three predominant groups within the site area are B, C, and C/D. In areas where Group C/D is identified, we are assuming a developed/ impacted area, and Group D is assumed. (See Technical Appendix A: Exhibit 1A: USDA Soil Group).

The Curve Number Method is the selected infiltration method. This method uses pervious and impervious land areas, runoff curve numbers (CN) and a design storm. The runoff curve numbers are determined based on the land use, cover type, hydrologic condition and hydrologic soil groups (See Technical Appendix A: Exhibit 1C NRCS Curve Numbers).

Depression storage is the initial abstraction by the process of surface ponding, surface wetting, interception and evaporation. All depression storage must be filled before runoff begins and hence influences the volume that is conveyed downstream. Depression storage controls the amount of runoff that immediately runs off a surface. A percentage of Zero Detention Storage can be applied to represent an amount of impervious area that has no depression storage, and contributes 100% of its rainfall volume to surface runoff. Table 2-5 lists the depression storage parameters that were used to calibrate the model.

Table 2-5 Depression Storage Infiltration Parameters

Impervious Depression Storage, inches	Pervious Depression Storage, inches	Zero Detention Storage, %
0.0625	0.2500	25%

2.2.5 Rainfall and Evaporation

Rainfall Data

Fairview's average annual rainfall is 45-inches. Storms during the winter rainy season are often of long duration/low intensity extending two to three days. Shorter duration/high intensity events are typical in spring, and last a few hours. Rain gauge data was used from the Portland-Troutdale Airport rain gauge (KTTD).

Table 2-6 Rain Gauge Location Table

Gauge Name	Period of Record Used (Data and Time)
Portland-Troutdale Airport (KTTD)	2/28/2018 1:19 - 23:53 12/7/2015 - 12/8/2015 0:00 - 24:00, 0:00 - 16:30

Evaporation

Evaporation is used to renew surface depression storage. It is subtracted from the rainfall at each time step and is important to continuous simulation modeling. A default value of 0.1 in/day was used as a conservative estimate.

2.3 Hydraulic Data

2.3.1 Data Sources

The City of Fairview provided the primary data sources for this analysis. City GIS shapefiles were received in July 2016 and September 2017 and include; FVSTORM_CatchBasins, FVSTORM_Cleanouts, FVSTORM_Manholes, FVSTORM_Culverts, FVSTORM_Facilities, FVSTORM_Pipes, FVSTORM_Outfalls, FVSTORM_Swales, FVSTORM_OtherLines, and FVSTORM_OtherPoints. Data from these shapefiles were imported into the XPSWMM hydraulic model. The GIS shapefile data was reviewed for accuracy and as-builts provided by the city were used to fill in and add data to the model. A meeting with Public Works and the Public Works Operations and Maintenance staff was also held on January 9th, 2018 in order to learn about known problem areas so they can be captured within the model appropriately.

The City provided XPSWMM models previously developed that encompassed Fairview and No-Name Creek. These models were developed by the City of Gresham for their Fairview Creek Stormwater Master Plan (May 2003), and the City of Wood Village for their Storm Water System Facility Plan Update (November 2011).

LiDAR data from Oregon DOGAMI includes tile bh45122e4. The LiDAR data includes 3 feet by 3 feet cell size in Esri grid format. Structures and vegetation have been removed from the bare-earth file so that only ground elevation data is provided. The LiDAR data was used to delineate drainage sub-basins, and create cross sections of small open channels and drainage ways not surveyed. Additionally, LiDAR data was used to estimate rim elevations for storm structures (manholes, catch basins) where GIS data was unavailable.

Additional information, including as-constructed plans, verification of GIS data and photos were obtained.

2.3.2 Conveyance System Information

Node and Conduit Data

The City of Fairview GIS data for the City's storm sewer system contained: pipe identification, pipe length, upstream invert, downstream invert and pipe diameter within the FVSTORM_Pipes shapefile. FVSTORM_Manholes, catch basin, node identification and rim elevations were provided within the FVSTORM_Manholes, FVSTORM_CatchBasins, and FVSTORM_OtherPoints shapefiles.

In the XPSWMM model, Cardno has attempted to maintain the naming convention established within the City of Fairview GIS data. For all links, the Object ID was used. This is a unique number for all pipes. For all nodes, the Node ID was used. In cases where this information was not available, a unique ID easily distinguishable from the Object ID format was used instead.

The hydraulic model is limited to mainline storm drain lines and does not include connections to catch basins. Catch basins included in the model are limited to those flow-through structures or those collecting a large drainage area. Drainage basins were directed to the upstream manhole when catch basins were not included within the model.

Node and Conduit Roughness Coefficients

The roughness coefficient (Manning's "n") is used to estimate friction loss within an open channel or closed conduit. For this analysis a value of 0.013 was used for all storm pipes.

Manning's "n" values used for culverts were defaulted to 0.013, with higher values ranging from 0.012 to 0.035 where appropriate. These values were obtained by previous master plans in Wood Village and Gresham.

Open Channel Data

Open channels include Fairview Creek, its tributary No-Name Creek, and Clear Creek, along with smaller drainage channels including conveyance ditches, such as roadside ditches. Cross sections were taken where the channel had visible changes in geometry.

Left and right banks were estimated from cross sectional and photo information. Channels are identified within XPSWMM by the abbreviated creek name followed by the link number counting downstream to upstream (e.g. FVC_0140 is the 14th link modeled in Fairview Creek).

Open Channel Roughness Coefficients

Manning's "n" values can be estimated from published tables and from flow and stage measurements. This analysis used flow and stage data when available, and published table values when unavailable. The selected Manning's "n" values used for Fairview's streams range from 0.005 to 0.500. Specifically, the overbanks of the streams ranged from 0.005 to 0.500 and the main channel ranged from 0.0050 to 0.100. The Manning's "n" determination methodology is discussed in Section 3.

Manning's "n" tables provide Manning's "n" values for different vegetation conditions. Table 3-1 Manning's "n" Values from *HEC-RAS River Analysis System, Hydraulic Reference Manual* by US Army Corps of Engineers dated February 2016 were used as a reference (See Technical Appendix A: Table 3-1 Manning's "n" Values).

2.3.3 <u>Culverts and Bridges</u>

The City of Fairview has several culvert and bridge structures. These structures range from the large box culverts that pass flow under I-84 to 18-inch driveway culverts. Culverts were modeled to the best data available. Photos and survey information were used to classify inlet type, material and shape. Previous data was also used from the Gresham and Wood Village master plans where no field data was available.

All culverts and bridges have been assigned an inlet type and an entrance/exit loss coefficient. XPSWMM uses the selected inlet type for inlet controlled conditions. In all other conditions, XPSWMM uses the specified entrance/exit loss coefficient (See Technical Appendix A: Exhibit 3: Culvert Location Map and Culvert Summary Table). Entrance and exit loss coefficients were obtained from *Table 12 – Entrance Loss Coefficients from the Hydraulic Design of Highway Culvert HDS No. 5*. Common entrance loss coefficients range from 0.2 to 0.9 and exit loss coefficient is the typical value of 1. (See Technical Appendix A: *Table 12 – Entrance Loss Coefficients*).

2.3.4 Detention Facilities

The City of Fairview maintains GIS data of known public and private detention facilities throughout the City. Stormwater facilities that retain stormwater runoff for either treatment or flow control include underground detention pipes, surface ponds, wetlands and swales. A control structure (with orifices and weirs) or a pipe, limits the amount of water leaving the facility.

The largest detention facilities were included within the hydraulic model. As-built documents provided by the City of Fairview were used. (See Technical Appendix A: Exhibit 3: Detention Facility Location Map).

2.4 Boundary Conditions

2.4.1 Upstream Boundary Conditions

Fairview Creek's headwaters is outside the study area; therefore upstream boundary conditions were developed. Upstream boundary conditions establish discharge rates entering the hydraulic model at Fairview's city limit. No-Name Creek is completely contained within the study area, and is included within the hydraulic model. No definition of upstream boundary conditions is required for this.

A complete hydraulic analysis of the upstream basin is outside the scope of this project. For this report, an idealized one node upstream basin was developed for Fairview Creek. The upstream basin has attempted to reproduce the peak flows and approximate volume generated. This was accomplished through virtual links that lag the direct basin flow before entering the modeled system.

Upstream basins were delineated based on information from the Fairview Creek Stormwater Master plan developed by the City of Gresham (2003) and the Wood Village Storm Water System Facility Plan Update (2011). Upstream basins are located between the City of Gresham and the City of Fairview, within Multnomah County. The primary land use is residential. The upstream basins contain the primary creek channel, but are dominantly comprised of developed area with associated underground storm sewer infrastructure.

Table 2-7 Basin Upstream Area Summary Table

Creek	Total Upstream Drainage Area, acres
Fairview	2,555
No-Name	0

2.4.2 Downstream Boundary Conditions

The Columbia River Slough is the ultimate discharge location for Fairview's streams. Fairview Creek discharges into Fairview Lake then into the Columbia River Slough. No-Name Creek is a tributary of Fairview Creek, thus discharges into Fairview Creek.

Downstream boundary conditions were evaluated for just Fairview Creek. Fairview Lake is pump-controlled and maintains a consistent elevation of 14 feet. Therefore, the downstream boundary for Fairview Creek is a fixed backwater elevation.

2.4.3 Initial Conditions

An initial water level was set for Fairview Lake at 14 feet. A constant inflow was entered to account for stream base flow. This flow is entered at the upper most node along with the upstream basin information. The base flow was established as part of the calibration process following a review of information gathered by the USGS.

3 Calibration and Results

A key goal of this project was to develop a well-calibrated, existing-conditions model of the City of Fairview storm system within the Fairview Creek and No-Name Creek basins. An accurate existing conditions model requires both reliable hydrologic data and a truthful depiction of physical conditions. As described in the sections above, the hydrologic and hydraulic existing conditions have been obtained and incorporated into the XPSWMM model, setting the foundation for model calibration.

Model calibration is the comparison of stage, flow and volume from the model output to gauge readings, flow measurement, and observations of storm events. Parameters are then adjusted to match a historical calibration storm. This is an iterative process, where one parameter is changed and output is observed until stage, flow, and volume are considered well-matched.

The calibration approach began with identifying discrepancies within the model. Where discrepancies occurred, further investigations were completed to determine whether the discrepancy was a model calibration issue or if there was something in the field creating the discrepancy, such as incorrect inverts, pipe slopes, or partially blocked pipes. Structures were identified and presented to City staff for field verification by either surveying the structure or locating as-built drawings. Drainage reports were obtained where available and contributing area confirmed. Once field conditions were confirmed, the model was calibrated with a review of roughness, and other losses. Finally, the model was refined with infiltration parameters.

3.1 Storm Events

Due to a lack of historical gauged data available for Fairview Creek and No-Name Creek between Fairview Lake and NE Glisan Street, calibration storms applicable to the study area were limited to a time period between February and May of 2018. One storm was selected from this data and used to evaluate model accuracy. This storm occurred on February 28th, 2018 and lasted approximately 24 hours. Historical gauged data was available for Fairview Creek at NE Glisan Street (USGS 14211814), and this data was used to calibrate the upstream boundary condition for Fairview Creek. A peak flow rate at NE Glisan Street from a storm on December 7, 2015 was used to calibrate the upstream boundary condition. This storm is roughly equivalent to a 25-year event.

3.2 Sensitivity Analysis

A sensitivity analysis was completed to find which hydrologic parameters are most likely to adjust model results. The sensitivity parameters checked are: area, impervious percentage, width, slope, impervious and pervious depression storage, impervious and pervious Manning's "n", and two parameters related to infiltration; Soil Conservation Service (SCS) curve number, and initial abstraction factor.

The sensitivity analysis found area and impervious percentage are the most sensitive parameters, although these parameters are physically based and are fixed. Width is somewhat sensitive with slope being less so. SCS curve number is the most sensitive of the two infiltration parameters. This value is set by Fairview's soil and cover types, and influences the sensitivity of the pervious depression storage and Manning's "n".

3.3 Gauge Measurements

Data used to calibrate the model was gathered from two sources. The first source is USGS gauge 14211814 located on Fairview Creek at NE Glisan Street with a record from May 1992 to the present. The second source is a set of stream flow gauges installed by the City on Fairview Creek and No-Name Creek. These gauges are located at NE Sandy Blvd and at I-84 respectively, and were installed in February 2018 to capture flow data downstream of NE Glisan Street.

Table 3-1 lists the locations of gauge data used for calibration. The gauge type and recorded storm events are listed in the table (See Appendix A: Exhibit 4: Gauge Location Map).

Table 3-1 Gauge Measurement for Fairview Creek and No-Name Creek

Gauge Location	Gauge Location in Model	Type	Storm Events
Fairview Creek at NE Glisan St	FVSTORM-01451M	Stream	December 7, 2015 & February 28, 2018
Fairview Creek at NE Sandy Blvd	FVSTORM-01374S	Stream	February 28, 2018
No-Name Creek at I-84	FVSTORM-00914S	Stream	February 28, 2018

3.4 Model Analysis

The calibration process began by first reviewing the gauges installed by the City. Flow data was provided and used for calibration. Along the creeks, locations with downstream gauges were calibrated first, followed by upstream boundaries. Only minor adjustments to the study area were made to calibrate the model, with the addition of creek base flow, and the adjustment of width and slope for one large basin south of NE Arata Road for No-Name Creek. A complex hydrological system was developed for the upstream basin of Fairview Creek south of NE Glisan Street. This hydrology consists of a split basin and several links to attenuate the flow. This was done to calibrate the hydrology based off the December 7th, 2015 storm which approximates a 25-year storm event.

Being “well calibrated” was defined by comparing the shape and peaks of the creek’s hydrograph. A good match was considered when a small change in peak flow did not result in a large change in volume. The XPSWMM results provide a continuity check, a comparison between flow generated during the model run and flow leaving the model. The check accounts for initial and final storage volumes. A discrepancy occurs when there is instability within the model, and the program fails to converge flow results between conduits. The XPSWMM user manual has provided the following ranges for model performance as listed in Table 3-2 below.

Table 3-2 Continuity Check

Continuity Error as Percentage	Rating
Under 1	Excellent
1 to 2	Great
2 to 5	Good
5 to 10	Fair
10 to 25	Poor
25 to 50	Bad
Above 50	Terrible

Continuity error should be below 2% for the overall model. Note that a positive continuity error means loss of volume occurred through the model run, and a negative continuity error means gain of volume occurred through the model run.

3.5 Calibration Results

Figure 3-1, Figure 3-2, and Figure 3-3 show the calibrated model results at the City installed gauges in Fairview Creek, No-Name Creek, and the USGS gauge for Fairview Creek at Glisan Street. The two City installed gauges illustrate the February 28, 2018 event while the Glisan gauge illustrates the December 7, 2015 event. The December 7, 2015 event was used to calibrate the upstream boundary condition at Glisan Street as it approximates a 25-year event.

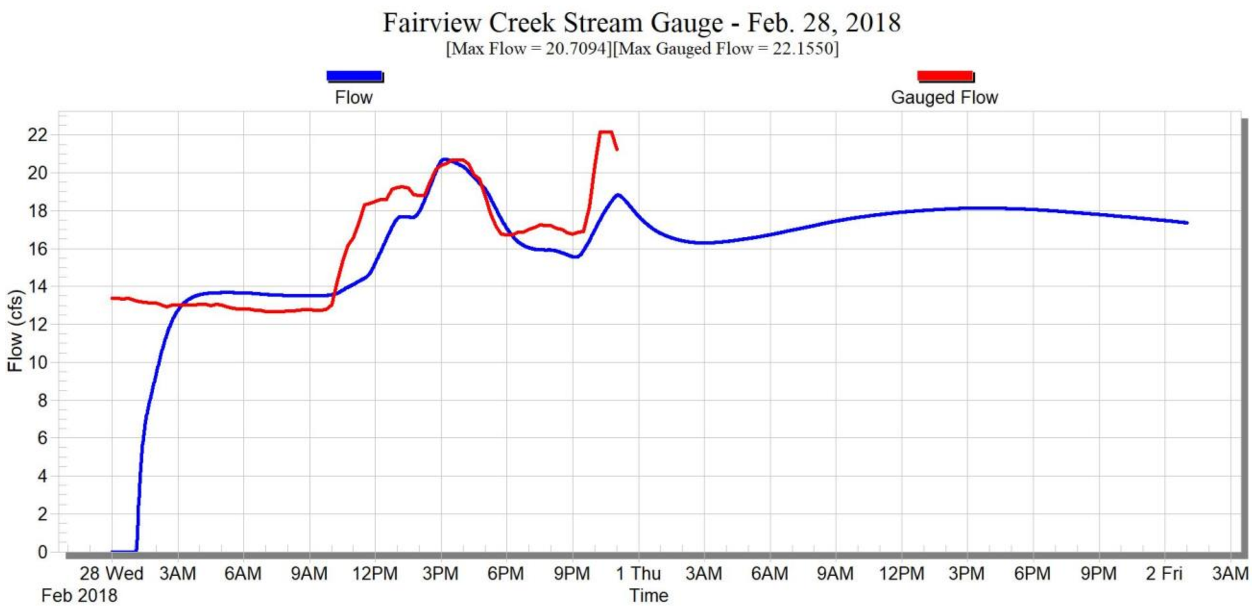


Figure 3-1 Fairview Creek Gauge – February 28, 2018

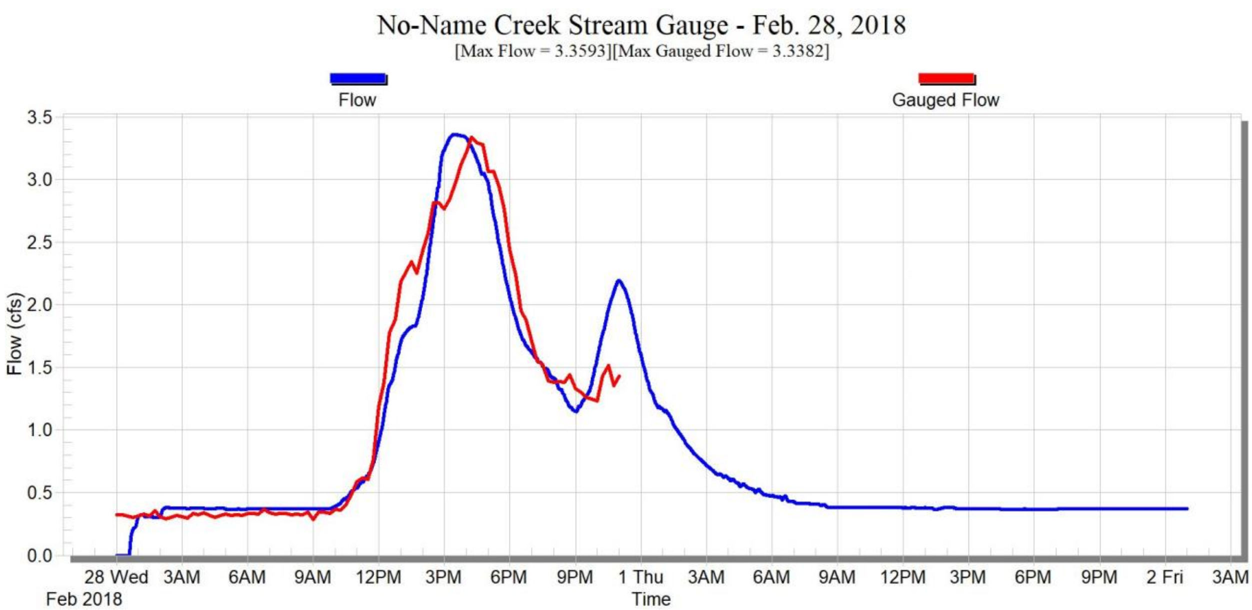


Figure 3-2 No-Name Creek Gauge – February 28, 2018

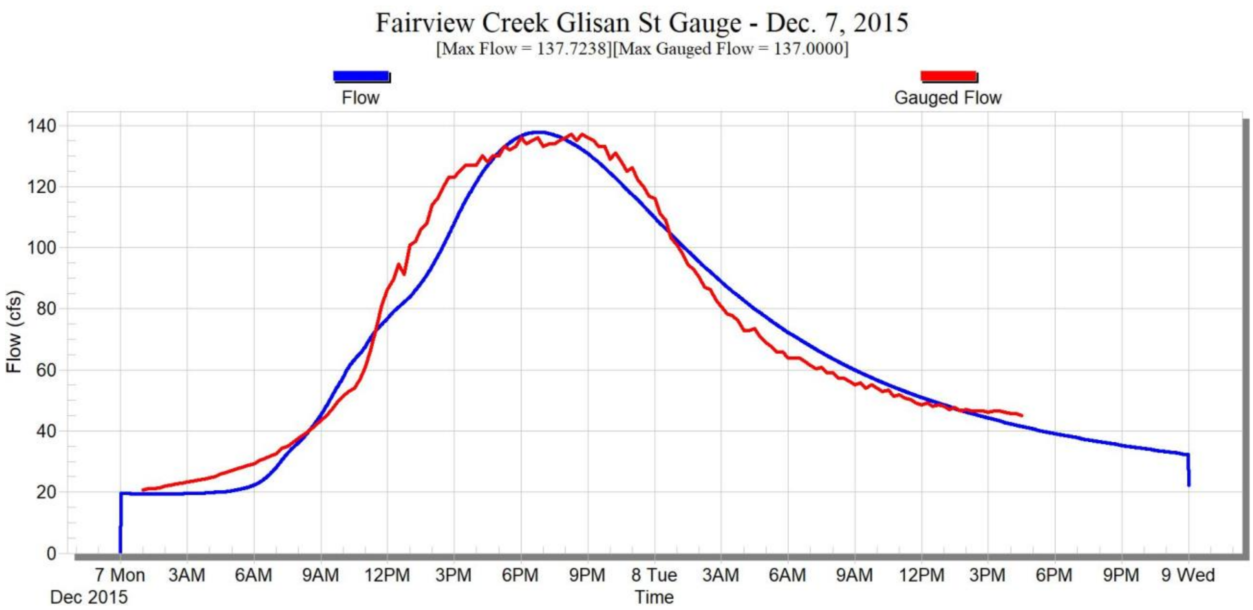


Figure 3-3 Fairview Creek Glisan Street Gauge – December 7, 2015

4 Storm System Capacity Evaluation

4.1 Conveyance Evaluation Criteria

4.1.1 Storm Sewer

The evaluation criteria for this section are outlined in the City of Fairview *Design Standards and Standard Details,* dated May 30, 2017. This manual was used to evaluate the performance of the stormwater sewer system. The manual classifies storm pipe by the amount of area draining to them. Storm sewers collecting a larger area have a more restrictive design standard. Table 4-1 below lists the conveyance standards as outlined within the Engineering Standards.

Table 4-1 City of Fairview Standards

Drainage System Element	Facility Type	Design Storm Return Period, years
Minor:	Streets, curbs, gutters, inlets, catch basin, and connector drains.	10
Major:	Laterals (collectors) <250 tributary acres	25
	Trunk > 250 tributary acres	50*
	Arterial Streets and the Drainage System in or under Arterial Streets	50
Watercourses:	Without designated floodplain	50
	With designated floodplain	100
Bridges:		100
Detention Facilities:	Storage volume (onsite)	25
	Discharge rate	Function of downstream capacity
Retention Facilites:	Drywell infiltration capacity	25**

** Surcharged conditions for pipe systems and culverts and bank-full conditions for open ditches and channels are acceptable only for demonstrating the adequacy of the conveyance system to convey the peak runoff for the 25 or 50-year design storms (as required) provided that:*

1. *Runoff is contained within defined conveyance system elements; AND*
2. *The hydraulic grade line does not exceed the elevation of the roadway subgrade; AND*
3. *No portions of a building will be flooded.*

*** Maximum allowable design capacity = 1200 GPM = 2.67 CFS per drywell.*

These Engineering Standards apply to new development and redevelopment projects and were put in place after much of the City developed. A conveyance deficiency has been defined by the following criteria:

> A pipe designated as a collector with a 25-year freeboard at upstream and/or downstream structures less than one foot

> A pipe designated as a trunk with a 50-year freeboard at upstream and/or downstream structures less than one foot

Pipe velocities were reviewed to identify locations exceeding 15 feet per second. High velocities can reduce the life of a storm pipe by resulting in pipe abrasion.

4.1.2 Culverts and Bridges

The City's major culverts and bridges were also analyzed for conveyance capacity. The City of Fairview's design standards do not specifically identify conveyance criteria for bridges and culverts. Planning criteria for natural creeks with a channel shown on the Flood Insurance Rate Map (FIRM) stipulate the 100-year storm event. As such, bridge and culvert crossings, open channels, and creeks have been designed to the 100-year storm event. Stream crossings must also be designed to meet Oregon Department of Fish and Wildlife fish passage requirements and FEMA's water surface rise standards. The roadway classification and designation as a safety corridor will also require the crossing be designed to the 100-year storm event.

One foot of clearance between the water surface and the top of roadway or bank (whichever is lowest) was used to classify a deficient system. Removal of the structures was recommended in some cases.

4.2 Known Problem Areas

City operation and maintenance staff were interviewed in January 2018 to determine known problem areas within the City's stormwater system. The following list summarizes the results of the interview:

- Flooding occurs along No-Name Creek at the Sandy Blvd culvert.
- The Fairview Creek culvert under 223rd Ave has issues with accumulating debris possibly linked to issues with the culvert.
- Flooding issues caused by a diversion manhole located along No-Name Creek north of the Fairview Woods Apartments.
- Flooding occurs along No-Name Creek at Bridge Street.
- Fence crossing No-Name Creek at Fairview Woods Apartments collects debris.
- Erosion issues at No-Name Creek diversion outlet.
- Channel capacity issues along No-Name Creek at the Fairview Woods Apartments.
- Flooding occurs at the Ukrainian Bible Church adjacent to No-Name Creek.
- Flooding occurs along Fairview Creek at Halsey Street.

4.3 Deficiency List

This section describes the identified deficiencies for the existing condition hydrology and build-out condition hydrology scenarios. Detailed tables identifying and describing each deficiency are located in Appendix B.

4.3.1 Existing Condition

Along Fairview Creek, the most notable deficiencies in the existing condition scenario occur between 223rd Ave and Walnut Lane. These modeled issues are caused by shallow slopes and depth in the Fairview Creek channel within this stretch. Deficiencies also occur within the storm system in 3rd Street between Main Street and Cedar Street. These deficiencies occur due to an undersized pipe in Cedar Street.

Along No-Name Creek, the most notable deficiencies in the existing condition scenario occur between Arata Road and Bridge Street. These modeled issues are caused by the flow diversion north of the Fairview Woods Apartments, a deficient culvert within the apartments, and high flows along No-Name

Creek between Arata Road and Halsey Street. Issues also occur at Sandy Blvd caused by culvert capacity issues.

4.3.2 Built-Out Condition

Existing deficiencies are exacerbated in the build-out condition for both Fairview Creek and No-Name Creek. New deficiencies occur within the Fairview Creek basin along Lincoln Street between 5th Street and 223rd Ave, Cedar Street between 4th Street and 2nd Street, and at Depot Street at 2nd Street. These deficiencies are caused by undersized pipes.

5 Capital Improvement Projects Update

5.1 CIP Development

Projects for the conveyance issues identified in the existing system were evaluated using the XPSWMM model. These issues were identified through the model and through City maintenance staff as described in Section 4.2 and 4.3.1. Projects identified for the built-out condition system were identified and evaluated using the XPSWMM model and identified in Section 4.3.2.

The projects for the Fairview Creek basin and No-Name Creek basin can be described generally, as increasing conveyance and providing additional detention. This can be accomplished by upsizing pipe diameter in order to better convey detained stormwater during peak flow storm events.

Each project includes the following components:

- Existing or Build-Out: Each project will identify whether it is an existing or build-out issue.
- Problem Location: Location of identified problem.
- Land Ownership: States whether the problem is located on public or privately owned land.
- Problem Summary: Describes the system issue using the evaluation criteria.
- Technical Details: Description of pipe sizes, flow rates, and flooded volume.
- Alternative Summary: Narrative of the components that make up each proposed solution including pipe size changes, length of channel improvements, and other improvements needed in order to implement the project.
- Benefits: Identifies how each project resolves the issue and other enhancements to adjacent or connecting portions of the system or area surrounding.
- Implementation Issues: Describes the issues with the implementation of each project.
- Cost: Estimated cost for each project.

5.2 CIP Sizing and Design Assumptions

5.2.1 Improvement Criteria

Pipe improvement and channel criteria will follow the City of Fairview public design standards. Pipe design criteria related to material, minimum dimensions, and cover will be followed. The Oregon Department of Transportation design criteria were used when City standards did not specify a condition.

Proposed culvert and bridge criteria will follow Oregon Department of Fish and Wildlife fish passage requirements. Only box culverts will be recommended for culverts requiring fish passage. The design criteria are listed below in Table 5-1.

Table 5-1 Improvement Design Criteria

Facility Type	Defenition
	Pipes and Culverts
Minimum Pipe Diameter	12-inch, 10-inch for inlet leads
Velocity	Minimum 3 feet/second, Maximum 15 feet/second
Minimum Cover	3 feet - PVC, 2.5 feet - Ductile iron, 1.5 feet - reinforced concrete
Flow-Through Inlets	Four inlets may be connected together at intersections
Spacing	400 feet - Inlet, 500 feet - Manholes
Manning's 'n'	0.013 new pipes, 0.024 new culverts
	Ditches and Channels
Manning's 'n'	0.018 - 0.104 depending on channel type
Side Slopes	Maximum of 2:1, 3:1 for roadside ditches, 4:1 if safety is a concern

5.2.2 Solution Hierarchy

Solutions are focused on minimizing design and construction costs, including reviewing each design for the shortest distance, easiest maintenance, greatest accessibility, constructability, sufficient pipe cover and pipe slope, and reviewed for other potential conflicts (e.g. sanitary sewer and franchise utility crossings).

Recommended solutions were approached with the following hierarchy of preference:

- Upsize Existing System: This approach involves upsizing the existing conveyance piping to provide sufficient conveyance.
- Run Parallel Lines: This approach will propose installing a second parallel pipe when an existing pipe with sufficient cover is unavailable.
- Reroute Stormwater Flows: This approach reroutes the stormwater system to decrease downstream flooding issues, and to potentially provide a stormwater utility to areas currently lacking stormwater drainage.
- New Stormwater System: This approach is limited to underserved communities, and new communities where stormwater systems are proposed. The number of new discharge locations will be limited to decrease the associated permitting challenges and costs. The design of new stormwater systems were limited to trunk lines, excluding catch basin laterals and other peripheral pipes.

5.3 CIP Unit Cost Estimates

Cost estimates have been completed at the master plan level for the locations of deficiencies identified within the hydraulic analysis. As each project enters a detailed design stage for construction, actual and more detailed construction costs will be realized. The costs are based on anticipated construction costs, engineering costs, environmental and permitting costs and other capital cost such as administration, legal fees and contingencies.

Itemized cost sheets for existing and build-out conditions CIPs can be found in Appendix B.

5.3.1 Engineering and Administration Costs

Engineering and administration costs associated with projects often include surveying, geotechnical exploration, preparation of drawings and specifications, environmental investigations, construction management, inspections, and construction staking.

The costs for these services are estimated to be 35 percent of the project cost for projects up to $100,000, and 25 percent for projects over $100,000. Engineering and administration costs were calculated including the 20 percent contingency in the total project cost.

5.3.2 Permitting Costs

The necessary environmental permits for a particular project can be highly variable depending on the location, scope and what is found at the construction site. Some permits are more common than others such as wetland permits, 401 and 404 certifications, and general environmental assessments. The Department of State Lands (DSL) requires a permit for work in a wetland or body of water that involves more than 50 cubic yards of fill or removal, which is expected for some of these projects knowing the area has poor drainage.

The costs for these services are not included in the estimate.

5.3.3 Mobilization Costs

Mobilization costs consist of preparatory work and operations. This includes associated costs for transporting equipment, supplies and incidentals to the project site on behalf of the contractor. It also covers the establishment of all offices, buildings and other general facilities necessary for the contractor's operations at the site, and all other work and operations which must be performed or cost incurred prior to beginning work on the project site.

The costs for these services are estimated to be 9 percent of the project cost (not including engineering and administrations costs) or $10,000, whichever is greater.

5.3.4 Contingency Costs

The project size and type will dictate the scope of services needed to obtain permits and commence construction. The range of services is unknown for any particular project; as a result, a contingency cost for these projects is estimated to be 20 percent of the construction subtotal, which is included in the total project cost.

5.3.5 Property Acquisition Costs

No allowance has been made for property acquisition and/or easements. It is expected at the beginning of design for each project that an evaluation of needed property or easements would be completed. There may be situations where additional easements or property is needed to complete a project.

5.3.6 Unit Pricing

The unit pricing is based on 2016 and 2017 Oregon Department of Transportation (ODOT) weighted average item prices and 2018 ODOT Standard Specifications.

5.3.7 Pipe Replacement

In order to minimize cost, the costs for pipe replacement projects assumed minor adjustments to the existing manholes, wherever possible, instead of proposing new structures.

5.3.8 Twin Barrel Culvert under Sandy Boulevard

The work to replace the existing twin barrel culvert under Sandy Boulevard assumes that pavement replacement will require a 2" grind and inlay.

5.4 Prioritization Criteria and Scoring

All CIPs – Existing, New, and Updated – have been scored and prioritized using the matrix outlined in Table 5-2. This table was originally developed by the City of Fairview and Brown and Caldwell in October 2007.

Table 5-2 Prioritization Criteria Matrix

Prioritization Criteria Matrix				
Criteria	**Weight**	**Score**		
		3	**2**	**1**
1. Cost	0.2	< 100,000	>100,000 and <250,000	>250,000
2. Potential Funding Source	0.4	Possible grant/SRF/FEMA funding	Joint/Jurisdictional Funded project; Non-	No likely outside funding source
3. Mandates	0.8	Federal or State Mandate with deadline	Mandated with flexible timeline over 2 FY's	No Mandate
4. Special Interest	0.8	Pet project, City Council directed	-	-
5. Safety/ Livability	1	Significant Hazard, threat to life and limb and/or property	-	-
6. Complexity	0.6	May be done by small crew in less than a months time	Typical moderate level of difficulty	Requires significant design, contract SP's,
7. Impact	1	Affects region-wide with significant downstream	Affects small sub-basin	Affects only 1 or 2 individual properties
8. Concurrence	0.4	Required/ pre-requisite project for other budgeted	Related work within 2-3 FY's	No related/ dependent work
9. Environmental Benefit	0.8	Significantly improves water quality and wildlife habitat	Moderately improves water quality and wildlife	None
10. Permitting	0.6	No permitting issues	Potential permitting issues	Significant issues. Possibly not permittable
11. Sustainability	0.8	No imbalance.	-	Imbalance
12. Livability	0.8	"This is what our grandkids would want."	"This will work for my generation."	"Okay for now."

Criteria Definition	
1. Cost	Total estimated cost of the CIP.
2. Potential Funding Source	Is the cost supported by grant money or is there an opportunity for a joint project?
3. Mandates	Is the project mandated by the state or federal government, or under court order?
4. Special Interest	Is this project directed by the City Council?
5. Safety/ Livability	What potential safety and/or liability issues are involved?
6. Complexity	How quickly can the solution be implemented and with what level of effort?
7. Impact	How large an area and/or how many people does the project directly benefit?
8. Concurrence	Does the work coincide with other City work or another jurisdiction's scheduled work?
9. Environmental Benefit	Are there direct environmental benefits associated with the projects?
10. Permitting	In the current permitting environment, will this project have difficulties in obtaining local, federal or state permits?
11. Sustainability	Can the project be done without causing an imbalance in resources (i.e., funding, manpower, environment, etc.)?
12. Livability	Are we improving the quality of life for the people of Fairview? Is this what our grandkids would want?

5.5 Recommended Project Prioritization and Final CIP Priority Ranking

The final scoring and recommended project priority is outlined in Table 5-3.

Table 5-3 - Prioritized Projects

Ranking Matrix				Performance Criteria Scores										
ID	Project Name	Cost (in 1,000's)	Rating	Cost	Funding Source	Mandate	Special Interest	Safety Liability	Complexity	Impact	Environ. Impact	Permitting	Sustainability	Livability
				1	*0.4*	*0.4*	*0.3*	*1*	*0.6*	*1*	*0.4*	*0.4*	*0.4*	*0.4*
GN-1	CCTV Inspection	$ 18	**15.6**	3	1	2	2	3	3	2	2	3	2	3
GN-2	Pipe Replacement and Rehabilitation Over 15 Years*	$ 49	**13.4**	3	1	1	2	2	3	2	1	3	2	2
FV-8	Fairview Village Detention Ponds	$ 17	**13.3**	3	1	2	1	1	3	2	2	3	3	2
RT-1	Railroad Crossing	$ 32	**13.0**	3	1	1	2	3	2	2	1	2	2	1
GN-3	Catch Basin Retrofits Over 10 Years*	$ 18	**13.0**	3	1	3	2	1	2	2	2	3	2	2
NN-4b	Undersized culverts at Fairview Woods Appartments	$ 115	**12.9**	2	1	1	1	3	1	3	1	2	2	3
FV-5	Old Town Green Streets Over 10 Years*	$ 73	**12.3**	3	1	2	1	1	2	2	3	3	1	2
NN-4a	Undersized pipes at NE 227th Ave.	$ 251	**11.9**	1	1	1	1	3	1	3	1	2	2	3
NN-5	Undersized pipe at Townsend Way	$ 50	**11.1**	3	1	1	1	1	3	1	1	3	3	1
NN-1a	Undersized Culvert at Sandy	$ 448	**10.8**	1	2	1	2	3	1	2	1	2	1	2
FV-10	Cedar St. Between Fairview Ave. & 3rd St.	$ 308	**10.5**	1	1	1	1	2	2	2	1	3	2	2
FV-11	1st St. from Depot St. to Main St.	$ 107	**10.5**	2	1	1	1	1	2	2	1	3	3	1
FV-1	Fairview Creek between Halsey and I-84	$ 705	**9.9**	1	3	1	1	3	1	1	1	1	3	1
FV-9	Lincoln St Between Fairview Ave. & 4th St.	$ 287	**9.5**	1	1	1	1	1	2	2	1	3	3	1
	Total:	**$ 2,478**												

Notes:

Grey fill means not paid for by Stormwater Fund (Private, County, Parks)

* The cost for these projects are per year

5.6 CIP Maps and Cost Estimates

The projects listed below were analyzed as part of the Fairview Creek Stormwater Master Plan Update, as well as existing projects listed in the Consolidated Stormwater Master Plan that are currently ongoing or not yet completed. These projects, developed in 2007, have not been updated as part of this project.

The following analysis sheets include information on existing conditions, problem analysis, modeling information, proposed solutions, design assumptions, project benefits, and estimated project costs. Each project has an associated figure that illustrates the conceptual project elements.

5.6.1 Project List

General/Programmatic Projects (GN)

- *GN-1: Closed-Circuit Television Inspection (Existing Project)*
- *GN-2: Pipe, manhole, and catch basin rehabilitation (Existing Project)*
- *GN-3: Catch basin retrofit program (Existing Project)*

Fairview Creek Projects (FV)

- FV-1: Fairview Creek between Halsey Street and Interstate 84
- *FV-5: Old Town Green Streets Opportunities (Existing Project)*
- *FV-8: Fairview Village Detention Ponds (Existing Project)*
- FV-9: Lincoln Street between Fairview Ave and 4th Street
- FV-10: Cedar Street between Fairview Ave and 3rd Street
- FV-11: 1st Street from Depot Street to Main Street

No-Name Creek Projects (NN)

- NN-1: Undersized culvert for No-Name Creek at Sandy Blvd
- NN-4: Replacement of undersized pipes and storm sewer extension at NE 227th Ave
- NN-5: Townsend Way

Raintree Sub-Basin Projects (RT)

- *RT-1: Raintree Creek culvert under Railroad (Existing Project)*

Project Name: CCTV Inspection
Project Type: Flood hazard reduction

Project Number: GN-1
Sub-Basin: General or city-wide

Existing Conditions: As storm sewer pipes are aging and reaching the end of their expected lifespan their condition is deteriorating. The City is currently resurfacing streets on an annual basis and replacement of aging pipe could occur concurrently. The City would like to establish a pipe rehabilitation program to provide funding for replacing pipes according to age and condition or as opportunities arise during street work.

Problem Analysis: There are 72,000 feet of storm sewer culverts, inlet leaders, and pipe in the City of Fairview (according to the GIS coverages) that are not considered private. The expected life of corrugated steel and metal pipe is 25 years. The expected lifespan of concrete, ductile iron and plastic (ABS, ADS, HDPE, PVC, RCSP) sewer pipe is usually estimated at 75-100 years. 12,000 feet of the City's storm system is older than 25 years and 1,100 feet of pipe are of unknown age. To determine if replacement of pipe is necessary, check for cross connections with the sanitary sewer and look for pipe settlement, an inspection program should be completed. Recommend inspecting pipes that have a high consequence of failure first.

Modeling Information: No modeling was performed for this analysis.

Proposed Solution/Project Description: Inspection of all pipes that are older than 25 years or have an unknown age, a total of 13,100 feet.

Design Assumptions: Assumed closed circuit television inspection of all pipes over 25 years and of unknown age. Inspection and cleaning costs approximately $1.50/ft, assuming easy access and no traffic control requirements. Cost can go up if access is difficult.

Project Benefit to City

During pipe inspection, crews can check for cross connections with sanitary sewer. Eliminating cross connections will reduce bacteria.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
CCTV Inspection	LF	$ 1.50	13,100	$ 19,650
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
			Total	$ 19,650
			Contingency (20%)*	
			Sub-Total	$ 19,650
			Engineering and Administration (**%)	$ 6,878
			Total Land Costs	$ -
			***Project Cost**	**$ 26,528**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2007 dollars*

Project Name: Pipe, manhole, and catchbasin rehabilitation
Project Type: Flood hazard reduction

Project Number: GN-2
Sub-Basin: General or city-wide

Existing Conditions: As storm sewer pipes are aging and reaching the end of their expected lifespan their condition is deteriorating. The City is currently resurfacing streets on an annual basis and replacement of aging pipe could occur concurrently. The City would like to establish a pipe rehabilitation program to provide funding for replacing pipes according to age and condition or as opportunities arise during street work.

Problem Analysis: There are 72,000 feet of storm sewer culverts, inlet leaders, and pipe in the City of Fairview (according to the GIS coverages) that are not considered private. The expected life of corrugated steel and metal pipe is 25 years. The expected lifespan of concrete and plastic (ABS, ADS, HDPE, PVC, RCSP) sewer pipe is usually estimated at 75-100 years. 1,800 feet of the City's storm system is older than 25 years and constructed with metal pipe (CMP, Steel). There are approximately 500 feet of metal pipe with an unknown age. We recommend inspection and replacement of all metal pipe over 25 years old and of unknown age; and regular inspection of all pipe that provides critical services. Manholes and catchbasins should be replaced simultaneously.

In the future, plastic pipe and concrete pipe will need to be brought into the rehabilitation program. If it was assumed that all pipes last 100 years and all pipes are of equal value, the City should replace 10% of their pipes per year. In reality, that is not the case since pipes have different levels of criticality and different consequences of failure. See project GN-1 for closed circuit television inspection costs.

Modeling Information: No modeling was performed for this analysis.

Proposed Solution/Project Description: Assumed all metal pipe older than 25 years and of unknown age needs to be replaced. If the city replaces 150 feet per year, over the course of approximately 15 years all the metal pipe currently older than 25 years and of unkown age will be replaced. Pipe rehabilitation program of approximately $50,000/year used to replace approximately 150 feet of pipe, 1 manholes, and 2 catchbasins. Consider replacing with concrete or plastic pipe for longer life. This project is dependent on the outcome of project GN-1 CCTV Inspection and the amount may need to be increased over time to include all pipes and avoid falling further behind in needed repairs.

Design Assumptions: Pipe replacement construction cost approximately $150 per foot. Assumes pipe replacement will be incorporated into other street projects; does not include costs for mobilization, traffic control, street paving, and removal of existing infrastructure. (NOTE: 12" CSP estimated at $100/ft for RT-3. This GN-1 cost est. higher to account for larger pipes.)

Project Benefit to City

Replacement of aging storm sewer pipes will reduce the risk of pipe collapse and potential associated flooding issues. Eliminating cross connections will reduce bacteria.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Pipe rehabilitation	LF	$ 150	150	$ 22,500
Manhole replacement	LS	$ 5,000	1	$ 5,000
Catchbasin replacement	LS	$ 1,500	2	$ 3,000
				$ -
				$ -
				$ -
				$ -
			Total	$ 30,500
			Contingency (20%)	$ 6,100
			Sub-Total	$ 36,600
			Engineering and Administration (**%)	$ 12,810
			Total Land Costs	$ -
			***Project Cost**	**$ 49,410**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2007 dollars*

Project Name: Catch basin retrofits
Project Type: Water quality

Project Number: GN-3
Sub-Basin: General or city-wide

Existing Conditions: The 6/7/06 "Development of Retrofit Options" memo from GeoSyntec recommends catch basin retrofits (under Site X, city-wide) and parking lot retrofits (under Site V, city-wide) for water quality improvement in Fairview.

Problem Analysis: The City currently has 449 catch basin sumps, 2 water quality manholes, and 48 catch basins. Based on the 6/7/06 memo from GeoSyntec, we recommend adding sumps to the 48 remaining catch basins. The proposed catch basin retrofits in the GeoSyntec memo include replacement of existing self cleaning catch basins with sumped catch basins (also known as water quality inlets) to provide for storage and removal of sediment loads from publicly owned catch basins in higher pollutant source areas; and addition of catch basin inserts to publicly owned catch basins. The proposed parking lot retrofits include installation of oil/water separators; catch basin inserts; and swales in publicly owned parking lots. Catch basin inserts evaluated for both options included grate inlet skimmer boxes, filtration units, and throat openings to capture oil.

Modeling Information: No modeling was performed for this analysis.

Proposed Solution/Project Description: Catch basin retrofit program of $18,023 per year to replace approximately 5 catch basins with sumped catch basins, resulting in 50 new sumped catch basins over ten years for a total project cost of $180,023 over ten years.

Design Assumptions: Design assumptions for catch basin retrofits based on the 6/7/06 GeoSyntec memo. City recommended using a unit cost of $500 for removal of self-cleaning inlets and $1500 for replacement of catch basins with sumped catch basins. Based on the high maintenance efforts required, we are not recommending catch basin inserts.

Project Benefit to City

Self cleaning catch basins do not function as effective sediment traps, therefore retrofit of catch basins in higher pollutant load areas will improve water quality. Water quality benefits which may be achieved through catch basin retrofits include reductions in the following TMDL parameters: TSS and nutrients (TP and TN).

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization (per 5 catch basins)	LS	$ 1,000	1	$ 1,000
Traffic Control (per 5 catch basins)	LS	$ 125	1	$ 125
Removal of self cleaning inlets	EA	$ 500	5	$ 2,500
Catchbasins (Concrete sumped inlets,	EA	$ 1,500	5	$ 7,500
				$ -
				$ -
				$ -
				$ -
			Total	$ 11,125
			Contingency (20%)	$ 2,225
			Sub-Total	$ 13,350
			Engineering and Administration (**%)	$ 4,673
			Total Land Costs	$ -
			***Project Cost**	**$ 18,023**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2007 dollars*

Project Name: Fairview Creek Between Halsey and I-84
Project Type: Flood Hazard Reduction
Project Number: FV-1
Sub-Basin: Fairview Creek

Existing Conditions: A study completed by CH2M Hill, "Assessment of Fairview Creek Flow Control Options" (July, 2000) indicates that during the 100-year storm Fairview Creek has the potential to cause localized flooding of houses and private property along the 223rd reach of Fairview Creek between Halsey Street and Bridge Street. This was confirmed by Brown and Caldwell in 2007, and recommended a 48" high-flow bypass pipe along 223rd/Fairview Road.

Problem Analysis: The XP-SWMM model was updated with more detailed information for this reach and confirmed the flood risk. Furthermore, it was shown that flow from Fairview Creek was escaping the channel and draining east to No-Name Creek along Halsey. The model showed that shallow channel grades between 223rd/Fairview and Matney were a major contributor to high water surface elevations. The alternative proposed by Brown and Caldwell (Project number FV-1) was analyzed as a solution.

Modeling Information: The reach in question is between Halsey and just downstream of Matney street on Fairview Creek. During the 100-year event for future conditions, flows range between 337 cfs and 340 cfs. The slope of the creek ranges between 4% and 0.3%.

Proposed Solution/Project Description: High flow bypass between Halsey and Matney.

Design Assumptions: Assume southbound lane of 223rd Ave will require 2" grind and inlay and an 8' wide trench for pipe installation.

Project Benefit to City

Protect private homes from flooding.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 43,000	1	$ 43,000
48" RCP	LF	$ 250	805	$ 201,250
Erosion control	LS	$ 8,000	1	$ 8,000
2" grind and inlay	SY	$ 60	1800	$ 108,000
Video inspection	LF	$ 20	805	$ 16,100
Sawcut pavement	LF	$ 10	1650	$ 16,500
72" Manhole	EA	$ 12,000	2	$ 24,000
Outfall protection	EA	$ 10,000	1	$ 10,000
Trench resurfacing	SY	$ 60	720	$ 43,200
				$ -
			Total	$ 470,050
			Contingency (35%)*	$ 164,518
			Sub-Total	$ 634,568
			Engineering and Administration (**%)	$ 158,642
			Total Land Costs	$ -
			***Project Cost**	**$ 793,209**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: Old Town Green Streets Opportunities
Project Type: Water Quality Retrofit
Project Number: FV-5
Sub-Basin: Fairview Creek

Existing Conditions: The City is repaving streets in Old Town and there are opportunities to simultaneously improve water quality through implementation of Green Streets and other low impact development features. Green Streets use vegetated facilities to manage stormwater runoff at its source. The Old Town streets already provide some management of stormwater using vegetated areas, primarily lawns adjacent to streets and swales in alleys. Most streets in Old Town do not have sidewalks or curb and gutter systems. Alleys between streets are grassy swales and gravel roads. The area is very flat and generally has low infiltration, and there may be large boulders. Bioretention is a possibility.

Problem Analysis: Ahead of re-paving projects, evaluate opportunities for systematic retrofits throughout Old Town. There is an opportunity to add bioretention planting strips, vegetated swales, and other low impact development (LID) features (similar to City of Portland vegetated stormwater facilities) to the streets as they are repaved. Design alternatives vary depending upon whether curb & gutter systems are added. These systems would primarily serve as water quality features to contribute to meeting TMDL requirements, with some limited uptake of flow potentially reducing flood flows in Fairview Crk.

Modeling Information: No modeling was performed for this analysis.

Proposed Solution/Project Description: Establish a Green Streets retrofit program of $73,000 per year. In first year, develop City of Fairview design standards for pass-through bioretention planting strips and construct 2 pilot study sites. In following 9 years, construct an average of 4 sites per year. The number of pass-through bioretention planting strips that can be constructed each year will depend on the size of the facilities and complexity of the installation. Program could begin with Lincoln Street during repaving in 2008.

Design Assumptions: Assume construction costs for bioretention planting strips or flow-through planter boxes are approximately $10,000 each, based on average drainage area of approximately 1 to 1.5 acres of mixed residential and light commercial land use. Construction costs will vary depending on sizing and complexity of installation. There are approximately 28 blocks in the Old Town area, ranging in size from 2 to 4 acres. Approximately 2 bioretention planting strips could be used per block to treat the runoff from the block, resulting in a potential opportunity for installation of up to 56 bioretention planting strips total. However, it is estimated that site constraints and other conditions will limit application to approximately 38 sites.
Cost estimate does not include re-paving (due to expectation that work will be performed in conjunction with planned street repaving projects) or significant modifications to existing storm sewer pipe. This project will have a high up front engineering cost however this will reduce to a standard drawing once the City has installed a few of the retrofits.

Project Benefit to City

Water quality benefits from bioretention planting strips or boxes which may contribute toward addressing TMDLs include reductions in nutrients (TP and TN), bacteria, and TSS. The additional soil filtration of stormwater and street shading provided through planting strips or boxes that include street trees could also potentially provide limited credit towards addressing the temperature TMDL. This program primarily benefits water quality but, through infiltration, could also slightly reduce peak flows during high storm events.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Bioretention planting strip or box	each	$ 10,000	4	$ 40,000
(4 per year for 10 years)				
Mobilization (1 per year for 10 years)	LS	$ 5,000	1	$ 5,000
				$ -
			Total	$ 45,000
			Contingency (20%)	$ 9,000
			Sub-Total	$ 54,000
			Engineering and Administration (**%)	$ 18,900
			Total Land Costs	
			***Project Cost**	**$ 72,900**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2007 dollars*

Project Name: Fairview Village Detention Ponds - Market, Chinook, Multnomah
Project Type: Water Quality Retrofit
Project Number: FV-8
Sub-Basin: Fairview Creek

Existing Conditions: Market Drive Detention Pond – currently maintaining to bring back to grade. The swale has a clay bottom and there is no infiltration. Will operate as a retention pond. Chinook Detention Pond – Pond with swale in the bottom. Multnomah Pond – Used to be an agricultural pond. Evaluate design for improvements. Very shallow, there may be opportunities for retrofits.

Problem Analysis: The Market Drive Pond is maintained by mowing short due to recreational use of the area by residents and dogs. Although there would be greater water quality treatment if the vegetation were allowed to grow taller, mowing is preferred because residents are more likely to pick up after their dogs if the grass is short. "Dogi Pot" waste removal bags are provided. There is some dry weather flow through the pond, likely to due groundwater infiltration into the storm drainage pipes and runoff from lawn irrigation. There is a swale around the outside of the pond area that is intended to receive low flows. Low flows are currently bypassing the swale until the vegetation is fully re-established in it. The inflow manhole may need to have a flow bypass weir installed to direct low flows to the swale. Rock weirs could be added to the swale to reduce flow velocities. The berm between the pond and Fairview Creek was evaluated to determine how flow would leave the pond if the outlet became plugged during a high flow event (due to consideration over how such an event would affect the adjacent home). There is a low point in the berm that appears to provide an emergency overflow point.
The Chinook Detention Pond and the Multnomah Pond both contain forested areas and appear to be functioning well. There is blackberry invading both sites, which the City pays for mowing and removal of periodically. Both ponds contain standing water and function as wetlands at low points.
The Multnomah Pond would benefit from additional native plantings.

Modeling Information: Detailed modeling of the ponds was not performed.

Proposed Solution/Project Description: For the Market Drive Pond, add 5 rock weirs to the swale to reduce flow velocities and enhance water quality treatment through extended residence time. Install bypass weir in inflow manhole after vegetation in swale is established to provide low flow routing through swale. For Multnomah Pond, plant 0.2 acres of native trees and shrubs in open area adjacent to flow.

Design Assumptions: Assume cost of rock weirs = $1,000 each. Assume installation of bypass weir = $1,000. These estimated costs include mobilization, materials, equipment, and time. Assume no irrigation required for plantings.

Project Benefit to City

Water quality benefits which may be achieved through increasing the detention time of stormwater in the Market Drive swale using rock weirs and increased shrub vegetation include reductions in the following TMDL parameters: nutrients (TP and TN), bacteria, and TSS.

Additional water quality benefits which may be achieved through the overflow of Fairview Creek into the enhanced vegetation of the pond include reductions in nutrients (TP and TN), bacteria, and TSS.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Rock weirs (Market Pond & Swale)	each	$ 1,000	5	$ 5,000
Bypass weir in manhole (Market Pond	each	$ 1,000	1	$ 1,000
Planting (Market Pond & Swale)	acre	$ 15,000	0.1	$ 1,500
Planting (Multnomah Pond)	acre	$ 15,000	0.2	$ 3,000
				$ -
				$ -
			Total	$ 10,500
			Contingency (20%)	$ 2,100
			Sub-Total	$ 12,600
			Engineering and Administration (**%)	$ 4,410
			Total Land Costs	
			***Project Cost**	**$ 17,010**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2007 dollars*

Project Name: Lincoln Street between Fairview Ave. and 4th St.
Project Type: Flood Hazard Reduction

Project Number: FV-9
Sub-Basin: Fairview Creek

Existing Conditions: The existing 12" pipe that runs under Lincoln Street will not provide sufficient capacity for future build-out flows per City standards.

Problem Analysis: The updated XP-SWMM model showed that localized flooding could occur if the basins draining to this system were to be built to the maximum extent allowable.

Modeling Information: Modeled 25-year flows to increase ~80% between existing and future conditions.

Proposed Solution/Project Description: Replace existing pipe with new pipe to fully convey the future flows to City standards.

Design Assumptions: Cost estimate assumes the existing manholes will be reused. Erosion control should consist of inlet protection for the existing storm catch basins along Lincoln Street.

Project Benefit to City

Reduce potential flood risk.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 18,000	1	$ 18,000
15" RCP	LF	$ 90	690	$ 62,100
18" RCP	LF	$ 100	145	$ 14,500
Erosion control	LS	$ 6,000	1	$ 6,000
Remove existing pipe	LF	$ 15	835	$ 12,525
Trench resurfacing	SY	$ 75	420	$ 31,500
Video inspection	LF	$ 20	835	$ 16,700
Major adjustment of manhole	EA	$ 2,000	4	$ 8,000
Sawcut pavement	LF	$ 10	1700	$ 17,000
Outfall protection	EA	$ 5,000	1	$ 5,000
				$ -
			Total	$ 191,325
			Contingency (20%)*	$ 38,265
			Sub-Total	$ 229,590
			Engineering and Administration (**%)	$ 57,398
			Total Land Costs	$ -
			***Project Cost**	**$ 286,988**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: Cedar St. Between Fairview Ave. and 2nd St. Option 1

Project Type: Flood Hazard Reduction

Project Number: FV-10

Sub-Basin: Fairview Creek

Existing Conditions: Existing flows present in the storm system along Cedar Street results in a deficiency in 3rd Street. The existing pipe in Cedar Street has been in place for over 60 years.

Problem Analysis: The updated XP-SWMM model shows that a 12" pipe segment along Cedar Street from 3rd street to 2nd Street is constricting flow.

Modeling Information: The existing flow through Cedar Street at 3rd Street is 5 cfs, the pipe segment from 3rd to 2nd has a capacity of 3 cfs. Localized flooding does not occur before the 25-year event.

Proposed Solution/Project Description: Need to replace the 12" storm pipe in Cedar Street with a 15" pipe to adequately convey flow to City standards.

Design Assumptions: Cost estimate assumes reuse of existing storm manholes and erosion control consisting of inlet protection for catch basins along Cedar St.

Project Benefit to City

Replacement of aging storm sewer pipes will reduce the risk of pipe collapse and potential associated flooding issues. Brings the storm system up to City standards.

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 10,000	1	$ 10,000
18" RCP	LF	$ 100	370	$ 37,000
Erosion control	LS	$ 3,000	1	$ 3,000
Remove existing pipe	LF	$ 15	370	$ 5,550
Trench resurfacing	SY	$ 75	206	$ 15,450
Video inspection	LF	$ 20	370	$ 7,400
Major adjustment of manhole	EA	$ 2,000	2	$ 4,000
Sawcut pavement	LF	$ 10	750	$ 7,500
				$ -
			Total	$ 89,900
			Contingency (20%)*	$ 17,980
			Sub-Total	$ 107,880
			Engineering and Administration (**%)	$ 26,970
			Total Land Costs	$ -
			***Project Cost**	**$ 134,850**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: Cedar St. Between Fairview Ave. and 3rd Street

Project Number: FV-10

Project Type: Flood Hazard Reduction

Sub-Basin: Fairview Creek

Existing Conditions: Existing flows present in the storm system along Cedar Street results in a deficiency in 3rd Street. This is made worse by projected future flows. The existing pipe in Cedar Street has been in place for over 60 years.

Problem Analysis: The updated XP-SWMM model shows that the entire line between 3rd Street and Fairview Avenue is not adequately sized to convey future flows.

Modeling Information: The future flows through Cedar Street at 3rd Street range from 10 cfs to 13 cfs. Localized flooding is expected to occur for all events from the 2-year event.

Proposed Solution/Project Description: Need to replace the storm pipe in Cedar Street with pipe to adequately convey flow to City standards.

Design Assumptions: Cost estimate assumes reuse of existing storm manholes and erosion control consisting of inlet protection for catch basins along Cedar St.

Project Benefit to City

Replacement of aging storm sewer pipes will reduce the risk of pipe collapse and potential associated flooding issues. Reduces the risk of potential flooding due to potential development. Brings the storm system up to City standards.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 18,000	1	$ 18,000
18" RCP	LF	$ 100	370	$ 37,000
24" RCP	LF	$ 120	445	$ 53,400
Erosion control	LS	$ 6,000	1	$ 6,000
Remove existing pipe	LF	$ 15	815	$ 12,225
Trench resurfacing	SY	$ 75	440	$ 33,000
Video inspection	LF	$ 20	815	$ 16,300
Major adjustment of manhole	EA	$ 2,000	4	$ 8,000
Sawcut pavement	LF	$ 10	1650	$ 16,500
Outfall protection	EA	$ 5,000	1	$ 5,000
				$ -
			Total	$ 205,425
			Contingency (20%)*	$ 41,085
			Sub-Total	$ 246,510
			Engineering and Administration (**%)	$ 61,628
			Total Land Costs	$ -
			***Project Cost**	**$ 308,138**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: 1st St. from Depot St. to Main St.
Project Type: Flood Hazard Reduction

Project Number: FV-11
Sub-Basin: Fairview Creek

Existing Conditions: The future build-out flows expected along Depot Street result in deficiency in the system. The existing pipes in the Depot Street System are 40+ years old.

Problem Analysis: The updated XP-SWMM model shows that a 15" pipe segment in 1st Street between Depot and Main acts as a constriction. Localized flooding is expected for the 25-year storm.

Modeling Information: The existing 15" storm line has a capacity of 5.6 cfs. The future build-out 25-year flow rate of 8.2 cfs. The existing 25-year flow rate through the pipe is 6 cfs, with a future build-out rate expected to increase to 8.2 cfs. This pipe acts as a constriction and causes issues in the upstream Depot Street system.

Proposed Solution/Project Description: To resolve deficiency issues, the existing 15" pipe will need to be replaced with an 18" pipe to prevent a flow restriction.

Design Assumptions: Cost estimate assumes the existing manholes will be reused. Erosion control should consist of inlet protection for the existing storm catch basins along 1st St.

Project Benefit to City

Reduce potential flood risk.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 10,000	1	$ 10,000
18" RCP	LF	$ 100	210	$ 21,000
Erosion control	LS	$ 500	1	$ 500
Remove existing pipe	LF	$ 20	210	$ 4,200
Trench resurfacing	SY	$ 100	105	$ 10,500
Video inspection	LF	$ 35	210	$ 7,350
Major adjustment of manhole	EA	$ 3,000	2	$ 6,000
Sawcut pavement	LF	$ 15	430	$ 6,450
				$ -
			Total	$ 66,000
			Contingency (20%)*	$ 13,200
			Sub-Total	$ 79,200
			Engineering and Administration (**%)	$ 27,720
			Total Land Costs	$ -
			***Project Cost**	**$ 106,920**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: Undersized culvert for No-Name Creek at Sandy Blvd

Project Type: Flood Hazard Reduction

Project Number: NN-1a

Sub-Basin: No-Name Creek

Existing Conditions: The existing twin barrel 30" culvert near Townsend Farms on Sandy Blvd is currently undersized and causes flooding during high intensity storm events. Multnomah County has plans to widen Sandy Blvd. however, increasing culvert capacity is not part of the project scope. Most of this culvert lies on private property within a 20' wide slope and drainage easement dedicated to Multnomah County.

Problem Analysis: An existing pair of 30" CMP pipes, with a capacity of 55 cfs, conveys No-Name Creek under Sandy Boulevard. The existing 100-year flow rate upstream of the crossing is 94 cfs with future flows expected to increase to 111 cfs.

Modeling Information: This alternative considers replacing the existing culvert, as Brown and Caldwell determined previously that an upstream diversion would not replace the need of a new culvert.

Proposed Solution/Project Description: Assuming that an upstream diversion is not constructed prior to the culvert replacement, a culvert was sized to accommodate the full flow of No-Name Creek. Additionally, the culvert alignment was designed to better align it with No-Name Creek, and bring it out of private property for better access and maintenance. Due to shallow cover, a dual pipe system was sized as opposed to a single pipe.

Design Assumptions: Assume 2" grind and inlay 20' on either side of culvert. Unit cost for arch culvert is based on the inflation adjusted unit cost for 78-inch diameter culvert pipe provided in ODOT's 2016 Weighted Average Item Price Report. Easement coordination for new arch culvert not included in cost estimate.

Project Benefit to City

This alternative would eliminate a flooding hazard and maintenance issue present at Sandy Boulevard.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 27,000	1	$ 27,000
43" Rise x 34" span arch culvert	LF	$ 355	360	$ 127,800
Erosion control	LS	$ 5,000	1	$ 5,000
Trench resurfacing	SY	$ 100	370	$ 37,000
Traffic control	LS	$ 15,000	1	$ 15,000
2" grind and inlay	SY	$ 100	460	$ 46,000
Sawcut pavement	LF	$ 15	730	$ 10,950
Removal of existing utility vault	EA	$ 10,000	1	$ 10,000
72" manhole	EA	$ 10,000	2	$ 20,000
				$ -
			Total	$ 298,750
			Contingency (20%)*	$ 59,750
			Sub-Total	$ 358,500
			Engineering and Administration (**%)	$ 89,625
			Total Land Costs	$ -
			***Project Cost**	**$ 448,125**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: Undersized Culvert at Sandy Blvd. - Bypass flow to Fairview Creek
Project Type: Flood Hazard Reduction

Project Number: NN-1b
Sub-Basin: No Name Creek

Existing Conditions: An undersized culvert has been identified in prior Master Plans. The undersized culvert causes flooding on Sandy Blvd and closes the road during large storms in this important commercial area. The County plans to widen Sandy Blvd., but they haven't included a design to increase culvert capacity. This project requires immediate attention so that it can be incorporated during Sandy road construction or private development projects. This alternative examines increasing culvert capacity under Sandy Blvd. NN-1a examines increasing capacity of the culvert under Sandy Blvd. Downstream of the Sandy Blvd. culvert, there is a 30-inch pipe on private property (the Hufford Property) at 22713 NE Sandy Blvd. that appears to be undersized.

Problem Analysis: An existing pair of 30" CMP pipes, with a capacity of 55-cfs, conveys No Name Creek under Sandy Blvd. The area has reports of flooding. The headwall was observed and the entrances to the pipes are not aligned with the creek and the condition of the pipes are not ideal for hydraulic entrance into the pipes.

Modeling Information: This alternative considers diverting flow from No Name Creek to Fairview Creek upstream of Sandy Boulevard. The original Oakley Engineering report (April, 1993) showed this diversion channel along the south side of Sandy Boulevard. The reason for this was the flow from Node NN-2R1 was required in the diversion channel to justify the cost of constructing the channel. With an estimated capacity of 55-cfs and the 25-year flow from NN-2R1 as 68-cfs, if the diversion channel was moved upstream a new culvert would still be required under Sandy Blvd.

Proposed Solution/Project Description: Unless 98-cfs during the 25-year storm was diverted to Fairview Creek, the No Name Creek culvert at Sandy Boulevard would still flood. Therefore diverting all the 25-year flow along the I-84 embankment would not eliminate the need for replacing the No-Name culverts at Sandy Boulevard. Since the No Name Creek culverts at Sandy will need replacing, unless the diversion is along Sandy Boulevard, the best alternative would be Alternative NN-1a, to simply enlarge the culvert.

Design Assumptions: A diversion of this magnitude would require much greater detailed study of this specific area including bank and bed stability issues within the creek. The permitting issues for this magnitude of transfer between basins are unknown. Based on the above information, we recommend against this alternative and have not conducted further analysis of this project.

Project Benefit to City

This alternative would not eliminate the need for replacing the No Name Creek Culvert at Sandy Boulevard and has been eliminated from the alternatives.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
			Total	$ -
			Contingency (20%)	$ -
			Sub-Total	$ -
			Engineering and Administration (**%)	$ -
			Total Land Costs	$ -
			***Project Cost**	**$ -**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2007 dollars*

Project Name: Replacement of undersized pipes and storm sewer extension at NE 227th Ave.
Project Type: Flood Hazard Reduction

Project Number: NN-4a
Sub-Basin: No-Name Creek

Existing Conditions: Flooding consistently occurs at the Fairview Woods Apartments along No-Name Creek. City crews have been called to sand-bag the banks to prevent the floodwaters from reaching floor level apartments.

Problem Analysis: The XP-SWMM model was updated to analyze this area and confirmed that structures along No-Name creek are acting as flow restrictions.

Modeling Information: The reach in question is north of Halsey and south of Bridge Street. During the 100-year event for future flow conditions, flows range between 41 cfs and 48 cfs. The slope of the creek ranges between 10% and 0.7%.

Proposed Solution/Project Description: Several alternatives were considered to address the issues including (1) the redesign of a flow splitter downstream of the Fairview Woods Apartments, (2) replacement of the existing culvert in the Fairview Woods Apartments, and (3) the construction of a high-flow bypass which diverts flow from No-Name Creek and redirects it to Fairview Creek. No single alternative proved to address the problems completely so a combination of the three is proposed. This sheet outlines the high-flow bypass portion of this project.

Design Assumptions: Cost estimate includes replacement of existing 15-inch pipe, storm sewer extension to south end of Halsey, new 48" manhole at the north end of Halsey and a ditch inlet on the south end of Halsey.

Project Benefit to City

Protect private apartments from flooding.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 15,000	1	$ 15,000
12" RCP	LF	$ 75	105	$ 7,875
18" RCP	LF	$ 100	600	$ 60,000
Erosion control	LS	$ 6,000	1	$ 6,000
Trench resurfacing	SY	$ 60	400	$ 24,000
Video inspection	LF	$ 20	705	$ 14,100
Sawcut pavement	LF	$ 10	1450	$ 14,500
Major adjustment of manhole	EA	$ 3,000	3	$ 9,000
48" manhole	EA	$ 7,000	1	$ 7,000
Remove existing pipe	LF	$ 15	310	$ 4,650
Ditch inlet	EA	$ 5,000	1	$ 5,000
				$ -
			Total	$ 167,125
			Contingency (20%)*	$ 33,425
			Sub-Total	$ 200,550
			Engineering and Administration (**%)	$ 50,138
			Total Land Costs	$ -
			***Project Cost**	**$ 250,688**
			Total Cost	**$ 366,072**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: Replacement of undersized Culverts at Fairview Woods Apartments

Project Number: NN-4b

Project Type: Flood Hazard Reduction

Sub-Basin: No-Name Creek

Existing Conditions: Flooding consistently occurs at the Fairview Woods Apartments along No-Name Creek. City crews have been called to sand-bag the banks to prevent the floodwaters from reaching floor level apartments.

Problem Analysis: The XP-SWMM model was updated to analyze this area and confirmed that structures along No-Name creek are acting as flow restrictions.

Modeling Information: The reach in question is north of Halsey and south of Bridge Street. During the 100-year event for future flow conditions, flows range between 41 cfs and 48 cfs. The slope of the creek ranges between 10% and 0.7%.

Proposed Solution/Project Description: Several alternatives were considered to address the issues including (1) the redesign of a flow splitter downstream of the Fairview Woods Apartments, (2) replacement of the existing culvert in the Fairview Woods Apartments, and (3) the construction of a high-flow bypass which diverts flow from No-Name Creek and redirects it to Fairview Creek. No single alternative proved to address the problems completely so a combination of the three is proposed. This sheet outlines the flow splitter redesign and the culvert replacement.

Design Assumptions: Cost estimate assumes location of proposed improvements is accessible.

Project Benefit to City

Protect private apartments from flooding.

*Project Costs

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 30,000	1	$ 30,000
12" RCP	LF	$ 75	25	$ 1,875
36" RCP	LF	$ 180	20	$ 3,600
53" elliptical culvert	LS	$ 300	40	$ 12,000
Erosion control	LS	$ 6,000	1	$ 6,000
Trench resurfacing	SY	$ 100	30	$ 3,000
Sawcut pavement	LF	$ 15	70	$ 1,050
Removal of curb	LF	$ 15	20	$ 300
Remove existing culvert	LF	$ 40	85	$ 3,400
Restore private property	LS	$ 10,000	1	$ 10,000
				$ -
			Total	$ 71,225
			Contingency (20%)*	$ 14,245
			Sub-Total	$ 85,470
			Engineering and Administration (**%)	$ 29,915
			Total Land Costs	$ -
			***Project Cost**	**$ 115,385**
			Total Cost	**$ 366,072**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000

** The estimated costs are based on year 2018 dollars*

Project Name: Townsend Way
Project Type: Flood Hazard Reduction

Project Number: NN-5
Sub-Basin: No-Name Creek

Existing Conditions: Existing flows present in Townsend Way east of 230th cause localized flooding along an adjacent private property.

Problem Analysis: The updated XP-SWMM model shows that a 12" line downstream of a private connection in the cul-de-sac of Townsend Way is not adequately sized to receive the overflow from the private stormwater facility.

Modeling Information: The existing 12" pipe has a capacity of 5.6 cfs. The 25-year flow from the upstream site is 10 cfs. The downstream system has sufficient freeboard to convey the full flow within City standards.

Proposed Solution/Project Description: Replace the 12" public pipe segment with an 18" pipe segment.

Design Assumptions: Cost estimate assumes the existing manholes will be reused. Erosion control to consist of inlet protection for the existing storm catch basins at the start of the cul-de-sac bulb.

Project Benefit to City

Eliminate a potential flood hazard, and reduce the risk of potential future flood issues.

***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Mobilization	LS	$ 10,000	1	$ 10,000
18" RCP	LF	$ 100	50	$ 5,000
Erosion control	LS	$ 1,000	1	$ 1,000
Remove existing pipe	LS	$ 20	50	$ 1,000
Trench resurfacing	SY	$ 150	25	$ 3,750
Video inspection	LF	$ 55	50	$ 2,750
Major adjustment of manhole	EA	$ 3,000	2	$ 6,000
Sawcut pavement	LF	$ 15	110	$ 1,650
				$ -
			Total	$ 31,150
			Contingency (20%)*	$ 6,230
			Sub-Total	$ 37,380
			Engineering and Administration (**%)	$ 13,083
			Total Land Costs	$ -
			***Project Cost**	**$ 50,463**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2018 dollars*

Project Name: Raintree Railroad Crossing
Project Type: Flood Hazard Reduction
Project Number: RT-1
Sub-Basin: Raintree Creek

Existing Conditions: Raintree Railroad Crossing, Depot Street, 6th to 7th (Project D from Source #21) - 36-inch pipe feeds area. Outlet is an 18-inch CMP under the Union Pacific Railroad. Invert elevation going in is 105.4, coming out is 103.6 and the top of the rail above the CMP is 124.0 As a result of the undersized culvert, the area is acting as a detention pond. This site is high maintenance (crew goes out several times/winter to clear). Limited water quality treatment. Need to make sure new development will not adversely affect water quality or increase flooding. There is currently no flooding of homes. Need to know the risk to homes if the culvert fails.

Problem Analysis: City will be requiring new development on Depot St. to provide on-site treatment and storage. Maintenance concerns for undersized culvert at railroad tracks remain. The City may need to negotiate an access easement with the new development along Depot Street and Union Pacific Railroad to ensure City staff can access culvert for maintenance. A trash rack at the culvert could improve maintenance problems. Increasing the size of the culvert (as recommended in the 2000 City CIP from 18" to 36") could increase downstream flows and cause unanticipated flooding downstream. A full analysis of downstream culverts and channel capacity would be required prior to increasing the size of the railroad culvert.

Modeling Information: Modeling results indicate railroad will flood if culvert is plugged, providing an outlet for the water and reduced the flooding risk to home sites along Depot Street. The maximum WSEL modeled for future 100-year storm conditions immediately upstream of the railroad culvert is 117.4 ft and the maximum flow is 29.9 cfs (at Node 00583 S).

Proposed Solution/Project Description: Add a trash rack to the railroad culvert and provide regularly scheduled maintenance crew removal of debris several times a year (or as needed). Negotiate an access easement with new development and Union Pacific Railroad along Depot Street for culvert maintenance (if needed).

Design Assumptions: Due to the location of the trash rack and potential access problems, we assumed that the trash rack would require a sophisticated design. The cost could also include installing a trail for access.

Project Benefit to City

Adding a trash rack to the railroad culvert and providing regularly scheduled maintenance to remove debris could reduce nuisance flooding associated with the undersized culvert.

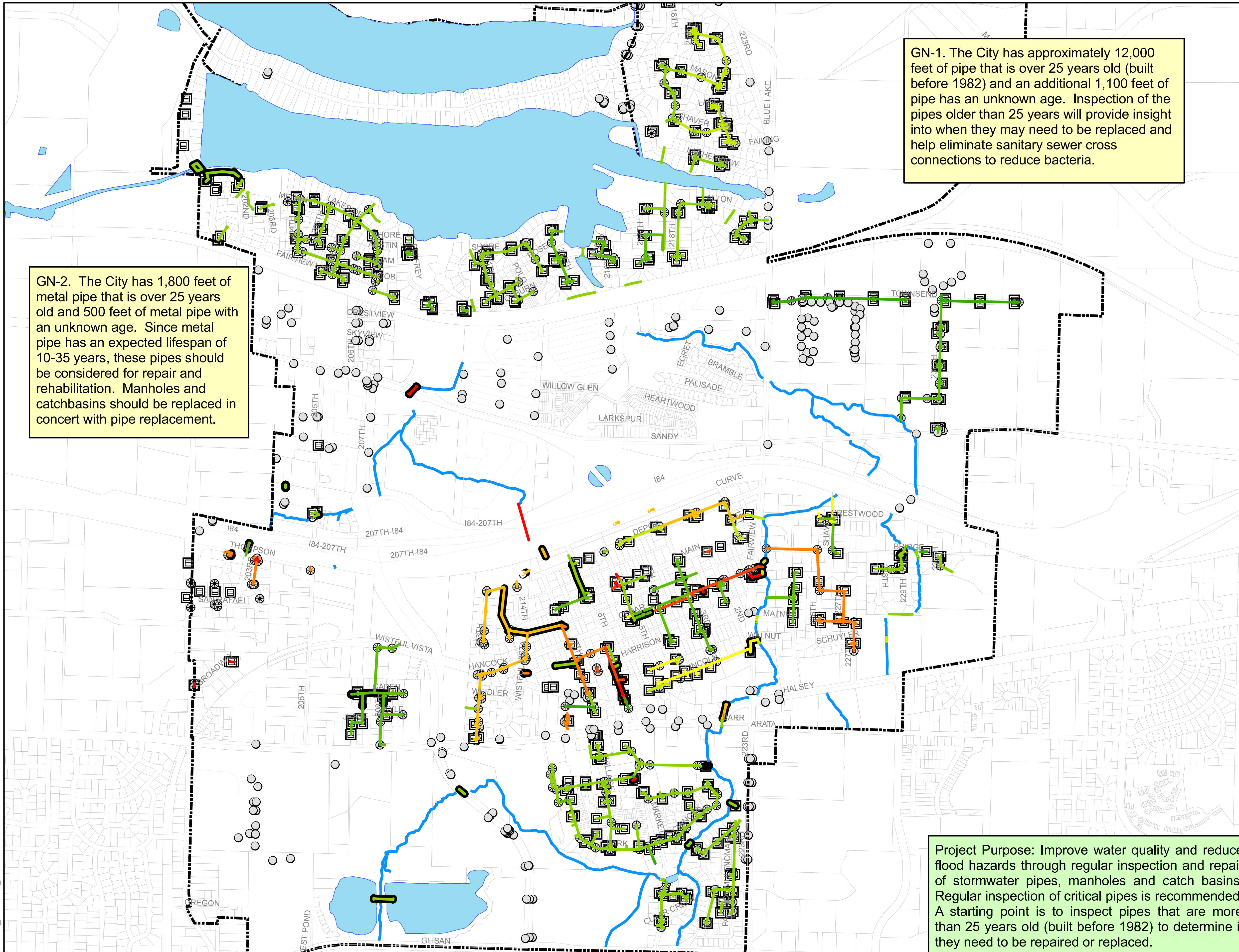
***Project Costs**

Item	Unit	Unit Cost	Quantity	Cost
Trash rack	LS	$ 20,000	1.0	$ 20,000
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
			Total	$ 20,000
			Contingency (20%)	$ 4,000
			Sub-Total	$ 24,000
			Engineering and Administration (**%)	$ 8,400
			Total Land Costs	
			***Project Cost**	**$ 32,400**

** 35% for construction costs up to $100,000
25% for construction cost over $100,000
** The estimated costs are based on year 2007 dollars*

City of Fairview
Project: GN-1, 2

Infrastructure Repair and Rehabilitation



GN-1. The City has approximately 12,000 feet of pipe that is over 25 years old (built before 1982) and an additional 1,100 feet of pipe has an unknown age. Inspection of the pipes older than 25 years will provide insight into when they may need to be replaced and help eliminate sanitary sewer cross connections to reduce bacteria.

GN-2. The City has 1,800 feet of metal pipe that is over 25 years old and 500 feet of metal pipe with an unknown age. Since metal pipe has an expected lifespan of 10-35 years, these pipes should be considered for repair and rehabilitation. Manholes and catchbasins should be replaced in concert with pipe replacement.

Project Purpose: Improve water quality and reduce flood hazards through regular inspection and repair of stormwater pipes, manholes and catch basins. Regular inspection of critical pipes is recommended. A starting point is to inspect pipes that are more than 25 years old (built before 1982) to determine if they need to be repaired or replaced.

Legend

City Pipe Age

- Unknown
- 1957
- 1971-74
- 1975-79
- 1985-89
- 1990-94
- 1995-99
- 2000-04
- 2005-07
- CMP/Steel Pipe
- Fairview City Limits
- Basins
- taxlots
- City property
- Catchbasins
- Manholes
- Private MHs, CBs
- Private pipe
- Pipe
- Bridge; Box Culvert
- Private Box Culvert
- Tributary
- Pond
- Swale
- Pond and Swale
- Proposed Project Features
- Existing Project Features

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

N

Consolidated Stormwater Master Plan

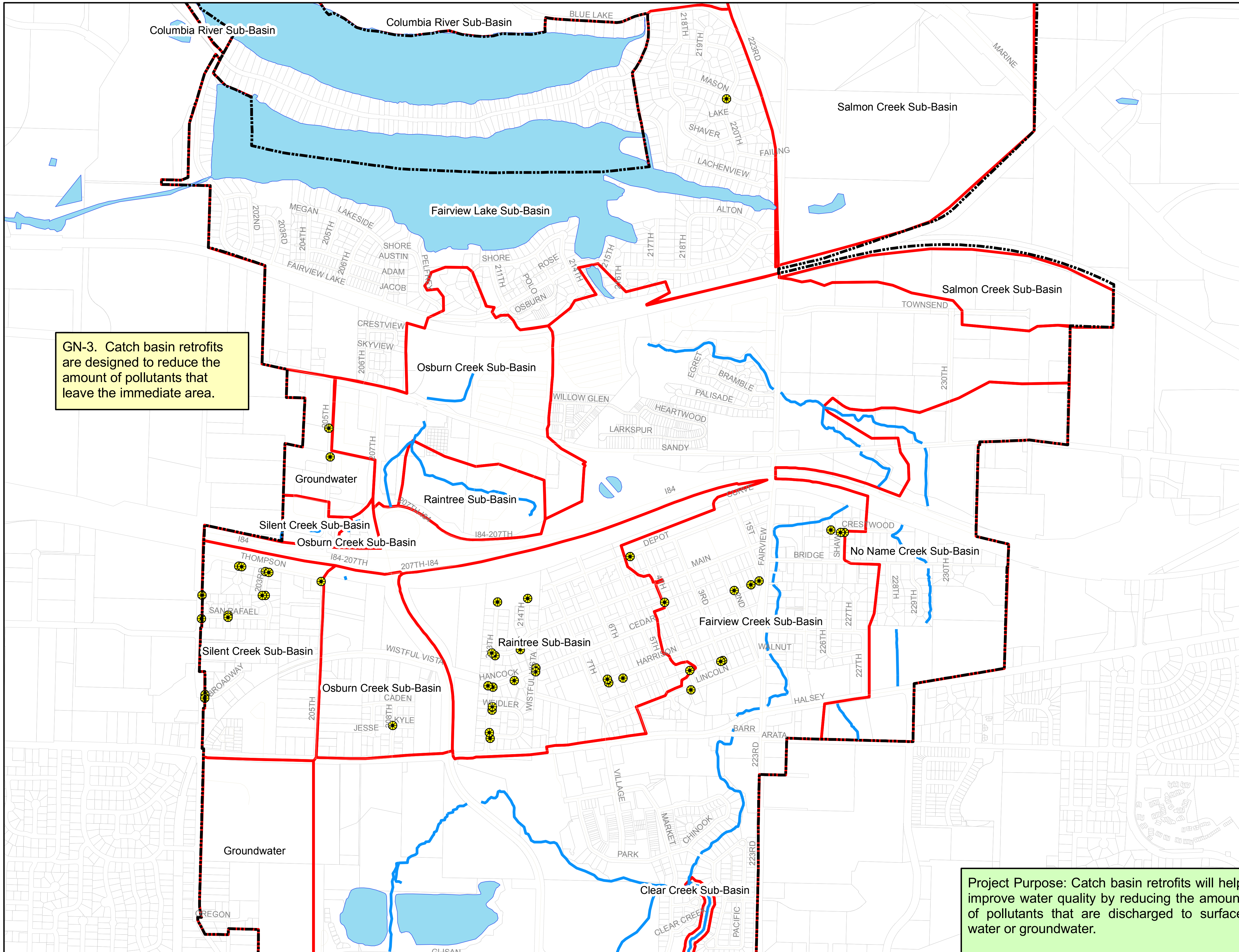
BROWN AND CALDWELL

Data Source: City of Fairview GIS

P:\133088_GIS\GN-1_2.mxd, 11-28-2007, LGP.

City of Fairview
Project: GN-3

Catch basin retrofits



GN-3. Catch basin retrofits are designed to reduce the amount of pollutants that leave the immediate area.

Project Purpose: Catch basin retrofits will help improve water quality by reducing the amount of pollutants that are discharged to surface water or groundwater.

Legend

- CBs that need sumps
- Fairview City Limits
- Basins
- taxlots
- City property
- Catchbasins
- Manholes
- Private MHs, CBs
- Private pipe
- Pipe
- Bridge; Box Culvert
- Private Box Culvert
- Tributary
- Pond
- Swale
- Pond and Swale
- Proposed Project Features
- Existing Project Features

N

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

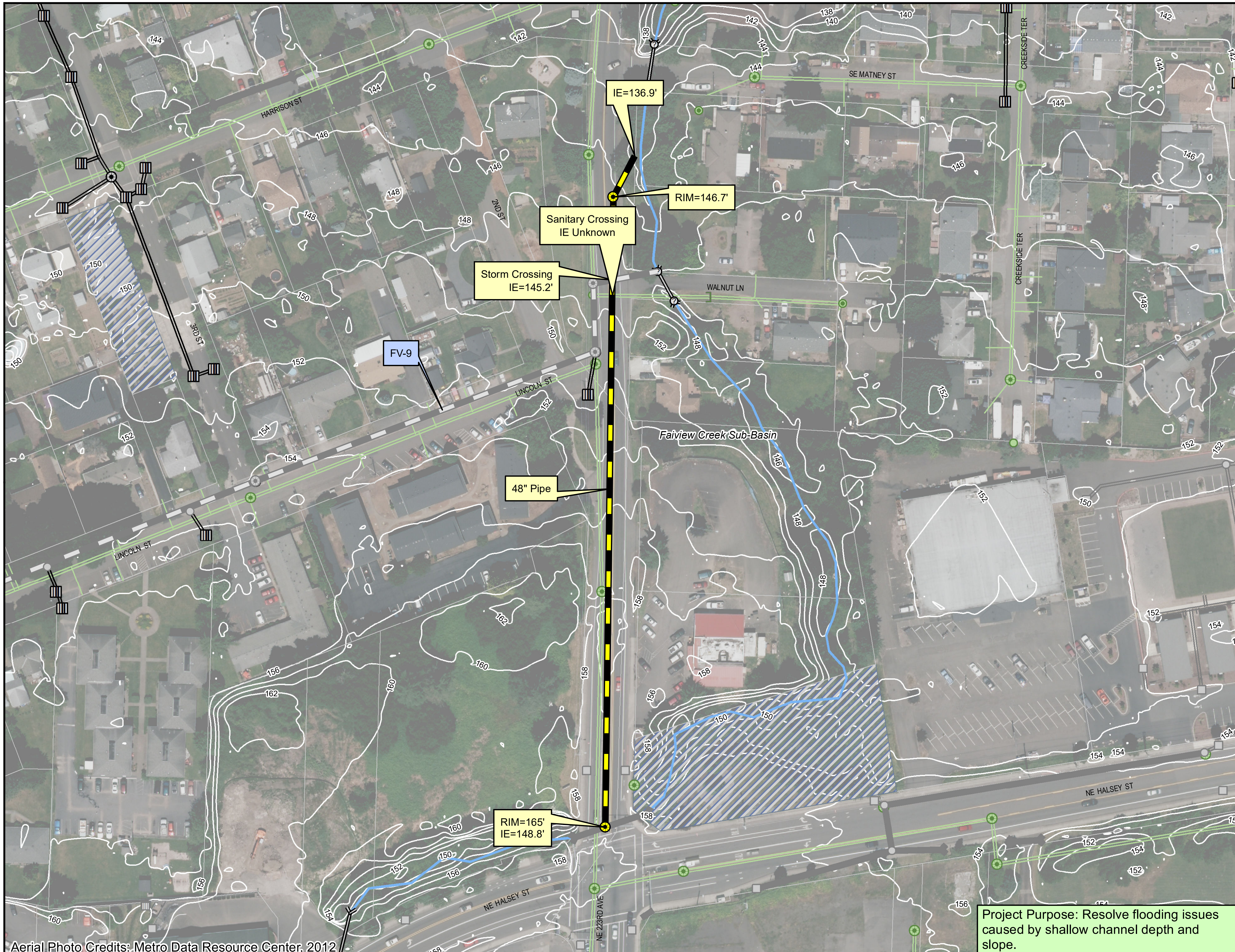
Consolidated Stormwater Master Plan

CITY OF FAIRVIEW

BROWN AND CALDWELL

Data Source: City of Fairview GIS

P:\133088_GIS\GN-3.mxd, 11-28-2007, LGP



Fairview Creek Project: FV-1

Fairview Creek between Halsey and I-84

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary

Sanitary Sewer

- Cleanout
- Manhole
- Other Feature
- Plug
- Pump Station
- Valve
- Sanitary Lateral
- Sanitary Pipe

N

0 50 100 200 Feet

1 inch equals 100 feet

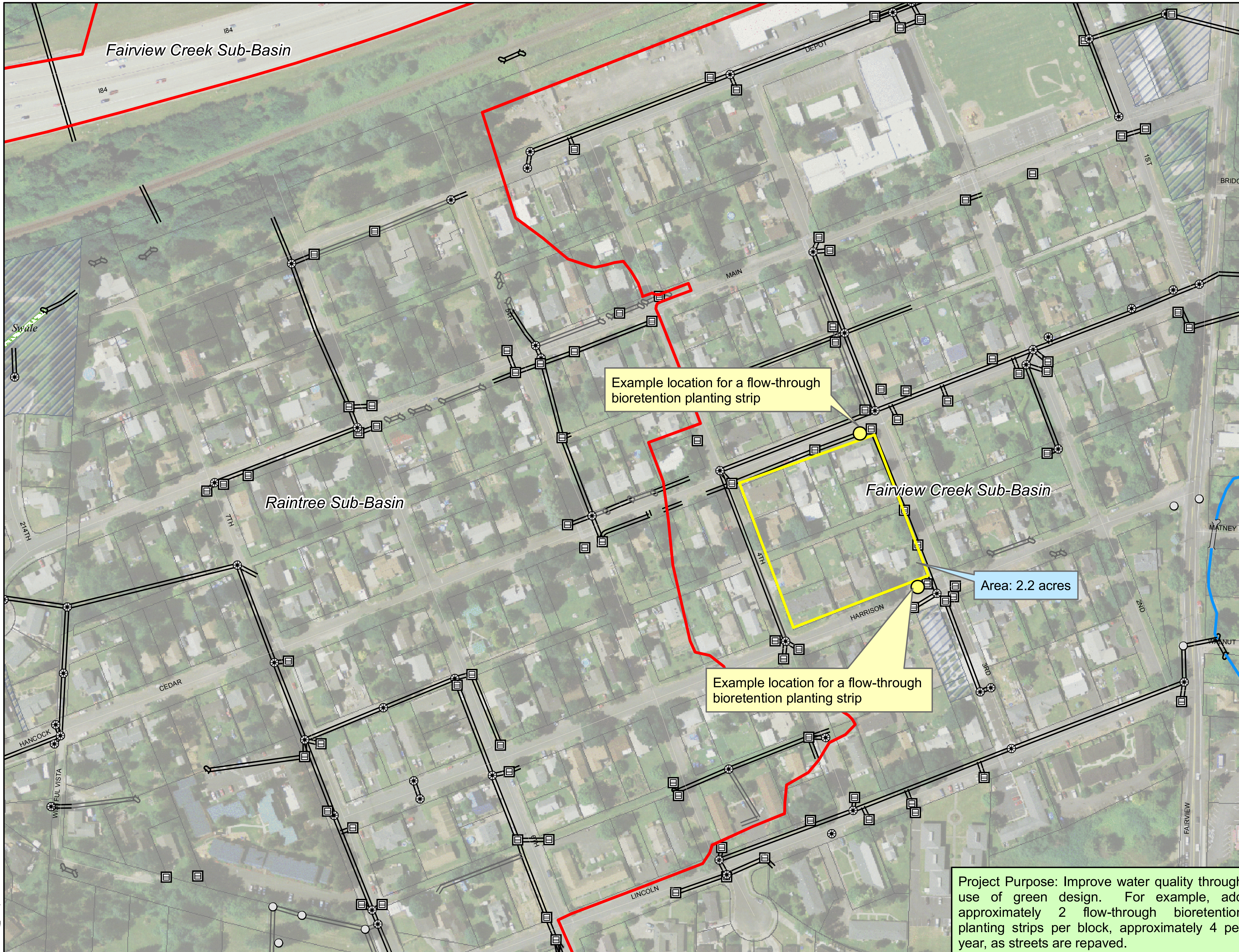
Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS

Fairview Creek Project: FV-5

Old Town Green Streets Opportunities



Project Purpose: Improve water quality through use of green design. For example, add approximately 2 flow-through bioretention planting strips per block, approximately 4 per year, as streets are repaved.

Legend

- Fairview City Limits
- Basins
- taxlots
- City property
- Catchbasins
- Manholes
- Private MHs, CBs
- Private pipe
- Pipe
- Bridge; Box Culvert
- Private Box Culvert
- Tributary
- Pond
- Swale
- Pond and Swale
- Proposed Project Features
- Existing Project Features

N

0 100 200 400 Feet

1 inch equals 200 feet

Consolidated Stormwater Master Plan

CITY OF FAIRVIEW

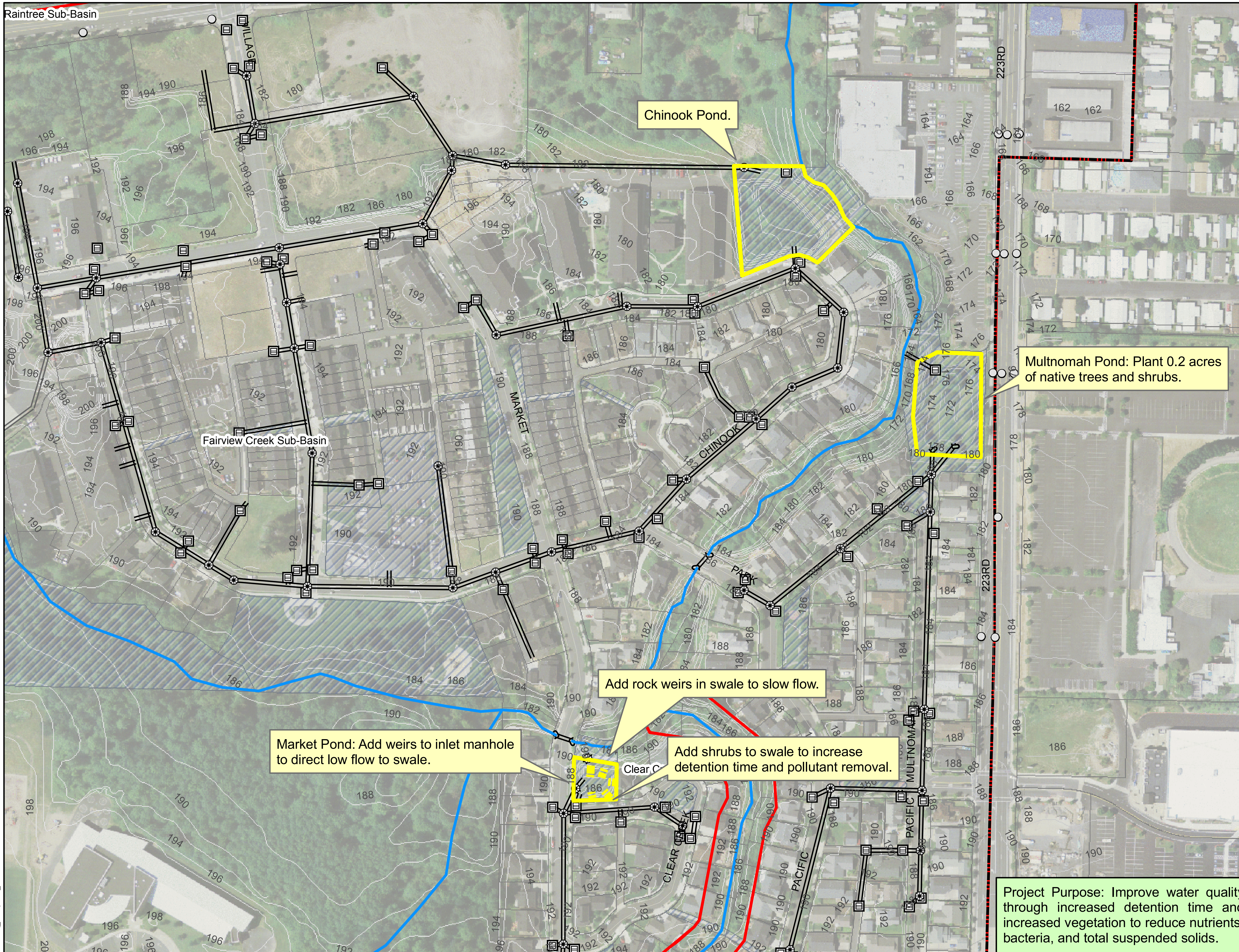
BROWN AND CALDWELL

Data Source: City of Fairview GIS

P:\133088_GIS\FV-5.mxd. 11-28-2007. LGP.

Fairview Creek
Project: FV-8

Fairview Village Detention Ponds



Project Purpose: Improve water quality through increased detention time and increased vegetation to reduce nutrients, bacteria, and total suspended solids.

Legend

- Fairview City Limits
- Basins
- taxlots
- City property
- Catchbasins
- Manholes
- Private MHs, CBs
- Private pipe
- Pipe
- Bridge; Box Culvert
- Private Box Culvert
- Tributary
- Pond
- Swale
- Pond and Swale
- Proposed Project Features
- Existing Project Features

N

0 100 200 400 Feet

1 inch equals 200 feet

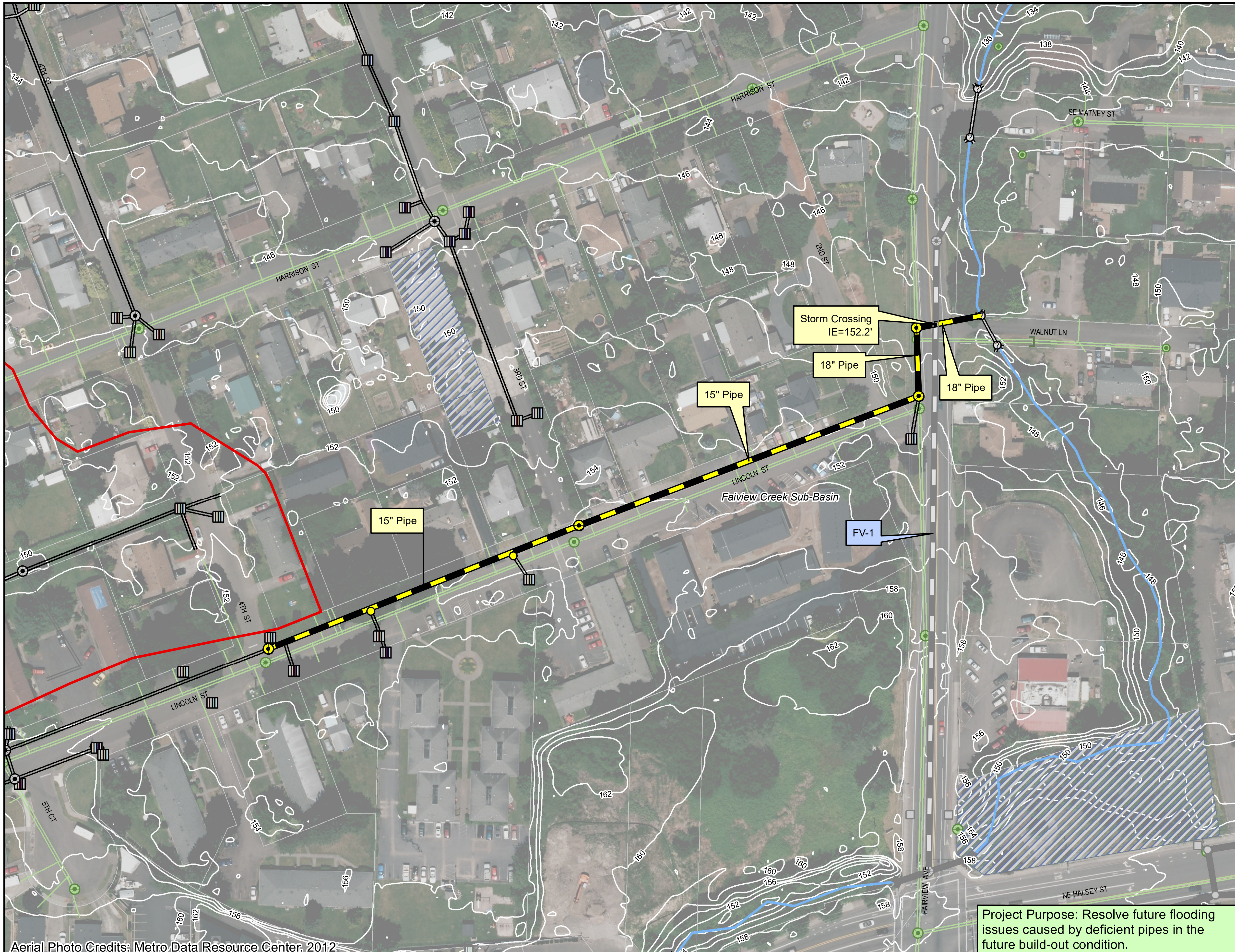
Consolidated Stormwater Master Plan

CITY OF FAIRVIEW

BROWN AND CALDWELL

Data Source: City of Fairview GIS

P:\133088_GIS\FV-8_Market.mxd 11-28-2007 LGP



Fairview Creek
Project: FV-9

Lincoln Street between Fairview Ave and 4th Street

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary

Sanitary Sewer

- Cleanout
- Manhole
- Other Feature
- Plug
- Pump Station
- Valve
- Sanitary Lateral
- Sanitary Pipe

N

0 50 100 200 Feet

1 inch equals 100 feet

Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS

Fairview Creek
Project: FV-10

Cedar Street between Fairview Ave and 3rd Street

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary

Sanitary Sewer

- Cleanout
- Manhole
- Other Feature
- Plug
- Pump Station
- Valve
- Sanitary Lateral
- Sanitary Pipe

N

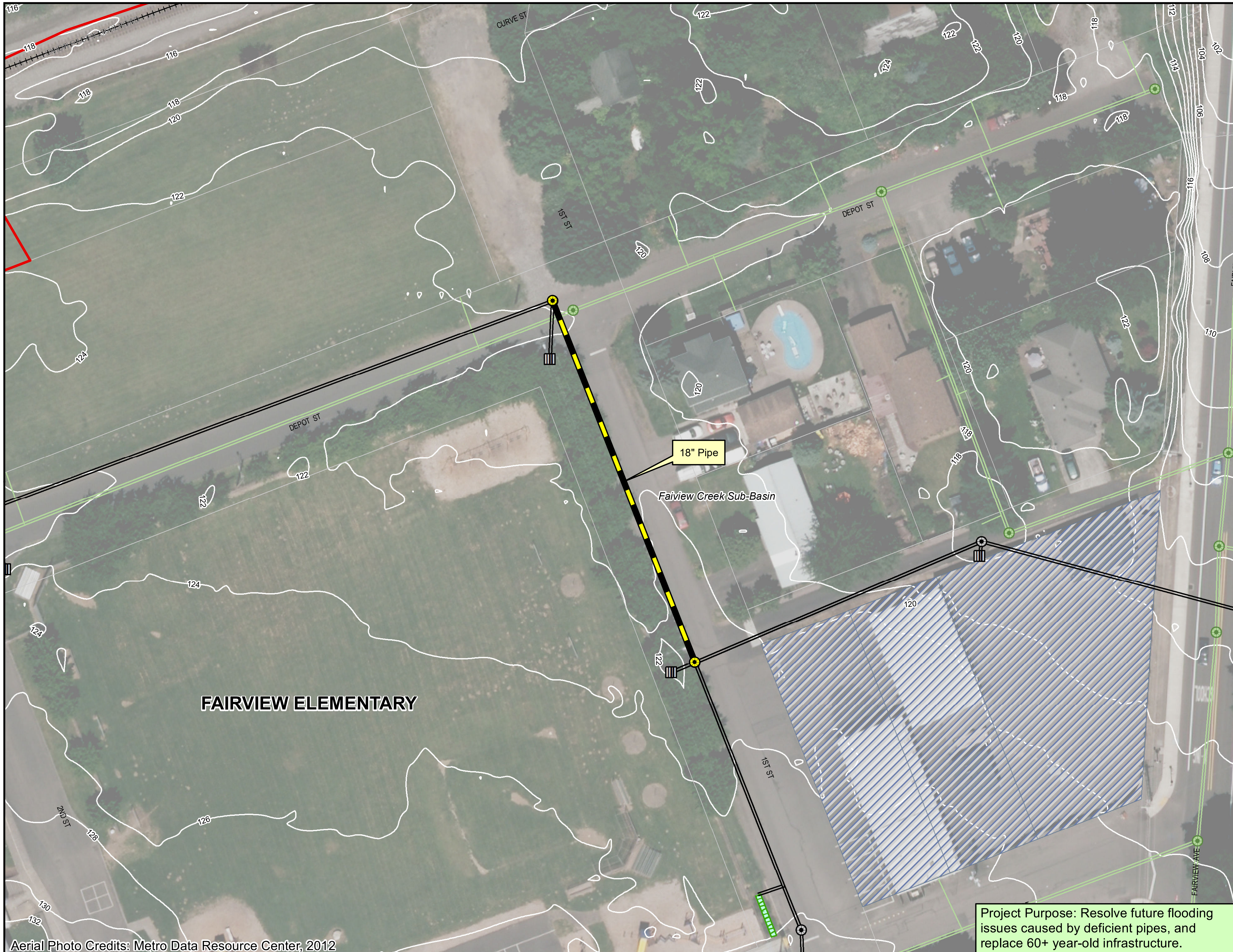
0 50 100 200 Feet

1 inch equals 100 feet

Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS



Aerial Photo Credits: Metro Data Resource Center, 2012

Project Purpose: Resolve future flooding issues caused by deficient pipes, and replace 60+ year-old infrastructure.

Fairview Creek
Project: FV-11

1st Street from Depot Street to Main Street.

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary

Sanitary Sewer

- Cleanout
- Manhole
- Other Feature
- Plug
- Pump Station
- Valve
- Sanitary Lateral
- Sanitary Pipe

N

0 25 50 100 Feet

1 inch equals 50 feet

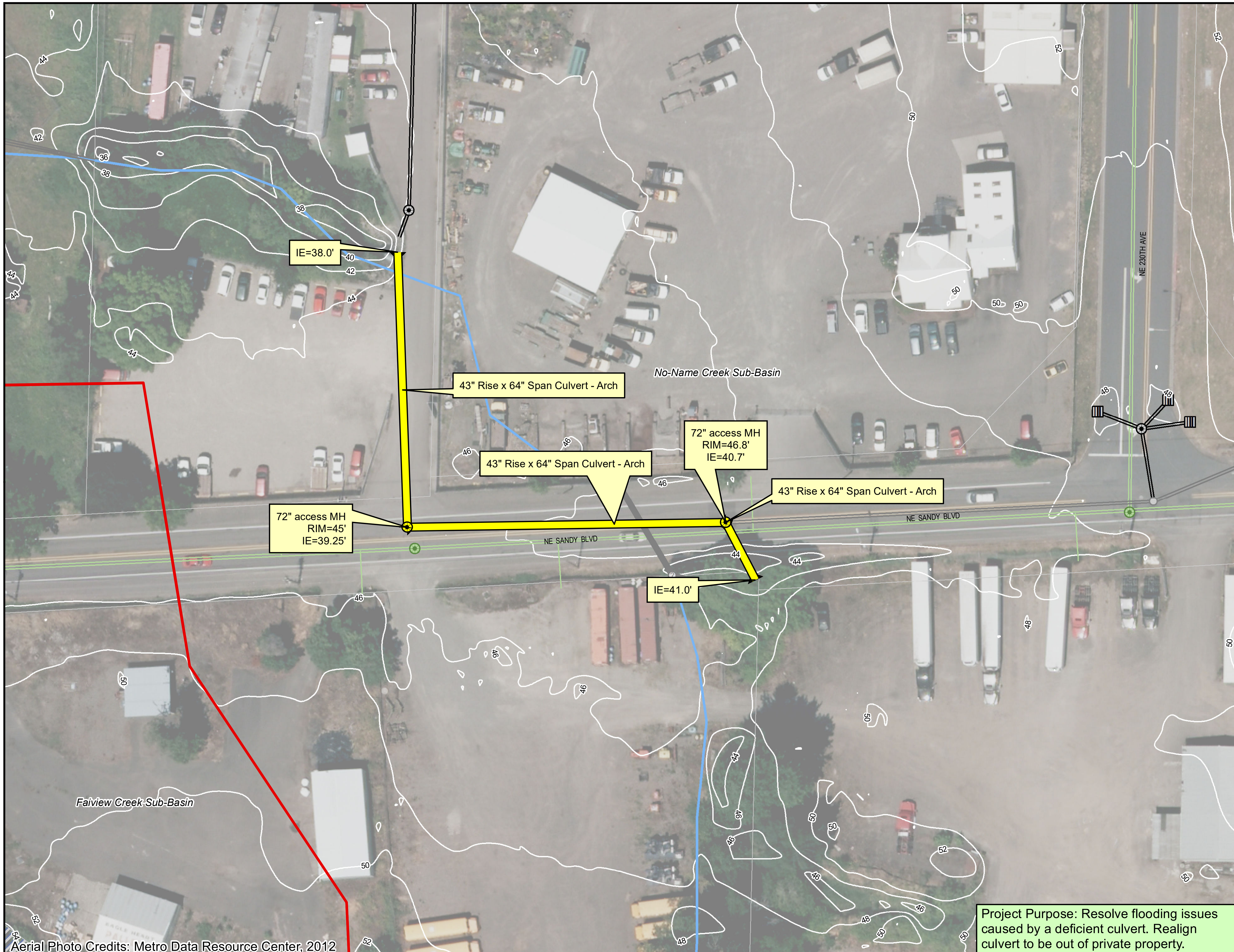
Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS

Fairview Creek
Project: NN-1a

Undersized culvert for No-Name Creek at Sandy Blvd



Project Purpose: Resolve flooding issues caused by a deficient culvert. Realign culvert to be out of private property.

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary

Sanitary Sewer

- Cleanout
- Manhole
- Other Feature
- Plug
- Pump Station
- Valve
- Sanitary Lateral
- Sanitary Pipe

N

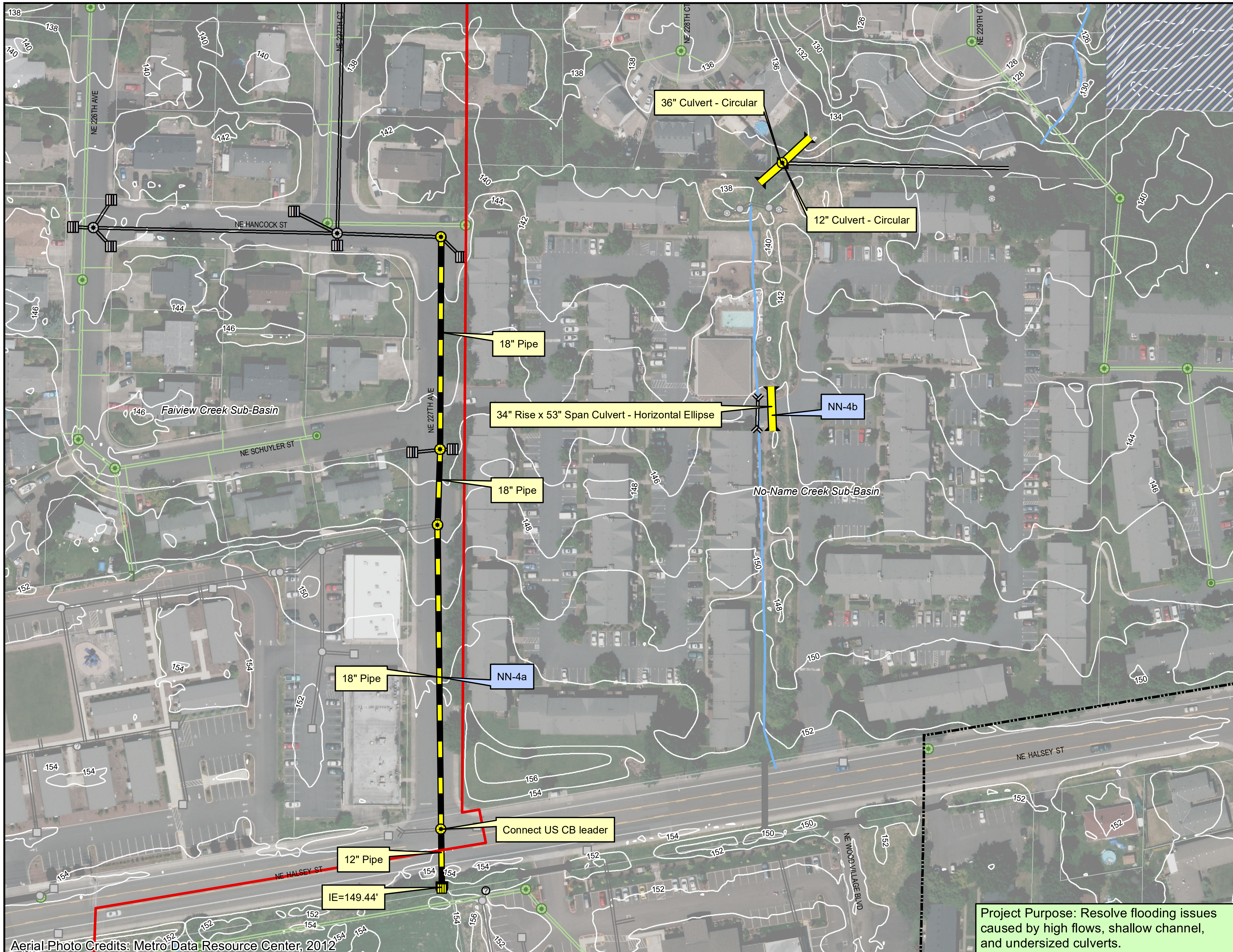
0 25 50 100 Feet

1 inch equals 50 feet

Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS



Project Purpose: Resolve flooding issues caused by high flows, shallow channel, and undersized culverts.

Fairview Creek
Project: NN-4a & 4b

Replace undersized pipes and storm extension at NE 227th Ave

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary

Sanitary Sewer

- Cleanout
- Manhole
- Other Feature
- Plug
- Pump Station
- Valve
- Sanitary Lateral
- Sanitary Pipe

N

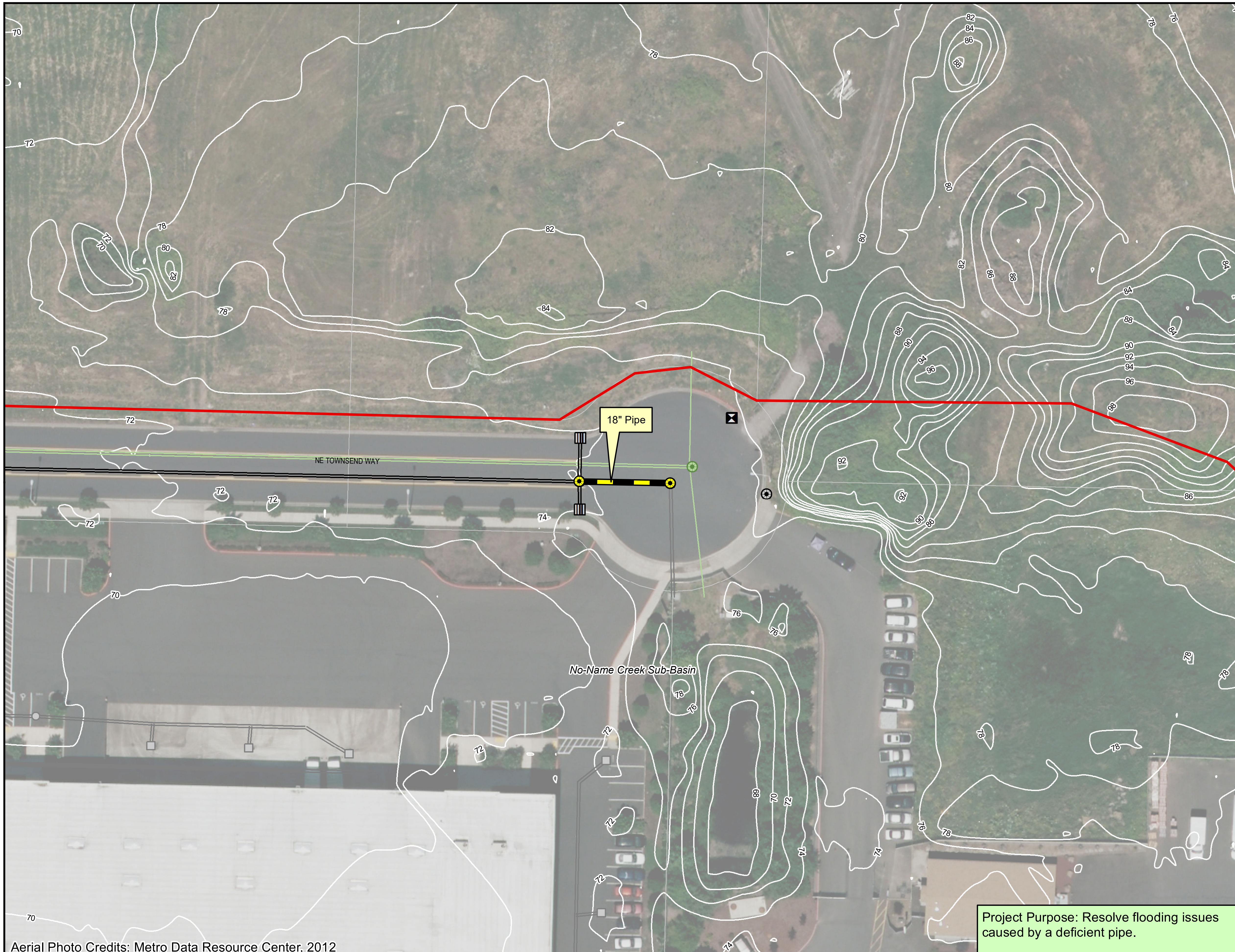
0 50 100 200 Feet

1 inch equals 100 feet

Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS



Fairview Creek Project: NN-5

Townsend Way

Legend

- Fairview City Limits
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary

Sanitary Sewer

- Cleanout
- Manhole
- Other Feature
- Plug
- Pump Station
- Valve
- Sanitary Lateral
- Sanitary Pipe

N

0 25 50 100 Feet

1 inch equals 50 feet

Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS

P:\133088_GIS\RT1_2_3 w contours.mxd. 11-28-2007. LGP.

Raintree Creek
Project: RT 1, 2

Raintree Railroad Crossing, Park Cleone Detention Pond Retrofit, Daylight Pipe

Legend

- Fairview City Limits
- Basins
- taxlots
- City property
- Catchbasins
- Manholes
- Private MHs, CBs
- Private pipe
- Pipe
- Bridge; Box Culvert
- Private Box Culvert
- Tributary
- Pond
- Swale
- Pond and Swale
- Proposed Project Features
- Existing Project Features

N

0 50 100 200 Feet

1 inch equals 100 feet

Consolidated Stormwater Master Plan

CITY OF FAIRVIEW

BROWN AND CALDWELL

Data Source: City of Fairview GIS

Fairview Creek Stormwater
Master Plan Addendum

APPENDIX

A

MODEL DEVELOPMENT

Appendix A
Model Development

- Exhibit 1-A: USDA Hydrologic Soil Group
- Exhibit 1-B: Vegetative Cover
- Exhibit 1-C: NRCS Curve Numbers

- Exhibit 2: Bridge/Culvert Location Map
- Bridge/Culvert Summary Table

- Exhibit 3: Detention Facility Location Map
- Detention Summary Table

- Exhibit 4: Gauge Location Map

- Exhibit 5: Fairview Creek Basin Delineation
- Fairview Creek Summary Table

- Exhibit 6: No-Name Creek Basin Delineation
- No-Name Creek Summary Table

- Exhibit 7: Excluded Sub-Basins

- Standards Tables
  - Table 3-1 - Manning's "n" Values
  - Table 6-3 Entrance Loss Coefficient for Pipe Culverts
  - Table 6-4 Entrance Loss Coefficient for Reinforced Concrete Box Culverts

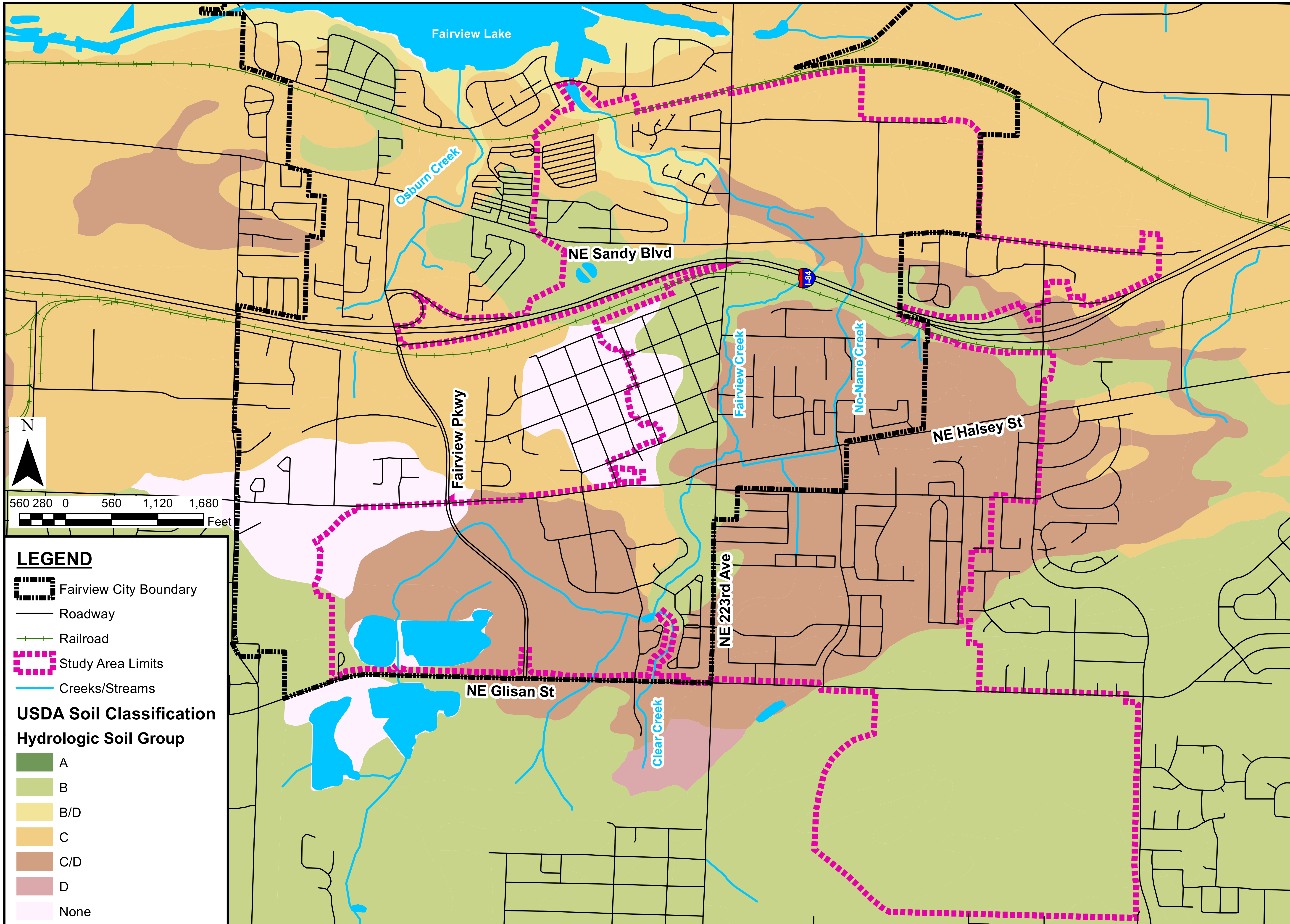


EXHIBIT 1-A

USDA HYDROLOGIC SOIL GROUP

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

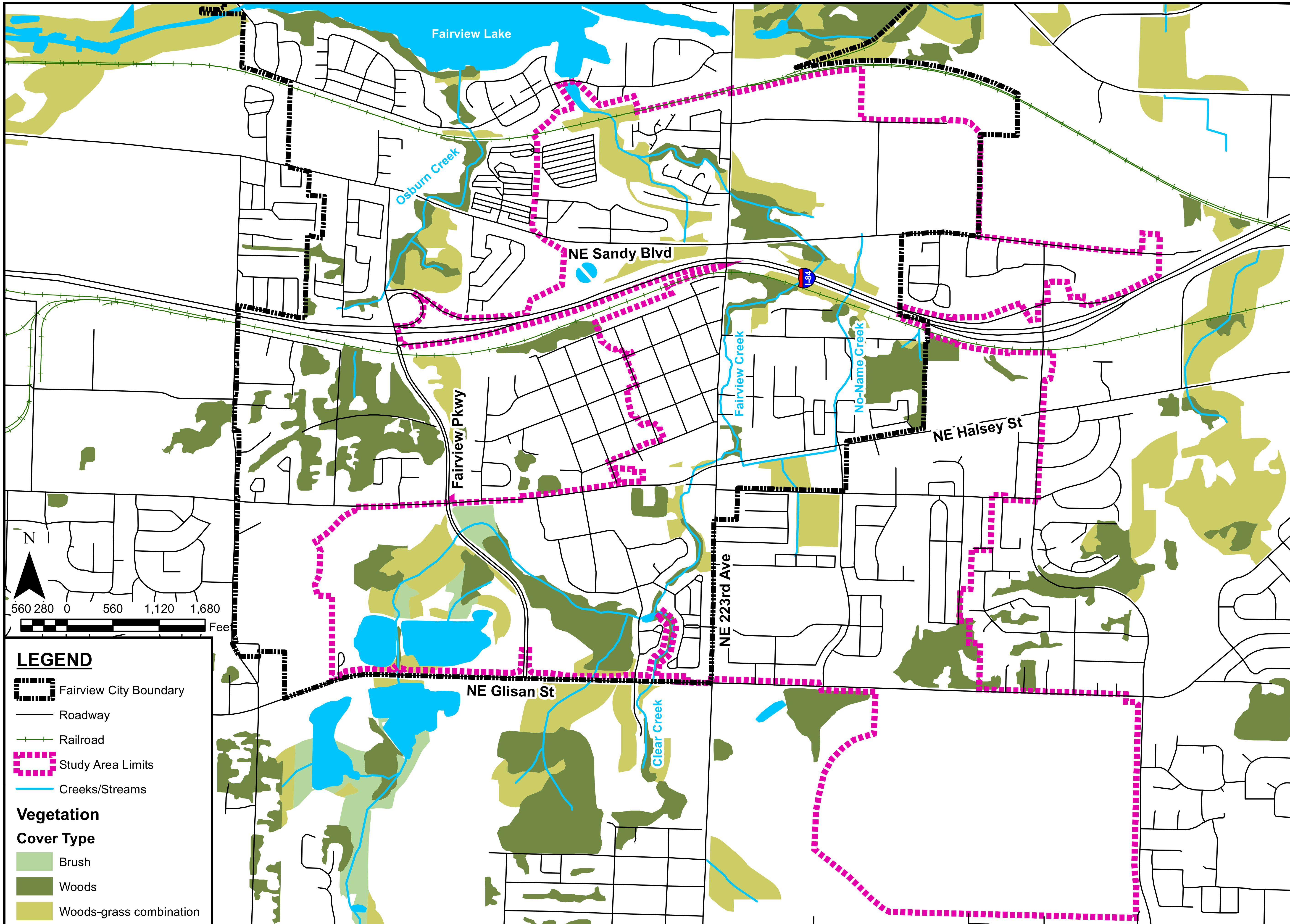


EXHIBIT 1-B

VEGETATIVE COVER

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

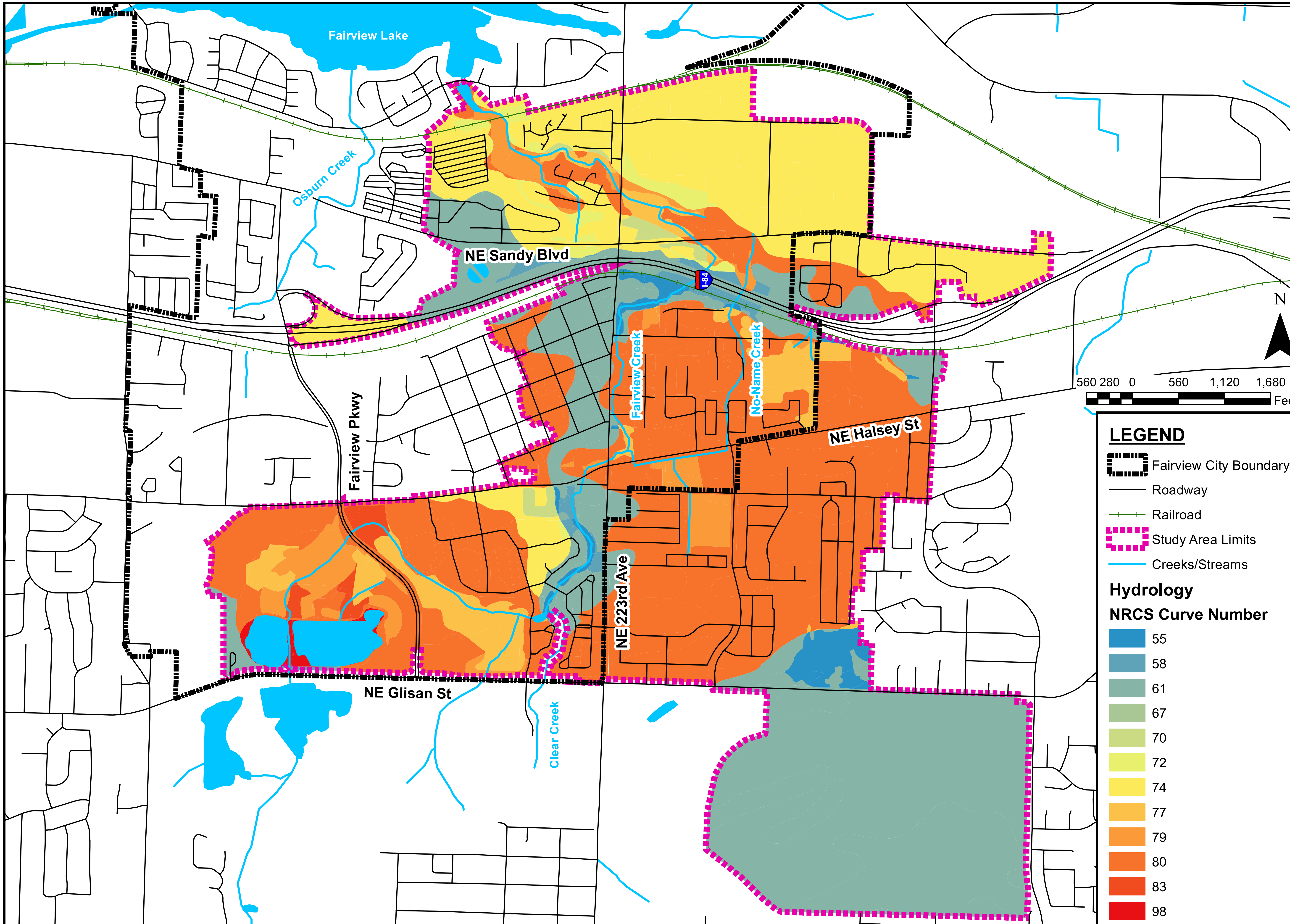


EXHIBIT 1-C

NRCS CURVE NUMBERS

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

Cardno

CITY OF FAIRVIEW OREGON EST 1908

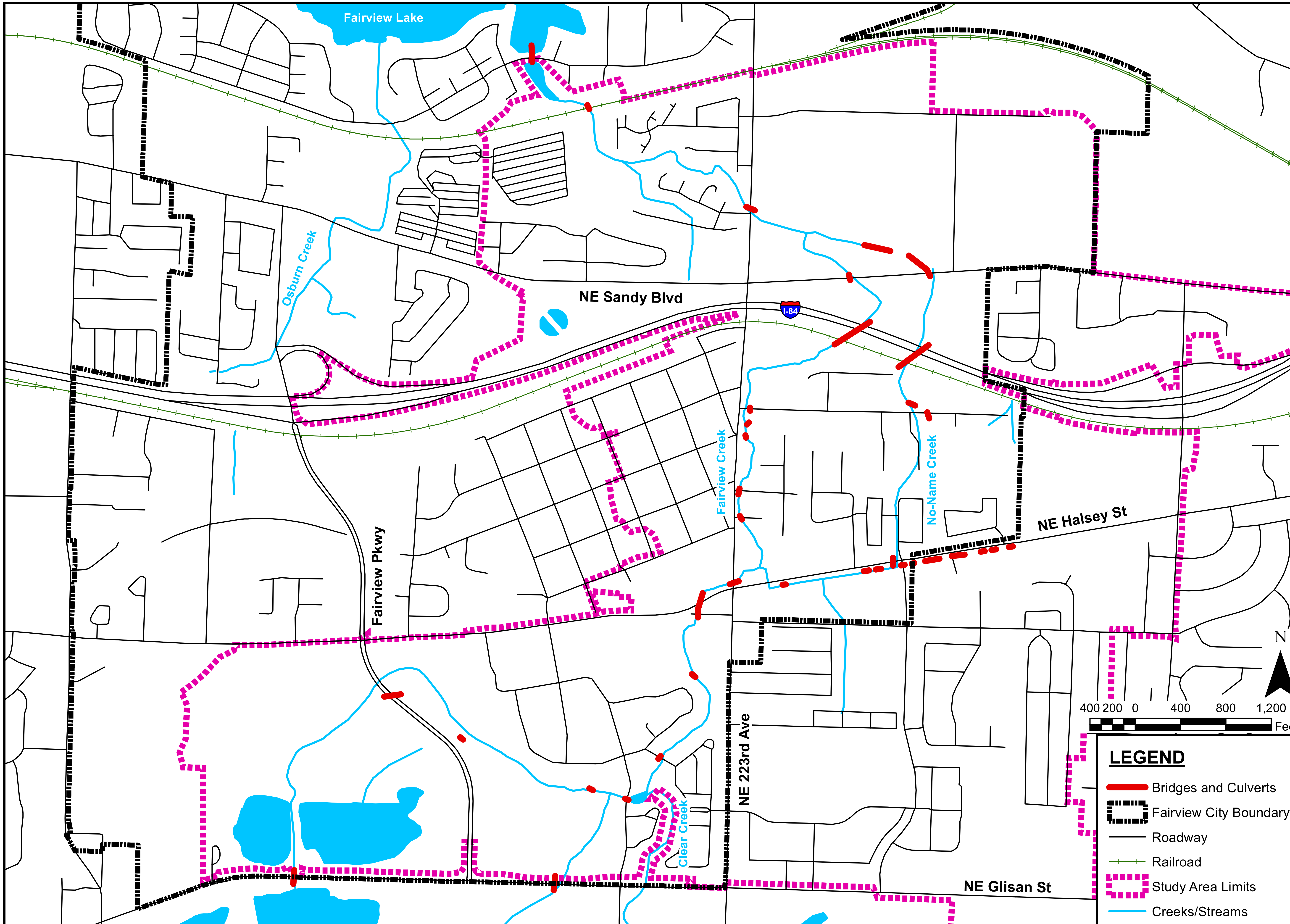


EXHIBIT 2

BRIDGE/CULVERT LOCATION MAP

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

Fairview - No-Name Creek - Culvert and Bridge Summary Table					
ID	Crossing Type	Inlet Type	Entrance Loss	Exit Loss	Manning's 'n'
1277	Bridge	None (,)	0.3	1.0	0.030
3721	Bridge	None (,)	0.0	0.0	0.020
980a1	Bridge	None (,)	0.0	0.0	0.015
ECovBrg	Bridge	None (,)	0.0	0.0	0.020
FootBrg	Bridge	None (,)	0.0	0.0	0.020
FVC_0010	Bridge	None (,)	0.0	0.0	0.014
FVC_0040	Bridge	None (,)	0.0	0.0	0.014
9	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.013
88	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.013
318	Culvert	30 to 75 deg Wingwall Flares (Rect, Conc)	0.4	1.0	0.013
544	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.013
546	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.013
571	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
589	Culvert	30 to 75 deg Wingwall Flares (Rect, Conc)	0.4	1.0	0.019
918	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.017
920	Culvert	Mitered to Slope (Circ, Corr Metal)	0.7	1.0	0.020
949	Culvert	0 deg Wingwall Flares (Rect, Conc)	0.7	1.0	0.030
950	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.018
951	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.014
956	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.013
957	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.013
1182	Culvert	90 and 15 deg Wingwall Flares (Rect, Conc)	0.5	1.0	0.013
1478	Culvert	Groove End with Projecting (Circ, Conc)	0.5	1.0	0.015
1479	Culvert	Groove End with Projecting (Circ, Conc)	0.5	1.0	0.015
953b	Culvert	0 deg Wingwall Flares (Rect, Conc)	0.7	1.0	0.015
978b	Culvert	Groove End with Projecting (Circ, Conc)	0.5	1.0	0.013
980a2	Culvert	Groove End with Projecting (Circ, Conc)	0.5	1.0	0.015
980b2	Culvert	Groove End with Projecting (Circ, Conc)	0.5	1.0	0.015
Culv #1	Culvert	Groove End with Projecting (Circ, Conc)	0.2	1.0	0.012
Culv #2	Culvert	Groove End with Projecting (Circ, Conc)	0.2	1.0	0.012
Culv #3	Culvert	Groove End with Projecting (Circ, Conc)	0.2	1.0	0.012
Culv #4	Culvert	Groove End with Projecting (Circ, Conc)	0.2	1.0	0.012
Culv #5	Culvert	Groove End with Projecting (Circ, Conc)	0.2	1.0	0.012
Glisan_1	Culvert	30 to 75 deg Wingwall Flares (Rect, Conc)	0.4	1.0	0.035
Glisan_2	Culvert	30 to 75 deg Wingwall Flares (Rect, Conc)	0.4	1.0	0.035
Halsey_1	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.013
L166	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L38	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L40	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L45	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L47	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L49	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L52	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L54	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014
L56	Culvert	Projecting (Circ, Corr Metal)	0.9	1.0	0.014

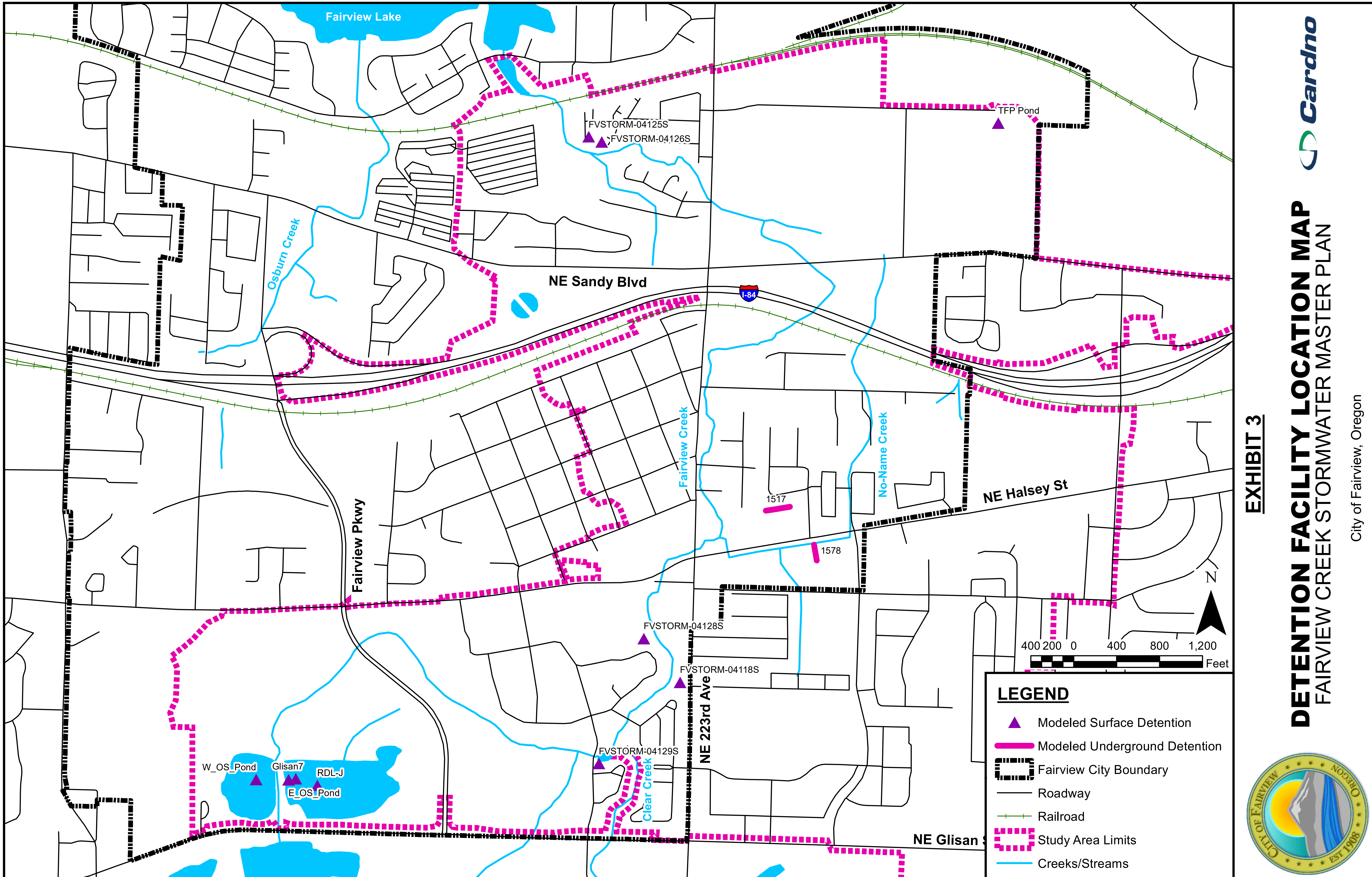


EXHIBIT 3
DETENTION FACILITY LOCATION MAP
FAIRVIEW CREEK STORMWATER MASTER PLAN
City of Fairview, Oregon
Cardno
Fairview Lake
Osburn Creek
NE Sandy Blvd
I-84
Fairview Creek
No-Name Creek
Clear Creek
NE Halsey St
Fairview Pkwy
NE 223rd Ave
NE Glisan S
FVSTORM-04125S
FVSTORM-04126S
TFP Pond
1517
1578
FVSTORM-04128S
FVSTORM-04118S
FVSTORM-04129S
W_OS_Pond
Glisan7
RDL-J
E_OS_Pond
N
400 200 0 400 800 1,200
Feet
LEGEND
Modeled Surface Detention
Modeled Underground Detention
Fairview City Boundary
Roadway
Railroad
Study Area Limits
Creeks/Streams
CITY OF FAIRVIEW
OREGON
EST 1908

Fairview - No-Name Creek - Detention Summary Table

ID	Detention Type	Detention Volume (cu-ft)	Depth/Diameter (feet)
FVSTORM-04118S	Surface Detention	41,529	4.11
FVSTORM-04125S	Surface Detention	40,868	5.50
FVSTORM-04126S	Surface Detention	4,356	4.00
FVSTORM-04128S	Surface Detention	186,642	12.50
FVSTORM-04129S	Surface Detention	23,397	5.90
TFP Pond	Surface Detention	22,539	6.00
RDL-J	Surface Detention	858,000	10.00
Glisan7	Surface Detention	1,484,340	17.30
W_OS_Pond	Surface Detention	3,808,668	15.00
E_OS_Pond	Surface Detention	7,546,116	15.00
1578	Pipe Detention	1,885	4.00
1517	Pipe Detention	2,702	4.00

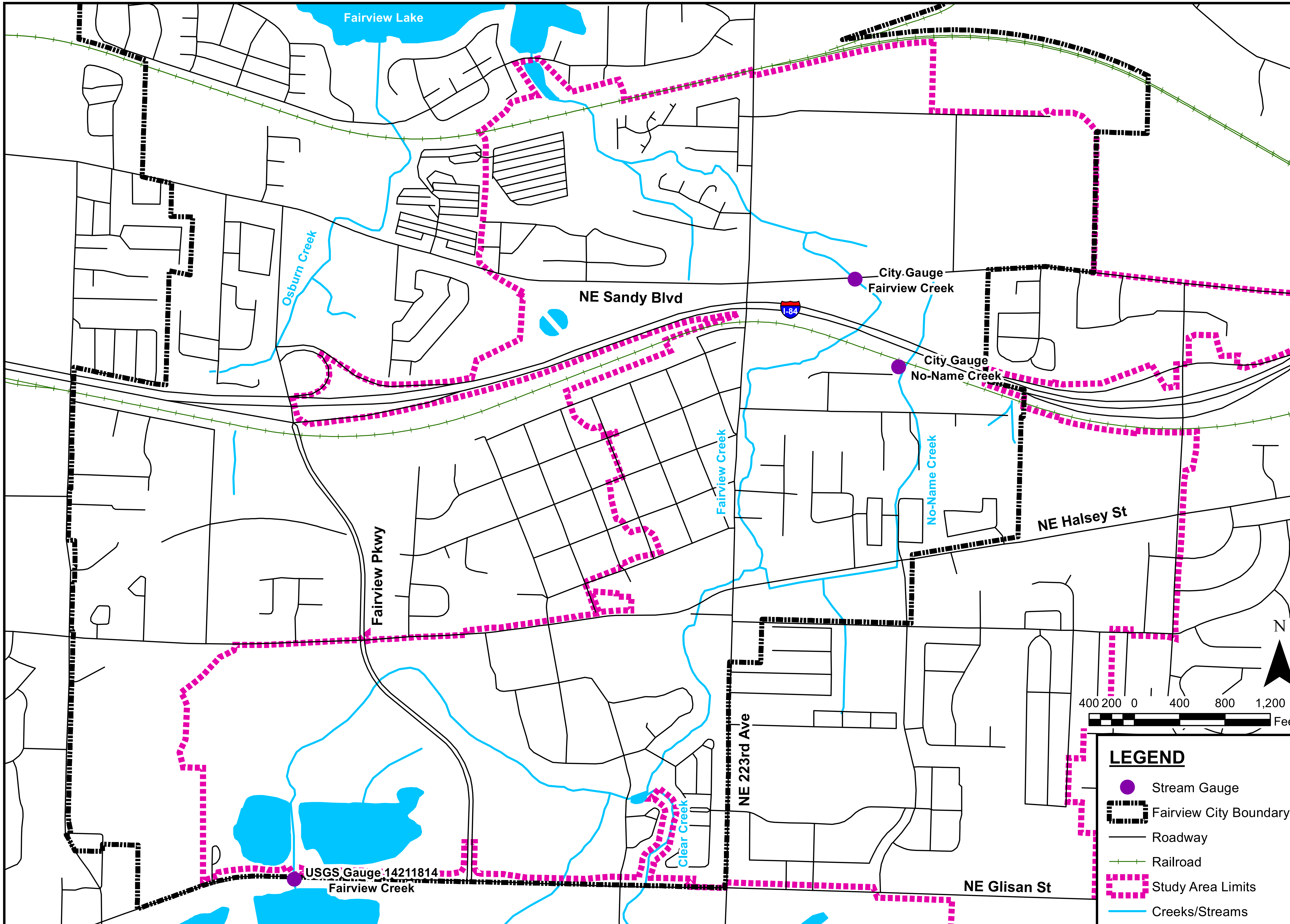


EXHIBIT 4

GAUGE LOCATION MAP

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

Cardno

CITY OF FAIRVIEW · OREGON · EST 1908

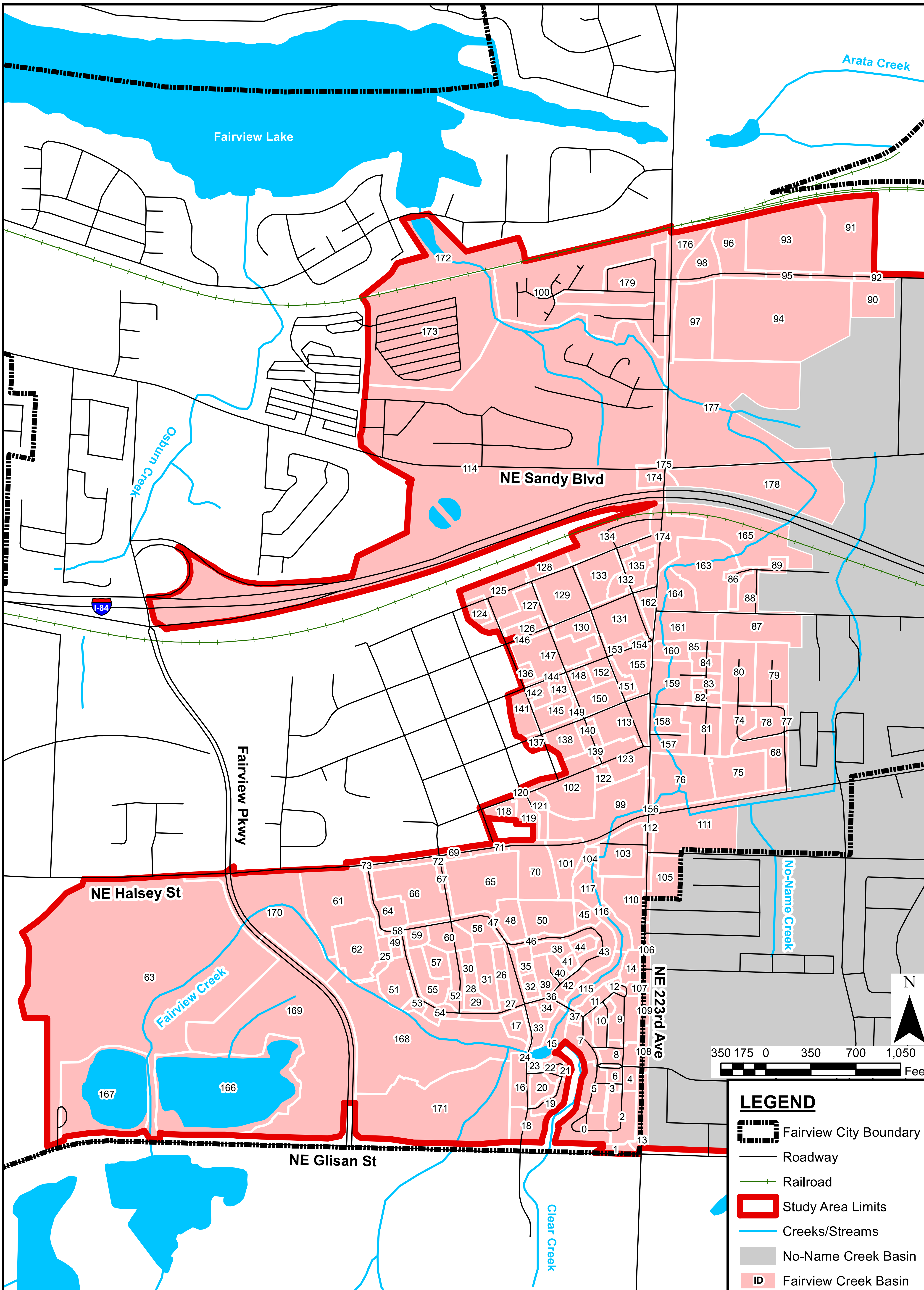


EXHIBIT 5

FAIRVIEW CREEK BASIN DELINEATION

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

Fairview Creek - 1D Model Sub-Basin Table

FID	Assigned Node	Area, ac	Existing Impervious %	Build-Out Impervious %	Width, ft	Slope, ft/ft	Pervious Curve Number
0	FVSTORM-01015S	2.223	71	95	378	0.0169	80
1	223RD_0080	0.458	85	95	82	0.0058	80
2	FVSTORM-01527S	2.066	71	95	263	0.0116	80
3	FVSTORM-01090S	0.226	71	95	35	0.0110	80
4	FVSTORM-01526S	0.514	71	95	134	0.0195	80
5	FVSTORM-01016S	1.558	71	95	263	0.0117	77
6	FVSTORM-01525S	0.425	71	95	153	0.0301	80
7	FVSTORM-01030S	1.345	71	95	234	0.0114	61
8	FVSTORM-00005N	1.197	71	95	216	0.0126	78
9	FVSTORM-01520S	2.152	71	95	336	0.0134	63
10	FVSTORM-01121S	0.979	71	95	101	0.0072	62
11	FVSTORM-01121S	0.650	71	95	118	0.0135	61
12	FVSTORM-01519S	0.546	71	95	183	0.0203	61
13	223RD_0060	1.377	85	95	145	0.0120	80
14	FVSTORM-04118S	0.817	0	0	228	0.0293	58
15	FVC_N_0800	1.334	0	95	229	0.0348	63
16	FVSTORM-01167S	1.400	71	95	188	0.0083	79
17	FVSTORM-01695S	0.857	71	95	110	0.0042	80
18	FVSTORM-01162S	1.556	71	95	200	0.0124	79
19	FVSTORM-01169S	0.877	71	95	233	0.0168	80
20	FVSTORM-01167S	0.836	71	95	147	0.0081	80
21	FVSTORM-01169S	0.249	71	95	66	0.0093	67
22	FVSTORM-01168S	0.614	71	95	86	0.0045	76
23	FVSTORM-04129S	0.177	0	95	164	0.0709	80
24	FVSTORM-01037S	0.147	71	95	64	0.0331	80
25	FVSTORM-01540S	0.719	90	95	47	0.0033	80
26	FVSTORM-01189S	0.908	90	95	99	0.0043	80
27	FVSTORM-01695S	2.169	50	95	263	0.0078	80
28	FVSTORM-01142S	0.115	85	95	78	0.0106	80
29	FVSTORM-01187S	0.644	71	95	154	0.0072	80
30	FVSTORM-01143S	0.634	90	95	95	0.0036	80
31	FVSTORM-01189S	1.545	90	95	192	0.0077	80
32	FVSTORM-01190S	0.505	90	95	115	0.0097	74
33	FVSTORM-01190S	0.919	71	95	158	0.0101	75
34	FVSTORM-01191S	0.564	71	95	186	0.0178	66
35	FVSTORM-01210S	0.581	90	95	54	0.0048	76
36	FVSTORM-01191S	0.099	85	95	48	0.0235	61
37	FVSTORM-01123S	0.326	71	95	97	0.0174	61
38	FVSTORM-01199S	0.781	90	95	82	0.0077	74
39	FVSTORM-01192S	1.014	71	95	245	0.0202	73
40	FVSTORM-01199S	0.559	71	95	103	0.0145	71
41	FVSTORM-01199S	0.301	71	95	76	0.0144	73
42	FVSTORM-01199S	0.749	71	95	132	0.0115	61
43	FVSTORM-01203S	2.015	71	95	280	0.0089	64
44	FVSTORM-01013S	0.493	90	95	150	0.0178	71
45	FVSTORM-04128S	0.690	0	0	345	0.1087	64
46	FVSTORM-01210S	0.590	85	95	80	0.0203	76
47	FVSTORM-01210S	0.216	85	95	78	0.0119	80
48	FVSTORM-01407S	1.336	71	95	13	0.0011	77
49	FVSTORM-01537S	0.340	90	95	93	0.0061	80
50	FVSTORM-01408S	2.508	71	95	320	0.0212	74
51	FVSTORM-01125S	2.090	90	95	152	0.0046	80
52	T-001	1.161	85	95	171	0.0056	80

Fairview Creek - 1D Model Sub-Basin Table

FID	Assigned Node	Area, ac	Existing Impervious %	Build-Out Impervious %	Width, ft	Slope, ft/ft	Pervious Curve Number
53	FVSTORM-01127S	0.665	71	95	65	0.0059	80
54	FVSTORM-01133S	0.734	71	86	59	0.0035	80
55	FVSTORM-01105S	1.643	90	95	193	0.0050	80
56	FVSTORM-01533S	1.511	85	95	9	0.0004	80
57	FVSTORM-01104S	0.955	90	95	178	0.0047	80
58	FVSTORM-01531S	0.233	85	95	1	0.0001	80
59	FVSTORM-01126S	0.716	90	95	6	0.0003	80
60	FVSTORM-01145S	1.470	85	95	9	0.0001	80
61	FVSTORM-01541S	5.841	90	95	45	0.0004	80
62	FVC_N_0940	3.080	100	100	42	0.0005	80
63	FVC_N_0960	50.049	21	21	419	0.0012	79
64	FVSTORM-01530S	1.629	85	95	164	0.0071	80
65	FVSTORM-01406S	5.258	0	95	182	0.0054	76
66	FVSTORM-01401S	4.444	90	90	271	0.0142	80
67	FVSTORM-01403S	0.322	85	95	134	0.0199	78
68	FVSTORM-04337N	2.356	42	90	367	0.0197	80
69	FVSTORM-00550S	0.805	85	95	29	0.0146	74
70	FVSTORM-00544S	3.100	21	95	26	0.0028	73
71	FVSTORM-00546S	0.554	85	95	23	0.0041	77
72	FVSTORM-00490S	0.400	85	95	69	0.0384	74
73	FVSTORM-00560S	0.501	85	95	11	0.0015	76
74	FVSTORM-00836S	1.920	42	83	111	0.0066	80
75	FVSTORM-04321N	3.038	90	95	127	0.0021	80
76	FVC_N_0580	4.210	42	78	251	0.0073	77
77	FVSTORM-00835S	0.165	85	95	45	0.0159	80
78	FVSTORM-00833S	1.526	42	86	194	0.0097	80
79	FVSTORM-00830S	2.902	42	83	337	0.0104	80
80	FVSTORM-00831S	2.850	42	83	164	0.0055	80
81	FVSTORM-00971S	2.364	42	85	272	0.0129	80
82	FVSTORM-00971S	0.482	42	85	123	0.0124	80
83	FVSTORM-01475S	0.691	42	84	162	0.0117	80
84	FVSTORM-01479S	0.912	42	83	155	0.0056	80
85	FVSTORM-01476S	0.539	42	83	54	0.0043	80
86	FVSTORM-00867S	0.749	42	85	101	0.0370	80
87	FVSTORM-01483S	3.593	42	82	178	0.0054	80
88	FVSTORM-01484S	1.431	42	88	137	0.0180	80
89	FVSTORM-01484S	0.507	42	88	34	0.0025	80
90	FVSTORM-04017S	2.244	90	90	144	0.0062	74
91	FVSTORM-04014S	5.934	90	90	162	0.0031	74
92	FVSTORM-04007S	0.472	85	95	72	0.0203	74
93	FVSTORM-04216S	6.820	90	90	213	0.0034	74
94	FVSTORM-04065S	14.929	50	90	790	0.0156	74
95	FVSTORM-04005S	0.478	85	95	82	0.0157	74
96	FVSTORM-04003S	2.601	21	91	182	0.0213	74
97	FVSTORM-04370N	4.169	90	90	447	0.0085	74
98	FVSTORM-04001S	1.898	21	91	176	0.0277	74
99	FVSTORM-04343N	5.281	42	95	27	0.0005	74
100	FVSTORM-04125S	14.117	42	64	584	0.0104	74
101	FVSTORM-00543S	2.061	21	95	10	0.0010	66
102	FVSTORM-00504S	3.998	42	83	188	0.0024	70
103	00821	2.900	90	95	285	0.0113	65
104	FVC_N_0710	0.520	0	95	136	0.0412	59
105	FVSTORM-00001N	2.075	85	95	203	0.0148	62

Fairview Creek - 1D Model Sub-Basin Table							
FID	Assigned Node	Area, ac	Existing Impervious %	Build-Out Impervious %	Width, ft	Slope, ft/ft	Pervious Curve Number
106	FVSTORM-00002N	0.362	85	95	14	0.0032	75
107	FVSTORM-00003N	0.568	85	95	29	0.0033	61
108	FVSTORM-00006N	0.731	85	95	83	0.0070	80
109	FVSTORM-00004N	0.495	85	95	58	0.0050	64
110	223RD_0040	3.182	90	95	204	0.0112	61
111	FVSTORM-03101	6.229	50	95	26	0.0003	80
112	223RD_0030	0.384	85	95	97	0.0086	79
113	FVSTORM-01429S	2.832	42	86	22	0.0008	65
114	FVSTORM-01382N	84.779	50	64	1134	0.0200	69
115	FVC_N_0760	1.521	0	0	180	0.0266	57
116	FVC_N_0740	1.124	0	0	176	0.0388	56
117	FVC_N_0720	1.374	0	95	229	0.0421	59
118	FVSTORM-00764S	0.851	42	86	150	0.0273	80
119	FVSTORM-00764S	0.891	42	86	204	0.0277	80
120	FVSTORM-00506S	0.226	42	95	43	0.0165	80
121	FVSTORM-00652S	0.799	42	86	93	0.0200	80
122	FVSTORM-00505S	0.502	42	82	74	0.0037	61
123	FVSTORM-00840S	2.281	42	85	34	0.0015	61
124	FVSTORM-00487S	0.813	42	84	158	0.0224	80
125	FVSTORM-00756S	2.814	63	89	241	0.0162	73
126	FVSTORM-00756S	0.714	42	89	60	0.0021	69
127	FVSTORM-00756S	1.524	42	89	184	0.0244	72
128	FVSTORM-00661S	1.007	90	91	169	0.0065	73
129	FVSTORM-00609S	3.128	85	91	359	0.0262	63
130	FVSTORM-00904S	1.177	42	84	57	0.0012	61
131	FVSTORM-00904S	3.010	42	84	261	0.0158	61
132	FVSTORM-00659S	0.535	50	91	129	0.0196	61
133	FVSTORM-00485S	2.152	21	91	287	0.0144	61
134	*Excluded*	-	-	-	-	-	-
135	FVSTORM-00822S-D	1.262	42	61	215	0.0173	61
136	FVSTORM-00793S	0.441	42	83	132	0.0088	80
137	FVSTORM-00804S	0.452	42	90	102	0.0098	80
138	FVSTORM-00785S	1.547	42	84	137	0.0061	80
139	FVSTORM-02069S	0.137	42	95	74	0.0200	61
140	FVSTORM-02066S	0.825	42	88	154	0.0102	69
141	FVSTORM-00634S	1.595	42	84	237	0.0168	80
142	FVSTORM-00633S	0.525	42	84	120	0.0146	80
143	FVSTORM-03344S	0.553	42	82	151	0.0132	80
144	FVSTORM-00495N	0.216	42	95	38	0.0072	80
145	FVSTORM-00632S	1.328	42	84	176	0.0145	80
146	FVSTORM-00797S	0.420	42	95	23	0.0008	72
147	FVSTORM-00790S	3.401	42	83	329	0.0033	77
148	FVSTORM-00495S	0.795	42	85	171	0.0106	80
149	FVSTORM-00784S	0.159	42	90	32	0.0122	80
150	FVSTORM-00783S	1.583	42	85	330	0.0154	64
151	FVSTORM-00781S	0.634	42	85	81	0.0063	61
152	FVSTORM-00493S	1.306	42	87	179	0.0057	66
153	FVSTORM-02109S	0.233	42	86	47	0.0088	61
154	FVSTORM-02110S	0.202	50	87	46	0.0085	61
155	FVSTORM-00895S	1.921	42	87	13	0.0006	62
156	FVSTORM-00964S	0.385	85	95	12	0.0004	76
157	FVC_N_0560	1.146	42	83	324	0.0162	74
158	FVSTORM-01431S	1.420	42	83	292	0.0170	80

Fairview Creek - 1D Model Sub-Basin Table							
FID	Assigned Node	Area, ac	Existing Impervious %	Build-Out Impervious %	Width, ft	Slope, ft/ft	Pervious Curve Number
159	FVSTORM-01481N	2.730	42	82	193	0.0138	79
160	FVSTORM-02113N	0.989	42	81	34	0.0038	79
161	FVSTORM-02112N	2.464	42	82	109	0.0058	77
162	FVSTORM-00969N	0.878	50	50	25	0.0043	62
163	FVSTORM-00902N	4.704	42	80	442	0.0401	68
164	FVSTORM-00969N	1.994	42	50	109	0.0153	65
165	FVC_N_0340	6.375	21	88	111	0.0055	60
166	E_OS_Pond	15.628	85	85	1136	0.0095	94
167	W_OS_Pond	9.799	21	30	886	0.0184	87
168	FVC_N_0880	15.682	0	15	648	0.0079	78
169	FVC_N_0920	21.910	50	50	606	0.0062	80
170	FVC_N_0950	9.145	50	50	173	0.0038	81
171	FVC_N_0871	13.818	50	50	606	0.0085	79
172	FVC_N_0020	6.866	21	52	498	0.0345	76
173	FVC_N_0050	17.440	42	66	952	0.0206	75
174	FVSTORM-00327S	4.891	42	88	37	0.0042	62
175	223RD_0090	0.374	85	95	35	0.0623	76
176	223RD_0110	2.945	85	93	100	0.0107	74
177	FVC_N_0150	17.552	21	91	1049	0.0359	75
178	FVC_N_0280	8.767	21	83	224	0.0277	71
179	FVSTORM-01382S	4.876	42	80	246	0.0072	74

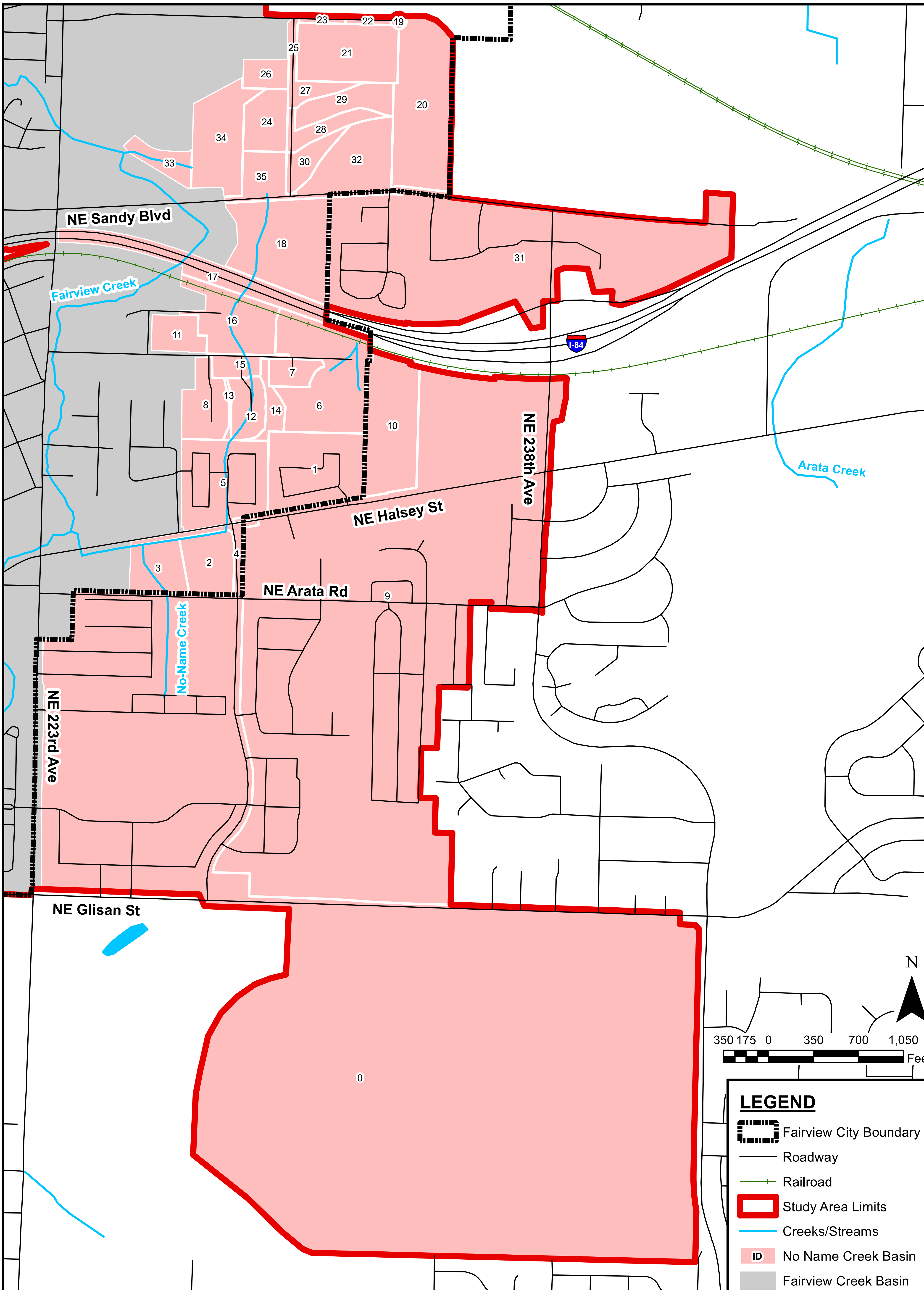


EXHIBIT 6

NO-NAME CREEK BASIN DELINEATION

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

No-Name Creek - 1D Model Sub-Basin Table							
FID	Assigned Node	Area, ac	Existing Impervious %	Build-Out Impervious %	Width, ft	Slope, ft/ft	Pervious Curve Number
0	NNC_N_0160	306.944	33.8	33.8	1929	0.0314	66
1	*Excluded*	-	-	-	-	-	-
2	FVSTORM-03426S	4.177	90	95	327	0.0139	80
3	N40	3.846	0	95	377	0.0225	79
4	FVSTORM-00943S	1.909	85	95	155	0.0164	80
5	FVSTORM-00942S	10.090	71	80	474	0.0196	80
6	*Excluded*	-	-	-	-	-	-
7	*Excluded*	-	-	-	-	-	-
8	FVSTORM-00842S	4.268	42	83	386	0.0346	80
9	59-A	151.567	49.9	80	1889	0.0328	76
10	*Excluded*	-	-	-	-	-	-
11	FVSTORM-01659N	2.658	42	80	189	0.0328	80
12	FVSTORM-00978S	2.896	42	83	183	0.0243	80
13	N_55	0.271	42	80	32	0.0560	80
14	FVSTORM-00921N	1.520	0	36	156	0.0579	78
15	FVSTORM-00828S	1.751	42	85	151	0.0187	80
16	FVSTORM-00912N	6.774	21	85	223	0.0181	71
17	FVSTORM-01467S	7.030	90	94	393	0.0373	61
18	NNC_N_0060	11.736	21	94	639	0.0541	72
19	FVSTORM-04020S	0.263	85	95	31	0.0083	74
20	TFP Pond	13.270	85	90	682	0.0171	74
21	FVSTORM-04177S	8.155	90	90	321	0.0067	74
22	FVSTORM-04019S	0.487	85	95	58	0.0089	74
23	FVSTORM-04018S	0.496	85	95	59	0.0088	74
24	FVSTORM-02044S	3.579	0	90	377	0.0349	74
25	FVSTORM-02057S	0.539	85	94	70	0.0154	74
26	FVSTORM-02056S	1.936	85	90	286	0.0224	74
27	FVSTORM-02053S	1.798	21	95	221	0.0387	74
28	FVSTORM-02038S	2.313	21	95	180	0.0422	74
29	FVSTORM-02048S	3.454	0	95	205	0.0212	74
30	FVSTORM-02032S	2.167	21	95	218	0.0422	74
31	16-C	54.681	78.6	78.6	1122	0.0155	74
32	FVSTORM-02031S	7.456	21	95	537	0.0405	74
33	NNC_N_0010	2.318	21	90	239	0.0434	78
34	NNC_N_0011	7.458	85	90	402	0.0178	76
35	FVSTORM-01470S	3.258	90	95	218	0.0133	75

EXHIBIT 7

EXCLUDED SUB-BASINS

FAIRVIEW CREEK STORMWATER MASTER PLAN

City of Fairview, Oregon

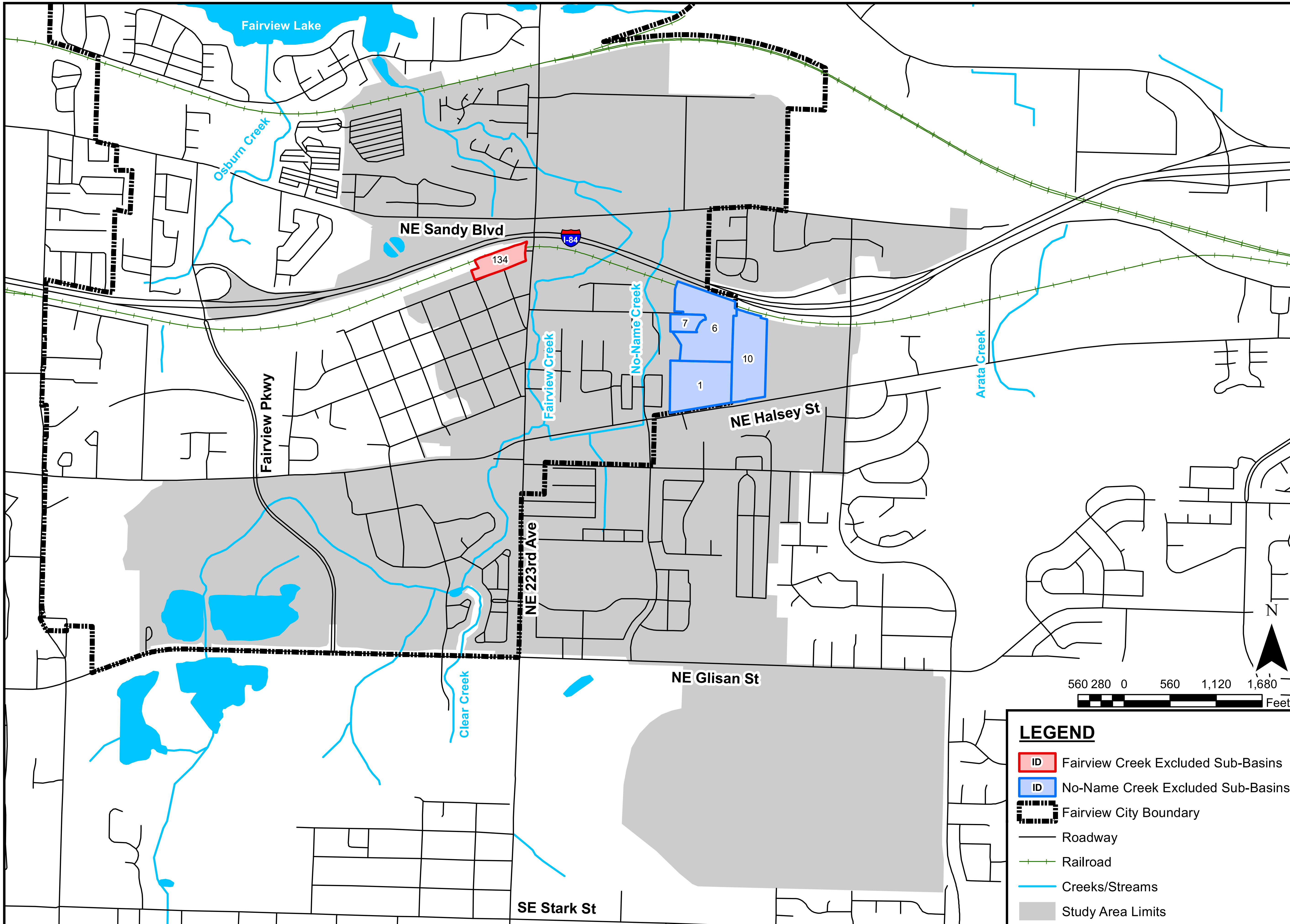


Table 3-1 Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
3. **Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged**			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

Table 3-1 (Continued) Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
B. *Lined or Built-Up Channels*			
1. **Concrete**			
a. Trowel finish	0.011	0.013	0.015
b. Float Finish	0.013	0.015	0.016
c. Finished, with gravel bottom	0.015	0.017	0.020
d. Unfinished	0.014	0.017	0.020
e. Gunite, good section	0.016	0.019	0.023
f. Gunite, wavy section	0.018	0.022	0.025
g. On good excavated rock	0.017	0.020	
h. On irregular excavated rock	0.022	0.027	
2. **Concrete bottom float finished with sides of:**			
a. Dressed stone in mortar	0.015	0.017	0.020
b. Random stone in mortar	0.017	0.020	0.024
c. Cement rubble masonry, plastered	0.016	0.020	0.024
d. Cement rubble masonry	0.020	0.025	0.030
e. Dry rubble on riprap	0.020	0.030	0.035
3. **Gravel bottom with sides of:**			
a. Formed concrete	0.017	0.020	0.025
b. Random stone in mortar	0.020	0.023	0.026
c. Dry rubble or riprap	0.023	0.033	0.036
4. **Brick**			
a. Glazed	0.011	0.013	0.015
b. In cement mortar	0.012	0.015	0.018
5. **Metal**			
a. Smooth steel surfaces	0.011	0.012	0.014
b. Corrugated metal	0.021	0.025	0.030
6. **Asphalt**			
a. Smooth	0.013	0.013	
b. Rough	0.016	0.016	
7. **Vegetal lining**	0.030		0.500

Table 3-1 (Continued) Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
C. *Excavated or Dredged Channels*			
1. **Earth, straight and uniform**			
a. Clean, recently completed	0.016	0.018	0.020
b. Clean, after weathering	0.018	0.022	0.025
c. Gravel, uniform section, clean	0.022	0.025	0.030
d. With short grass, few weeds	0.022	0.027	0.033
2. **Earth, winding and sluggish**			
a. No vegetation	0.023	0.025	0.030
b. Grass, some weeds	0.025	0.030	0.033
c. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
d. Earth bottom and rubble side	0.028	0.030	0.035
e. Stony bottom and weedy banks	0.025	0.035	0.040
f. Cobble bottom and clean sides	0.030	0.040	0.050
3. **Dragline-excavated or dredged**			
a. No vegetation	0.025	0.028	0.033
b. Light brush on banks	0.035	0.050	0.060
4. **Rock cuts**			
a. Smooth and uniform	0.025	0.035	0.040
b. Jagged and irregular	0.035	0.040	0.050
5. **Channels not maintained, weeds and brush**			
a. Clean bottom, brush on sides	0.040	0.050	0.080
b. Same as above, highest stage of flow	0.045	0.070	0.110
c. Dense weeds, high as flow depth	0.050	0.080	0.120
d. Dense brush, high stage	0.080	0.100	0.140

Other sources that include pictures of selected streams as a guide to n value determination are available (Fasken, 1963; Barnes, 1967; and Hicks and Mason, 1991). In general, these references provide color photos with tables of calibrated n values for a range of flows.

Although there are many factors that affect the selection of the n value for the channel, some of the most important factors are the type and size of materials that compose the bed and banks of a channel, and the shape of the channel. Cowan (1956) developed a procedure for estimating the effects of these factors to determine the value of Manning’s n of a channel. In Cowan's procedure, the value of n is computed by the following equation:

Table 6-3 Entrance Loss Coefficient for Pipe Culverts

Type of Structure and Design of Entrance	Coefficient, k_{en}
Concrete Pipe Projecting from Fill (no headwall):	
Socket end of pipe	0.2
Square cut end of pipe	0.5
Concrete Pipe with Headwall or Headwall and Wingwalls:	
Socket end of pipe (grooved end)	0.2
Square cut end of pipe	0.5
Rounded entrance, with rounding radius = 1/12 of diameter	0.2
Concrete Pipe:	
Mitered to conform to fill slope	0.7
End section conformed to fill slope	0.5
Beveled edges, 33.7 or 45 degree bevels	0.2
Side slope tapered inlet	0.2
Corrugated Metal Pipe or Pipe-Arch:	
Projected from fill (no headwall)	0.9
Headwall or headwall and wingwalls square edge	0.5
Mitered to conform to fill slope	0.7
End section conformed to fill slope	0.5
Beveled edges, 33.7 or 45 degree bevels	0.2
Side slope tapered inlet	0.2

Table 6-4 Entrance Loss Coefficient for Reinforced Concrete Box Culverts

Type of Structure and Design of Entrance	Coefficient, k_{en}
Headwall Parallel to Embankment (no wingwalls):	
Square-edged on three edges	0.5
Three edges rounded to radius of 1/12 barrel dimension	0.2
Wingwalls at 30 to 75 degrees to Barrel:	
Square-edge at crown	0.4
Top corner rounded to radius of 1/12 barrel dimension	0.2
Wingwalls at 10 to 25 degrees to Barrel:	
Square-edge at crown	0.5
Wingwalls parallel (extension of sides):	
Square-edge at crown	0.7
Side or slope tapered inlet	0.2

Fairview Creek Stormwater
Master Plan Addendum

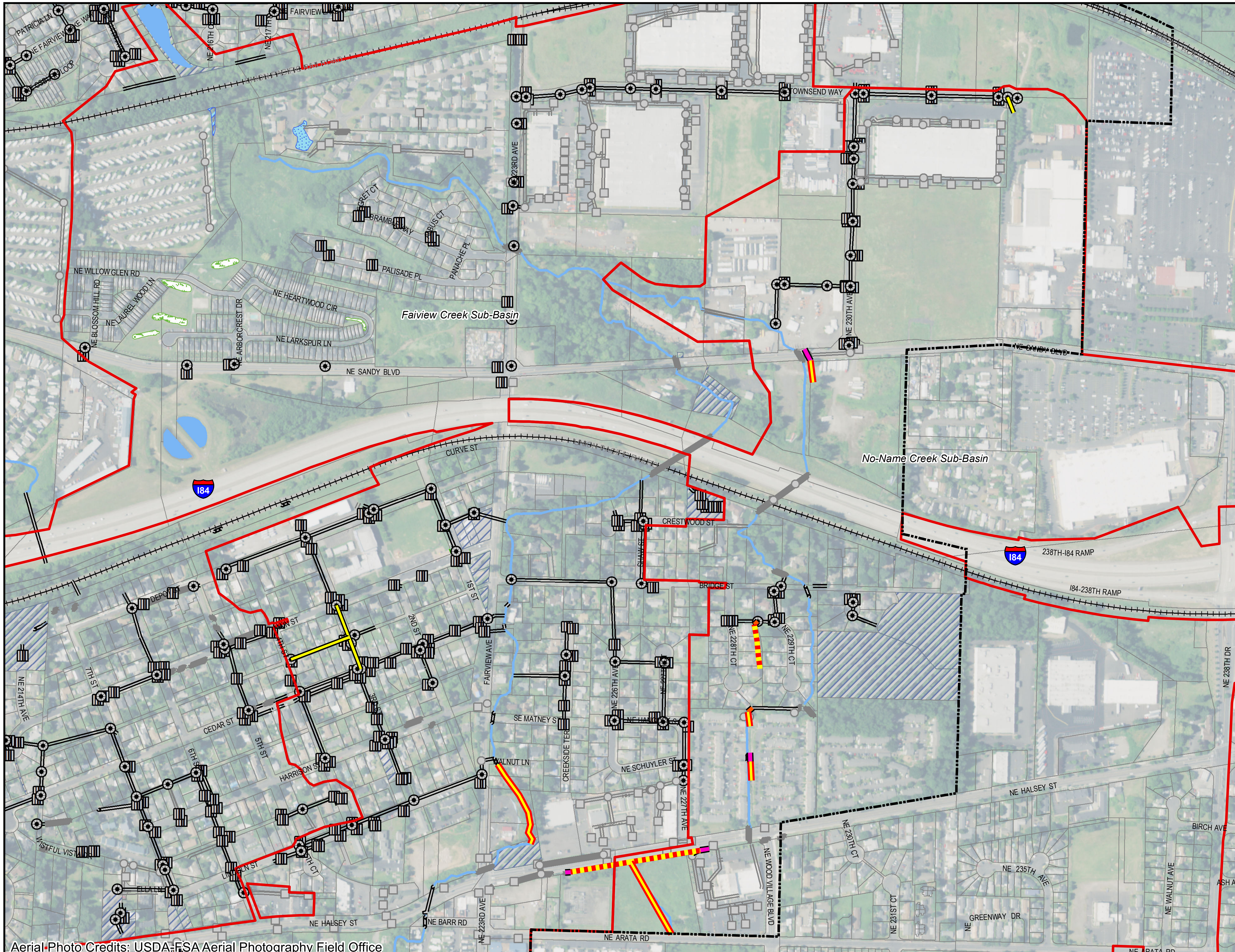
APPENDIX B

MODEL RESULTS

Appendix B
Model Results

- Existing Deficiency Key Map
- Existing Deficiency Tables

- Build-Out Deficiency Key Map
- Build-Out Deficiency Tables



Existing Deficiency Key Map

-

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary
- Pond
- Swale
- Settling Pond

Existing Deficiencies Classification

- Bridge/Culvert
- Pipe - Trunk
- Pipe - Collector
- Creek
- Ditch/Channel

N

0 250 500 1,000 Feet

1 inch equals 500 feet

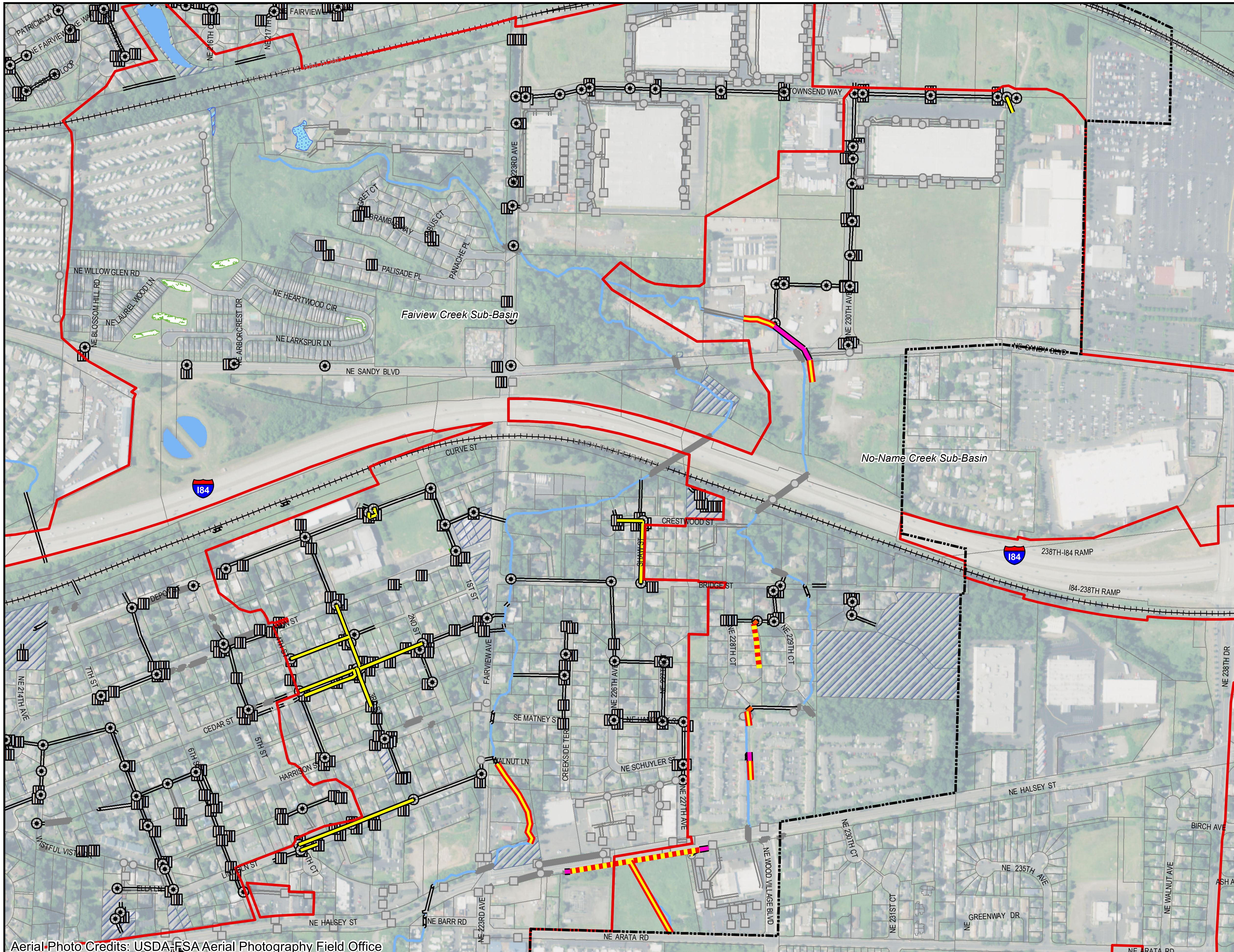
Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS

Fairview - No-Name Creek Basin
Existing Deficiencies

xpswmm/GIS ID	Upstream Node Name	Downstream Node Name	Designation	Design Storm	Node Properties				Conduit Properties						Modeled Flows				Upstream Node Freeboard				Downstream Node Freeboard			
					US Invert Elevation, ft	US Ground Elevation, ft	DS Invert Elevation, ft	DS Ground Elevation, ft	Length, ft	Slope %	Depth / Diameter, ft	US Cover, ft	DS Cover, ft	Design Capacity, cfs	10-Yr Flow, cfs	25-Yr Flow, cfs	50-Yr Flow, cfs	100-Yr Flow, cfs	10-Yr Flow, cfs	25-Yr Flow, cfs	50-Yr Flow, cfs	100-Yr Flow, cfs	10-Yr Flow, cfs	25-Yr Flow, cfs	50-Yr Flow, cfs	100-Yr Flow, cfs
980a1	FVSTORM-02062S	FVSTORM-01470S	Bridge/Culvert	100-Yr	37.80	47.35	37.60	47.35	35.00	0.57	2.50	7.05	7.05	26.87	41.34	44.34	46.18	47.52	4.89	4.53	4.30	4.11	4.42	4.00	3.72	3.50
980a2	FVSTORM-01469S	FVSTORM-02062S	Bridge/Culvert	100-Yr	38.00	47.35	37.80	47.35	35.00	0.57	2.50	6.85	6.85	26.87	40.89	43.83	45.56	46.78	4.42	4.00	3.72	3.50	2.39	1.67	1.20	0.85
980b1	FVSTORM-02062S	FVSTORM-01470S	Bridge/Culvert	100-Yr	37.80	47.35	37.60	47.35	35.00	0.57	2.50	7.05	7.05	26.87	41.34	44.34	46.18	47.52	4.89	4.53	4.30	4.11	4.42	4.00	3.72	3.50
980b2	FVSTORM-01469S	FVSTORM-02062S	Bridge/Culvert	100-Yr	38.00	47.35	37.80	47.35	35.00	0.57	2.50	6.85	6.85	26.87	40.89	43.83	45.56	46.78	4.42	4.00	3.72	3.50	2.39	1.67	1.20	0.85
FVW_CULV	FVW_PVT DRIVE_US	FVW_PVT DRIVE_DS	Bridge/Culvert	100-Yr	143.62	147.13	142.84	147.13	37.60	2.07	3.00	0.51	0.51	70.99	34.96	36.05	36.05	36.05	1.85	1.81	1.81	1.81	0.31	0.00	0.00	0.00
Halsey_1	Hlsy_w2	Hlsy_w3	Bridge/Culvert	100-Yr	147.98	155.24	149.12	155.08	62.28	-1.94	1.50	5.76	5.76	14.64	10.27	10.66	10.67	10.66	3.56	1.50	1.07	0.84	2.17	1.56	1.20	0.97
L38	N41	N42	Bridge/Culvert	100-Yr	148.27	154.11	148.20	154.11	46.77	0.15	3.00	2.84	2.84	23.96	35.69	39.23	41.22	42.55	1.99	1.55	1.29	1.14	1.09	0.47	0.10	0.00
FVC_0560	FVC_N_0560	FVSTORM-01432S	Creek	100-Yr	145.24	149.81	144.61	149.81	67.20	0.94	2.97	1.60	1.60	167.68	257.13	310.51	323.87	342.99	1.87	1.46	1.36	1.22	1.04	0.74	0.66	0.55
FVC_0580	FVC_N_0580	FVC_N_0560	Creek	100-Yr	144.08	159.20	145.24	149.81	409.24	-0.28	2.98	12.14	12.14	76.17	257.07	310.45	323.90	343.54	1.04	0.74	0.66	0.55	9.54	9.17	9.08	8.95
NNC_0050	NNC_N_0050	FVSTORM-01469S	Creek	100-Yr	38.20	58.20	38.00	47.35	20.00	1.00	6.00	14.00	14.00	666.54	81.84	87.62	91.14	93.52	2.39	1.67	1.20	0.85	13.24	12.52	12.05	11.70
NNC_0130	FVW_FB1_DS	FVSTORM-00930N	Creek	100-Yr	139.33	143.44	130.30	135.00	88.52	10.20	3.94	0.17	0.17	784.51	38.74	41.11	41.11	41.11	0.21	0.00	0.00	0.00	3.11	3.09	3.09	3.09
NNC_0150	FVW_FB2_DS	FVW_PVT DRIVE_US	Creek	100-Yr	145.82	149.45	143.62	147.13	115.47	1.39	2.37	1.26	1.26	75.88	38.76	43.14	45.33	46.91	0.31	0.00	0.00	0.00	1.66	1.58	1.56	1.54
NNC_0170	NNC_N_0160	N40	Creek	100-Yr	150.00	154.00	149.03	154.94	390.00	0.25	2.82	1.18	1.18	25.89	51.53	59.92	64.93	65.87	1.86	1.26	0.89	0.66	0.33	0.00	0.00	0.00
557a	N_55	FVSTORM-00928N	Ditch/Channel	50-Yr	117.75	120.75	112.89	115.89	392.00	1.24	3.00	0.00	0.00	101.73	15.35	15.86	15.90	15.94	0.54	0.50	0.50	0.50	2.22	2.20	2.20	2.20
L207b	N40	Hlsy_w2	Ditch/Channel	50-Yr	149.03	154.94	147.98	155.24	322.67	-0.14	5.43	0.48	0.48	179.99	11.83	15.78	18.70	20.17	2.17	1.56	1.20	0.97	1.86	1.26	0.89	0.66
L37	N40	N41	Ditch/Channel	50-Yr	149.03	154.94	148.27	154.11	383.70	0.20	3.04	2.87	2.87	58.31	34.82	37.95	39.86	42.84	1.09	0.47	0.10	0.00	1.86	1.26	0.89	0.66
558	FVSTORM-00930N	FVSTORM-00929S	Pipe - Trunk	50-Yr	130.30	135.00	129.38	138.38	20.00	2.10	2.50	2.20	2.20	59.44	38.74	40.05	40.05	40.05	7.93	7.91	7.91	7.91	0.21	0.00	0.00	0.00
601	FVSTORM-00928N	FVSTORM-00927S	Pipe - Trunk	50-Yr	112.89	115.89	108.47	119.22	28.00	13.00	2.00	1.00	1.00	81.57	15.35	15.86	15.90	15.94	9.79	9.76	9.74	9.72	0.54	0.50	0.50	0.50
1577	UBC-DET	N41	Pipe - Lateral	25-Yr	150.66	155.72	148.27	154.11	11.00	0.70	1.00	4.06	4.06	3.40	2.81	3.32	3.64	3.85	1.09	0.47	0.10	0.00	2.69	2.06	1.68	1.45
491	FVSTORM-00790S	FVSTORM-00495S	Pipe - Lateral	25-Yr	134.27	138.58	132.68	139.72	174.97	0.29	1.00	3.31	3.31	1.92	1.53	1.62	1.64	1.63	4.64	2.30	1.29	1.20	3.26	0.87	0.00	0.00
494	FVSTORM-00793S	FVSTORM-00790S	Pipe - Lateral	25-Yr	137.44	140.76	134.27	138.58	329.00	0.75	0.50	2.82	2.82	0.49	0.15	0.24	0.27	0.27	3.26	0.87	0.00	0.00	3.13	2.76	1.60	1.47
497	FVSTORM-00797S	FVSTORM-00790S	Pipe - Lateral	25-Yr	135.03	140.02	134.27	138.58	182.30	0.36	1.00	3.99	3.99	2.14	0.21	0.34	-0.43	-0.52	3.26	0.87	0.00	0.00	4.68	2.31	1.41	1.42
Link1005	Node2150	FVSTORM-04021S	Pipe - Lateral	25-Yr	71.01	74.00	66.72	74.80	77.50	4.49	1.00	1.99	1.99	7.55	8.04	8.09	8.08	8.09	4.64	4.63	4.63	4.63	0.00	0.00	0.00	0.00



Build-Out Deficiency Key Map

\-

Legend

- Fairview City Limits
- Basins
- Taxlots
- City Property
- Private CBs
- Catch Basins
- Private MHs
- Manholes
- Private Box Culvert
- Bridge; Box Culvert
- Private Pipe
- Pipe
- Tributary
- Pond
- Swale
- Settling Pond

Future Deficiencies Classification

- Bridge/Culvert
- Pipe - Trunk
- Pipe - Collector
- Creek
- Ditch/Channel

N

0 250 500 1,000 Feet

1 inch equals 500 feet

Consolidated Stormwater Master Plan

Cardno

Data Source: City of Fairview GIS

Fairview - No-Name Creek Basin

Build-Out Deficiencies

xpswmm/GIS ID	Upstream Node Name	Downstream Node Name	Designation	Design Storm	Node Properties				Conduit Properties						Modeled Flows				Upstream Node Freeboard				Downstream Node Freeboard			
					US Invert Elevation, ft	US Ground Elevation, ft	DS Invert Elevation, ft	DS Ground Elevation, ft	Length, ft	Slope %	Depth / Diameter, ft	US Cover, ft	DS Cover, ft	Design Capacity, cfs	10-Yr Flow, cfs	25-Yr Flow, cfs	50-Yr Flow, cfs	100-Yr Flow, cfs	10-Yr Flow, cfs	25-Yr Flow, cfs	50-Yr Flow, cfs	100-Yr Flow, cfs	10-Yr Flow, cfs	25-Yr Flow, cfs	50-Yr Flow, cfs	100-Yr Flow, cfs
99	FVSTORM-01470S	FVSTORM-02043N	Bridge/Culvert	100-Yr	37.60	47.35	38.00	43.51	177.05	-0.22	3.50	6.25	2.01	47.82	97.76	108.49	116.74	121.41	3.91	2.68	2.26	2.02	1.71	0.88	0.77	0.73
980a1	FVSTORM-02062S	FVSTORM-01470S	Bridge/Culvert	100-Yr	37.80	47.35	37.60	47.35	35.00	0.57	2.50	7.05	7.25	26.87	48.05	53.15	57.08	59.32	3.29	1.92	1.38	1.07	3.91	2.68	2.26	2.02
980a2	FVSTORM-01469S	FVSTORM-02062S	Bridge/Culvert	100-Yr	38.00	47.35	37.80	47.35	35.00	0.57	2.50	6.85	7.05	26.87	45.95	47.47	48.00	48.79	0.78	0.23	0.12	0.06	3.29	1.92	1.38	1.07
980b1	FVSTORM-02062S	FVSTORM-01470S	Bridge/Culvert	100-Yr	37.80	47.35	37.60	47.35	35.00	0.57	2.50	7.05	7.25	26.87	48.05	53.15	57.08	59.32	3.29	1.92	1.38	1.07	3.91	2.68	2.26	2.02
980b2	FVSTORM-01469S	FVSTORM-02062S	Bridge/Culvert	100-Yr	38.00	47.35	37.80	47.35	35.00	0.57	2.50	6.85	7.05	26.87	45.95	47.47	48.00	48.79	0.78	0.23	0.12	0.06	3.29	1.92	1.38	1.07
FVW_CULV	FVW_PVT DRIVE_US	FVW_PVT DRIVE_DS	Bridge/Culvert	100-Yr	143.62	147.13	142.84	147.13	37.60	2.07	3.00	0.51	1.29	70.99	35.66	36.05	36.05	36.05	0.11	0.00	0.00	0.00	1.82	1.81	1.81	1.81
Halsey_1	Hlsy_w2	Hlsy_w3	Bridge/Culvert	100-Yr	147.98	155.24	149.12	155.08	62.28	-1.94	1.50	5.76	4.46	14.64	10.50	10.63	10.62	10.61	1.98	1.41	1.04	0.83	3.44	1.30	0.92	0.70
L38	N41	N42	Bridge/Culvert	100-Yr	148.27	154.11	148.20	154.11	46.77	0.15	3.00	2.84	2.91	23.96	36.83	40.05	42.05	43.44	0.89	0.31	0.00	0.00	1.85	1.44	1.19	1.05
FVC_0560	FVC_N_0560	FVSTORM-01432S	Creek	100-Yr	145.24	149.81	144.61	149.81	67.20	0.94	2.97	1.60	2.23	167.68	258.24	311.78	324.48	338.96	1.04	0.73	0.66	0.58	1.86	1.45	1.36	1.25
FVC_0580	FVC_N_0580	FVC_N_0560	Creek	100-Yr	144.08	159.20	145.24	149.81	409.24	-0.28	2.98	12.14	1.59	76.17	258.17	311.71	324.57	339.91	9.54	9.16	9.07	8.97	1.04	0.73	0.66	0.58
NNC_0020	FVSTORM-02043N	NNC_N_0011	Creek	100-Yr	38.00	43.51	37.60	44.00	169.59	0.24	5.51	0.00	0.89	436.35	119.09	131.78	143.32	149.59	1.71	0.88	0.77	0.73	2.34	1.44	1.34	1.29
NNC_0050	NNC_N_0050	FVSTORM-01469S	Creek	100-Yr	38.20	58.20	38.00	47.35	20.00	1.00	6.00	14.00	3.35	666.54	91.27	101.26	107.09	110.84	11.63	11.08	10.97	10.91	0.78	0.23	0.12	0.06
NNC_0130	FVW_FB1_DS	FVSTORM-00930N	Creek	100-Yr	139.33	143.44	130.30	135.00	88.52	10.20	3.94	0.17	0.76	784.51	40.29	41.11	41.11	41.11	3.10	3.09	3.09	3.09	0.00	0.00	0.00	0.00
NNC_0150	FVW_FB2_DS	FVW_PVT DRIVE_US	Creek	100-Yr	145.82	149.45	143.62	147.13	115.47	1.39	2.37	1.26	1.14	75.88	40.34	44.50	46.65	48.20	1.63	1.57	1.54	1.52	0.11	0.00	0.00	0.00
NNC_0170	NNC_N_0160	N40	Creek	100-Yr	150.00	154.00	149.03	154.94	390.00	0.25	2.82	1.18	3.09	25.89	51.34	59.64	62.90	65.20	0.23	0.00	0.00	0.00	1.67	1.11	0.74	0.52
557a	N_55	FVSTORM-00928N	Ditch/Channel	50-Yr	117.75	120.75	112.89	115.89	392.00	1.24	3.00	0.00	0.00	101.73	15.85	15.94	16.00	16.02	2.20	2.20	2.19	2.19	0.50	0.50	0.50	0.50
L207b	N40	Hlsy_w2	Ditch/Channel	50-Yr	149.03	154.94	147.98	155.24	322.67	-0.14	5.43	0.48	1.83	179.99	12.38	17.27	19.84	21.39	1.67	1.11	0.74	0.52	1.98	1.41	1.04	0.83
L37	N40	N41	Ditch/Channel	50-Yr	149.03	154.94	148.27	154.11	383.70	0.20	3.04	2.87	2.80	58.31	35.75	38.66	41.73	44.05	1.67	1.11	0.74	0.52	0.89	0.31	0.00	0.00
558	FVSTORM-00930N	FVSTORM-00929S	Pipe - Trunk	50-Yr	130.30	135.00	129.38	138.38	20.00	2.10	2.50	2.20	6.50	59.44	40.05	40.05	40.05	40.05	0.00	0.00	0.00	0.00	7.91	7.91	7.91	7.91
601	FVSTORM-00928N	FVSTORM-00927S	Pipe - Trunk	50-Yr	112.89	115.89	108.47	119.22	28.00	13.00	2.00	1.00	8.75	81.57	15.85	15.94	16.00	16.02	0.50	0.50	0.50	0.50	9.76	9.71	9.68	9.67
827	FVSTORM-01406S	FVSTORM-01405S	Pipe - Lateral	25-Yr	170.98	175.90	170.50	176.80	95.00	0.50	0.67	4.25	5.63	0.86	2.59	2.60	2.60	2.60	0.00	0.00	0.00	0.00	4.87	4.81	4.76	4.74
1000	FVSTORM-01484S	FVSTORM-00867S	Pipe - Lateral	25-Yr	111.91	115.45	112.16	114.02	132.00	1.27	1.00	2.54	0.86	4.01	3.13	3.67	3.96	3.96	0.84	0.54	0.00	0.00	1.58	1.56	1.54	1.54
1489	FVSTORM-00495N	FVSTORM-00631S	Pipe - Lateral	25-Yr	136.91	139.14	132.86	139.46	22.85	3.28	1.00	1.23	5.60	6.45	0.90	1.04	1.08	1.07	0.20	0.00	0.00	0.00	0.53	0.32	0.32	0.32
1490	FVSTORM-00631S	FVSTORM-00495S	Pipe - Lateral	25-Yr	132.86	139.46	132.68	139.72	14.47	1.24	1.00	5.60	6.04	3.97	4.99	5.46	5.47	5.48	0.53	0.32	0.32	0.32	1.05	0.89	0.88	0.87
1491	FVSTORM-03344S	FVSTORM-00495N	Pipe - Lateral	25-Yr	137.06	139.26	136.91	139.14	29.41	-1.02	1.00	1.20	1.23	3.60	0.74	0.88	0.97	1.04	0.31	0.10	0.10	0.10	0.20	0.00	0.00	0.00
1494	FVSTORM-00632S	FVSTORM-00631S	Pipe - Lateral	25-Yr	136.96	139.69	132.86	139.46	48.47	1.49	1.00	1.73	5.60	4.34	2.70	3.17	3.47	3.66	0.49	0.18	0.10	0.05	0.53	0.32	0.32	0.32
1577	UBC-DET	N41	Pipe - Lateral	25-Yr	150.66	155.72	148.27	154.11	11.00	0.70	1.00	4.06	4.84	3.40	2.96	3.48	3.77	3.99	2.48	1.90	1.53	1.31	0.89	0.31	0.00	0.00
1579	FVSTORM-03429S	FVSTORM-04346N	Pipe - Lateral	25-Yr	150.69	155.72	150.66	155.72	5.50	0.50	1.00	4.03	4.06	2.63	3.07	3.60	3.93	4.15	0.77	0.67	0.62	0.58	0.81	0.72	0.68	0.65
327	FVSTORM-00661S	FVSTORM-00610S	Pipe - Lateral	25-Yr	122.42	124.63	122.12	123.92	40.00	0.65	0.67	1.54	1.13	0.98	0.73	0.84	0.91	0.95	1.57	0.52	0.49	0.47	0.98	0.00	0.00	0.00
328	FVSTORM-00610S	FVSTORM-00609S	Pipe - Lateral	25-Yr	122.12	123.92	120.48	124.68	41.11	4.23	0.83	0.97	3.37	4.50	0.84	0.95	0.95	0.97	0.98	0.00	0.00	0.00	1.77	0.77	0.76	0.75
329	FVSTORM-00609S	FVSTORM-00486S	Pipe - Lateral	25-Yr	120.48	124.68	119.00	124.98	28.17	3.62	0.67	3.53	5.31	2.30	2.98	3.18	3.17	3.21	1.77	0.77	0.76	0.75	3.73	2.69	2.48	2.33
360	FVSTORM-00506S	FVSTORM-00504S	Pipe - Lateral	25-Yr	149.68	154.42	148.61	153.13	300.70	0.35	1.00	3.74	3.52	2.12	1.07	1.09	1.10	1.10	1.26	1.23	1.21	1.26	0.09	0.00	0.00	0.00
361	FVSTORM-00504S	FVSTORM-00505S	Pipe - Lateral	25-Yr	148.61	153.13	147.14	154.74	354.52	0.39	1.00	3.52	6.60	2.21	2.92	2.93	2.95	2.95	0.09	0.00	0.00	0.00	3.91	3.72	3.65	3.60
363	FVSTORM-00652S	FVSTORM-00764S	Pipe - Lateral	25-Yr	151.34	153.12	149.68	154.61	91.17	1.44	1.00	0.78	3.93	4.27	0.52	-0.62	-0.69	-0.72	0.00	0.00	0.00	0.00	1.45	1.42	1.40	1.42
380	FVSTORM-00495S	FVSTORM-00493S	Pipe - Lateral	25-Yr	132.68	139.72	129.79	139.15	353.17	0.82	1.00	6.04	8.36	3.22	5.03	5.06	5.07	5.07	1.05	0.89	0.88	0.87	6.48	6.03	5.81	5.66
381	FVSTORM-00497S	FVSTORM-00631S	Pipe - Lateral	25-Yr	135.21	143.01	132.86	139.46	332.31	0.71	1.00	6.80	5.60	3.00	1.41	1.68	1.85	1.95	3.59	3.17	3.02	2.92	0.53	0.32	0.32	0.32
442	FVSTORM-00633S	FVSTORM-03344S	Pipe - Lateral	25-Yr	138.18	139.82	137.06	139.26	108.63	0.94	0.67	0.97	1.53	1.17	0.37	0.44	0.48	0.51	0.77	0.53	0.49	0.46	0.31	0.10	0.10	0.10
443	FVSTORM-00634S	FVSTORM-00633S	Pipe - Lateral	25-Yr	139.73	141.88	138.18	139.82	182.83	1.33	0.50	1.65	1.14	0.65	0.00	0.00	0.00	0.01	1.77	1.61	1.38	1.22	0.77	0.53	0.49	0.46
485	FVSTORM-00784S	FVSTORM-00632S	Pipe - Lateral	25-Yr	138.80	142.88	136.96	139.69	181.20	0.99	1.00	3.08	1.73	3.54	1.81	2.11	2.30	2.42	3.24	2.74	2.55	2.41	0.49	0.18	0.10	0.05
491	FVSTORM-00790S	FVSTORM-00495S	Pipe - Lateral	25-Yr	134.27	138.58	132.68	139.72	174.97	0.29	1.00	3.31	6.04	1.92	1.79	1.81	1.82	1.83	0.00	0.00	0.00	0.00	1.05	0.89	0.88	0.87
494	FVSTORM-00793S	FVSTORM-00790S	Pipe - Lateral	25-Yr	137.44	140.76	134.27	138.58	329.00	0.75	0.50	2.82	3.81	0.49	0.30	0.36	0.39	0.42	1.30	0.92	0.65	0.46	0.00	0.00	0.00	0.00
497	FVSTORM-00797S	FVSTORM-00790S	Pipe - Lateral	25-Yr	135.03	140.02	134.27	138.58	182.30	0.36	1.00	3.99	3.31	2.14	-0.79	-0.92	-0.89	-0.78	1.26	1.30	1.34	1.38	0.00	0.00	0.00	0.00
82	FVSTORM-02042S	FVSTORM-02043N	Pipe - Lateral	25-Yr	39.15	44.05	38.00	43.51	15.00	1.00	3.00	1.90	2.51	66.70	23.72	26.13	27.75	28.93	2.25	1.40	1.28	1.23	1.71	0.88	0.77	0.73
996	FVSTORM-01482S	FVSTORM-01484S	Pipe - Lateral	25-Yr	122.24	126.42	111.91	115.45	320.00	3.23	1.00	3.18	2.54	6.40	2.15	2.53	2.78	2.95	3.78	3.74	3.70	3.68	0.84	0.54	0.00	0.00
Link1005	Node2150	FVSTORM-04021S	Pipe - Lateral	25-Yr	71.01	74.00	66.72	74.80	77.50	4.49	1.00	1.99	7.08	7.55	8.06	8.08	8.10	8.08	0.00	0.00	0.00	0.00	4.63	4.63	4.62	4.62

About Cardno

Cardno is an ASX-200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage, and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

Cardno Zero Harm

Cardno ZERO HARM EVERY JOB. EVERY DAY.

At Cardno, our primary concern is to develop and maintain safe and healthy conditions for anyone involved at our project worksites. We require full compliance with our Health and Safety Policy Manual and established work procedures and expect the same protocol from our subcontractors. We are committed to achieving our Zero Harm goal by continually improving our safety systems, education, and vigilance at the workplace and in the field. Safety is a Cardno core value and through strong leadership and active employee participation, we seek to implement and reinforce these leading actions on every job, every day.