SPRING 2026
TUALATIN

CE 484: CIVIL & ENVIRONMENTAL ENGINEERING CAPSTONE
PORTLAND STATE UNIVERSITY

Hedges Creek Stormwater Management Study

Ghalyah Alawadhi, Hamza Almutairi, Dalal Bukhadhour, Nhy Le, Santos Damian, and Adam Hamling
Report Authors ▪ Portland State University

Patrick McLaughlin
Senior Instructor, Civil and Environmental Engineering ▪ Portland State University



UNIVERSITY OF OREGON
Portland State UNIVERSITY
CITY of TUALATIN
SCI Sustainable Cities Institute
SCYP Sustainable City Year Program

About SCI

The Sustainable Cities Institute (SCI) is an applied think tank focusing on sustainability and cities through applied research, teaching, and community partnerships. We work across disciplines that match the complexity of cities to address sustainability challenges, from regional planning to building design and from enhancing engagement of diverse communities to understanding the impacts on municipal budgets from disruptive technologies and many issues in between.

SCI focuses on sustainability-based research and teaching opportunities through two primary efforts:

1. Our Sustainable City Year Program (SCYP), a massively scaled university-community partnership program that matches the resources of the University with one Oregon community each year to help advance that community's sustainability goals; and
2. Our Urbanism Next Center, which focuses on how autonomous vehicles, e-commerce, and the sharing economy will impact the form and function of cities.

In all cases, we share our expertise and experiences with scholars, policymakers, community leaders, and project partners. We further extend our impact via an annual Expert-in-Residence Program, SCI China visiting scholars program, study abroad course on redesigning cities for people on bicycle, and through our co-leadership of the Educational Partnerships for Innovation in Communities Network (EPIC-N), which is transferring SCYP to universities and communities across the globe. Our work connects student passion, faculty experience, and community needs to produce innovative, tangible solutions for the creation of a sustainable society.

About SCYP

The Sustainable City Year Program (SCYP) is a yearlong partnership between SCI and a partner in Oregon, in which students and faculty in courses from across the university collaborate with a public entity on sustainability and livability projects. SCYP faculty and students work in collaboration with staff from the partner agency through a variety of studio projects and service- learning courses to provide students with real-world projects to investigate. Students bring energy, enthusiasm, and innovative approaches to difficult, persistent problems. SCYP's primary value derives from collaborations that result in on-the-ground impact and expanded conversations for a community ready to transition to a more sustainable and livable future.

Community partnerships are possible in part due to support from U.S. Senators Ron Wyden and Jeff Merkley, as well as former Congressman Peter DeFazio, who secured federal funding for SCYP through Congressionally Directed Spending.

About City of Tualatin

The City of Tualatin is a thriving, welcoming community of nearly 28,000 residents known for its exceptional quality of life, strong community involvement, and attractive location. Tualatin offers a balance of small-town charm and big-city access. Its strategic location 12 miles south of Portland and 30 miles north of Salem, at the crossroads of Interstates 5 and 205, combined with commuter rail access via the Westside Express Service (WES), makes Tualatin a vital hub for both residents and businesses in the Portland metropolitan area.



The city's history dates back to the mid-1800s and is rooted in entrepreneurship and transportation. From its early days as a ferry crossing and rail depot, Tualatin has grown into a forward-thinking city with a strong economic base. Today, its economy is anchored by key industry clusters in advanced manufacturing, software and technology, health and wellness, transportation and logistics, and corporate services.

Tualatin's residents enjoy over 200 acres of public parks and riverfront spaces, top-rated schools through the Tigard-Tualatin School District, and one of Oregon's premier shopping destinations—Bridgeport Village. The city is also rich in recreational and cultural offerings, including the famed Giant Pumpkin Regatta.

Downtown Tualatin, anchored by the Lake at the Commons, serves as a central gathering place for residents and visitors alike. With its blend of residential, retail, and office space surrounding a small manmade lake and public plaza, the Commons exemplifies the city's emphasis on livability and smart design.

Course Participants

CIVIL ENGINEERING STUDENTS

Ghalyah Alawadhi
Hamza Almutairi
Dalal Bukhadhour
Nhy Le
Santos Damian
Adam Hamling

Course Description

PORTLAND STATE UNIVERSITY CIVIL & ENVIRONMENTAL ENGINEERING (PSU CE 484):

Portland State University Civil & Environmental Engineering (PSU CE 484) is a capstone course covering engineering design processes, including owner design, professional constructor relationships, procurement procedures, project evolution; contracts, dispute resolution, bonds, warranties; construction documents, including specifications; cost estimating, planning, and scheduling; construction administration; group process, diversity, and leadership.

DESIGN REPORT

Hedges Creek Stormwater Management Study

Group: The Tualatin Creek-Its



June 7, 2026

Prepared by:

Adam Hamling
Dalal Bukhadhour
Ghalyah Alawadhi
Hamza Almutairi
Nhy Le
Santos Damian

Client: City of Tualatin

Portland State UNIVERSITY

Civil & Environmental Engineering Capstone

`

PROJECT DISCLAIMER

This report was prepared as part of a class project for the Civil and Environmental Engineering Project Management and Design course at Portland State University. The contents of this report were developed by the student authors and do not necessarily reflect the views of Portland State University and the City of Tualatin. The analyses, conclusions, and recommendations contained in the report should not be construed as an engineering report or used as a substitute for professional engineering services.

ACKNOWLEDGEMENTS

We would like to offer our sincere thanks and gratitude to the people that helped us with this report. Mike McCarthy, Quin Brunner, Sid Sin, Lauren Irving, and Abby McFetridge from the City of Tualatin had an important role in the development of this report. Thank you for taking time to share your knowledge and insight to help drive the project forward. Thank you to the faculty members at Portland State University that assisted with the project, including Dr. Samantha Hartzell, Dr. Annette Dietz, Dr. Gwynn Johnson, Dr. Scott Wells, and Pat McLaughlin, our project supervisor and mentor. Thank you to Megan Banks and the University of Oregon Sustainable City Year Program for including Portland State capstone groups in this year's edition of the program.

We offer gratitude for the land and our opportunity to be here today. Let us acknowledge our presence on the unceded homelands and waters of the Atfalati (“at-fall-uh-tee”) Kalapuyans (“cal-uh-poo-yuns”). Today they are represented by the Confederated Tribes of the Grand Ronde and the Confederated Tribes of the Siletz. It is our duty to acknowledge the generational impacts of settler colonialism, forced displacement, and assimilation on Native American families. We recognize these First Peoples, who coexisted in interdependent and sustainable relationships with the land: they are still here and connected to this place. We honor past, present, and future Indigenous members of the Tualatin community (City of Tualatin, Oregon, 2021).

`

TABLE OF CONTENTS

Executive Summary **3**
Introduction **5**
1.0 Project Understanding **5**
1.1 Project Overview 5
1.2 Existing Site Conditions 8
1.3 Stakeholders 10
2.0 Alternatives Analysis **10**
2.1 Selection Criteria 11
2.1.1 Cost 11
2.1.2 Environmental Impact and Pollution Management 11
2.1.3 Aesthetics 11
2.1.4 Ease of Maintenance 12
2.1.5 Efficiency of Land Use 12
2.1.6 Volume of Water Retained 12
2.2 Alternatives 12
2.2.1 No Action 12
2.2.2 Blue /Green Roofs with Drywells 13
2.2.3 Bioswales / Planters 14
2.2.4 Infiltration / Detention Vaults 15
2.3 Preferred Alternative 16
3.0 Design Development **17**
3.1 Bioswale Volume and Dimensions 17
3.2 Runoff Analysis 18
3.3 Area of Effectiveness Calculations 19
3.4 Vegetation for Bioswales 23
3.5 Construction Cost Estimate 27
3.6 Preliminary Construction Schedule 27
4.0 Design Requirements, Regulatory Compliance, and Permitting **29**
4.1 Design Requirements 29
4.2 Code Requirements 30
4.3 Permitting 31
4.4 Summary of Codes 31
5.0 Conclusion **35**
References **37**

`

APPENDICES

A: Drawings
B: Calculations
C: Construction Cost Estimate
D: Construction Schedule
E: Specifications
F: QC Checklist

LIST OF ABBREVIATIONS

BMP - Best Management Practice
DBH - Diameter at Breast Height
DEQ - Department of Environmental Quality
FEMA - Federal Emergency Management Agency
GIS - Geographic Information System
HDPE - High-density Polyethylene
IDF - Intensity, Duration, Frequency
MG - Million Gallons
PCSWMM - Personal Computer Storm Water Management Modeling
USDA - United States Department of Agriculture

`

EXECUTIVE SUMMARY

Hedges Creek flows through the city of Tualatin, Oregon and drains into the Tualatin River just north of the downtown area. This area is in the floodplain of the Tualatin River and has historically experienced high water and flooding events with regularity. The main causes of these issues are the high groundwater table, substantial impermeable areas, poor infiltration, and the water level in the Tualatin River backing up Hedges Creek. The City of Tualatin is focusing on revitalizing their downtown and this project's purpose is to develop strategies to help alleviate some of the stormwater flow causing flooding in the Hedges Creek watershed.

Hedges Creek watershed drains approximately 3,840 acres around the City of Tualatin resulting in a high peak flow at the time of concentration. The goal of the project is to reduce the peak flow during storm events as well as improve the water quality of the runoff. This led to the decision to design bioswales that can be modified to site specific dimensions in order to retain and slow runoff while simultaneously settling pollutants out of the water and allowing extended time for infiltration.

The bioswales are long and narrow and vary by site but will be designed to the maximum length available given the area and not more than eight feet wide to allow more time for particle settling. Vegetation will be chosen based on the current physical characteristics of the sites. The selection process involves examining the plants' height, diameter at breast height (DBH), originality, and the benefits after implementation. The slope is approximately 1.0% throughout the bioswale in order to prevent erosion and increase settling time. The capacity was determined based on a 2-year, 24-hour storm event per Oregon DEQ requirements, which is 2.5 inches of precipitation over 24 hours for Tualatin. There will be maintenance needed for each bioswale but should be minimal and consist of cleaning out sediment, clearing inlets and outlets of debris, and replanting vegetation if necessary.

The estimated cost to implement bioswales is $30.30 per square foot. This is a cost-effective measure to increase stormwater retention and improve water quality flowing into the waterways while only utilizing city property and maintaining parking areas needed for businesses and residences in the downtown area.

Other alternative stormwater management practices that were analyzed and could be useful for future development are green/blue roofs with dry wells and detention vaults. Permeable pavement could also be incorporated into feasible areas. These options can provide the same benefits as bioswales but are complex and cost prohibitive to install in

`

retrospect. However, a city code for new development to implement these strategies could be beneficial for the future of downtown Tualatin.

`

INTRODUCTION

This project is an analysis of stormwater management strategies in the Hedges Creek watershed in Tualatin, Oregon, with a focus on the downtown area of the city. The analysis was conducted by the Tualatin Creek-Its of the Portland State Civil & Environmental Engineering Department for their Capstone project. The client is the City of Tualatin, and they have an interest in increasing development in the downtown area while mitigating the effects of the waterways regularly flooding. The analysis will be conducted using PCSWMM hydraulic modeling software to determine the effectiveness of a given strategy. The following design report consists of background information, alternatives considered, and the design of the strategy or strategies that are determined to be in the best interests of the client and stakeholders.

1.0 PROJECT UNDERSTANDING

This section details the overarching aspects of the problem being investigated as well as the people that will have an interest in the project.

1.1 PROJECT OVERVIEW

The Downtown Tualatin Hedges Creek Stormwater Management Study was completed for the City of Tualatin as an analysis of stormwater management strategies in the Hedges Creek watershed due to stormwater issues affecting the downtown area. The city is revitalizing its downtown core and working to attract private investment in redevelopment projects. Stormwater management in the downtown area is challenging because of existing impervious development and could be discouraging redevelopment.

The purpose of the study was to provide a stormwater management analysis. The information gathered can be used by the city, community, and developers as a starting point during early redevelopment discussions. Future development projects would still be expected to complete a detailed site-specific stormwater analysis. The project also aims to provide a range of creative stormwater options that could address stormwater requirements while supporting a functional and attractive downtown environment.

Hedges Creek watershed intersects the downtown area and directs water from the north part of downtown to the Tualatin River. The Nyberg Creek watershed receives runoff from the south part of downtown and directs it east towards the same river. Hedges Creek has a greater flood risk than Nyberg Creek due to its elevation,

orientation, and watershed area (FEMA, 2026), which is why it is the focus of this analysis. When a flood reaches a significant elevation, such as the 125.2-foot flood in 1996, the flow from Hedges Creek and the Tualatin River will be redirected through downtown into the Nyberg Creek watershed (City of Tualatin, 2026).

The project location is the Hedges Creek drainage basin in western Tualatin. Hedges Creek starts just northwest of Tualatin High School, flows northwest under Tualatin Sherwood Road near 112th Avenue and then continues northeast to meet the Tualatin River just northwest of Boones Ferry Road. The downtown study area is near the confluence of Hedges Creek and the Tualatin River, within the floodplain. The city and project team identified the primary focus reach as the section of creek passing the community center and the walking trail. During high water conditions, water rises above the bridge in front of the community center and spreads into the community center parking lot. The project location is shown in Figures 1.1.1 and 1.1.2, which display the watershed extent and downtown focus.

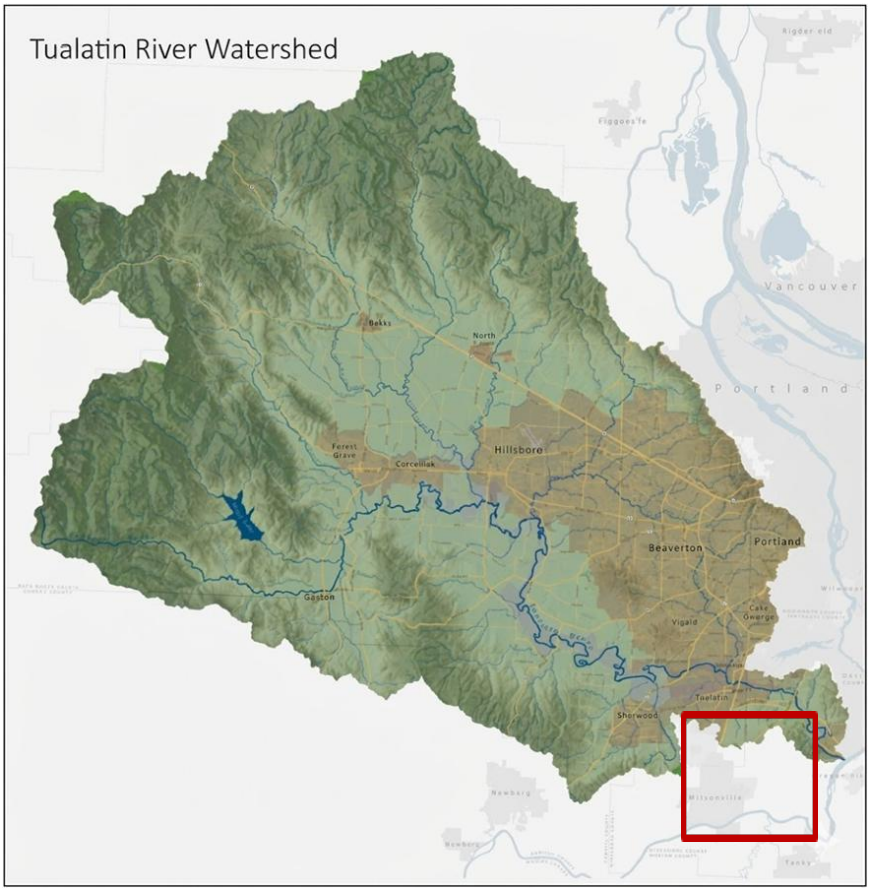


Figure 1.1.1*: Watershed map of the Tualatin River showing the location of the City of Tualatin in the red square.*

`

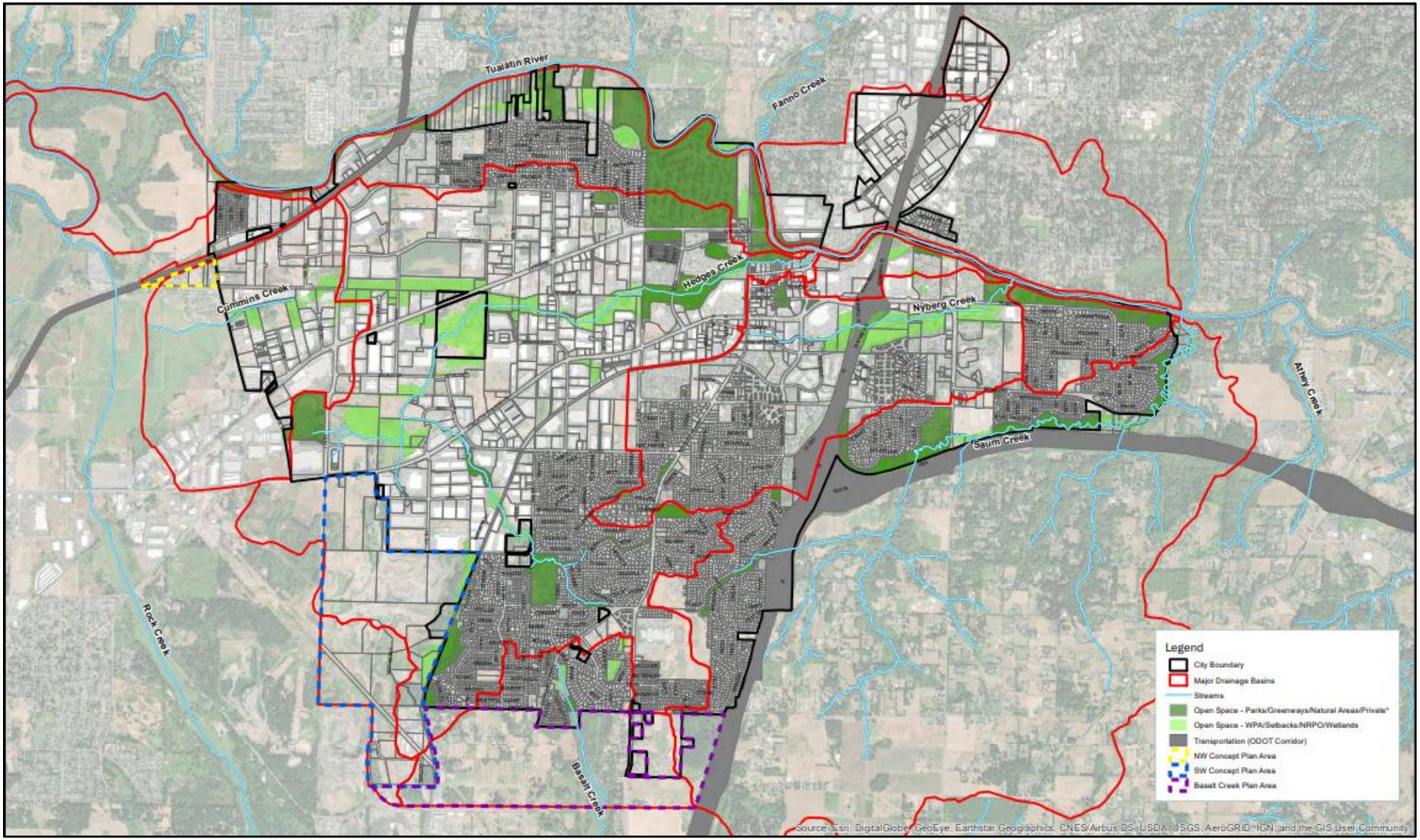


Figure 1.1.2*: Zoomed in view of Tualatin, Oregon showing the watershed boundaries.*

`

1.2 EXISTING SITE CONDITIONS

Downtown Tualatin is near the confluence of Hedges Creek and the Tualatin River. This entire area is in a floodplain and has flooded many times throughout the history of the city (Tualatin Historical Society, 2026). Hedges Creek currently has many large impermeable areas in close proximity contributing to excess stormwater runoff, which causes flooding near the mouth in the planned city park area. The creek starts northwest of Tualatin High School and flows north for about five miles. The slope for the entirety of the creek is very gradual without much elevation drop. The city operates a separate stormwater and wastewater system so runoff from the developments is flowing directly into the waterways.

There is one small reservoir just downstream from the start of Hedges Creek and wetland areas about one mile from the Tualatin River that gives way to a narrow section of creek with large impermeable areas along the southern banks. There is substantial riparian vegetation along the creek in the area around the park and also an undersized culvert under SW Tualatin Road just west of the park. The City of Tualatin is planning on developing the area around the mouth of Hedges Creek into a city park and Tualatin River access point and there are currently no structures east of the Juanita Pohl Center.

There are six different main soil classifications around the mouth of Hedges Creek and downtown Tualatin. They are cove silty clay loam, cove clay, Quatama loam, McBee silty clay loam, Chehalis silt loam, and Aloha silt loam. The wetland areas are predominantly clay which inhibits infiltration while the downtown region is mostly silt loam, as seen in Figure 1.2. The depth to the water table varies throughout the course of the creek, with less depth in the areas with clay, about 12 inches maximum, and greater depth ranging from 24 to 36 inches in the loam areas (USDA, 2026).

***Table 1.2**: Legend for the soil types in Figure 1.2.*

Map Symbol	Soil Type
1	Cove silty clay loam
2	Cove clay
3	Quatama loam
4	McBee silty clay loam
5	Chehalis silt loam
6	Aloha silt loam

`

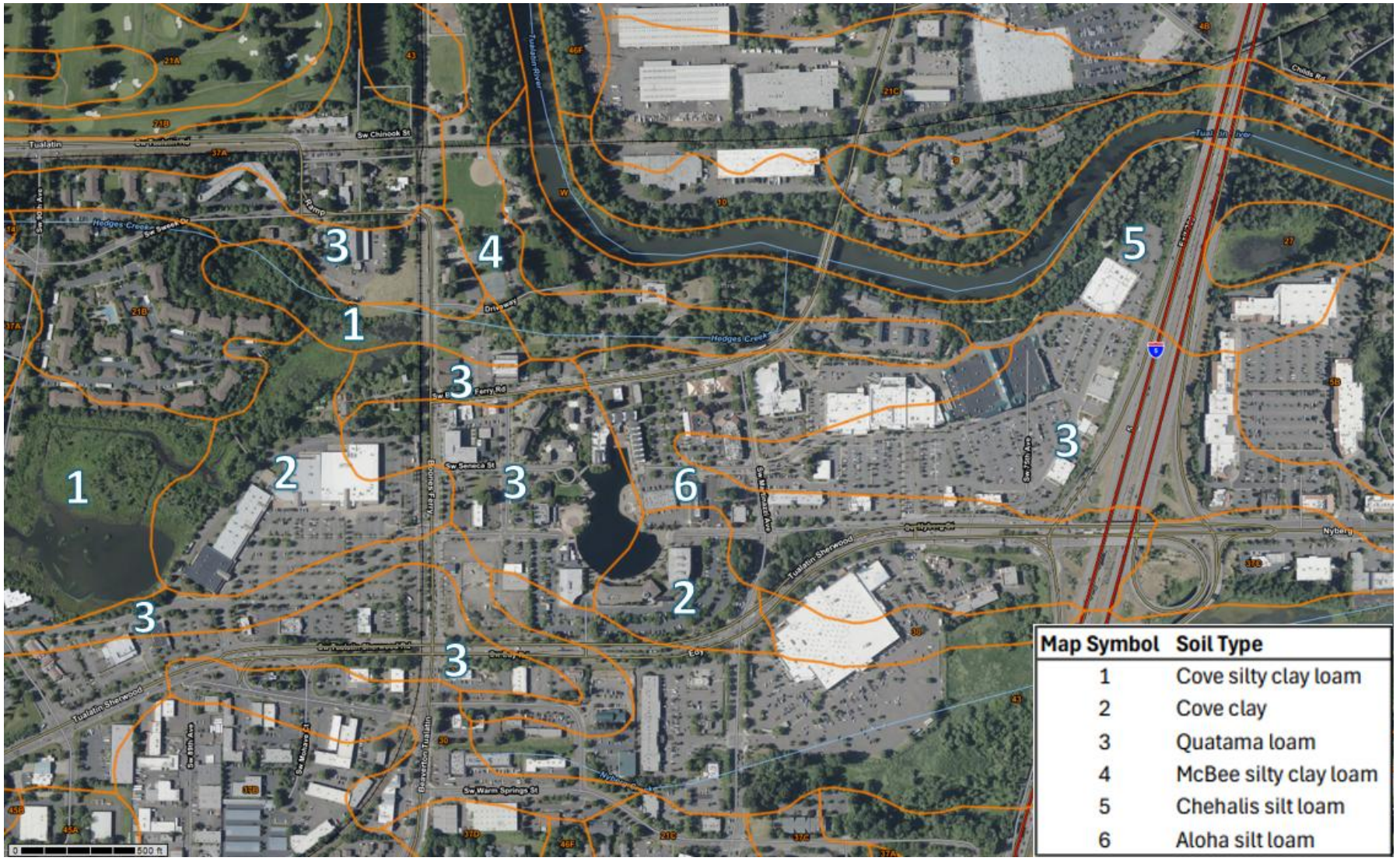


***Figure 1.2**: Aerial view of Downtown Tualatin showing different soil type zones.*

`

1.3 STAKEHOLDERS

This section acknowledges the stakeholders that are driving the project forward and their potential impact on the project and/or the project's impact on them. Megan Banks and the University of Oregon Sustainable City Year Program are using this analysis as part of their yearly initiative to connect students with cities that need help with specific projects. The program is a collaboration between students and the City of Tualatin to help enhance quality of life, support economic and community development efforts, and address sustainability goals (University of Oregon, 2026). The University of Oregon does not have an engineering program so Portland State University is providing engineering students for the project.

The community members of Tualatin who live, work, and recreate around the Hedges Creek watershed have a stake in the project as it could improve their public and private places. Commuters that pass through the area by foot and bicycle may benefit from improved stormwater management during rain events. The development could also beautify the area with new public spaces. Local businesses may also benefit from increased foot traffic to the area.

The City of Tualatin desires to improve stormwater management in the downtown area for increased development and community benefit. They will receive a document with proposed ideas from an outside perspective that they can use to allocate funding. City maintenance workers may also benefit from more controlled stormwater by alleviating some of the burden of flooding events. The ideal management plan would make their tasks easier, safer and more straightforward.

Potential developers may benefit from new stormwater management as they create new buildings or renovate existing areas. An update to building requirements could lay out a clear path to stormwater management for each development. This will help encourage growth as each property can work together to control runoff.

2.0 ALTERNATIVES ANALYSIS

Analysis of the downtown Tualatin area in regard to Hedges Creek was evaluated based on the impermeable areas that have been developed along the creek. The goal of the analysis was to determine the most efficient and cost-effective method to reduce stormwater runoff and improve water quality reaching the waterways. A major challenge with the Hedges Creek watershed is that it intersects the downtown area so only a small portion of the runoff streams toward the creek, while the majority of the stormwater would be directed to Nyberg Creek. However, in a major flooding event, based on the minor changes in elevation between the watersheds, the elevated water levels can lead to altered patterns of flow through the downtown area, causing floodwater from Hedges Creek and the Tualatin River to redirect through downtown to Nyberg Creek. Based on

these issues, there will be four alternatives assessed for this project. These alternatives will be ranked based on selection criteria developed with input from the client. These alternatives can be helpful but will not be effective in the case of a flood stage that reaches above 125 feet due to the limitations imposed by the Tualatin River.

2.1 SELECTION CRITERIA

Several criteria were chosen to evaluate the alternatives. These criteria were chosen with regard to the stakeholders needs and concerns. Each alternative may be combined with another method of stormwater management to accomplish different objectives. There will be a 1 through 4 ranking for each alternative criteria with 4 being the most favorable option and 1 being the least favorable in comparison to each other. The six criteria that will be considered are cost, environmental impact, aesthetics, pollution management, efficiency of land use, and volume of water retained. There will be a rubric at the end of the section displaying the outcome of the rankings and the chosen alternative moving forward.

2.1.1 COST

This is the driving factor for most projects and initial costs as well as yearly maintenance costs will be included for an overall cost impact analysis. These are estimates based on other similar projects and expert insight.

2.1.2 ENVIRONMENTAL IMPACT AND POLLUTION MANAGEMENT

The environmental impact criteria will focus on animal habitat, impact of construction, maintenance, and water quality. The Hedges Creek watershed runs into the Tualatin River which ends up in the Willamette River. This is an important waterway where many animals live and humans recreate. There will be a focus on limiting impact to aquatic species as stormwater management directly impacts their well-being. They were also evaluated based on their ability to remove pollutants from the water cycle and how well they are contained. The effectiveness of each method will be determined from studies conducted on each as well as insight from professionals.

2.1.3 AESTHETICS

The City of Tualatin would like to maintain a beautiful and attractive downtown area and an ideal solution would blend into its surroundings and enhance the area for those living and working there. The goal is for a walkable and cyclable region where stormwater management is present but unnoticed and has an enjoyable

street atmosphere. This ranking is subjective and based on visualized completion of the alternative.

2.1.4 EASE OF MAINTENANCE

Ease of maintenance was considered based on how often it needs to be performed as well as the difficulty level involved. Another factor used in the ranking is the number of people required, or equipment needed to safely and efficiently maintain the structure.

2.1.5 EFFICIENCY OF LAND USE

The area of land being used for the stormwater management strategy will be considered. The benefit of using the area for stormwater will be weighed against the value of the land as it is currently. An ideal space would be unused or underutilized and could be worked into the stormwater management plan.

2.1.6 VOLUME OF WATER RETAINED

This factor is very important as the alternative that retains and slows down the peak stormwater flow at the highest level will have the greatest impact on flooding. This may or may not help with pollution management and the ranking will be solely dependent on stormwater retention. Delaying stormwater from reaching Hedges Creek will allow time for a storm's peak intensity to pass and help slow down significant flooding.

2.2 ALTERNATIVES

The following alternatives were considered as well as a potential combination of multiple options to achieve the desired results based on the selection criteria.

2.2.1 NO ACTION

The first and simplest approach to the Hedges Creek stormwater management strategy is to take no action. There are already devices and strategies in place to mitigate some of the issues that affect the city. Hedges Creek mainly floods because of the elevated water level of the Tualatin River causing the creek to back up. Further urbanization along the creek will continue to exacerbate flooding issues (FEMA, 2018) and unless measures are taken further upstream on the Tualatin River, these flooding events will occur with regularity. This option provides cost savings but does nothing to address stormwater management or the quality of the runoff. More aggressive stormwater management techniques and

requirements further up the Hedges Creek watershed and an examination of flood mitigation strategies upstream of the Tualatin River would be beneficial but are outside the scope of this project.

2.2.2 BLUE /GREEN ROOFS WITH DRYWELLS

The blue/green roof with dry wells alternative directs stormwater at the construction scale by incorporating rooftop retention, controlled detention, and subsurface infiltration to decrease peak discharge and total runoff volume entering the downtown stormwater system. Rainfall is first taken in and retained within the engineered soil media from the green roof, where a part is removed through evapotranspiration, decreasing overall runoff volume. A substantial green roof with 3.0 - 4.0 inches of media can retain about 0.5 - 1.0 inches of rainfall before runoff begins. When combined with 1.0 - 2.0 inches of acceptable blue roof collecting, total roof storage is usually 1.5 - 3.0 inches of rainfall. The system is mostly effective for big storm events up to roughly 2.0 - 3.0 inches of rainfall, where retention and controlled detention substantially reduce peak discharge.

The system becomes overwhelmed when rainfall depth outperforms total storage or when rainfall intensity exceeds the restricted drain release, causing the dry wells to overflow and eventually the storm system. When medium to large storm events occur, excess water is temporarily stored on the roof surface by controlled flow restrictors that delay discharge and lower peak flow rates. Overflow is then redirected to underground dry wells for the water to infiltrate into native soils instead of directly entering storm pipes. This process converts rapid rooftop runoff into a partially infiltrated release that is delayed, reducing hydraulic loading to Hedges Creek during storm events.

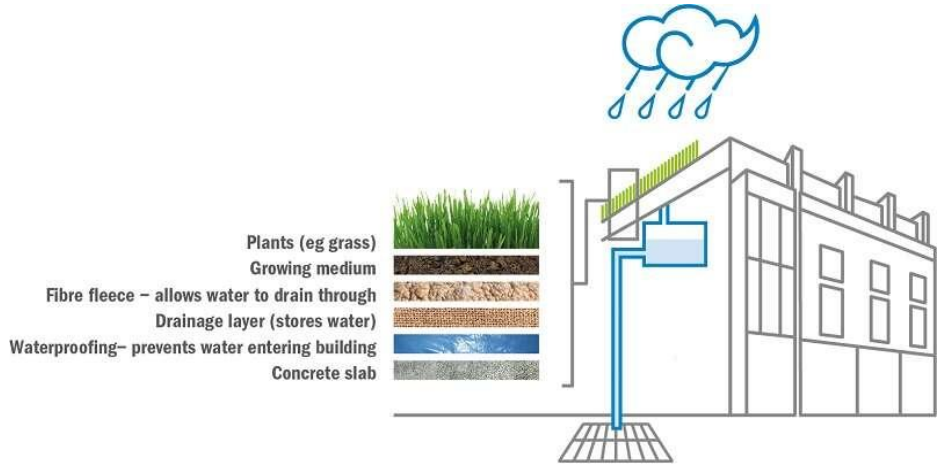


Figure 2.2.2: *Blue/Green Roof with Drywell Schematic from the Institution of Physics (IOP).*

`

Due to the highly impervious areas in downtown Tualatin, this alternative shows effective flood mitigation and water quality advantages without needing additional surface footprint, which is aligned with redevelopment goals while still benefiting stormwater capacity limitations.

2.2.3 **BIOSWALES / PLANTERS**

Bioswales, also known as planters, function as a combination of temporary detention units and filtration systems. They collect rainfall runoff from the roofs and the streets (including sidewalks), then channel it into a small concrete-walled detention basin with vegetation via downspouts, curb cuts, or inlets. Runoff is temporarily stored in a shallow basin, then filtered through plant roots and engineered soil. During the filtration process, sediments and chemical toxins are trapped in the roots and the engineered soil. As a result, the runoff either drains into the stormwater system through an underdrain or infiltrates native soil.

Bioswales are able to slow down peak flows while detaining sediments and filtering pollutants, such as chemical toxins and wastes released by transportation systems, and man-made products. They can also filter nutrients such as nitrogen, phosphorus, and potassium that can have adverse effects on the nearby bodies of water in large enough quantities.



Figure 2.2.3: *Bioswale in Pleasant Plains, Washington D.C. Picture taken by Erica Fischer.*

Choosing the right vegetation is essential in building a bioswale. Based on the local site conditions and the size of multiple bioswales combined, numerous vegetation options can be combined and chosen from the local flora. As the flora needs to be drought tolerant, juncus effuses, or common rushes, are often chosen. They are a type of grass that generally performs well under the mentioned conditions. These grasses are evergreen, wet-tolerant, slow down water, and allow sediment pollution to settle out of the stormwater. When customizing, other vegetation types can be considered as needed to fit the local rainfall and runoff conditions.

2.2.4 INFILTRATION / DETENTION VAULTS

There are various types of infiltration vaults that could be considered. The most common are a horizontal pipe with holes pierced through it or an open-bottomed corrugated plastic pipe that serves as a temporary subsurface water storage until it infiltrates the soil. They are also generally made using thermoplastics like polypropylene or polyethylene (HPDE). A rock trench can also be added to serve as a soakage trench. According to section 3.3.3 from the City of Gresham's Stormwater Management Manual, any type of infiltration vaults should be installed in well-draining soil. However, they have been used in infiltration areas with infiltration rates less than two inches per hour. DEQ regulations require a minimum five foot vertical separation between the bottom of the trench and seasonal high ground water.

There are also detention vaults, usually designed as tanks, vaults, and oversized pipes that detain stormwater and slowly release it. Known for their durability, withstanding corrosive chemicals, heavy surface loadings, and electrochemical soil conditions, they do require a sedimentation manhole to funnel upstream sediment to the vault. The manhole does create poor water quality that will need to be addressed. These storage vaults can serve as a downstream detention facility in areas where infiltration cannot be achieved. The maximum depth of a vault or tank invert is 20 feet, while the maximum internal depth is only 3 feet. These options are not a feasible option in many areas in Tualatin because of the high water table.

`



Figure 2.2.4: *Typical detention vault.*

2.3 PREFERRED ALTERNATIVE

The preferred alternative for this project is the design and construction of bioswales within the Hedges Creek watershed. This approach was chosen based on the scoring of the six criteria. Table 2.3 shows the selection matrix with the results of the analysis. The alternatives were ranked in comparison to each other with four being the best option for that criterion and one being the least preferred. Bioswales received high scores in each category and can be implemented in many different ways to alleviate stormwater flow and mitigate pollution. The constructability of bioswales is straightforward and provides long-term runoff management with limited maintenance.

Table 2.3: *Selection matrix displaying the criteria.*

Selection Matrix (Scored 1-4)				
Criteria	No Action (2.2.1)	Green / Blue Roofs (2.2.2)	Bioswales (2.2.3)	Vaults (2.2.4)
Cost	4	2	3	1
Environmental	1	4	3	2
Aesthetics	2	3	4	1
Maintenance	4	1	3	2
Land Use	1	4	3	2
Water Retained	1	2	3	4
Total	13	16	19	12

`

The scoring system in Table 2.3 was based on publicly available data, industry professional's input, and the team's judgment to determine the most favorable option. The scoring reflects the advantages and limitations of each alternative considered. The focus of the design will be bioswales because they will be the simplest to retrofit into the existing systems. However, for new developments, green/blue roofs with dry wells and vaults could be a viable option to manage more stormwater flow. These could also be combined with permeable pavement in order to reduce impermeable surfaces in areas with sandy and loamy soil.

3.0 DESIGN DEVELOPMENT

This section details the design process that will be presented to the client. There will be a standard bioswale design as well as options for customization depending on the space available. The analysis will estimate the volume of water that the bioswales can contain and how it will help slow down peak runoff during storm events. Modeling will be conducted based on the chosen locations of new bioswales to estimate the effectiveness of the method.

Bioswales are used to minimize runoff and filter pollutants, especially the contaminants of a "first flush," which occurs during the first rainfall after an extended dry period. However, their stormwater detention capability is limited so the number of bioswales developed will need to be higher to impact runoff. They are low-cost technology with relatively simple and quick implementation. Little maintenance is required once they are established.

3.1 BIOSWALE VOLUME AND DIMENSIONS

The proposed bioswales are intended to function as long and narrow vegetated stormwater facilities that collect, slow, temporarily store, and treat runoff before it reaches Hedges Creek. A long and narrow layout is preferred because it increases the length of the flow path through the facility, reduces runoff velocity, allows more time for sediment settling, and improves contact between stormwater, vegetation and engineered soil media. Since the proposed facilities are located in a developed environment, the exact dimensions of each bioswale will vary depending on available public space, existing pavement, parking areas, sidewalks, utilities, slopes, and maintenance access.

Initially, 20 bioswale locations were considered but after further research, two of the locations have existing stormwater management facilities so they were excluded from the analysis. Those two existing sites, 6 and 12, can be seen in Figure C in Appendix C. Each bioswale is assumed to have a maximum typical width of

approximately six feet where practical. This width is intended to keep the facilities narrow enough for retrofit conditions while still providing enough area for temporary ponding, vegetation, and treatment. The length of each bioswale varies by location and will be maximized where space allows. The current design assumes 18 conceptual bioswale locations with a total estimated bioswale area of 36,000 ft². This gives an average area of approximately 2,000 ft² per bioswale. If a six-foot typical width is used, the average representative bioswale length is approximately 333 feet. The preliminary sizing relationship used for the bioswale surface area is:

$$\text{Bioswale Surface Area} = \text{Length} \times \text{Width}$$

Temporary storage volume can be estimated by multiplying the surface area by the assumed ponding depth:

$$\text{Temporary Storage Volume} = \text{Surface Area} \times \text{Ponding Depth}$$

The final storage volume will depend on the actual length, width, side slopes or planter wall geometry, ponding depth, soil media depth and overflow elevation selected during final design. The bioswales are intended to have a gentle longitudinal slope of approximately 0.5% to 1.0% to reduce erosion and promote sediment settling. In areas where the groundwater table is high or infiltration is limited by soil conditions, an underdrain may be required. A liner may also be required where separation from groundwater or adjacent infrastructure is insufficient.

At this stage, the dimensions should be considered conceptual. The proposed locations and typical geometry are shown in Appendix A, and supporting preliminary sizing calculations are provided in Appendix B.

3.2 RUNOFF ANALYSIS

Modeling was conducted using PCSWMM software. IDF curves were based on rain gauges at Portland Community College - Sylvania. This method was used to analyze point precipitation data of storms. Using data from rain gauges, we generated IDF curves that helped determine the total rainfall for a specific time period. We used a SCS type 1A storm and the total rainfall to simulate a rain event and establish a baseline estimate of the amount of runoff possible in the Hedges Creek watershed. The goal is to compare the runoff value of predevelopment, current development, and post development. Other methods used in PCSWMM include Horton's infiltration model, where accurate infiltration rates may be unavailable.

`

3.3 AREA OF EFFECTIVENESS CALCULATIONS

Each bioswale will be designed for a maximum of five acres of contributing drainage area (Anderson County, 2013). Downtown Tualatin and the Hedges Creek watershed adjacent areas are calculated at roughly 140 acres based on measurements on Google Maps. However, the entire Hedges Creek watershed contributes runoff from approximately 3,840 acres within the city, (City of Tualatin Stormwater Master Plan, 2019) so there is substantially more runoff entering the downtown area from upstream. One bioswale per five acres is ideal with a focus on placement closer to downtown Tualatin. Each location will account for a differing area depending on impermeable surfaces and slopes. Due to using publicly available land, there will not be an even area per bioswale, but they will instead be placed where space permits and they can be most effective.

Areas for each bioswale were calculated using measurements from satellite imagery of the surrounding impermeable areas. The total area can be seen in Table 3.3. These effective area estimates could be greater if private organizations are willing to divert runoff from parking areas into stormwater management devices as well. This analysis is looking at only public use areas.

It was determined that the bioswales, at an average depth of 1 foot, would retain approximately 43% of the runoff for a 2-year, 24-hour storm over the effective area. If the groundwater levels and topography permit, an average depth of 2 feet per bioswale would accumulate approximately 86% of the same runoff, doubling storage capacity. The peak discharge was calculated using the Rational Method (ODOT, 2014). These calculations can be found in Appendix B.

In order to achieve the greatest size of effective area and contain the largest volume of runoff, it is recommended that the three bioswale locations that should be prioritized are 2, 3, and 8. These locations all cover a large amount of impermeable area while having enough slope to gather the runoff in intermittent locations. The priority locations can be seen in Figures 3.3.1, 3.3.2, and 3.3.3.

`



***Figure 3.3.1**: Location of proposed bioswale 2 on SW 124th Avenue.*



***Figure 3.3.2**: Location of proposed bioswale 3 on SW Tualatin-Sherwood Road.*

`



***Figure 3.3.3**: Location of proposed bioswale 8 on SW Herman Road.*

`

***Table 3.3**: Table of estimated effective areas for each planned bioswale.*

Bioswale Location	Estimated Effective Area in Square Feet	Acres
1	26,000	0.60
2	67,200	1.54
3	40,000	0.92
4	6,300	0.14
5	28,000	0.64
6	Existing	Existing
7	30,000	0.69
8	40,000	0.92
9	35,000	0.80
10	11,200	0.26
11	29,100	0.67
12	Existing	Existing
13	29,250	0.67
14	13,000	0.30
15	25,000	0.57
16	27,500	0.63
17	13,860	0.32
18	6,800	0.16
19	10,000	0.23
20	13,500	0.31
Total	451,710	10.37

`

3.4 VEGETATION FOR BIOSWALES

Vegetation selection for bioswales was performed using the iTree tool. In brief, iTree is a tool created and monitored by the USDA Forest Service in collaboration with five public and private entities: Davey Tree Expert Company, The Arbor Day Foundation, Urban and Community Forestry Society, International Society of Arboriculture, and Casey Trees. It provides peer-reviewed urban and forestry analysis, environment and economic benefits estimation, quantification of forest structure, and other researched benefits that tree provides. While the tool mainly focuses on trees, it also has a large database of other types of vegetation such as shrubs and herbaceous.

Considering limitations on which plants are appropriate for planting, the main limitation is identified as the high water table, which is only two feet deep on average. The high water table eliminates the selection of trees. Most trees have root configurations that will need more than two feet to grow and be established. Once established enough to bring in benefits, most trees' roots are about five to seven feet deep. With the high water table, planting trees will yield an unsuccessful outcome that might escalate the cost of maintenance due to tree deaths. Trees will die when there is no buffering room in the aggregated soil media to reach deeper. Having to consider tree deaths, the main selection of vegetation focuses on shrubs. In conjunction with the limitation, the main criteria in vegetation selection is the ability to be tolerant of drought during heavy rainfall seasons, such as fall and winter, and irregular precipitation patterns throughout the year. Table 2.5 provides detailed information about the chosen shrubs along with their images.

Figure B4.1 shows the pre-analysis parameters per iTree suggestions for any new project. This vegetation analysis utilizes these parameters. There are ten parameters which require the user's inputs. These inputs are shown on Figure B4.2 in Appendix B. iTree relies on these inputs to perform saving cost estimations for avoided runoff, and other items such as carbon sequestration and avoided, energy saved, and air pollution. The product of the performance is a graph showing the cumulative cost saved over forty years, as a result from planting the selected vegetation.

Regarding the content of the input parameters, referring to Figure 3.6, 44% of the total bioswales (8 out of 18) are south of their nearest building (6 being in south and 2 being in southeast). Hence the configuration of directions was generalized using the southern orientation. The method of generalizing the directions of the bioswales to the nearest building is merely an assumption made in order to fill in the Distance to

Nearest Building; more research should be conducted to yield a better method to identify the directions for the parameter. Per one location of bioswales and using their chosen standard dimensions, 2 of each type of shrubs are chosen to be planted. Since there are 6 types of shrubs, 12 plants will be planted per location. With 18 locations, the total number of shrubs is 216 plants. It is worth noting that spreading rush (scientifically named, *Juncus patens*) is not selected in this analysis, although its effectiveness in tolerating drought is the reason why this plant is popular to put in bioswales. *Juncus patens* is not chosen because iTree does not list it in the program. More research on this lack of listing of *Juncus patens* while using iTree is highly recommended. The chosen shrubs are a native species.

The result in Figure B5.1 shows the growth of the chosen shrubs over a 40-year life span. Figures B5.2 and B6 show that in the 40-year of project lifetime, the bioswales save $13,216 in runoff remediation, when planting at least 6 types and 216 plants of chosen vegetation at the same time. It should be noted that the costs of buying young bushes or saplings are not factored in the result. While there are small-business gardens and plant outlets along the west coast of Oregon and Washington state, the costs of transportation and buying the plants should be considered as alteration in vegetation selection might be needed.

Table 3.4: *Specifications of shrubs, with example images to show what the shrubs will look like once roots are established.*

Group Identifier	Common Name	Scientific Name	Image
5	Sparkleberry	*Vaccinium arboreum*	

`

Group Identifier	Common Name	Scientific Name	Image
8	Charity	*Mahonia ssp*	
9	European Black Elderberry	*Sambucus nigra*	

`

Group Identifier	Common Name	Scientific Name	Image
11	Manzanita	*Arctostaphylos*	
12	Grevillea species	*Grevillea*	
13	California Lilac	*Ceanothus*	

`

3.5 CONSTRUCTION COST ESTIMATE

The estimated cost for bioswales is $5.50 - $24.00 per square foot (NOAA, 2020). This estimate was from six years ago so we will adjust for inflation. Using an inflation adjustment calculator that updates our cost range to $6.94 - $30.30 per square foot (US Inflation Calculator, 2026). This cost includes design, engineering, permitting, materials, and installation.

The estimated bioswale area for this project is 36,000 ft^2 therefore the estimated cost for implementing 18 bioswale locations is $1,090,800. This can be updated going forward based on the designed length and width of each unit.

A table with a breakdown of estimated cost per bioswale can be found in Appendix C.

3.6 PRELIMINARY CONSTRUCTION SCHEDULE

The first step will be a survey of the areas to confirm elevations and that placement is within the right of way. Construction will begin with excavation and the removal of concrete if amending an existing impermeable area. This will be followed by grading the area to ensure a slope of about 1.0% along the length of the bioswale, if possible. The minimum slope will be at least 0.5%.
After the ground is prepped, concrete will be poured to create the detaining walls of the bioswale. The height of the walls will differ for each bioswale. The concrete will take time to cure so the planting of native grasses and plants will begin after a two day waiting period. Depending on the soil type and depth to groundwater table in the location, engineered soil might need to be put down to help with water retention and infiltration. Planting may also be delayed until the following spring for best results depending on the weather outlook.

A preliminary construction schedule for the initial round of bioswale implementation in chart form can be found in Appendix D. This schedule is for the completion of the three facilities with the highest importance.

`



Figure 3.6: *Satellite view of proposed bioswale locations marked by pink circles and Hedges Creek shown with the orange line. Downtown Tualatin is in the upper right corner of the image.*

`

4.0 DESIGN REQUIREMENTS, REGULATORY COMPLIANCE, AND PERMITTING

This section identifies the design requirements, code considerations, regulatory approvals and permits associated with the proposed bioswale facilities. The project is currently at the conceptual design stage and the requirements described in this section should be understood as preliminary design and permitting guidance rather than final agency approval.

4.1 DESIGN REQUIREMENTS

Bioswales are constructed to transport, slow, and treat stormwater runoff. The bioswale slope is established to allow for sufficient slowing of the water to prevent erosion within the bioswales. Bioswales typically drain areas of up to five acres in size. Prior to entering the bioswale channels, the areas should be stabilized to prevent erosion of the inlets, and pretreatment methods (such as grass filter strips) should be established to remove some of the sediment from the stormwater prior to entering the bioswale. The outlet structures of the bioswales are constructed to both allow for the release of the treated stormwater and to prevent erosion from occurring at the exit of the bioswales. Additionally, dense vegetation is planted within the bioswale channels to slow the movement of stormwater, filter pollutants from the stormwater, and to stabilize the soil.

Each bioswale should meet certain basic design requirements. Each bioswale site should be long and narrow in shape, with widths of approximately six feet where possible, and slopes of approximately 0.5% to 1.0% to ensure that the bioswales help to naturally settle some of the stormwater sediments. Runoff should enter bioswales through curb cuts, inlet openings, and spreaders. In some instances, pretreatment steps are performed in the bioswales prior to the main channels to remove some of the sediment from the stormwater prior to entering the bioswales.

Each bioswale should also include vegetation and soil that help treat the stormwater that passes through the bioswales. The bioswales should contain both wet-tolerant and drought-tolerant native plant species that can handle periods of dry weather as well as periods of inundation with stormwater. Additionally, access to the bioswales should be provided to allow for inspection and maintenance of the bioswale channels and vegetation. Vegetation within bioswales should not obstruct the movement of stormwater, the overflow of the bioswales, or access to those areas for maintenance.

The bioswales to be constructed within the study area of Tualatin will be affected by the area's high groundwater and variable soils. Each bioswale site will need to be

individually evaluated prior to construction. Where infiltration of stormwater into the bioswale site is limited, an underdrain should be constructed to allow for the conveyance of the treated bioswale water to a suitable discharge point. In instances where the bioswale depths are insufficient to separate the bioswale from the groundwater table and where infiltration of bioswale water could impact existing underground utilities, a liner will be constructed between the bioswale and those underground utilities. Each site will also need to be individually evaluated for specific requirements, after which the bioswale designs can be finalized following review of each proposal by the City of Tualatin.

4.2 CODE REQUIREMENTS

The bioswale facilities that are to be constructed will have to comply with the requirements that are applicable to the location. The City of Tualatin Public Works Construction Code will be the primary set of local regulations to which the bioswales will have to comply. The design of the bioswales must be approved by the City of Tualatin Engineering Division prior to construction.

A Public Works Permit will be required from the city for the work that will be performed on the site. That type of permit will be required due to the fact that the bioswale will involve drainage improvements, excavation, grading, pavement removal, and the potential for connection to existing stormwater infrastructure. The work that will be performed within the public right of way will have to comply with additional requirements of the city.

The requirements of the region's Clean Water Services will apply to bioswales. This organization publishes stormwater design information regarding vegetated swales and stormwater treatment facilities. The Oregon Department of Environmental Quality construction stormwater and erosion control requirements will be utilized in the development of the bioswales to ensure that the construction site will be managed in a way to minimize the negative impacts of stormwater runoff. The requirements of FEMA regarding floodplain mapping and development will apply to the bioswales. The area of study in downtown Tualatin is near both the Hedges Creek and Tualatin River floodplain.

The information that was published in Portland's 2025 Stormwater Management Manual will be utilized as only reference material for the bioswales. Specifically, the manual contains information about the design details of stormwater facilities in general. Such details will be referenced in the construction plans but will not be the final requirements of the City of Tualatin. The information from the manual can be

utilized as a concept for the bioswales but will have to be modified to meet the requirements of the city.

4.3 PERMITTING

Any construction of bioswales or stormwater infrastructure within Tualatin will require review and approval from the City of Tualatin Engineering Division. The Public Works Permit will likely be required to make drainage improvements to the area, especially if the bioswales are to be constructed within public areas, or if the bioswales will impact the existing stormwater infrastructure in that area. The Public Works Department will require construction plans and drawings of the bioswale to be constructed, calculations of the design of the bioswale, plans to control erosion within the bioswale, specifications regarding the construction of the bioswale, and plans to inspect the bioswale following its construction.

An Erosion Control Permit will be required for the site for the construction of the bioswales. The construction of bioswales will require excavation of the site, grading of the site, and removal of existing pavements or concrete from the site. Measures will be required both prior to and during the construction of the bioswales in order to prevent sediment from leaving the bioswales and entering the stormwater system, Hedges Creek, or the Tualatin River.

If any of the bioswales are constructed within a mapped floodplain then review of those areas will be required to ensure that construction of the bioswales will not have an unacceptable impact upon the floodplain.

A permit for performing work within the public right-of-way may also be required. Such a permit may be required for constructing bioswales within sidewalks, trails, public utilities, or roadways. In each of these areas, notice will be required for public utilities to be performed prior to excavation of bioswales. Each of these permits will impact the construction of bioswales and the cost of constructing those bioswales. Therefore, these permits and their costs should be included in any future implementation plans for constructing bioswales.

4.4 SUMMARY OF CODES

Table 4.4 summarizes the main codes, standards, permits and guidance documents that are expected to apply to the proposed bioswale design. These requirements should be verified during final design because agency requirements may change.

`

Table 4.4: *Summary of codes.*

Code, Standard, Permit or Reference	Responsible Agency / Source	Project Relevance	Application
City of Tualatin Public Works Construction Code	City of Tualatin	Provides design, material, workmanship, public improvement, utility, water quality facility and erosion/sediment control requirements for work within the City of Tualatin.	Used as the primary local reference for public stormwater infrastructure, bioswale construction requirements, materials, inspection and work affecting public improvements.
Public Works Permit	City of Tualatin Engineering Division	Required for public works improvements and work that may affect public infrastructure, drainage facilities or public ROW.	Final bioswale plans would need to be submitted to the City for review and approval before construction. The submittal would likely include drawings, calculations, specifications and inspection requirements.
Erosion Control / Construction Stormwater Requirements	Oregon Department of Environmental Quality and local permitting authority	Applies where excavation, grading, pavement removal or other soil-disturbing activities may create sediment laden runoff.	Bioswale construction would require erosion and sediment control measures before and during construction to prevent sediment from entering the stormwater system, Hedges Creek or the Tualatin River.

`

Code, Standard, Permit or Reference	Responsible Agency / Source	Project Relevance	Application
1200-C Construction Stormwater Permit Guidance	Oregon Department of Environmental Quality	Regulates construction stormwater discharges from qualifying construction activities to surface waters of the state.	The final design team should confirm whether 1200-C permit coverage or local equivalent construction stormwater approval is required based on the total disturbed area and final construction approach.
Clean Water Services Vegetated Swale Guidance	Clean Water Services	Provides regional stormwater guidance for vegetated swales, including flow control, treatment geometry, side slopes, detention time, and water quality performance.	Used as supporting guidance for bioswale geometry, stormwater treatment function, vegetation based filtration, and preliminary design assumptions.
FEMA Floodplain Mapping / National Flood Hazard Layer	Federal Emergency Management Agency	Identifies mapped flood hazard areas, including floodplain and floodway constraints near waterways.	Used to determine whether proposed bioswale locations may require floodplain development review or additional coordination because the project area is near Hedges Creek and the Tualatin River floodplain.

`

Code, Standard, Permit or Reference	Responsible Agency / Source	Project Relevance	Application
City of Portland 2025 Stormwater Management Manual and CAD Support Details	City of Portland Bureau of Environmental Services	Provides standard stormwater management facility details and CAD support files for planters, underdrains, overflow structures and planting layouts.	Used as reference material only for conceptual bioswale details. Details were adapted to the Hedges Creek site conditions and must be modified to meet City of Tualatin requirements during final design.
Portland Transportation Stormwater Facility Details	City of Portland Transportation	Provides standard details for inlets, planter walls, curb and outlet notches, beehive inlets, overflow structures, utility clearances, and liner pipe penetrations.	Used as optional reference material for inlet, outlet, overflow, wall, and underdrain-related CAD details in the conceptual drawing package.
Utility Notification Requirements	Oregon Utility Notification Center / Local Utility Providers	Requires utility notification and field utility locates before excavation to reduce the risk of damaging underground utilities.	Utility locates would be required before excavation for bioswales, underdrains, outlet structures, or any stormwater infrastructure connection.
Stormwater Facility Operation and Maintenance Guidance	Local stormwater review agency / stormwater design manuals	Stormwater facilities require long-term maintenance access, inspection, sediment removal, vegetation management, and inlet/outlet cleaning.	Used to identify future maintenance needs, including sediment removal, inlet and outlet clearing, vegetation replacement, and underdrain cleanout inspection.

`

5.0 CONCLUSION

The recommended design for the Hedges Creek Stormwater Management Study is to implement bioswales/planters at the eighteen locations that were selected within the downtown Tualatin and Hedges Creek study area. Bioswales were the preferred alternative to manage stormwater at these locations due to their ability to adapt to the available public space at those locations, provide temporary storage for stormwater, reduce the volume of stormwater runoff from the area, and provide benefits to the City of Tualatin of developing an area that is more visually attractive. The design includes 18 confirmed bioswale locations, an area of 36,000 ft² for the bioswales, and an estimated construction cost of $1,090,800 for installing bioswales at these locations.

The bioswales will help manage stormwater in a variety of different ways as they will help to manage stormwater runoff from numerous impervious surfaces within the watershed. The bioswales will allow for the settling of some of the stormwater sediments and pollutants prior to reaching Hedges Creek and improve the quality of the stormwater that runs into the creek and its tributaries.

However, there are some limitations to the bioswales proposal. While the bioswales are located at the 18 selected locations, the dimensions for those bioswales, and where various components of the bioswales will be located beneath the bioswale locations, are yet to be fully verified. The bioswale locations were determined through the use of mapping software, GIS software, general assumptions, draft calculations, and the use of standard references regarding stormwater management design details. The final bioswale designs will need to be determined through refined stormwater models that account for the high groundwater table.

While the bioswales will help to manage stormwater runoff into Hedges Creek, they will not eliminate flooding within the downtown area of Tualatin. The flooding issues are largely related to the connection of Hedges Creek to the Tualatin River, and the flooding that occurs with the Tualatin River. The bioswales will help with managing stormwater from the area but they will not eliminate flooding from that area. It is estimated that the bioswales will help to manage the smaller and more frequent storm events, reduce the amount of runoff that drains directly off of impervious surfaces into Hedges Creek, and improve the quality of that stormwater.

The next steps in the process will include a detailed PCSWMM model for the watershed to determine impact and effectiveness of the implementations at the chosen locations. The drawings, necessary calculations, and cost estimate will need to be updated for each bioswale site chosen for construction. This plan offers the City of Tualatin flexibility in

`

construction as they can choose to implement stormwater management strategies as they work on other infrastructure projects to ease the burden of labor and costs associated with these improvements.

`

REFERENCES

1Build. (June 10, 2021). The Most Expensive States to Build in. URL: https://www.1build.com/blog/commercial-construction-cost

Anderson County, South Carolina. (January 2013). Anderson County Technical Specification: WQ-06: Bioswales. URL: https://www.andersoncountysc.org/wp-content/uploads/2021/03/WQ-06_Bioswale_COMPLETE.pdf

Avent, T. (2024, October 13). *Re-imagining Mahonia - Juniper Level Botanic Garden*. Juniper Level Botanic Garden. URL: https://www.juniperlevelbotanicgarden.org/re-imagining-mahonia/

Baker, R. (March 5, 2022). The Ice Age Didn't Provide Tualatin's Only Floods. URL: https://www.tualatinhistory.org/did-you-know/meridianmarker-fd37b

Boston Landscape Co. (April 14, 2025). Bioswales: 7 Powerful Benefits for Sustainable Stormwater. URL: https://bostonlandscapeco.com/bioswales/

City of Gresham. (June 2025). *Stormwater Management Manual: An Implementation Guide for Development Projects*. URL: https://www.greshamoregon.gov/globalassets/city-departments/environmental-services/water-resources/watershed-management/2025-draft-stormwater-management-manual.pdf

City of Portland, Bureau of Environmental Services. (2025). Stormwater Management Manual Design Details and CAD Support Files. URL: https://www.portland.gov/bes/stormwater/2025-stormwater-management-manual/design-details-and-cad-support-files

City of Portland. (n.d.). Approved Street Tree Planting Lists. URL: https://www.portland.gov/trees/street-tree-planting-listsPortland.gov

City of Portland. (n.d.). How to Measure a Tree. URL: https://www.portland.gov/trees/tree-care-and-resources/how-measure-treePortland.gov

City of Tualatin. (n.d.). Flooding in our Area. URL: https://www.tualatinoregon.gov/publicworks/flooding-our-area

`

City of Tualatin. (n.d.). Public Works Construction Code. URL: https://www.tualatinoregon.gov/engineering/public-works-construction-code-0

City of Tualatin. (n.d.). Public Works Permit (PW). URL: https://www.tualatinoregon.gov/engineering/public-works-permit-pw

City of Tualatin. (February 2020). Draft Final Tualatin Stormwater Master Plan. URL: https://www.tualatinoregon.gov/sites/default/files/fileattachments/engineering/page/51931/draft-final_tualatin_stormwater_master_plan_feb2020-_web.pdf

City of Tualatin. (November 2021). *Proposed Acknowledgement of Native Land and People* (Publication 1 of 1). URL: https://mccmeetingspublic.blob.core.usgovcloudapi.net/tualtnor-meet-c8d51d1528644a17ae7b3de2a3745e18/ITEM-Attachment-001-5de5f7146e0a4f508d2f5fcb2847077e.pdf

Clean Water Services. (February 2022). Vegetated Swale. URL: https://cleanwaterservices.org/wp-content/uploads/2022/06/vegetated-swale-1.pdf

EUROPEAN ELDERBERRY Sambucus Nigra - 25+ SEEDS. (2026). Desertcart.com. URL: https://bahamas.desertcart.com/products/180072552-european-elderberry-sambucus-nigra-25-seeds

Federal Emergency Management Agency (FEMA). (n.d.). FEMA Flood Map Service Center: Search By Address. URL:https://msc.fema.gov/portal/search?AddressQuery=tualatin%20or

Fischer, E. (2018). *Bioswale* [Online Image]. Flickr. URL: https://www.flickr.com/photos/walkingsf/40369762221/

Grevillea spp. - Grevillea species | PlantMaster. (2025). Plantmaster.com. URL: https://plantmaster.com/plants/eplant.php?plantnum=6139&project=50538

i-Tree. (n.d.). i-Tree Tools. URL:https://www.itreetools.org/

Institute of Physics. (November 2019). *Blue-green roof*. URL: https://www.iop.org/explore-physics/physics-around-you/sustainable-building/blue-green-roof

`

Iowa Department of Natural Resources. (n.d.). Elderberry-Elder. URL: https://nursery.iowadnr.gov/Elderberry_p_167.html

Lofgren, K. (2024). *How to Grow and Care for Ceanothus (California Lilac)*. Gardener's Path. URL: https://gardenerspath.com/plants/ornamentals/grow-ceanothus/

market.foxleigha.com. (2025). Sparkleberry | 25+ Seeds | Farkleberry / Huckleberry | Vaccinium Arboreum / *Tree*. Foxleigha.com. URL: https://market.foxleigha.com/product-p-384358.html

Minnesota Pollution Control Agency. (n.d.). Design criteria for wet swale (wetland channel). URL: https://stormwater.pca.state.mn.us/design_criteria_for_wet_swale_wetland_channel

National Oceanic and Atmospheric Administration, Office for Coastal Management, Digital Coast. (July 2020). Nature-Based Solutions Installation and Maintenance Costs. URL: https://coast.noaa.gov/data/digitalcoast/pdf/nature-based-solutions-installation-maintenance.pdf

Oregon Department of Environmental Quality. (February 2021). Construction Stormwater Best Management Practices Manual: 1200-C NPDES General Permit. URL: https://www.oregon.gov/deq/wq/Documents/wqpBMPManual.pdf

Oregon Department of Transportation. (April 2014). ODOT Hydraulics Manual: Appendix F – Rational Method. URL: https://www.oregon.gov/odot/hydraulics/Docs_Hydraulics_Manual/Hydraulics-07-F.pdf

Oregon State University, Department of Horticulture. (n.d.). Mahonia aquifolium. URL: https://landscapeplants.oregonstate.edu/plants/mahonia-aquifolium

Portland Nursery. (n.d.). Juncus: Rush. URL: https://www.portlandnursery.com/grasses/juncus

Portland Nursery. (n.d.). Mahonia: Oregon Grape. URL: https://www.portlandnursery.com/natives/mahonia

`

Portland Nursery. (n.d.). Rain Gardens and Bioswales. URL: https://portlandnursery.com/docs/garden-planning/Rain-Gardens-and-Bioswales.pdf

Portland State University, Department of Civil and Environmental Engineering. (December 2014). *Civil and Environmental Departmental Style Guide* (Version 2.1). URL: https://drive.google.com/file/d/1fciIVdWHf8eZ169lzBJCx0BUSoWEzYdS/view

River City Environmental Inc. *Bioswale Remediation*. URL: https://rivercityusa.com/services/bioswale-remediation/

San Marcos Growers. (n.d.). Plant database: Plant display. URL: https://www.smgrowers.com/products/plants/plantdisplay.asp?plant_id=20

Sillick, J.M., Jacobi, W.R., and Hammond, E. (Reviewed August 2025). Healthy Roots and Healthy Trees. Colorado State University Extension. URL: https://extension.colostate.edu/resource/healthy-roots-and-healthy-trees/

Stoven, H. (2024). California Lilac (Ceanothus) for Western Oregon gardens. OSU Extension Service. URL: https://extension.oregonstate.edu/gallery/california-lilac-ceanothus-western-oregon-gardens

Stoven, H. (2024). Drought-tolerant landscape plants for Western Oregon: site selection and preparation. OSU Extension Service. URL: https://extension.oregonstate.edu/catalog/em-drought-tolerant-landscape-plants-western-oregon-site-selection-preparation

Stoven, H. (2025, April). Grevillea for Western Oregon gardens. OSU Extension Service. URL: https://extension.oregonstate.edu/gallery/grevillea-western-oregon-gardens

Stoven, H. (2024). Manzanitas for Western Oregon Gardens. OSU Extension Service. URL: https://extension.oregonstate.edu/gallery/manzanitas-western-oregon-gardens

Stoven, H., and Bell, N. (April 2025). Grevillea for Western Oregon Gardens. Oregon State University Extension Service. URL: https://extension.oregonstate.edu/gallery/grevillea-western-oregon-gardens

`

Stoven, H., and Bell, N. (July 2024). Drought-tolerant landscape plants for Western Oregon: Site Selection and Preparation. Oregon State University Extension Service. URL: https://extension.oregonstate.edu/catalog/em-drought-tolerant-landscape-plants-western-oregon-site-selection-preparation

Stoven, H., and Bell, N. (October 2024). Manzanitas for Western Oregon Gardens. Oregon State University Extension Service. URL: https://extension.oregonstate.edu/gallery/manzanitas-western-oregon-gardens

Theodore Payne Foundation. (n.d.). Juncus patens. https://theodorepayne.org/nativeplantdatabase/index.php?title=Juncus_patens

United States Department of Agriculture, Natural Resources Conservation Service, National Cooperative Soil Survey. (Generated on February 7, 2026). *Custom Soil Resource Report for Washington County, Oregon (Publication No.)*. URL: https://websoilsurvey.nrcs.usda.gov/app/

United States Department of Homeland Security, Federal Emergency Management Agency (FEMA). (October 19, 2018). *Flood Insurance Study Number 41067CV001B* (Publication No. 1 of 3). URL: https://map1.msc.fema.gov/data/41/S/PDF/41067CV001B.pdf?LOC=2b7d5898bd921ba5ea9900b4b125557f

United States Environmental Protection Agency. (December 2021). *Stormwater Best Management Practice: Green Roofs* (Publication No. EPA-832-F-21-031R). URL: https://www.epa.gov/system/files/documents/2021-11/bmp-green-roofs.pdf?utm_source=chatgpt.com

University of Oregon, Sustainable Cities Institute, Sustainable City Year Program. (n.d.). SCYP Faculty Guide. URL: https://sci.uoregon.edu/scyp-faculty-guide

US Inflation Calculator. (n.d.). Inflation Calculator: Find US Dollar's Value From 1913-2026. URL: https://www.usinflationcalculator.com/

Vega Civil Engineering, LLC. (May 2, 2022). Preliminary Drainage Report: Plambeck Gardens, 23500 & 23550 SW Boones Ferry Road, Tualatin, Oregon 97062. URL: https://www.tualatinoregon.gov/sites/default/files/fileattachments/planning/project/54341/preliminary_stormwater_report.pdf

`

West Virginia University Extension. (n.d.). Elderberry. URL: https://extension.wvu.edu/agriculture/horticulture/elderberry

`

APPENDICES

The following appendices are attached.

A. Drawings

B. Calculations

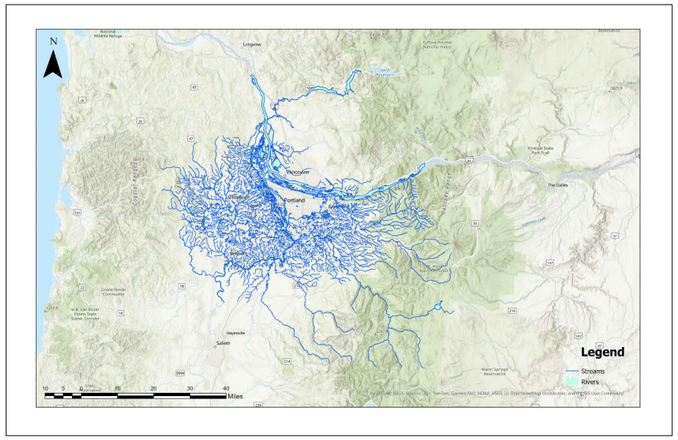
C. Construction Cost Estimate

D. Construction Schedule

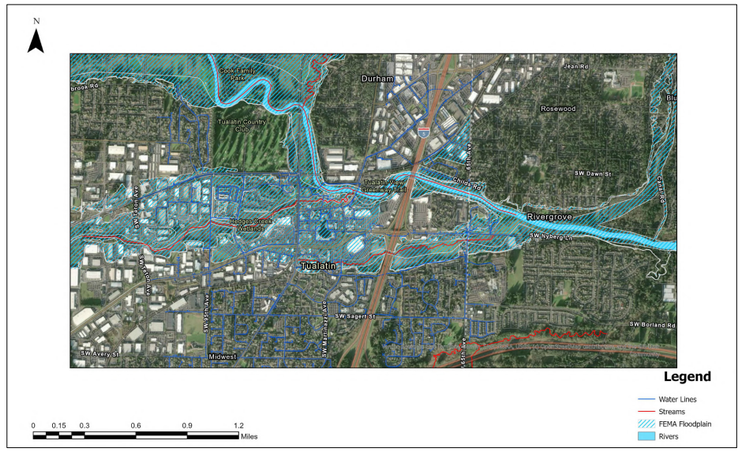
E. Specifications

F. QC Checklist

APPENDIX A
DRAWINGS



VICINITY MAP



HEDGES CREEK STUDY AREA

DESIGN INFORMATION

PROJECT: HEDGES CREEK STORMWATER MANAGEMENT STUDY
LOCATION: DOWNTOWN TUALATIN, OREGON, NEAR HEDGES CREEK AND THE TUALATIN RIVER
CLIENT: CITY OF TUALATIN
PROJECT TEAM: GROUP 2 – THE TUALATIN CREEK–ITS
PROJECT PURPOSE:
THE PROJECT EVALUATES CONCEPTUAL STORM WATER MANAGEMENT STRATEGIES FOR DOWNTOWN TUALATIN. THE PROPOSED DESIGN FOCUSES ON BIOSWALES/PLANTERS TO REDUCE RUNOFF VELOCITY, PROVIDE TEMPORARY STORM WATER STORAGE, IMPROVE WATER QUALITY, AND SUPPORT FUTURE DOWNTOWN REDEVELOPMENT.
DESIGN STATUS: DRAFT 3 – CONCEPTUAL DESIGN (NOT FOR CONSTRUCTION)
PREFERRED ALTERNATIVE: BIOSWALES / STORMWATER PLANTERS
ESTIMATED NUMBER OF BIOSWALE LOCATIONS: 20 CONCEPTUAL LOCATIONS
ESTIMATED TOTAL BIOSWALE AREA: 39,900 SQ FT
DESIGN STORM: 2–YEAR, 24–HOUR STORM EVENT
PRIMARY DESIGN CONSTRAINTS:
HIGH GROUNDWATER TABLE, FLOODPLAIN CONDITIONS, EXISTING IMPERVIOUS AREAS, LIMITED PUBLIC SPACE, EXISTING UTILITIES, AND RETROFIT CONSTRUCTION CONSTRAINTS.

ABBREVIATIONS

CAD – COMPUTER–AIDED DESIGN
CWS – CLEAN WATER SERVICES
DEQ – DEPARTMENT OF ENVIRONMENTAL QUALITY
FEMA – FEDERAL EMERGENCY MANAGEMENT AGENCY
HDPE – HIGH–DENSITY POLYETHYLENE
MG – MILLION GALLONS
NTS – NOT TO SCALE
ROW – RIGHT–OF–WAY
SWMM – STORMWATER MANAGEMENT MANUAL
TYP – TYPICAL
USDA – UNITED STATES DEPARTMENT OF AGRICULTURE

CODES AND DESIGN REFERENCES

THE FOLLOWING CODES, MANUALS, AND GUIDANCE DOCUMENTS WERE USED AS PRELIMINARY DESIGN REFERENCES:

1. CITY OF TUALATIN PUBLIC WORKS CONSTRUCTION CODE.
2. CITY OF TUALATIN PUBLIC WORKS PERMIT REQUIREMENTS.
3. CITY OF TUALATIN STORMWATER MASTER PLAN.
4. CLEAN WATER SERVICES STORMWATER DESIGN GUIDANCE AND VEGETATED SWALE REFERENCES.
5. OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY CONSTRUCTION STORMWATER BMP MANUAL.
6. FEMA FLOOD INSURANCE STUDY AND FLOODPLAIN MAPPING FOR WASHINGTON COUNTY, OREGON.
7. USDA NRCS SOIL SURVEY DATA FOR WASHINGTON COUNTY, OREGON.
8. CITY OF PORTLAND 2025 STORMWATER MANAGEMENT MANUAL AND STANDARD STORMWATER FACILITY DETAILS, USED AS REFERENCE DETAILS ONLY AND ADAPTED TO THE HEDGES CREEK SITE CONDITIONS.
9. PORTLAND STATE UNIVERSITY CIVIL AND ENVIRONMENTAL ENGINEERING CAPSTONE DESIGN REPORT INSTRUCTIONS AND CAD REFERENCE GUIDANCE.

INDEX OF SHEET

INDEX OF SHEET	SHEET TITLE
C–001	COVER SHEET
C–002	GENERAL NOTES
C–101	EXISTING CONDITIONS PLAN
C–102	PROPOSED BIOSWALE LOCATION
C–201	TYPICAL BIOSWALE PLAN & PROFILE
C–301	INLET, OUTLET & UNDERDRAIN DETAILS

GENERAL NOTES

1. THESE DRAWINGS ARE PRELIMINARY CAPSTONE DESIGN DRAWINGS PREPARED FOR THE HEDGES CREEK STORMWATER MANAGEMENT STUDY IN TUALATIN, OREGON.
2. THE PROPOSED BIOSWALE LOCATIONS AND DIMENSIONS ARE CONCEPTUAL AND SHALL BE FIELD VERIFIED PRIOR TO FINAL DESIGN OR CONSTRUCTION.
3. BASE MAPPING IS COMPILED FROM PUBLICLY AVAILABLE GIS DATA, AERIAL IMAGERY, FEMA FLOOD MAPPING, CITY OF TUALATIN INFORMATION, AND REGIONAL GIS SOURCES.
4. EXISTING CONDITIONS, PROPERTY LIMITS, UTILITIES, STORMWATER STRUCTURES, AND DRAINAGE PATHS SHOWN ON THESE DRAWINGS ARE APPROXIMATE.
5. FINAL DESIGN SHALL REQUIRE TOPOGRAPHIC SURVEY, UTILITY LOCATES, SOIL/INFILTRATION TESTING, GROUNDWATER VERIFICATION, AND CITY OF TUALATIN REVIEW.
6. BIOSWALE FACILITIES SHALL BE ADAPTED TO SITE–SPECIFIC CONDITIONS, INCLUDING AVAILABLE RIGHT–OF–WAY, EXISTING UTILITIES, GRADING, SOILS, AND GROUNDWATER DEPTH.
7. PROPOSED STORMWATER FACILITIES ARE INTENDED TO SLOW RUNOFF, PROVIDE TEMPORARY STORAGE, IMPROVE WATER QUALITY, AND REDUCE DIRECT DISCHARGE TO HEDGES CREEK.
8. BIOSWALES ARE NOT INTENDED TO ELIMINATE MAJOR FLOODING CAUSED BY TUALATIN RIVER BACKWATER CONDITIONS.
9. ALL FINAL WORK SHALL COMPLY WITH APPLICABLE CITY, STATE, FEDERAL, AND REGIONAL STORMWATER REQUIREMENTS.
10. SEE SHEET C–002 FOR ADDITIONAL NOTES, LEGEND, ABBREVIATIONS, AND DESIGN REFERENCES.

A	DRAFT 3 DRAWINGS/ PRELIMINARY	HA	05/01/26

REV:	DESCRIPTION:	BY:	DATE:
STATUS:			

PORTLAND STATE UNIVERSITY
DEPARTMENT OF CEE
GROUP 2 CAPSTONE PROJECT

CLIENT: CITY OF TUALATIN

GROUP MEMBERS:
GHALYAH ALAWADHI, HAMZA ALMUTARI
DALAL BUKHADHOUR, SANTOS DAMIAN
ADAM HAMLING, NHY LE

PROJECT TITLE: DOWNTOWN TUALATIN HEDGES CREEK STORMWATER MANAGEMENT STUDY
TITLE: COVER SHEET

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
1:50, 1:100	06/04/26	DJ	DJ

PROJECT NO:	DRAWING NO:	REVISION:
2	C-001	A

GENERAL NOTES

1. THESE DRAWINGS ARE PRELIMINARY CAPSTONE DESIGN DRAWINGS FOR THE HEDGES CREEK STORMWATER MANAGEMENT STUDY IN TUALATIN, OREGON.
2. THE DRAWINGS ARE INTENDED TO COMMUNICATE A CONCEPTUAL BIOSWALE / STORMWATER PLANTER DESIGN FOR DRAFT 3 REVIEW. THEY ARE NOT FOR CONSTRUCTION.
3. ALL EXISTING CONDITIONS SHOWN ARE APPROXIMATE AND BASED ON PUBLICLY AVAILABLE GIS DATA, AERIAL IMAGERY, PROJECT BACKGROUND INFORMATION, AND AVAILABLE STORMWATER REFERENCES.
4. FINAL DESIGN SHALL BE BASED ON FIELD SURVEY, RIGHT–OF–WAY VERIFICATION, UTILITY LOCATES, SOIL INVESTIGATION, INFILTRATION TESTING, GROUNDWATER VERIFICATION, AND CITY OF TUALATIN REVIEW.
5. FINAL CONSTRUCTION SHALL COMPLY WITH ALL APPLICABLE FEDERAL, STATE, REGIONAL, AND LOCAL REQUIREMENTS.
6. THE CONTRACTOR SHALL VERIFY ALL EXISTING CONDITIONS BEFORE CONSTRUCTION. ANY CONFLICTS SHALL BE REPORTED TO THE ENGINEER OR OWNER PRIOR TO PROCEEDING.
7. EXISTING UTILITIES, STORMWATER STRUCTURES, PROPERTY LIMITS, AND DRAINAGE FEATURES ARE APPROXIMATE AND SHALL BE FIELD VERIFIED
8. THE PROPOSED BIOSWALE LOCATIONS ARE CONCEPTUAL AND MAY BE ADJUSTED BASED ON GRADING, UTILITY CONFLICTS, AVAILABLE SPACE, MAINTENANCE ACCESS, AND CITY REVIEW.
9. BIOSWALES ARE PROPOSED TO REDUCE RUNOFF VELOCITY, PROVIDE TEMPORARY STORAGE, IMPROVE WATER QUALITY, AND REDUCE DIRECT RUNOFF TO HEDGES CREEK.
10. BIOSWALES ARE NOT INTENDED TO ELIMINATE LARGE–SCALE FLOODING CAUSED BY TUALATIN RIVER BACKWATER CONDITIONS.

CONSTRUCTION AND PERMITTING NOTES

1. PROPOSED WORK MAY REQUIRE REVIEW AND APPROVAL BY THE CITY OF TUALATIN ENGINEERING DIVISION.
2. A PUBLIC WORKS PERMIT MAY BE REQUIRED FOR DRAINAGE IMPROVEMENTS, WORK IN PUBLIC AREAS, OR CONNECTION TO PUBLIC STORMWATER INFRASTRUCTURE.
3. AN EROSION CONTROL PERMIT MAY BE REQUIRED FOR EXCAVATION, GRADING, PAVEMENT REMOVAL, OR OTHER SOIL–DISTURBING ACTIVITIES.
4. FLOODPLAIN DEVELOPMENT REVIEW MAY BE REQUIRED IF PROPOSED WORK FALLS WITHIN A MAPPED FLOODPLAIN OR FLOODWAY REVIEW AREA.
5. WORK WITHIN PUBLIC RIGHT–OF–WAY MAY REQUIRE RIGHT–OF–WAY PERMITTING, TRAFFIC CONTROL, PEDESTRIAN ACCESS CONTROL, AND UTILITY COORDINATION.
6. EROSION AND SEDIMENT CONTROL MEASURES SHALL BE INSTALLED PRIOR TO SOIL DISTURBANCE.
7. INLETS AND DOWNSTREAM DRAINAGE FEATURES SHALL BE PROTECTED DURING CONSTRUCTION.
8. DISTURBED AREAS SHALL BE STABILIZED AFTER CONSTRUCTION.

DESIGN BASIS

PROJECT TYPE:
CONCEPTUAL STORMWATER MANAGEMENT STUDY

PREFERRED ALTERNATIVE:
BIOSWALES / STORMWATER PLANTERS

DESIGN STORM:
2–YEAR, 24–HOUR STORM EVENT

ESTIMATED TOTAL BIOSWALE AREA:
36,000 SQ FT

ESTIMATED NUMBER OF BIOSWALE LOCATIONS:
18 CONCEPTUAL LOCATIONS

TYPICAL MAXIMUM BIOSWALE WIDTH:
6 FT

TYPICAL LONGITUDINAL SLOPE:
0.5% TO 1.0%

PRIMARY DESIGN CONSTRAINTS:
HIGH GROUNDWATER, FLOODPLAIN CONDITIONS, EXISTING IMPERVIOUS AREAS, AVAILABLE PUBLIC SPACE, UTILITIES, AND RETROFIT CONSTRUCTION LIMITATIONS.

STORMWATER / BIOSWALE DESIGN NOTES

1. BIOSWALES SHALL BE DESIGNED AS VEGETATED STORMWATER FACILITIES THAT COLLECT, SLOW, TEMPORARILY STORE, AND TREAT RUNOFF.
2. PROPOSED BIOSWALES SHALL BE ADAPTED TO AVAILABLE SITE CONDITIONS, INCLUDING PUBLIC SPACE, RIGHT–OF–WAY, EXISTING PAVEMENT, UTILITIES, SLOPES, SOILS, AND GROUNDWATER DEPTH.
3. PRELIMINARY DESIGN IS BASED ON A 2–YEAR, 24–HOUR DESIGN STORM.
4. TYPICAL BIOSWALE WIDTH SHALL NOT EXCEED APPROXIMATELY 8 FT WHERE PRACTICAL.
5. LONGITUDINAL SLOPE SHALL BE APPROXIMATELY 0.5% TO 1.0% WHERE PRACTICAL TO REDUCE EROSION AND PROMOTE SEDIMENT SETTLING.
6. INLET AREAS SHALL BE STABILIZED TO PREVENT EROSION AND SEDIMENT TRANSPORT INTO THE FACILITY.
7. OVERFLOW STRUCTURES SHALL BE PROVIDED WHERE REQUIRED TO SAFELY CONVEY FLOWS EXCEEDING FACILITY STORAGE CAPACITY.
8. UNDERDRAINS MAY BE REQUIRED WHERE INFILTRATION IS LIMITED BY HIGH GROUNDWATER, LOW–PERMEABILITY SOILS, OR ADJACENT INFRASTRUCTURE.
9. LINERS MAY BE REQUIRED WHERE GROUNDWATER SEPARATION IS INSUFFICIENT OR WHERE INFILTRATION MAY ADVERSELY AFFECT ADJACENT INFRASTRUCTURE.
10. FINAL FACILITY SIZING SHALL BE CONFIRMED AFTER CONTRIBUTING DRAINAGE AREAS ARE DELINEATED FOR EACH BIOSWALE LOCATION.

ABBREVIATIONS

BMP – BEST MANAGEMENT PRACTICE
CAD – COMPUTER–AIDED DESIGN
CWS – CLEAN WATER SERVICES
DEQ – DEPARTMENT OF ENVIRONMENTAL QUALITY
FEMA – FEDERAL EMERGENCY MANAGEMENT AGENCY
GIS – GEOGRAPHIC INFORMATION SYSTEM
HDPE – HIGH–DENSITY POLYETHYLENE
MG – MILLION GALLONS
NTS – NOT TO SCALE
ROW – RIGHT–OF–WAY
SF – SQUARE FEET
SWMM – STORMWATER MANAGEMENT MANUAL
TYP – TYPICAL
USDA – UNITED STATES DEPARTMENT OF AGRICULTURE

REFERENCE DETAILS

THE FOLLOWING STORMWATER DETAILS WERE USED AS REFERENCES AND ADAPTED TO THE HEDGES CREEK SITE CONDITIONS:

CITY OF PORTLAND STORMWATER MANAGEMENT MANUAL DESIGN DETAILS AND CAD SUPPORT FILES

SW–206 PLANTER, UNLINED
SW–207 PLANTER, UNLINED WITH UNDERDRAIN
SW–208 PLANTER, LINED
SW–213 UNLINED FACILITY, STANDARD UNDERDRAIN WITH BEEHIVE OVERFLOW
SW–214 UNLINED FACILITY, RECESSED UNDERDRAIN WITH BEEHIVE OVERFLOW
SW–216 CONFIGURATION CROSS SECTIONS
SW–318 UNDERDRAIN WITH CLEANOUT CONFIGURATION
SW–321 PLANT SPACING
SW–322 EXAMPLE PLANTING TEMPLATE – SLOPED BASINS / SWALES
SW–323 EXAMPLE PLANTING TEMPLATE – PLANTERS

REFERENCE DETAILS SHALL BE MODIFIED AS NEEDED FOR FINAL SITE–SPECIFIC DESIGN.

SURVEY AND UTILITY NOTES

1. A TOPOGRAPHIC SURVEY SHALL BE COMPLETED PRIOR TO FINAL DESIGN OR CONSTRUCTION.
2. FINAL BIOSWALE LOCATIONS SHALL BE CONFIRMED AGAINST EXISTING RIGHT–OF–WAY, PROPERTY LIMITS, SIDEWALKS, PARKING AREAS, TRAILS, UTILITIES, AND GRADING CONSTRAINTS.
3. ALL EXISTING UTILITIES SHALL BE FIELD LOCATED PRIOR TO EXCAVATION.
4. THE CONTRACTOR SHALL CONTACT THE OREGON UTILITY NOTIFICATION CENTER PRIOR TO ANY EXCAVATION.
5. UTILITY CONFLICTS SHALL BE RESOLVED PRIOR TO FINAL FACILITY LAYOUT.
6. EXISTING STORMWATER INLETS, MANHOLES, PIPES, AND OUTFALLS SHOWN ON THESE DRAWINGS ARE CONCEPTUAL UNLESS FIELD VERIFIED.
7. CONNECTION TO EXISTING STORMWATER INFRASTRUCTURE SHALL BE CONFIRMED BY THE CITY OF TUALATIN DURING FINAL DESIGN.

GENERAL NOTES

1. THESE DRAWINGS ARE PRELIMINARY CAPSTONE DESIGN DRAWINGS PREPARED FOR THE HEDGES CREEK STORMWATER MANAGEMENT STUDY IN TUALATIN, OREGON.
2. THE PROPOSED BIOSWALE LOCATIONS AND DIMENSIONS ARE CONCEPTUAL AND SHALL BE FIELD VERIFIED PRIOR TO FINAL DESIGN OR CONSTRUCTION.
3. BASE MAPPING IS COMPILED FROM PUBLICLY AVAILABLE GIS DATA, AERIAL IMAGERY, FEMA FLOOD MAPPING, CITY OF TUALATIN INFORMATION, AND REGIONAL GIS SOURCES.
4. EXISTING CONDITIONS, PROPERTY LIMITS, UTILITIES, STORMWATER STRUCTURES, AND DRAINAGE PATHS SHOWN ON THESE DRAWINGS ARE APPROXIMATE.
5. FINAL DESIGN SHALL REQUIRE TOPOGRAPHIC SURVEY, UTILITY LOCATES, SOIL/INFILTRATION TESTING, GROUNDWATER VERIFICATION, AND CITY OF TUALATIN REVIEW.
6. BIOSWALE FACILITIES SHALL BE ADAPTED TO SITE–SPECIFIC CONDITIONS, INCLUDING AVAILABLE RIGHT–OF–WAY, EXISTING UTILITIES, GRADING, SOILS, AND GROUNDWATER DEPTH.
7. PROPOSED STORMWATER FACILITIES ARE INTENDED TO SLOW RUNOFF, PROVIDE TEMPORARY STORAGE, IMPROVE WATER QUALITY, AND REDUCE DIRECT DISCHARGE TO HEDGES CREEK.
8. BIOSWALES ARE NOT INTENDED TO ELIMINATE MAJOR FLOODING CAUSED BY TUALATIN RIVER BACKWATER CONDITIONS.
9. ALL FINAL WORK SHALL COMPLY WITH APPLICABLE CITY, STATE, FEDERAL, AND REGIONAL STORMWATER REQUIREMENTS.

A	DRAFT 1 DRAWINGS/ PRELIMINARY	DJ	5/04/26

REV:	DESCRIPTION:	BY:	DATE:
STATUS:			

PORTLAND STATE UNIVERSITY
DEPARTMENT OF CEE
GROUP 2 CAPSTONE PROJECT

CLIENT:
CITY OF TUALATIN

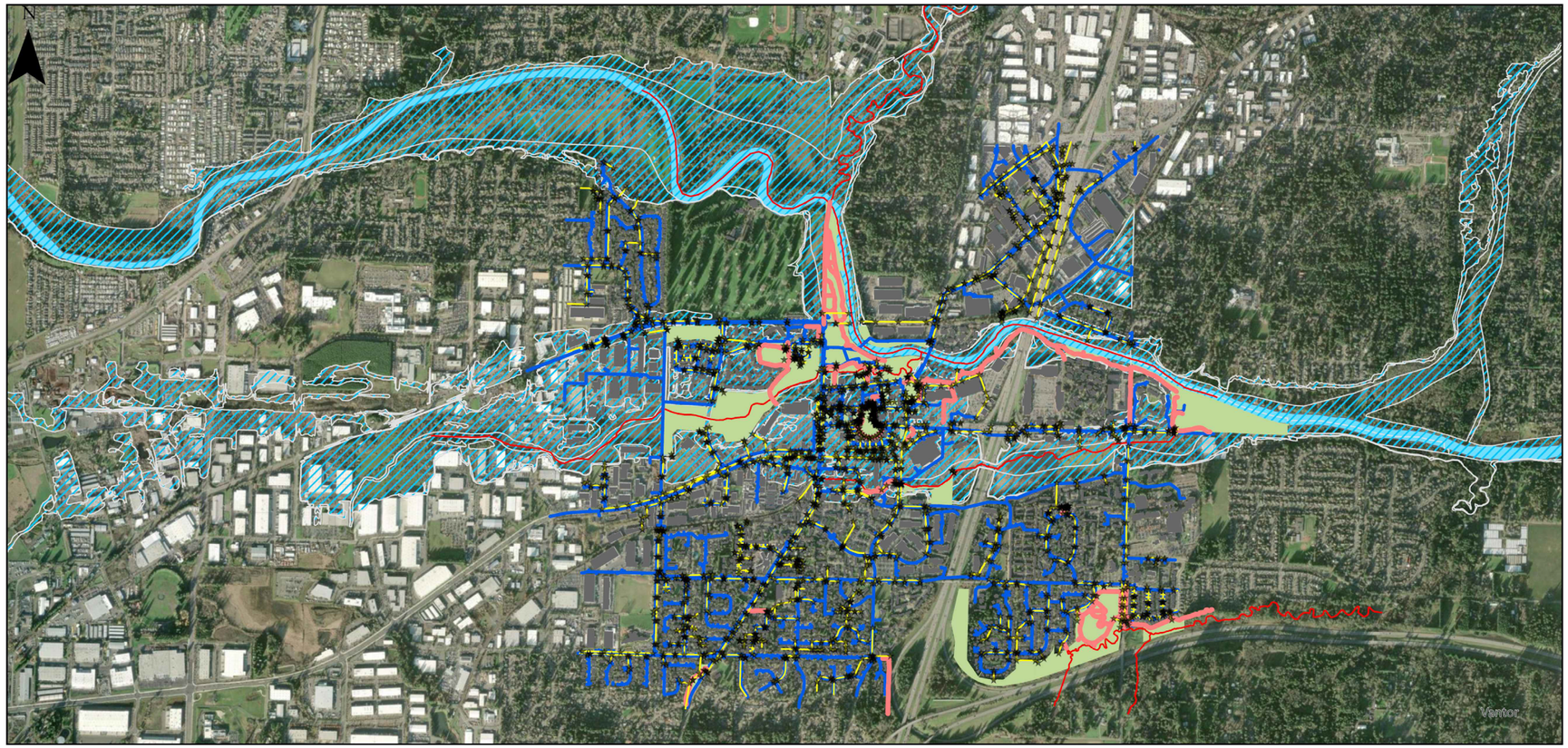
GROUP MEMBERS:
GHALYAH ALAWADHI, HAMZA ALMUTARI
DALAL BUKHADHOUR, SANTOS DAMIAN
ADAM HAMLING, NHY LE

PROJECT TITLE:
DOWNTOWN TUALATIN HEDGES CREEK STORMWATER MANAGEMENT STUDY

TITLE:
GENERAL NOTES

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
1:50, 1:100	06/04/26	DJ	DJ
PROJECT NO:	DRAWING NO:		REVISION:
2	C-002		A

EXISTING SITE PLAN



0 0.2 0.4 0.8 1.2 1.6 Miles

Legend

- Storm_Features
- Water Lines
- Streams
- FEMA Floodplain
- Rivers
- ParkTrails
- Storm_Lines
- BuildingFootprints
- TualatinLand

GENERAL NOTES

1. THESE DRAWINGS ARE PRELIMINARY CAPSTONE DESIGN DRAWINGS PREPARED FOR THE HEDGES CREEK STORMWATER MANAGEMENT STUDY IN TUALATIN, OREGON.
2. THE PROPOSED BIOSWALE LOCATIONS AND DIMENSIONS ARE CONCEPTUAL AND SHALL BE FIELD VERIFIED PRIOR TO FINAL DESIGN OR CONSTRUCTION.
3. BASE MAPPING IS COMPILED FROM PUBLICLY AVAILABLE GIS DATA, AERIAL IMAGERY, FEMA FLOOD MAPPING, CITY OF TUALATIN INFORMATION, AND REGIONAL GIS SOURCES.
4. EXISTING CONDITIONS, PROPERTY LIMITS, UTILITIES, STORMWATER STRUCTURES, AND DRAINAGE PATHS SHOWN ON THESE DRAWINGS ARE APPROXIMATE.
5. FINAL DESIGN SHALL REQUIRE TOPOGRAPHIC SURVEY, UTILITY LOCATES, SOIL/INFILTRATION TESTING, GROUNDWATER VERIFICATION, AND CITY OF TUALATIN REVIEW.
6. BIOSWALE FACILITIES SHALL BE ADAPTED TO SITE-SPECIFIC CONDITIONS, INCLUDING AVAILABLE RIGHT-OF-WAY, EXISTING UTILITIES, GRADING, SOILS, AND GROUNDWATER DEPTH.
7. PROPOSED STORMWATER FACILITIES ARE INTENDED TO SLOW RUNOFF, PROVIDE TEMPORARY STORAGE, IMPROVE WATER QUALITY, AND REDUCE DIRECT DISCHARGE TO HEDGES CREEK.
8. BIOSWALES ARE NOT INTENDED TO ELIMINATE MAJOR FLOODING CAUSED BY TUALATIN RIVER BACKWATER CONDITIONS.
9. ALL FINAL WORK SHALL COMPLY WITH APPLICABLE CITY, STATE, FEDERAL, AND REGIONAL STORMWATER REQUIREMENTS.

REV:	DESCRIPTION:	BY:	DATE:
A.	DRAFT 1 DRAWINGS/ PRELIMINARY	HA	03/03/26

STATUS:

PORTLAND STATE UNIVERSITY
DEPARTMENT OF CEE
GROUP 2 CAPSTONE PROJECT

CLIENT: CITY OF TUALATIN

GROUP MEMBERS:
GHALYAH ALAWADHI, HAMZA ALMUTARI
DALAL BUKHADHOUR, SANTOS DAMIAN
ADAM HAMLING, NHY LE

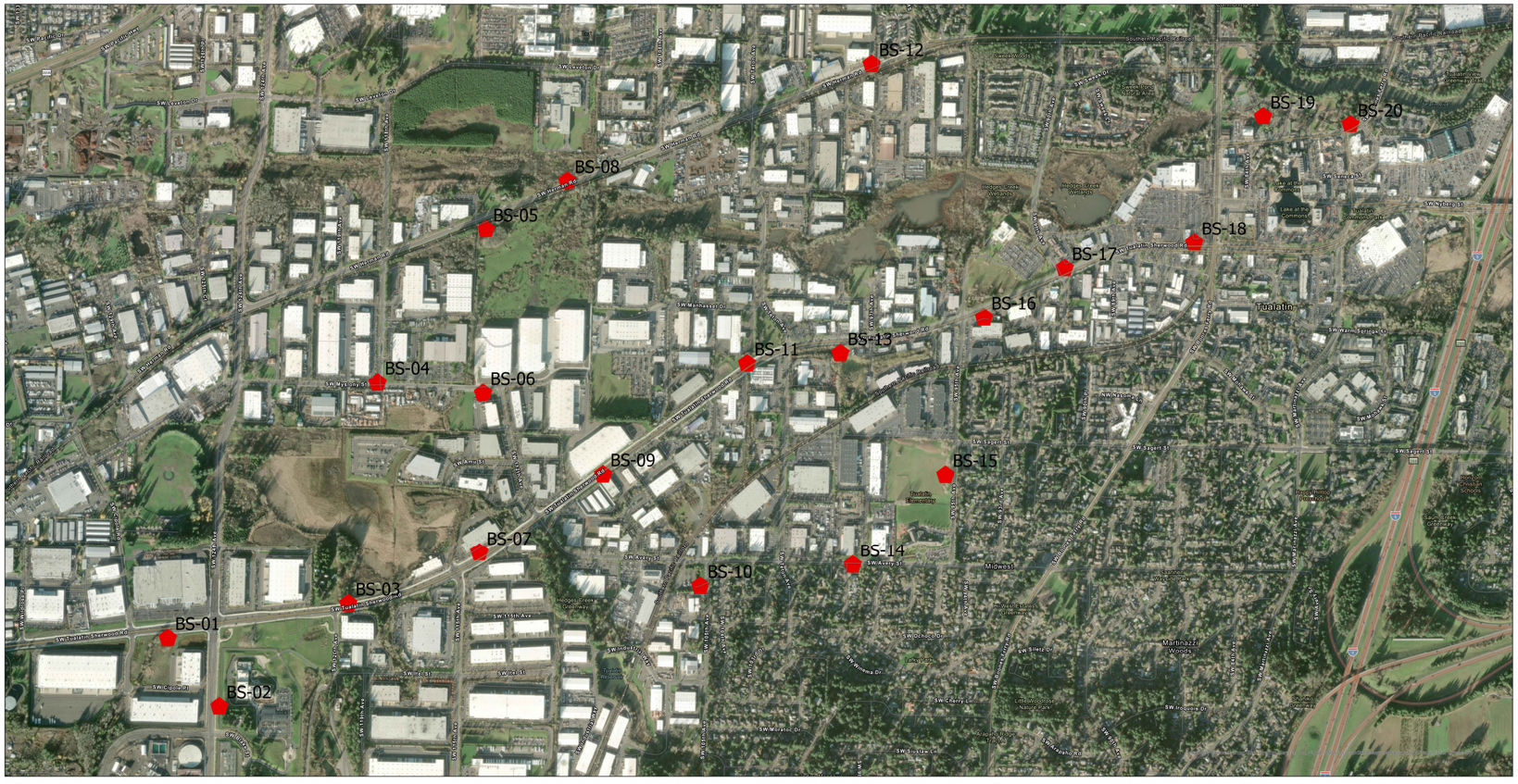
PROJECT TITLE: DOWNTOWN TUALATIN HEDGES CREEK STORMWATER MANAGEMENT STUDY

TITLE: EXISTING SITE PLAN

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
1:50, 1:100	06/04/26	DJ	DJ

PROJECT NO:	DRAWING NO:	REVISION:
2	C-101	A

PROPOSED BIOSWALE LOCATIONS



GENERAL NOTES

1. THESE DRAWINGS ARE PRELIMINARY CAPSTONE DESIGN DRAWINGS PREPARED FOR THE HEDGES CREEK STORMWATER MANAGEMENT STUDY IN TUALATIN, OREGON.
2. THE PROPOSED BIOSWALE LOCATIONS AND DIMENSIONS ARE CONCEPTUAL AND SHALL BE FIELD VERIFIED PRIOR TO FINAL DESIGN OR CONSTRUCTION.
3. BASE MAPPING IS COMPILED FROM PUBLICLY AVAILABLE GIS DATA, AERIAL IMAGERY, FEMA FLOOD MAPPING, CITY OF TUALATIN INFORMATION, AND REGIONAL GIS SOURCES.
4. EXISTING CONDITIONS, PROPERTY LIMITS, UTILITIES, STORMWATER STRUCTURES, AND DRAINAGE PATHS SHOWN ON THESE DRAWINGS ARE APPROXIMATE.
5. FINAL DESIGN SHALL REQUIRE TOPOGRAPHIC SURVEY, UTILITY LOCATES, SOIL/INFILTRATION TESTING, GROUNDWATER VERIFICATION, AND CITY OF TUALATIN REVIEW.
6. BIOSWALE FACILITIES SHALL BE ADAPTED TO SITE-SPECIFIC CONDITIONS, INCLUDING AVAILABLE RIGHT-OF-WAY, EXISTING UTILITIES, GRADING, SOILS, AND GROUNDWATER DEPTH.
7. PROPOSED STORMWATER FACILITIES ARE INTENDED TO SLOW RUNOFF, PROVIDE TEMPORARY STORAGE, IMPROVE WATER QUALITY, AND REDUCE DIRECT DISCHARGE TO HEDGES CREEK.
8. BIOSWALES ARE NOT INTENDED TO ELIMINATE MAJOR FLOODING CAUSED BY TUALATIN RIVER BACKWATER CONDITIONS.
9. ALL FINAL WORK SHALL COMPLY WITH APPLICABLE CITY, STATE, FEDERAL, AND REGIONAL STORMWATER REQUIREMENTS.
10. SEE SHEET C-002 FOR ADDITIONAL NOTES, LEGEND, ABBREVIATIONS, AND DESIGN REFERENCES.

A	DRAFT 1 DRAWINGS/ PRELIMINARY	nha	02/03/26

REV:	DESCRIPTION:	BY:	DATE:
STATUS:			

PORTLAND STATE UNIVERSITY
DEPARTMENT OF CEE
GROUP 2 CAPSTONE PROJECT

CLIENT:
CITY OF TUALATIN

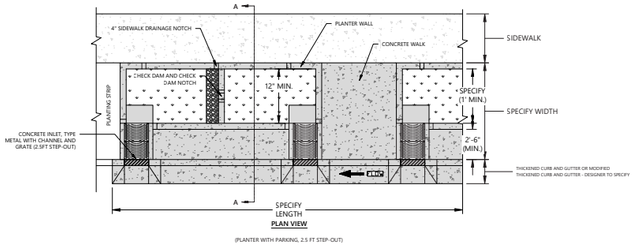
GROUP MEMBERS:
GHALYAH ALAWADHI, HAMZA ALMUTARI
DALAL BUKHADHOUR, SANTOS DAMIAN
ADAM HAMLING, NHY LE

PROJECT TITLE:
DOWNTOWN TUALATIN HEDGES CREEK STORMWATER MANAGEMENT STUDY

TITLE:
EXISTING SITE PLAN

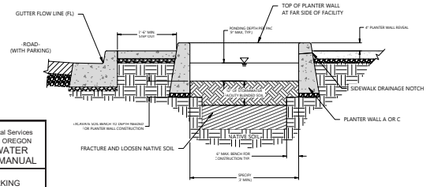
SCALE AT A1:	DATE:	DRAWN:	CHECKED:
1:50, 1:100	06/04/26	DJ	DJ

PROJECT NO:	DRAWING NO:	REVISION:
2	C-102	A



PLAN VIEW

(PLANTER WITH PARKING, 2.5 FT STEP-OUT)



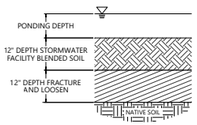
3 13/16"

Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL

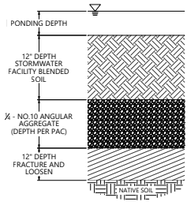
SWMM Reference Detail Title

PLANTER - WITH PARKING
1 FT STEP-OUT
PLAN AND SECTION VIEWS

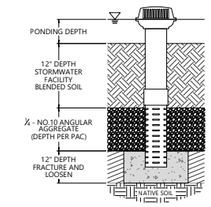
Effective Date: 03-01-2025 | SWMM Ref. Det. No. SW-303



INFILTRATION

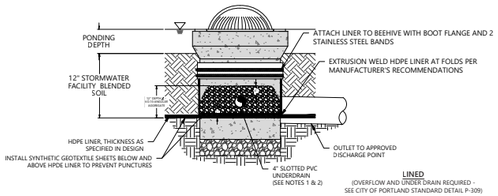


INFILTRATION WITH ROCK



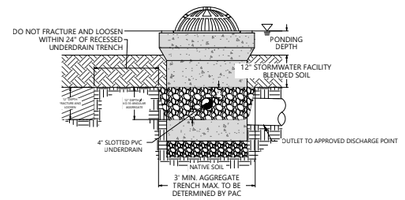
HYBRID

(OVERFLOW DIRECTED TO DRAIN ROCK - SEE CITY OF PORTLAND STANDARD DETAIL P-310)



LINED

(OVERFLOW AND UNDERDRAIN REQUIRED - SEE CITY OF PORTLAND STANDARD DETAIL P-309)



PARTIAL INFILTRATION

(OVERFLOW AND UNDER DRAIN REQUIRED - SEE CITY OF PORTLAND STANDARD DETAIL P-309)

Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL

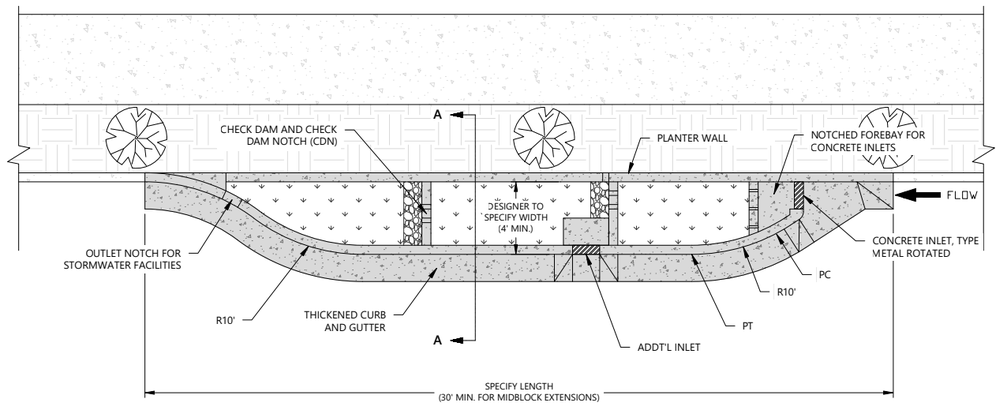
SWMM Reference Detail Title

FACILITY CONFIGURATION SECTIONS

Effective Date: 03-01-2025 | SWMM Ref. Det. No. SW-313

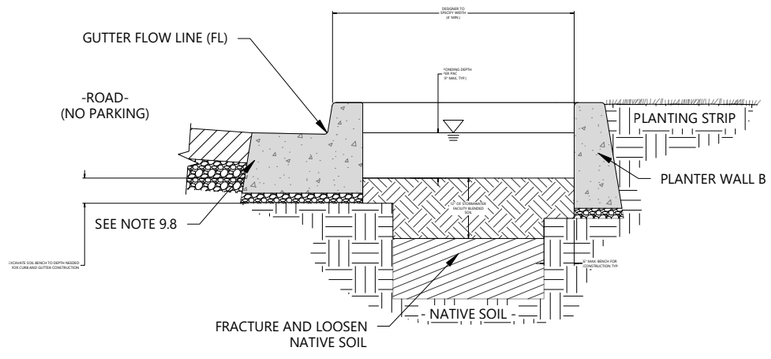
GENERAL NOTES

1. BIOSWALE PLAN AND PROFILE ARE CONCEPTUAL AND REPRESENTATIVE OF THE PROPOSED FACILITY TYPE.
2. FINAL BIOSWALE LENGTH, WIDTH, SLOPE, INLET LOCATION, OUTLET LOCATION, AND UNDERDRAIN REQUIREMENTS SHALL BE CONFIRMED DURING FINAL DESIGN.
3. BIOSWALE WIDTH SHALL NOT EXCEED APPROXIMATELY 8 FT WHERE PRACTICAL.
4. LONGITUDINAL SLOPE SHALL BE APPROXIMATELY 0.5% TO 1.0% WHERE PRACTICAL TO REDUCE EROSION AND PROMOTE SEDIMENT SETTLING.
5. INLET LOCATIONS SHALL BE STABILIZED TO PREVENT EROSION AND ALLOW RUNOFF TO ENTER THE BIOSWALE EVENLY.
6. CHECK DAMS OR FLOW SPREADERS MAY BE USED WHERE NEEDED TO REDUCE FLOW VELOCITY AND IMPROVE WATER DISTRIBUTION.
7. UNDERDRAINS MAY BE REQUIRED WHERE INFILTRATION IS LIMITED BY HIGH GROUNDWATER, LOW-PERMEABILITY SOILS, OR ADJACENT INFRASTRUCTURE.
8. LINERS MAY BE REQUIRED WHERE GROUNDWATER SEPARATION IS INSUFFICIENT OR WHERE INFILTRATION COULD AFFECT ADJACENT INFRASTRUCTURE.
9. OVERFLOW STRUCTURE SHALL BE PROVIDED TO SAFELY CONVEY FLOWS EXCEEDING BIOSWALE STORAGE CAPACITY.
10. FINAL CONNECTION TO EXISTING STORMWATER INFRASTRUCTURE SHALL BE CONFIRMED BY THE CITY OF TUALATIN.
11. DETAIL IS ADAPTED FROM CITY OF PORTLAND 2025 STORMWATER MANAGEMENT MANUAL STANDARD DETAILS AND SHALL BE MODIFIED TO MEET CITY OF TUALATIN REQUIREMENTS AND SITE-SPECIFIC CONDITIONS.
12. SEE SHEET C-301 FOR INLET, OUTLET, OVERFLOW, AND UNDERDRAIN DETAILS.



PLAN VIEW

(CURB EXTENSION NO PARKING)



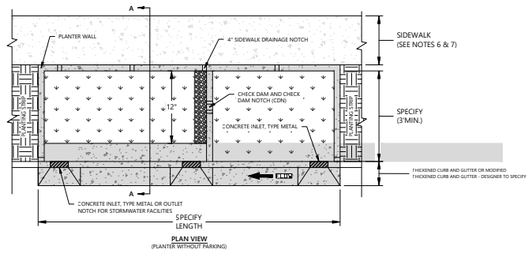
SECTION A-A

Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL

SWMM Reference Detail Title

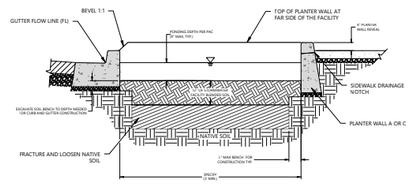
CURB EXTENSION
NO PLANTING STRIP
PLAN AND SECTION VIEWS

Effective Date: 03-01-2025 | SWMM Ref. Det. No. SW-304



PLAN VIEW

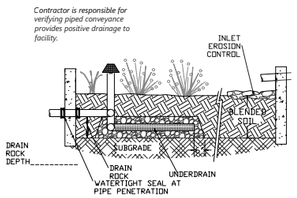
(PLANTER WITHOUT PARKING)



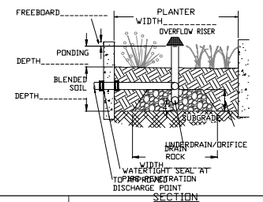
SECTION A-A

(PLANTER WITHOUT PARKING)

REPRESENTATIVE BIOSWALE DETAIL
FINAL DIMENSIONS TO BE VERIFIED BY SURVEY AND CITY REVIEW



PROFILE



SECTION

Bureau of Environmental Services

STORMWATER MANAGEMENT TYPICAL DETAILS FOR PRIVATE PROPERTY

PLANTER, UNLINED WITH UNDERDRAIN

SW-207

REV:	DESCRIPTION:	BY:	DATE:
A	DRAFT 1 DRAWINGS/ PRELIMINARY	HA	02/03/26

STATUS:

PORTLAND STATE UNIVERSITY
DEPARTMENT OF CEE
GROUP 2 CAPSTONE PROJECT

CLIENT:

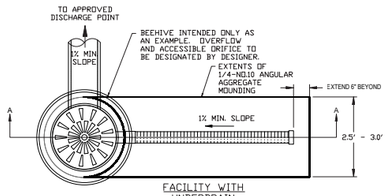
CITY OF TUALATIN

GROUP MEMBERS:
GHALYAH ALAWADHI, HAMZA ALMUTARI
DALAL BUKHADHOUR, SANTOS DAMIAN
ADAM HAMLING, NHY LE

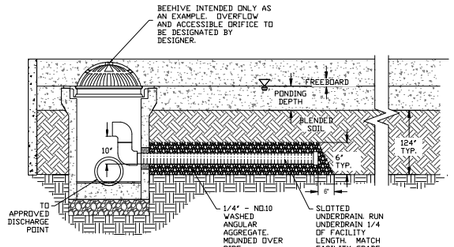
PROJECT TITLE:
DOWNTOWN TUALATIN HEDGES CREEK STORMWATER MANAGEMENT STUDY

TITLE:
BIOSWALE PLAN & PROFILE

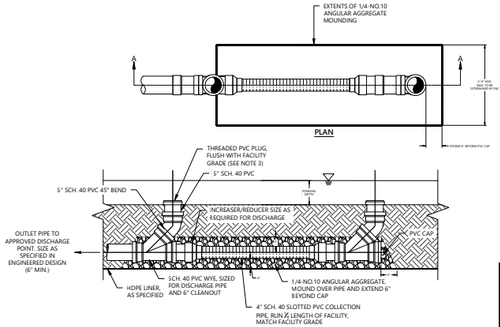
SCALE AT A1:	DATE:	DRAWN:	CHECKED:
1:50, 1:100	06/04/26	DJ	DJ
PROJECT NO:	DRAWING NO:		REVISION:
2	C-201		A



FACILITY WITH UNDERDRAIN
PLAN VIEW



FACILITY WITH UNDERDRAIN
LONGITUDINAL SECTION A-A



SECTION A-A

Bureau of Environmental Services

STORMWATER MANAGEMENT TYPICAL DETAILS FOR PRIVATE PROPERTY

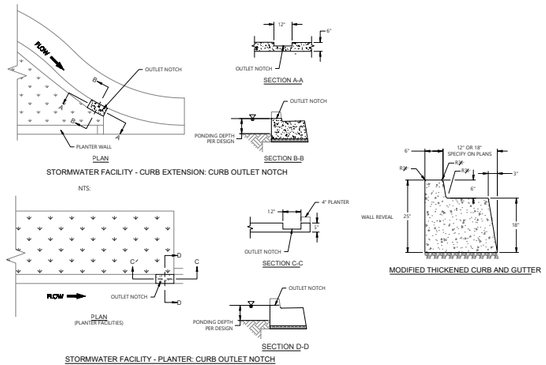
UNLINED FACILITY, RECESSED UNDERDRAIN WITH BEEHIVE OVERFLOW

SW-214

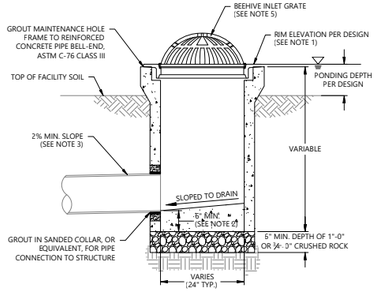
Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL
SWMM Reference Detail Title: UNDERDRAIN WITH CLEANOUT
Effective Date: 03-01-2025 | SWMM Ref. Det. No. SW-318

GENERAL NOTES

1. BIOSWALE PLAN AND PROFILE ARE CONCEPTUAL AND REPRESENTATIVE OF THE PROPOSED FACILITY TYPE.
2. FINAL BIOSWALE LENGTH, WIDTH, SLOPE, INLET LOCATION, OUTLET LOCATION, AND UNDERDRAIN REQUIREMENTS SHALL BE CONFIRMED DURING FINAL DESIGN.
3. BIOSWALE WIDTH SHALL NOT EXCEED APPROXIMATELY 8 FT WHERE PRACTICAL.
4. LONGITUDINAL SLOPE SHALL BE APPROXIMATELY 0.5% TO 1.0% WHERE PRACTICAL TO REDUCE EROSION AND PROMOTE SEDIMENT SETTLING.
5. INLET LOCATIONS SHALL BE STABILIZED TO PREVENT EROSION AND ALLOW RUNOFF TO ENTER THE BIOSWALE EVENLY.
6. CHECK DAMS OR FLOW SPREADERS MAY BE USED WHERE NEEDED TO REDUCE FLOW VELOCITY AND IMPROVE WATER DISTRIBUTION.
7. UNDERDRAINS MAY BE REQUIRED WHERE INFILTRATION IS LIMITED BY HIGH GROUNDWATER, LOW-PERMEABILITY SOILS, OR ADJACENT INFRASTRUCTURE.
8. LINERS MAY BE REQUIRED WHERE GROUNDWATER SEPARATION IS INSUFFICIENT OR WHERE INFILTRATION COULD AFFECT ADJACENT INFRASTRUCTURE.
9. OVERFLOW STRUCTURE SHALL BE PROVIDED TO SAFELY CONVEY FLOWS EXCEEDING BIOSWALE STORAGE CAPACITY.
10. FINAL CONNECTION TO EXISTING STORMWATER INFRASTRUCTURE SHALL BE CONFIRMED BY THE CITY OF TUALATIN.
11. DETAIL IS ADAPTED FROM CITY OF PORTLAND 2025 STORMWATER MANAGEMENT MANUAL STANDARD DETAILS AND SHALL BE MODIFIED TO MEET CITY OF TUALATIN REQUIREMENTS AND SITE-SPECIFIC CONDITIONS.
12. SEE SHEET C-301 FOR INLET, OUTLET, OVERFLOW, AND UNDERDRAIN DETAILS.

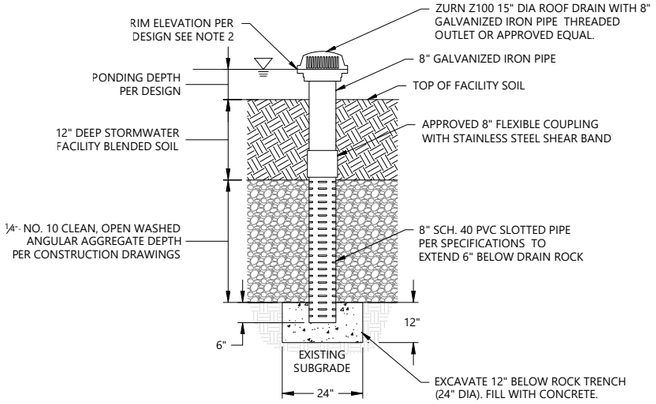


Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL
SWMM Reference Detail Title: CURB AND OUTLET NOTCH DETAILS
Effective Date: 03-01-2025 | SWMM Ref. Det. No. P-308

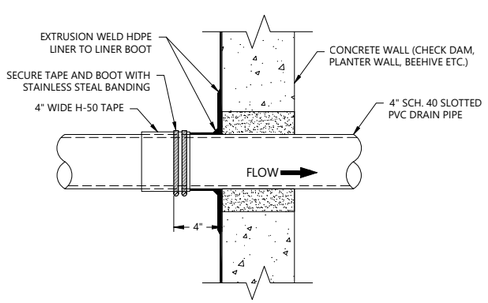


BEEHIVE INLET - SECTION

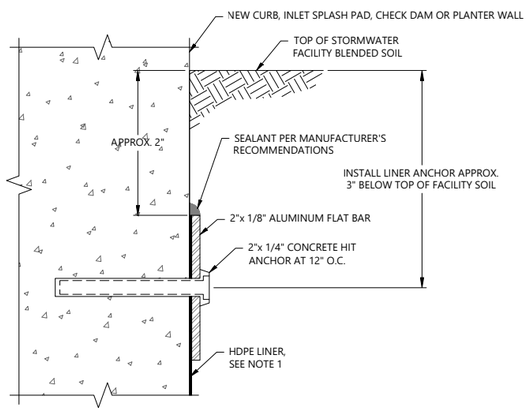
Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL
SWMM Reference Detail Title: CONCRETE INLET, TYPE BEEHIVE
Effective Date: 03-01-2025 | SWMM Ref. Det. No. P-309



Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL
SWMM Reference Detail Title: OVERFLOW SLOTTED DRAIN
Effective Date: 03-01-2025 | SWMM Ref. Det. No. P-310



PIPE BOOT



LINER ATTACHMENT

Bureau of Environmental Services
CITY OF PORTLAND, OREGON
2025 STORMWATER MANAGEMENT MANUAL
SWMM Reference Detail Title: LINER ATTACHMENT AND PIPE BOOT
Effective Date: 03-01-2025 | SWMM Ref. Det. No. P-311

REV:	DESCRIPTION:	BY:	DATE:
A	DRAFT 1 DRAWINGS/ PRELIMINARY	HA	02/03/26

STATUS:

PORTLAND STATE UNIVERSITY
DEPARTMENT OF CEE
GROUP 2 CAPSTONE PROJECT

CLIENT: CITY OF TUALATIN

GROUP MEMBERS:
GHALYAH ALAWADHI, HAMZA ALMUTARI
DALAL BUKHADHOUR, SANTOS DAMIAN
ADAM HAMLING, NHY LE

PROJECT TITLE: DOWNTOWN TUALATIN HEDGES CREEK STORMWATER MANAGEMENT STUDY

TITLE: OUTLET & DRAIN DETAILS

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
1:50, 1:100	06/04/26	DJ	DJ

PROJECT NO:	DRAWING NO:	REVISION:
2	C-301	A

APPENDIX B
CALCULATIONS

LIST OF CALCULATIONS

Peak runoff for a 2-year, 24-hour storm in Tualatin is 2.5 inches of rain over 24 hours.

Total potential runoff volume of design storm for Hedges Creek watershed:

$$Volume = Area \times Depth$$
$$Volume = 3{,}840\ acres \times 2.5\ inches$$
$$Volume = 9600\ acre\ inches$$
$$Volume = 9600\ acre\ inches \times \frac{43{,}560\ ft^2}{1\ acre} \times \frac{1\ ft}{12\ in}$$
$$Volume = 34{,}848{,}000\ ft^3\ or\ 260\ MG$$

Rational Method for determining peak discharge over our effective areas:

$$Q = CiA$$

Where Q is the discharge is in cfs, C is the runoff coefficient which will be 0.9 for pavement, i is the rainfall intensity in inches per hour, and A is the area in acres.

$$Q = 0.9 \times \frac{2.5\ in}{24\ hr} \times 10.37\ acres$$
$$Q = 0.97\ cfs$$

Assuming an average bioswale depth of 1 ft due to the high water table, our square footage is easily converted to volume.

$$Total\ bioswale\ volume\ to\ capture\ runoff = 36{,}000\ ft^2 \times 1\ ft = 36{,}000\ ft^3$$

Convert cfs to cubic feet per day over the effective area:

$$Q = 0.97\ \frac{ft^3}{sec} \times \frac{86{,}400\ sec}{1\ day} = 83{,}808\ \frac{ft^3}{day}$$

Total percentage of runoff captured per day:

$$\%\ of\ runoff\ captured\ in\ bioswales = \frac{36{,}000\ ft^3}{83{,}808\ ft^3} = 0.43\ or\ 43\%$$

This could be significantly more effective if an average depth of 2 feet per bioswale could be obtained:

$$\%\ of\ runoff\ captured\ in\ bioswales\ = \frac{72{,}000\ ft^3}{83{,}808\ ft^3} = 0.86\ or\ 86\%$$

MODELING PROGRESS

Disclosure: All of these calculations are based on our own assumptions. The parameters needed to accurately model this watershed were not acquired. These calculations are to build experience with PCSWMM and practice modeling.

Figure B1: Set the rain gauge to a Type 1A storm with a total rainfall of 2.5 inches during a 24 hour storm period.

Figure B2: The Hedges Creek watershed converted into a subcatchment to model the rain gauge from Figure 1 assuming 51% impervious area and infiltration rates between 0.5 - 2.5 inches per hour.

Figure B3: This total theoretical runoff is based on the parameters from Figures 1 and 2.

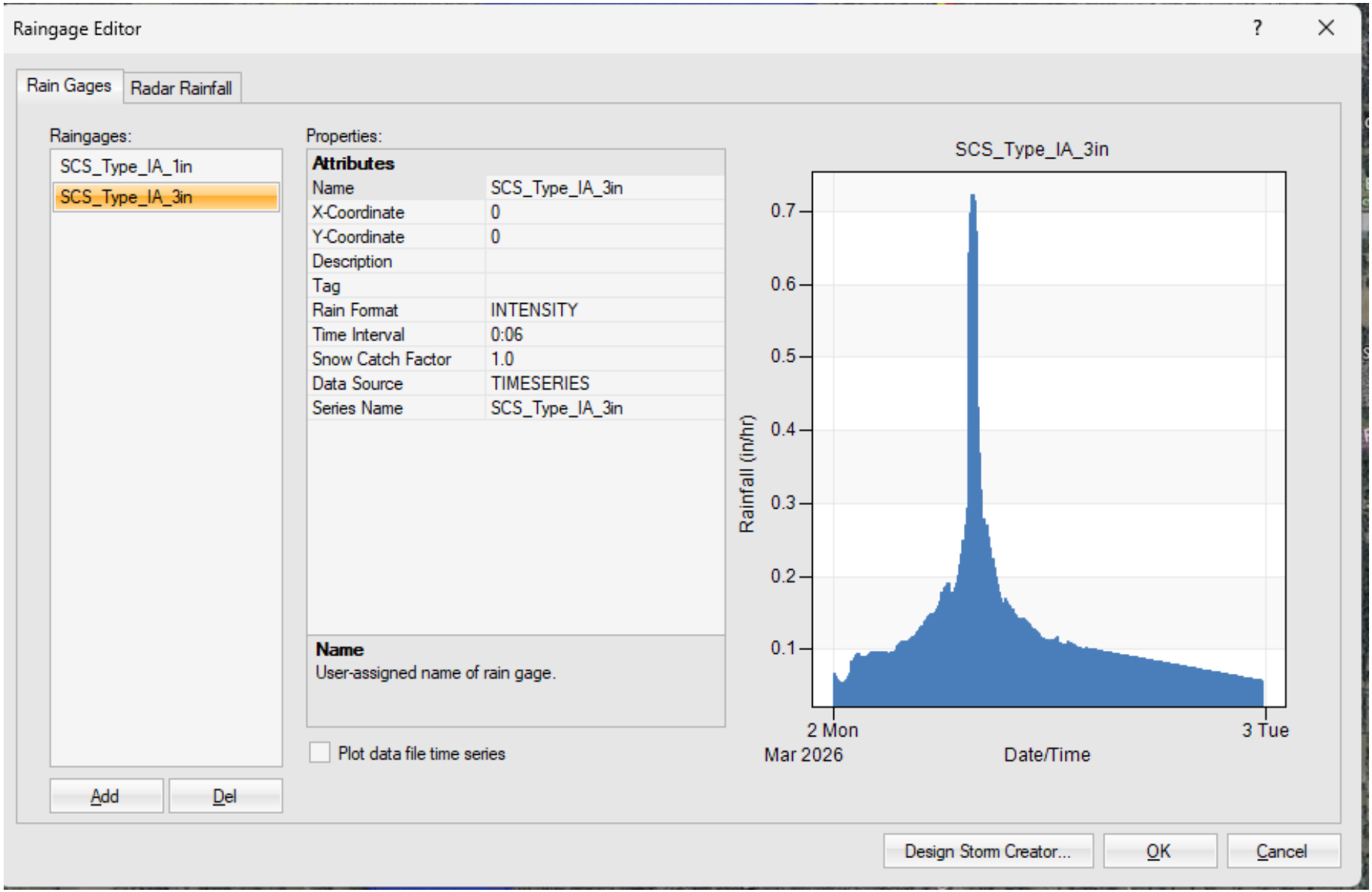

Raingage Editor
Rain Gages
Radar Rainfall
Raingages:
SCS_Type_IA_1in
SCS_Type_IA_3in
Add
Del
Properties:
Attributes
Name SCS_Type_IA_3in
X-Coordinate 0
Y-Coordinate 0
Description
Tag
Rain Format INTENSITY
Time Interval 0:06
Snow Catch Factor 1.0
Data Source TIMESERIES
Series Name SCS_Type_IA_3in
Name
User-assigned name of rain gage.
Plot data file time series
SCS_Type_IA_3in
Rainfall (in/hr)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
2 Mon
Mar 2026
3 Tue
Date/Time
Design Storm Creator...
OK
Cancel

Figure B1

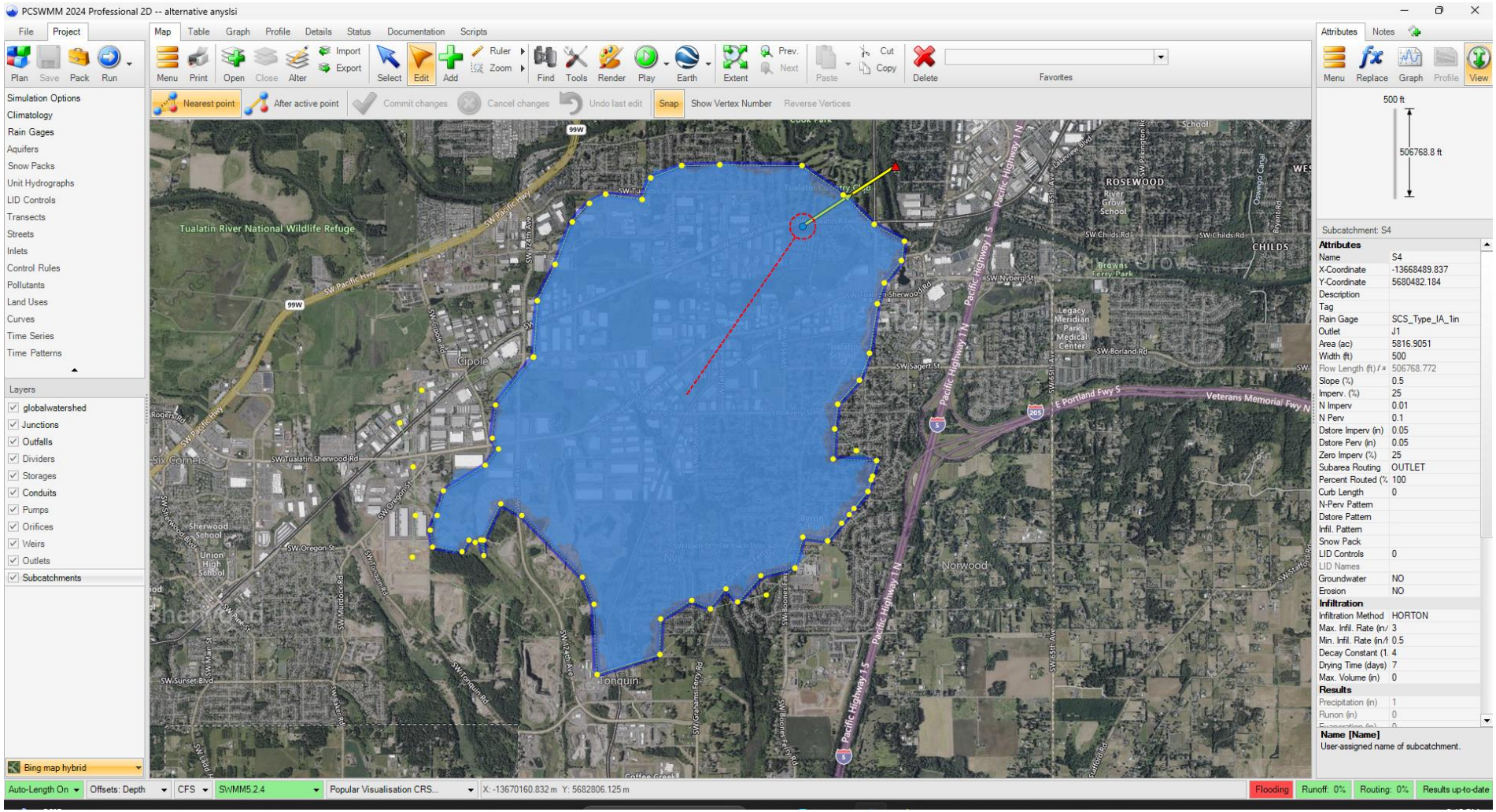

PCSWMM 2024 Professional 2D -- alternative anyslsi
Tualatin River National Wildlife Refuge
Cipole
Norwood
Tonquin
ROSEWOOD
CHILDS
Pacific Highway 1 N
Pacific Highway 1 S
E Portland Fwy 5
Veterans Memorial Fwy N
Subcatchment: S4
Name S4
X-Coordinate -13668489.837
Y-Coordinate 5680482.184
Rain Gage SCS_Type_IA_1in
Outlet J1
Area (ac) 5816.9051
Width (ft) 500
Flow Length (ft) 506768.772
Slope (%) 0.5
Imperv. (%) 25
N Imperv 0.01
N Perv 0.1
Dstore Imperv (in) 0.05
Dstore Perv (in) 0.05
Zero Imperv (%) 25
Subarea Routing OUTLET
Percent Routed (% 100
Curb Length 0
Groundwater NO
Erosion NO
Infiltration Method HORTON
Max. Infil. Rate (in/ 3
Min. Infil. Rate (in/l 0.5
Decay Constant (1. 4
Drying Time (days) 7
Max. Volume (in) 0
Precipitation (in) 1
Runon (in) 0
Name [Name]
User-assigned name of subcatchment.
500 ft
506768.8 ft
Flooding
Runoff: 0%
Routing: 0%
Results up-to-date

Figure B2

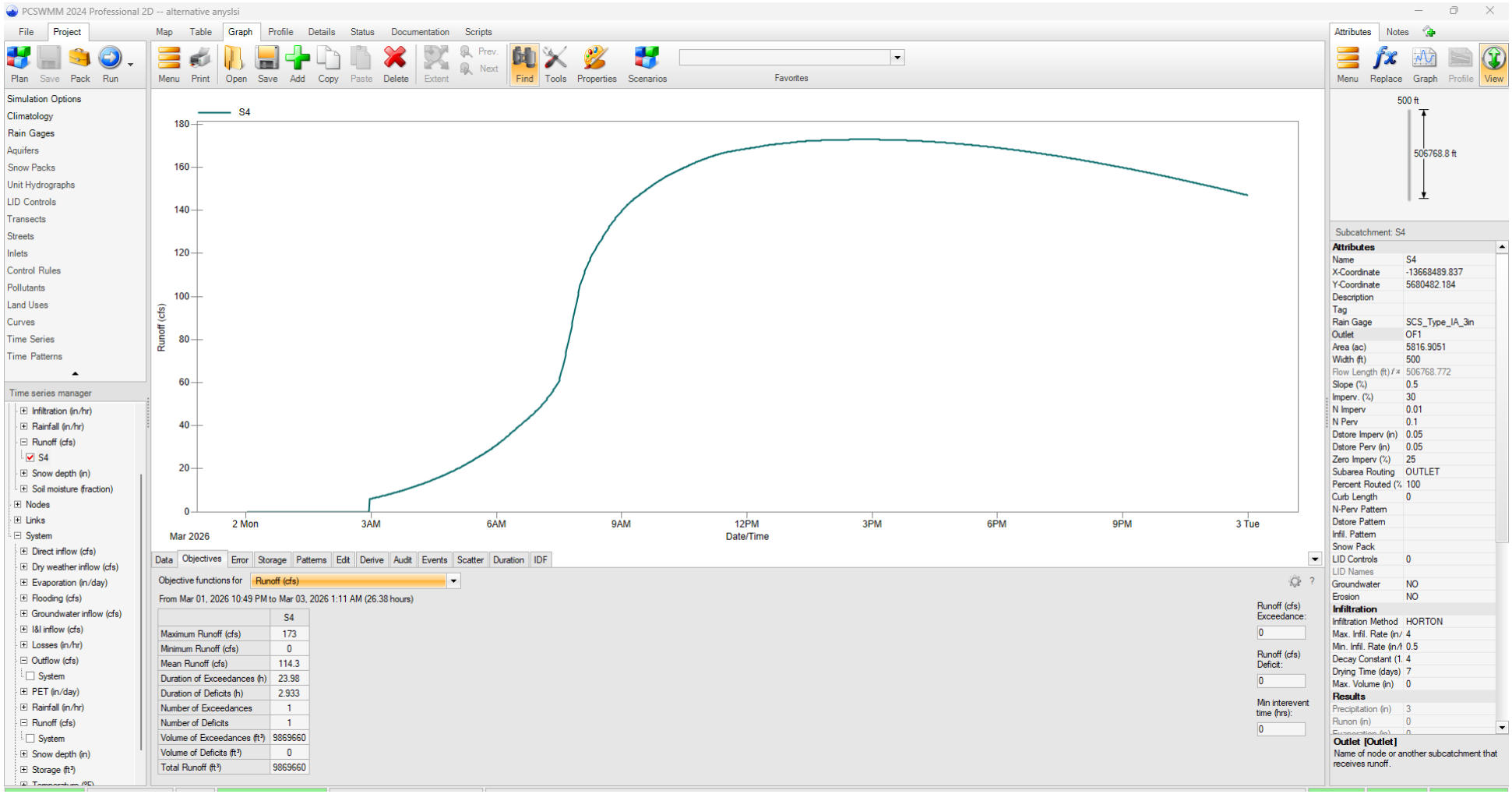

PCSWMM 2024 Professional 2D -- alternative anyslsi
File
Project
Map
Table
Graph
Profile
Details
Status
Documentation
Scripts
Plan
Save
Pack
Run
Menu
Print
Open
Save
Add
Copy
Paste
Delete
Extent
Prev.
Next
Find
Tools
Properties
Scenarios
Favorites
Attributes
Notes
Menu
Replace
Graph
Profile
View
Simulation Options
Climatology
Rain Gages
Aquifers
Snow Packs
Unit Hydrographs
LID Controls
Transects
Streets
Inlets
Control Rules
Pollutants
Land Uses
Curves
Time Series
Time Patterns
Time series manager
Infiltration (in/hr)
Rainfall (in/hr)
Runoff (cfs)
S4
Snow depth (in)
Soil moisture (fraction)
Nodes
Links
System
Direct inflow (cfs)
Dry weather inflow (cfs)
Evaporation (in/day)
Flooding (cfs)
Groundwater inflow (cfs)
I&I inflow (cfs)
Losses (in/hr)
Outflow (cfs)
System
PET (in/day)
Rainfall (in/hr)
Runoff (cfs)
System
Snow depth (in)
Storage (ft³)
S4
Runoff (cfs)
180
160
140
120
100
80
60
40
20
0
2 Mon
3AM
6AM
9AM
12PM
3PM
6PM
9PM
3 Tue
Mar 2026
Date/Time
Data
Objectives
Error
Storage
Patterns
Edit
Derive
Audit
Events
Scatter
Duration
IDF
Objective functions for
Runoff (cfs)
From Mar 01, 2026 10:49 PM to Mar 03, 2026 1:11 AM (26.38 hours)
S4
Maximum Runoff (cfs) 173
Minimum Runoff (cfs) 0
Mean Runoff (cfs) 114.3
Duration of Exceedances (h) 23.98
Duration of Deficits (h) 2.933
Number of Exceedances 1
Number of Deficits 1
Volume of Exceedances (ft³) 9869660
Volume of Deficits (ft³) 0
Total Runoff (ft³) 9869660
Runoff (cfs) Exceedance:
0
Runoff (cfs) Deficit:
0
Min interevent time (hrs):
0
500 ft
506768.8 ft
Subcatchment: S4
Attributes
Name S4
X-Coordinate -13668489.837
Y-Coordinate 5680482.184
Description
Tag
Rain Gage SCS_Type_IA_3in
Outlet OF1
Area (ac) 5816.9051
Width (ft) 500
Flow Length (ft) 506768.772
Slope (%) 0.5
Imperv. (%) 30
N Imperv 0.01
N Perv 0.1
Dstore Imperv (in) 0.05
Dstore Perv (in) 0.05
Zero Imperv (%) 25
Subarea Routing OUTLET
Percent Routed (% 100
Curb Length 0
N-Perv Pattern
Dstore Pattern
Infil. Pattern
Snow Pack
LID Controls 0
LID Names
Groundwater NO
Erosion NO
Infiltration
Infiltration Method HORTON
Max. Infil. Rate (in/ 4
Min. Infil. Rate (in/l 0.5
Decay Constant (1. 4
Drying Time (days) 7
Max. Volume (in) 0
Results
Precipitation (in) 3
Runon (in) 0
Outlet [Outlet]
Name of node or another subcatchment that receives runoff.

Figure B3

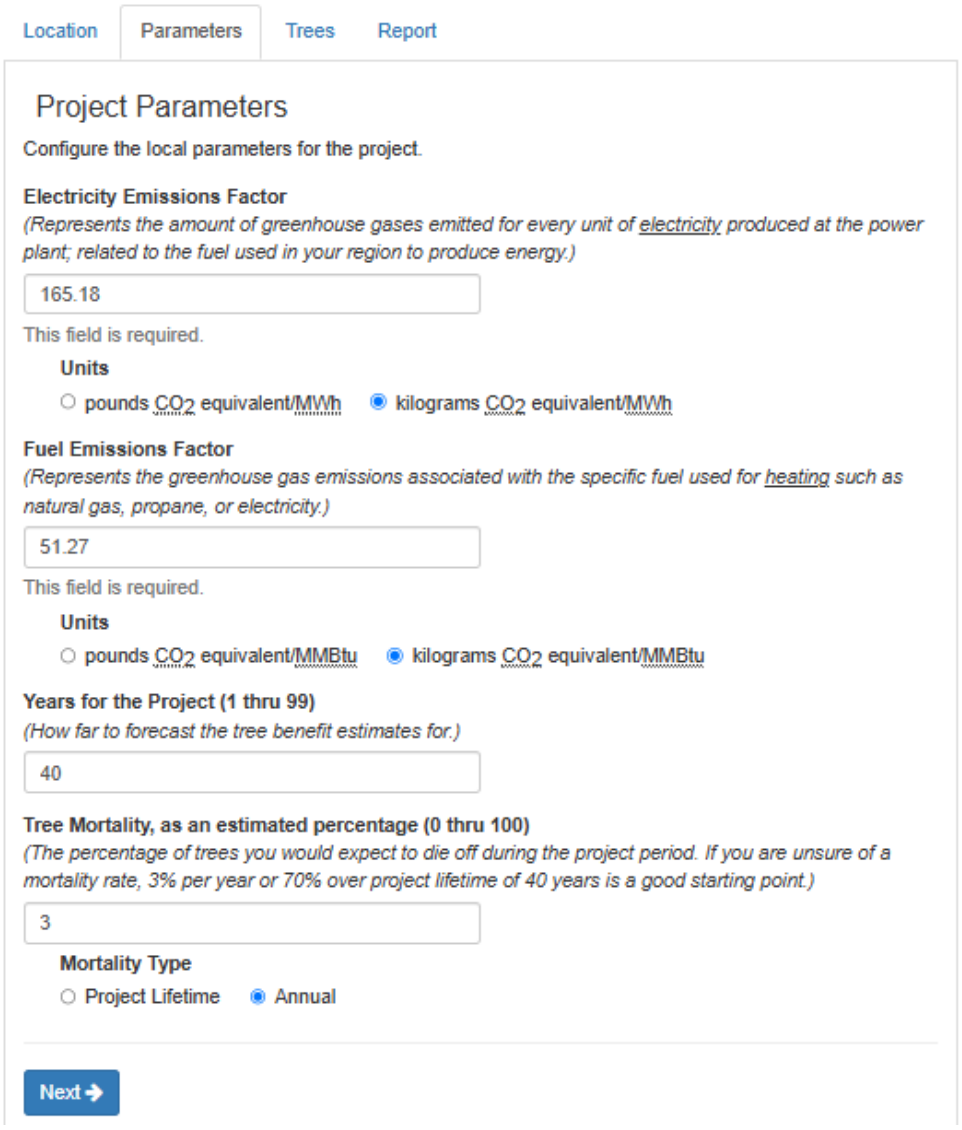

Location
Parameters
Trees
Report
Project Parameters
Configure the local parameters for the project.
Electricity Emissions Factor
(Represents the amount of greenhouse gases emitted for every unit of electricity produced at the power plant; related to the fuel used in your region to produce energy.)
165.18
This field is required.
Units
pounds CO2 equivalent/MWh
kilograms CO2 equivalent/MWh
Fuel Emissions Factor
(Represents the greenhouse gas emissions associated with the specific fuel used for heating such as natural gas, propane, or electricity.)
51.27
This field is required.
Units
pounds CO2 equivalent/MMBtu
kilograms CO2 equivalent/MMBtu
Years for the Project (1 thru 99)
(How far to forecast the tree benefit estimates for.)
40
Tree Mortality, as an estimated percentage (0 thru 100)
(The percentage of trees you would expect to die off during the project period. If you are unsure of a mortality rate, 3% per year or 70% over project lifetime of 40 years is a good starting point.)
3
Mortality Type
Project Lifetime
Annual
Next

Figure B4.1

Location | Parameters | Trees | Report

Tree Planting Configurations

ATTENTION: Please, limit projects to batches of 100 or less tree groups.

Enter the tree groups for the project - use the "+" button to enter additional groups. Search for a species by entering at least 2 characters of its name. DBH and Tree Details are for the time of planting. Building information is used to estimate the impact of trees on building energy usage; enter "None" for Climate Controls to exclude these estimates.

Units

(•) English (feet & inches) ( ) Metric (meters & cm)

Nomenclature

( ) Common Name (•) Scientific Name

	Tree Group Information			Building Information				Tree Details		
+	Group Number	Species	DBH in inches	Distance to Nearest in feet	Tree is _____ of Building	Building Vintage	Building Climate Control	Condition	Exposure to Sunlight	Number of Trees
×	5	Vaccinium arboreum	1	40-59	South (180°)	Built after 1980	Heat & Cool	Excellent	Full Sun	36
×	8	Mahonia (Genus)	1	40-59	South (180°)	Built after 1980	Heat & Cool	Excellent	Full Sun	36
×	9	Sambucus nigra	1	40-59	South (180°)	Built after 1980	Heat & Cool	Excellent	Full Sun	36
×	11	Arctostaphylos (Genus)	1	40-59	South (180°)	Built after 1980	Heat & Cool	Excellent	Full Sun	36
×	12	Grevillea (Genus)	1	40-59	South (180°)	Built after 1980	Heat & Cool	Excellent	Full Sun	36
×	13	Ceanothus (Genus)	1	40-59	South (180°)	Built after 1980	Heat & Cool	Excellent	Full Sun	36
+	Group Number	Species	DBH in inches	Distance to Nearest in feet	Tree is _____ of Building	Building Vintage	Building Climate Control	Condition	Exposure to Sunlight	Number of Trees

Consider periodically saving your project via Project > Save on the top menu to avoid data loss.

Next →

Figure B4.2. Group Number generates numbers randomly to keep track of the plant input. It does not interfere with the analysis.

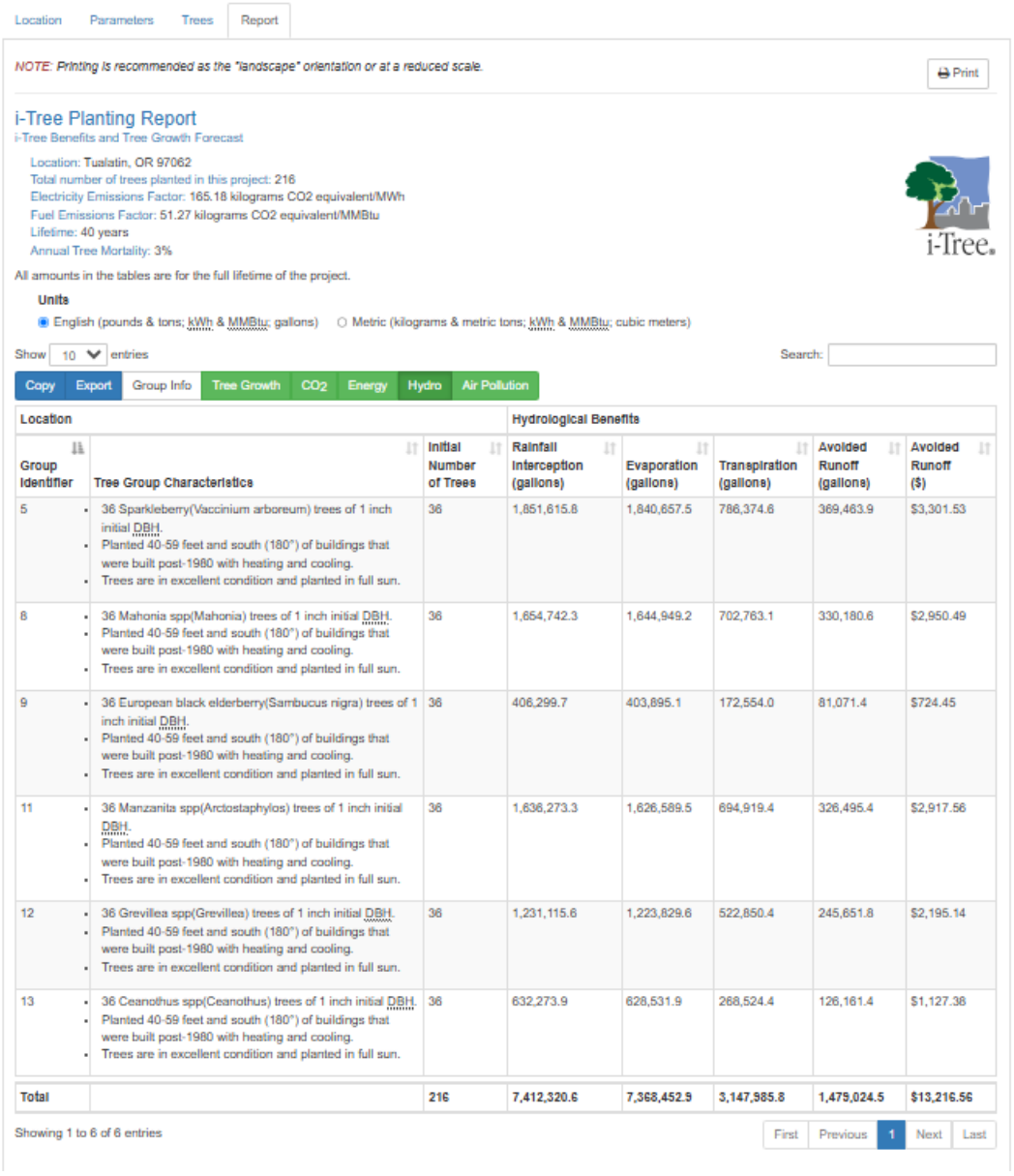
Copy | Export | Group Info | Tree Growth | CO_2 | Energy | Hydro | Air Pollution

Location			Characteristics in year 40						
Group Identifier	Tree Group Characteristics	Initial Number of Trees	DBH (inches)	Height (feet)	Surviving Trees	Basal Area (square feet)	Canopy Cover (square feet)	Leaf Area (square feet)	Biomass (short ton)
5	• 36 Sparkleberry(Vaccinium arboreum) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	16.3	81.1	11	15.9	13,466.9	53,958.7	23.0
8	• 36 Mahonia spp(Mahonia) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	16.3	69.6	11	15.9	11,406.5	68,199.5	25.9
9	• 36 European black elderberry(Sambucus nigra) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	13.2	16.8	11	10.5	2,668.1	10,277.5	4.7
11	• 36 Manzanita spp(Arctostaphylos) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	16.3	81.1	11	15.9	12,213.5	52,388.7	16.6
12	• 36 Grevillea spp(Grevillea) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	16.3	48.6	11	15.9	8,479.5	51,447.2	14.9
13	• 36 Ceanothus spp(Ceanothus) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	16.3	24.6	11	15.9	3,940.1	15,916.2	13.4
Total		**216**			**66**	**90.2**	**52,174.7**	**252,187.7**	**98.6**

Showing 1 to 6 of 6 entries

First | Previous | 1 | Next | Last

Figure B5.1



Location Parameters Trees Report

NOTE: Printing is recommended as the "landscape" orientation or at a reduced scale.

Print

i-Tree Planting Report

i-Tree Benefits and Tree Growth Forecast

Location: Tualatin, OR 97062
Total number of trees planted in this project: 216
Electricity Emissions Factor: 165.18 kilograms CO2 equivalent/MWh
Fuel Emissions Factor: 51.27 kilograms CO2 equivalent/MMBtu
Lifetime: 40 years
Annual Tree Mortality: 3%

i-Tree.

All amounts in the tables are for the full lifetime of the project.

Units

(•) English (pounds & tons; kWh & MMBtu; gallons) ( ) Metric (kilograms & metric tons; kWh & MMBtu; cubic meters)

Show 10 entries Search:

Copy Export Group Info Tree Growth CO_2 Energy Hydro Air Pollution

Location			Hydrological Benefits				
Group Identifier	Tree Group Characteristics	Initial Number of Trees	Rainfall Interception (gallons)	Evaporation (gallons)	Transpiration (gallons)	Avoided Runoff (gallons)	Avoided Runoff ($)
5	• 36 Sparkleberry(Vaccinium arboreum) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	1,851,615.8	1,840,657.5	786,374.6	369,463.9	$3,301.53
8	• 36 Mahonia spp(Mahonia) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	1,654,742.3	1,644,949.2	702,763.1	330,180.6	$2,950.49
9	• 36 European black elderberry(Sambucus nigra) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	406,299.7	403,895.1	172,554.0	81,071.4	$724.45
11	• 36 Manzanita spp(Arctostaphylos) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	1,638,273.3	1,626,589.5	694,919.4	326,495.4	$2,917.56
12	• 36 Grevillea spp(Grevillea) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	1,231,115.6	1,223,829.6	522,850.4	245,651.8	$2,195.14
13	• 36 Ceanothus spp(Ceanothus) trees of 1 inch initial DBH. • Planted 40-59 feet and south (180°) of buildings that were built post-1980 with heating and cooling. • Trees are in excellent condition and planted in full sun.	36	632,273.9	628,531.9	268,524.4	126,161.4	$1,127.38
Total		**216**	**7,412,320.6**	**7,368,452.9**	**3,147,985.8**	**1,479,024.5**	**$13,216.56**

Showing 1 to 6 of 6 entries First Previous 1 Next Last

Figure B5.2

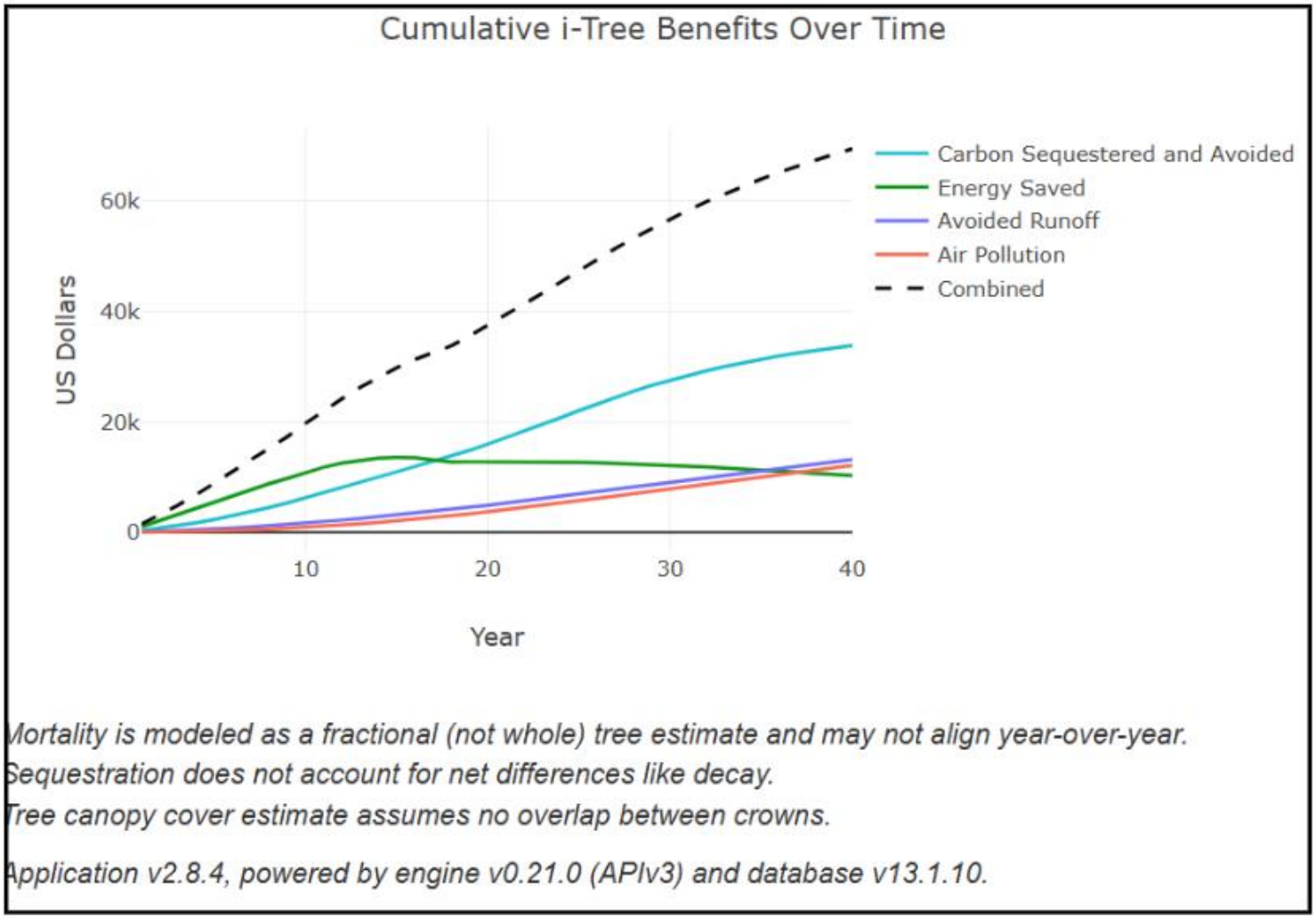

Cumulative i-Tree Benefits Over Time
US Dollars
60k
40k
20k
0
10
20
30
40
Year
Carbon Sequestered and Avoided
Energy Saved
Avoided Runoff
Air Pollution
Combined
Mortality is modeled as a fractional (not whole) tree estimate and may not align year-over-year.
Sequestration does not account for net differences like decay.
Tree canopy cover estimate assumes no overlap between crowns.
Application v2.8.4, powered by engine v0.21.0 (APIv3) and database v13.1.10.

Figure B6

APPENDIX C
CONSTRUCTION COST ESTIMATE

COST ESTIMATES

An estimated cost of $6.94 - $30.30 per square foot (NOAA, 2020) for each bioswale will be used. Oregon ranks as one of the more expensive states to build in so we assumed the higher value in that range for the total estimate. This cost is straightforward and can be adjusted easily depending on the size and number of bioswales implemented. Future maintenance costs are set at a rate of $0.08 - $0.27 per square foot per year. This cost covers basic maintenance such as pruning, weeding, litter removal, invasive species control, and making sure flow pathways are unblocked after major storm events. Again, the high side of the maintenance cost is used because of the high cost of labor in Oregon as well as the number of storm events.

Table C: *Estimated costs based on square footage of proposed bioswale sites.*

Bioswale Location	Estimated Square Footage	Estimated Construction Cost	Estimated Maintenance Cost Per Year
1	3,600	$109,080	$972
2	3,000	$90,900	$810
3	2,400	$72,720	$648
4	1,020	$30,906	$275
5	4,200	$127,260	$1,134
6	Existing facility at this location		
7	1,800	$54,540	$486
8	1,800	$54,540	$486
9	2,580	$78,174	$697
10	900	$27,270	$243
11	2,100	$63,630	$567
12	Existing facility at this location		
13	1,800	$54,540	$486
14	1,200	$36,360	$324
15	3,300	$99,990	$891
16	2,700	$81,810	$729
17	900	$27,270	$243
18	600	$18,180	$162
19	900	$27,270	$243
20	1,200	$36,360	$324
Totals	36,000	$1,090,800	$9,720

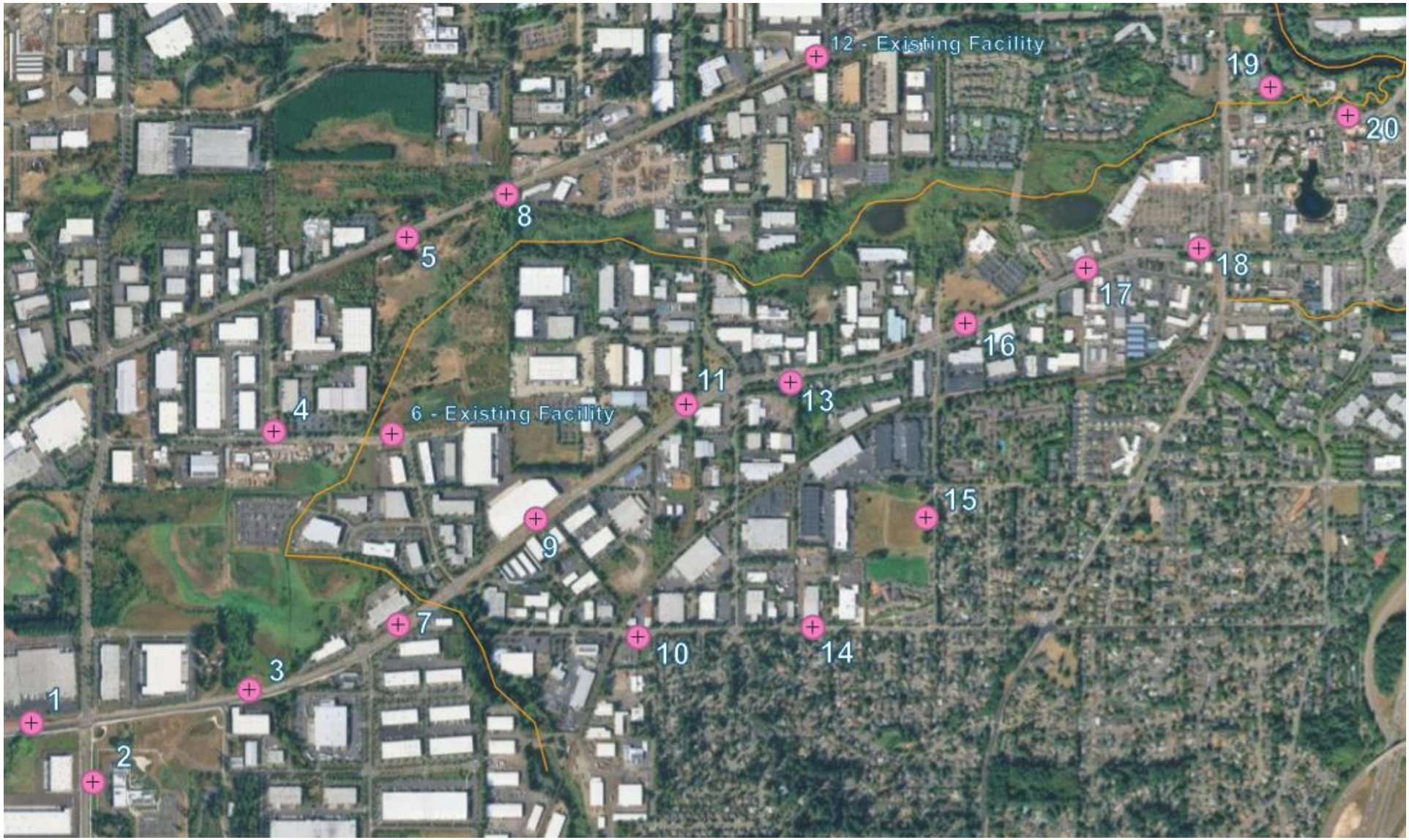
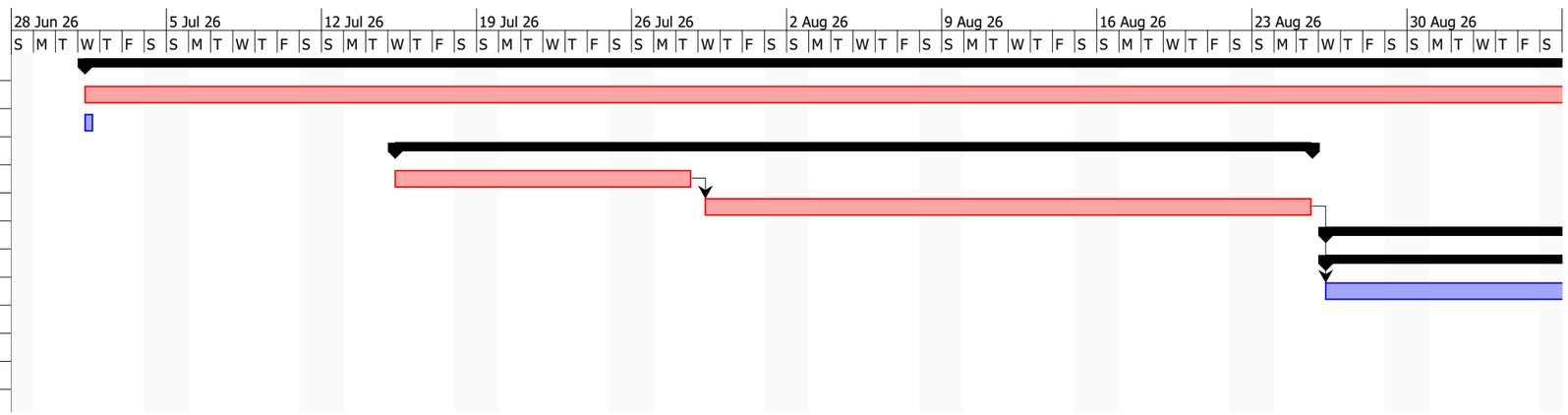


Figure C: *Numbered locations of proposed bioswales.*

APPENDIX D
CONSTRUCTION SCHEDULE

	WBS	Name	Duration	Start	Predecessors
1	**100**	**Project Administration**	**100 days**	**7/1/26, 8:00 AM**	
2	101	Contract Administration	100 days	7/1/26, 8:00 AM	
3	102	Project Kickoff Meeting	1 day	7/1/26, 8:00 AM	
4	**200**	**Site Preparation**	**30 days**	**7/15/26, 8:00 AM**	
5	201	Survey	10 days	7/15/26, 8:00 AM	
6	202	Excavation	20 days	7/29/26, 8:00 AM	5
7	**300**	**Structural**	**30 days**	**8/26/26, 8:00 AM**	
8	**301**	**Concrete**	**30 days**	**8/26/26, 8:00 AM**	
9	301.1	Walls	20 days	8/26/26, 8:00 AM	6
10	301.2	Inlets/Outlets	10 days	9/23/26, 8:00 AM	9
11	**400**	**Soil and Plants**	**25 days**	**10/7/26, 8:00 AM**	
12	401	Soil Fill	5 days	10/7/26, 8:00 AM	10
13	402	Planting	20 days	10/14/26, 8:00 AM	12



APPENDIX E
SPECIFICATIONS

The following specifications are preliminary and are provided to support the conceptual design for the Hedges Creek Stormwater Management Study. The specifications identify relevant construction, stormwater, erosion control, utility, planting and maintenance requirements for the proposed bioswale/stormwater planter facilities. Final specifications shall be developed during final design.

The specifications listed in this appendix are based on the City of Tualatin Public Works requirements, Oregon construction and environmental protection practices, Oregon DEQ stormwater best management practice (BMP) guidance, Clean Water Services vegetated swale guidance, and City of Portland 2025 Stormwater Management Manual details used as reference material for conceptual bioswale design.

APPENDIX E01: CITY OF TUALATIN PUBLIC WORKS REQUIREMENTS

The following requirements apply to work that affects public infrastructure, drainage improvements, public right-of-way and stormwater facilities within the City of Tualatin.

Public Works Permit Requirements

Any construction activity involving public drainage improvements, stormwater facility installation, excavation within public areas, or connection to public stormwater infrastructure shall be reviewed and approved by the City of Tualatin Engineering Division before construction.

The final submittal should include construction drawings, supporting calculations, specifications, erosion control information, utility coordination, and inspection requirements. Construction shall not begin until all required permits, approvals and inspections have been coordinated with the City.

Construction Layout and Survey Control

Construction layout, including actual lines, grades, elevations, and dimensions, shall be based on approved construction drawings and verified by field survey before construction. The contractor or final design team shall confirm horizontal and vertical control before layout.

Existing survey monuments shall be protected during construction. If survey monuments are disturbed, they shall be replaced according to applicable state and local requirements.

Existing Conditions Verification

Existing utilities, stormwater structures, property lines, right-of-way limits, pavements, sidewalks, trails, trees, and drainage paths shown in the Draft 3 drawings are approximate. All existing conditions shall be verified before final design or construction.

Where field conditions conflict with the drawings, the conflict shall be reported to the City or Engineer before work proceeds.

Utility Notification

Before excavation, utility notification shall be completed through the Oregon Utility Notification Center or other applicable utility locate process. Excavation shall not begin until underground utilities have been marked and conflicts have been reviewed.

Utility coordination shall include stormwater, sanitary sewer, water, gas, electrical, communication, and other utilities located within or near the bioswale construction limits.

Construction Documents on Site

The contractor shall keep a complete set of approved construction documents, permits, drawings, specifications, and addenda on the project site during construction. Any changes to the approved work shall be reviewed and approved before implementation.

APPENDIX E02: OREGON STANDARD CONSTRUCTION PRACTICES

The following specifications are relevant to general construction activities associated with bioswale installation, including staging, environmental protection, clearing, excavation, backfill, grading and compaction.

Part of 00290 - Environmental Protection

Staging and Disposal Sites

Staging areas, disposal areas, and material storage areas should be located in previously disturbed or improved areas where practical, such as existing paved or gravel areas. Equipment and materials should not be staged in sensitive environmental areas, parks, wetlands, stream corridors, or areas where runoff may directly enter Hedges Creek or the Tualatin River.

Water Conservation

Water used during construction should be minimized where practical. Leaks from construction equipment, water lines, tanks, or containers should be repaired promptly. Water use for dust control, soil moisture conditioning, and cleanup should be managed to avoid unnecessary runoff.

Waste, Hazardous Waste, and Hazardous Substances

Waste materials, hazardous waste, fuels, oils, and other hazardous substances shall be stored, handled, transported, and disposed of according to applicable federal, state, and local requirements. Waste materials shall not be disposed of in wetlands, waterways, floodplain areas or near Hedges Creek.

Part of 00320 - Clearing and Grubbing

Clearing and Grubbing

Clearing and grubbing includes removing vegetation, roots, debris, buried matter, and unsuitable material within the construction limits. Vegetation and site features designated to remain shall be protected.

For this project, clearing and grubbing should be limited to the area required for bioswale construction. Existing trees, riparian vegetation, public landscaping, trails, sidewalks and public facilities outside the work area should be protected.

Preservation of Existing Vegetation
Where bioswales are located near existing riparian or park areas, vegetation removal should be minimized. Tree and plant protection zones should be established where existing vegetation is to remain.

Part of 00330 - Earthwork

Earthwork
Earthwork includes excavation, grading, ditching, backfilling, embankment construction, and other soil-moving work required to construct the proposed bioswales.

For this project, earthwork includes removal of existing pavement or soil where required, excavation of the bioswale footprint, grading to the proposed bottom elevation, shaping of side slopes or planter walls, and preparation of subgrade for soil media, drain rock, underdrains, and planting.

Lines, Grades, and Cross Sections
Earthwork shall conform to the lines, grades, slopes, and cross sections shown on the final construction drawings. Since the Draft 3 drawings are conceptual, final bioswale elevations and grades shall be confirmed through topographic survey and final design.

Excavation
Excavation shall be performed only within the approved construction limits. Unsuitable materials encountered during excavation shall be removed and replaced with approved backfill or soil media as required by final design.

Excavated materials shall be separated and reused where appropriate. Excess or unsuitable materials shall be removed from the site and disposed of according to applicable requirements.

Excavation of Existing Surfaces
Where bioswales are proposed within existing paved areas, excavation may include removal of asphalt, concrete, curb, sidewalk, or other existing surfaces. Pavement removal shall be limited to the area required for construction and shall use clean saw cut limits where appropriate.

Backfill
Backfill materials shall be suitable for the intended use. General backfill, granular backfill, drain rock, and engineered soil media shall be placed only where shown on the final drawings or as directed during final design. Backfill around structures, underdrains, cleanouts, and outlet pipes shall be placed carefully to avoid damaging pipes, liners, or other stormwater facility components.

Compaction

Compaction shall be completed where required for pavement restoration, structural support, concrete walls, curbs, and adjacent surfaces. However, over-compaction of the bioswale bottom and engineered soil media shall be avoided because it can reduce infiltration and stormwater treatment performance. Compaction requirements should be clearly separated between structural/pavement areas and vegetated stormwater facility areas during final design.

Part of 00331 - Subgrade Stabilization

Subgrade Stabilization

If unstable subgrade is encountered during excavation, unstable material shall be removed and replaced with approved aggregate, structural backfill, or other stabilization material as shown on the final plans. For bioswale construction, subgrade stabilization may be required near existing pavement, curb lines, sidewalks, or utility trenches. Stabilization shall not block intended drainage or interfere with underdrain function.

APPENDIX E03: OREGON DEQ CONSTRUCTION STORMWATER BMP REQUIREMENTS

The following specifications apply to construction-phase erosion prevention and sediment control.

Erosion and Sediment Control

Erosion and sediment control measures should be installed before soil disturbance begins. Measures may include inlet protection, sediment barriers, temporary cover, stabilized construction access, sediment traps, check dams, and protection of downstream drainage features. Controls shall be inspected and maintained during construction, especially before and after rainfall events. Sediment shall not be allowed to leave the site or enter the public stormwater system, Hedges Creek or the Tualatin River.

Inlet Protection

Existing stormwater inlets near the construction area shall be protected before pavement removal, excavation, grading, or soil media placement begins. Inlet protection shall remain in place until disturbed areas are stabilized.

Stockpile Protection

Soil, aggregate, engineered media, and other loose materials shall be stored away from drainage paths where practical. Stockpiles shall be covered, surrounded by sediment control measures or otherwise protected to prevent sediment transport.

Stabilized Construction Access

Where construction vehicles enter or leave the work area, stabilized access shall be provided as needed to reduce tracking of sediment onto public roads, parking areas or sidewalks.

Site Stabilization

Disturbed areas shall be stabilized after construction. Stabilization may include planting, mulch, erosion control blankets, temporary cover, pavement restoration or other measures shown on the final design drawings.

APPENDIX E05: CITY OF PORTLAND 2025 STORMWATER MANAGEMENT MANUAL

The following City of Portland 2025 Stormwater Management Manual details are used as reference details only. They are not the final City of Tualatin construction details. Final details shall be modified to meet City of Tualatin requirements and Hedges Creek site specific conditions.

SW-206: Planter, Unlined

This detail is applicable where stormwater planter facilities can allow some infiltration into native soil. It may be used as a reference for planter geometry, vegetation, soil media, drain rock, and general facility layout. For this project, unlined facilities may be considered only where infiltration is acceptable and where groundwater separation is sufficient.

SW-207: Planter, Unlined with Underdrain

This detail is applicable where a planter or bioswale provides treatment and partial infiltration but also includes an underdrain to convey treated water to an approved outlet.

SW-208: Planter, Lined

This detail is applicable where infiltration is not recommended because of high groundwater, poor soil separation, nearby utilities, pavement, buildings, or other infrastructure. For this project, lined bioswales may be required in locations where groundwater separation is insufficient or where infiltration could affect adjacent infrastructure.

SW-213/SW-214: Underdrain with Beehive Overflow

These details are applicable where bioswale overflow and underdrain systems are needed. They provide reference configurations for conveying excess water from the facility to an approved outlet. For this project, overflow structures are required where flows exceed the temporary storage capacity of the bioswale.

SW-318: Underdrain with Cleanout Configuration

This detail is applicable where underdrains are installed and cleanouts are needed for inspection and maintenance. For this project, cleanouts shall be included where underdrains are used so that the facility can be maintained over time.

SW-321: Plant Spacing

This detail is applicable to planting layout and spacing within stormwater facilities. For

this project, plant spacing shall be finalized after the plant list is confirmed. Planting shall maintain access to inlets, outlets, overflow structures, and cleanouts.

SW-322/SW-323: Planting Templates

These details are applicable to planting templates for swales and planters. They may be used as references for arranging wet-tolerant and drought-tolerant plant zones. For this project, planting templates shall be adapted to the proposed bioswale dimensions, flow paths, maintenance access and site constraints.

APPENDIX E05: CLEAN WATER SERVICES VEGETATED SWALE GUIDANCE

The following specifications apply to vegetated bioswale function, geometry, flow control, and stormwater treatment.

Vegetated Swale Function

Bioswales shall be designed as vegetated stormwater facilities that slow runoff, encourage sediment settling, support filtration through vegetation and soil media and improve runoff quality before discharge.

Flow Path and Treatment Length

The bioswale layout should provide a long flow path where possible. A longer flow path improves treatment by increasing contact time between runoff, vegetation, and soil media. For the Hedges Creek project, the proposed bioswales are intended to be long and narrow with the final length adjusted to available site space, right-of-way, utility conflicts and grading constraints.

Side Slopes and Geometry

Side slopes, planter walls, or curbs shall be designed to maintain facility stability and allow safe maintenance access. Where open swales are used, side slopes should be gentle enough to reduce erosion and support vegetation establishment. Where planter-style bioswales are used, concrete walls or curbs may be used to contain the facility and protect adjacent pavement.

Inlet Stabilization

Runoff entering the bioswale shall pass through stabilized inlet areas, curb cuts, flow spreaders, sediment forebays, or similar features where necessary. Inlets shall be designed to prevent erosion and distribute flow into the facility.

Outlet and Overflow Control

Outlet and overflow structures shall safely convey flows exceeding the bioswale storage capacity. Overflow structures may include beehive inlets, outlet notches, overflow drains, or other approved structures. Overflow elevations shall be confirmed during final design based on ponding depth, grading, and connection to existing stormwater infrastructure.

Vegetation

Vegetation should be selected to tolerate wet and dry conditions. Plantings should stabilize the soil surface, slow flow, capture sediment, and support water quality treatment. Planting shall not block inlets, outlets, overflow structures or underdrain cleanouts.

APPENDIX E06: BIOSWALE MATERIAL SPECIFICATIONS

The following material specifications apply to the proposed bioswale elements shown in the Draft 3 drawing package.

Engineered Stormwater Soil Media

Engineered soil media shall support stormwater filtration, vegetation growth, and water quality treatment. Soil media shall be placed to the depth shown on the final drawings and protected from compaction during installation. Final soil media composition, depth, and gradation shall be confirmed during final design.

Drain Rock / Aggregate Layer

Drain rock or aggregate shall be clean, durable, and suitable for stormwater drainage. It shall be placed below the engineered soil media where underdrains are used. Aggregate shall be placed to the depth shown on the final drawings. Separation between soil media and aggregate shall be provided where required to prevent migration of fine particles.

Underdrain Pipe

Underdrain pipe shall be perforated HDPE or approved equivalent. Underdrains shall be installed where infiltration is limited by high groundwater, low-permeability soils, or adjacent infrastructure constraints. Pipe size, slope, alignment, outlet connection and clean out spacing shall be confirmed during final design.

Impermeable Liner

An impermeable liner shall be provided where groundwater separation is insufficient or where infiltration is not allowed. Liner material, seams, pipe penetrations, and pipe boots shall be detailed during final design. The liner shall be protected during construction and shall not be punctured or damaged during soil media or aggregate placement.

Concrete Curbs / Planter Walls

Concrete curbs or planter walls shall be used where needed to define facility boundaries, protect adjacent pavement, and direct runoff into the bioswale. Wall height, thickness, reinforcement, and joints shall be confirmed during final design.

Inlet Structures

Inlet structures shall be designed to allow runoff to enter the bioswale without causing erosion or localized scour. Inlets may include curb cuts, notches, concrete inlets, flow

spreaders, or stabilized rock pads.

Outlet and Overflow Structures

Outlet and overflow structures shall convey flows exceeding bioswale storage capacity to an approved stormwater system or discharge point. Outlet details shall include erosion protection where needed.

Planting

Planting shall include native or adapted vegetation suitable for stormwater facility conditions. Plantings shall tolerate periodic inundation and dry summer periods. Planting shall be arranged to maintain clear access to inlets, outlets, overflow structures, and underdrain cleanouts.

Maintenance Access

Bioswales should be designed to allow routine inspection and maintenance. Maintenance activities may include sediment removal, trash removal, inlet and outlet clearing, vegetation replacement, weed control, and inspection of underdrain cleanouts.

APPENDIX E07: CONSTRUCTION SEQUENCE SPECIFICATION

The following preliminary construction sequence applies to the proposed bioswale facilities.

1. Confirm final limits of work, survey control, utility locates, and right-of-way boundaries.
2. Install erosion and sediment control measures.
3. Protect existing stormwater inlets, utilities, pavement, sidewalks, trails, and vegetation to remain.
4. Remove pavement, curb, concrete or unsuitable material where required.
5. Excavate bioswale footprint to proposed subgrade.
6. Stabilize subgrade where required.
7. Install liner where required.
8. Install underdrain pipe, aggregate layer, and cleanouts where required.
9. Place engineered stormwater soil media.
10. Construct curbs, planter walls, inlets, outlets and overflow structures.
11. Grade bioswale surface to provide positive flow from inlet to outlet.
12. Install vegetation and surface stabilization.
13. Remove temporary controls only after disturbed areas are stabilized.
14. Complete final inspection and maintenance access review.

APPENDIX F
QC CHECKLIST

Group	*Group 2: The Tualatin Creek-its*
Project	*Downtown Tualatin Hedges Creek Stormwater Management Study*

Preparer	Checker	Checklist Item
AH	NL	***General***
AH	NL	*Proper grammar, spelling, punctuation, structures of sentences, etc.*
AH	NL	*Template followed*
AH	NL	*Consistent formatting*
AH	NL	*CEE Writing Style Guide followed*
AH	NL	*Technical writing style used (clear, concise, and easy to understand)*
AH	NL	*Work submitted in proper format*
AH	NL	*Descriptive file name*
AH	NL	*All tables and figures labeled*
AH	NL	*Descriptive headings for each section and subsection*
AH	NL	***Cover Page***
AH	NL	*Project Title*
AH	NL	*Team # and Name*
AH	NL	*Team Member Names*
AH	NL	*Client Name*
AH	NL	*Relevant figure*
AH	NL	*PSU logo & Capstone Caption/Disclaimer*
AH	NL	*Acknowledgements (including acknowledgement of client's assistance and land knowledgement)*
AH	NL	***Table of Contents***
AH	NL	*All sections, subsections listed, with page numbers*
AH	NL	*Appendices listed in order (no page numbers)*
AH	NL	*Abbreviation list*
AH	NL	***Executive Summary***
AH	NL	***Abbreviations***
AH	NL	***Introduction***
AH	NL	*Descriptive problem statement. Brief mention of methods used and contents of report*
AH	NL	***1.0 Project Understanding***
AH	NL	*Provide an introductory sentence to describe the sections and subsections.*
AH	NL	***1.1 Project Overview***
AH	NL	- *Project location w/ figure*
AH	NL	- *Need/purpose of project*
AH	NL	- *Work completed to date*
AH	NL	***1.2 Existing Conditions***
AH	NL	*Describe the project site in detail. Relevant information may include:*

AH	NL	- *Vegetation*
AH	NL	- *Soil*
AH	NL	- *Geometry (size, shape, slope, etc.)*
AH	NL	- *Neighboring properties*
AH	NL	- *Current uses*
AH	NL	*Provide at least one figure in this section. The figure could be an aerial photo or site photo. Additional site photos should be included as an attachment (i.e., do not put all site photos in this section).*
AH	NL	***1.3 Stakeholders***
AH	NL	- *Identify other interested parties*
AH	NL	- *Explain each party's stake/interest*
AH	NL	***2.0 Alternative Analysis***
AH	NL	- *Restating the problem statement and providing detailed description to why alternatives are needed*
AH	NL	- *At least 3 alternatives considered and identified*
AH	NL	***2.1 Selection Criteria***
AH	NL	- *Explanation to why criteria components are selected*
AH	NL	***2.1.1 Cost***
AH	NL	***2.1.2 Environmental Impact and Pollution Management***
AH	NL	***2.1.3 Aesthetics***
AH	NL	***2.1.4 Ease of Maintenance***
AH	NL	***2.1.5 Efficiency of Land Use***
AH	NL	***2.1.6 Volume of Water Retained***
AH	NL	***2.2 Alternatives***
AH	NL	- *Brief introduction, stating that alternatives can be combined*
AH	NL	- *Descriptive headings for each section and subsection*
AH	NL	***2.2.1 No Action***
AH	NL	- *Detailed description of the alternative (at least 5 sentences)*
AH	NL	- *Including at least one figure (and/or table if applicable)*
AH	NL	***2.2.2 Blue/Green Roof Analysis***
AH	NL	- *Detailed description of the alternative (at least 5 sentences)*
AH	NL	- *Answering questions: "What is unique about this alternative? How can it provide remediation for the existing conditions?"*
AH	NL	- *Including at least one figure (and/or table if applicable)*
AH	NL	- *Identify sources of research*
AH	NL	- *Including footnotes (and quotations, if necessary), referring to References section*
AH	NL	- *Including sources of research in the Reference section*
AH	NL	***2.2.3 Bioswale Analysis***
AH	NL	- *Detailed description of the alternative (at least 5 sentences)*
AH	NL	- *Answering questions: "What is unique about this alternative? How can it provide remediation for the existing conditions?"*

AH	NL	- *Including at least one figure (and/or table if applicable)*
AH	NL	- *Identify sources of research*
AH	NL	- *Including footnotes (and quotations, if necessary), referring to References section*
AH	NL	- *Including sources of research in the Reference section*
AH	NL	***2.2.4 Vault Analysis***
AH	NL	- *Detailed description of the alternative (at least 5 sentences)*
AH	NL	- *Answering questions: "What is unique about this alternative? How can it provide remediation for the existing conditions?"*
AH	NL	- *Including at least one figure (and/or table if applicable)*
AH	NL	- *Identify sources of research*
AH	NL	- *Including footnotes (and quotations, if necessary), referring to References section*
AH	NL	- *Including sources of research in the Reference section*
AH	NL	***2.3 Preferred Alternative***
AH	NL	- *Providing scoring table for alternatives (this is the Selection Matrix, in which scores will be used to rank alternatives)*
AH	NL	- *Explanation of scoring methodology and logic*
AH	NL	- *Identify the preferred alternative*
AH	NL	- *Including reason why this alternative is preferred at this early stage*
AH	NL	- *Explanation to why this alternative is unique compared to other options.*
AH	NL	- *Justification for why this alternative is chosen, using Section 2.1 Selection Criteria.*
AH	NL	***3.0 Design Development***
AH	NL	***3.1 Bioswale Volume and Dimensions***
AH	NL	***3.2 Runoff Analysis***
AH	NL	***3.3 Area of Effectiveness***
AH	NL	***3.4 Vegetation for Bioswales***
AH	NL	***3.5 Construction Cost Estimate***
AH	NL	***3.6 Preliminary Construction Schedule***
AH	NL	***4.0 Design Requirements, Regulatory Compliance, and Permitting***
AH	NL	***4.1 Design Requirements***
AH	NL	***4.2 Code Requirements***
AH	NL	***4.3 Permitting***
AH	NL	***4.4 Summary of Codes***
AH	NL	***5.0 Conclusion***
AH	NL	***References***
AH	NL	- *Proper citation format in alphabetical order of authors*
AH	NL	- *Citations appear in the body of the report (i.e footnotes, quotations, etc.)*
AH	NL	***Appendix A: Drawings***
AH	NL	***Appendix B: Calcualations***
AH	NL	- *Initial calculations included*

AH	NL	- *Professional format, according to CEE Writing Style Guide*
AH	NL	***Appendix C: Construction Cost Estimate***
AH	NL	***Appendix D: Construction Schedule***
AH	NL	***Appendix E: Specifications***
AH	NL	***Appendix F: QC Checklist***
AH	NL	- *Provide completed checklist*
AH	NL	- *Two group members sign and date*

Preparer	*Name: Adam Hamling*	*Signature:*	*Date: 6/7/2026*
Checker	*Name: Nhy Le*	*Signature:*	*Date: 6/7/2026*

SCI Directors and Staff

Marc Schlossberg	SCI Co-Director, and Professor of Planning, Public Policy and Management, University of Oregon
Nico Larco	SCI Co-Director, and Professor of Architecture, University of Oregon
Megan Banks	SCYP Director, University of Oregon
Lindsey Hayward	SCYP Assistant Program Manager, University of Oregon
Grace Craven	Report Coordinator
Danielle Lewis	Graphic Designer
Emma McFarland	Graphic Designer