



# FARMING IN THE FLOODPLAIN PROJECT FINDINGS AND RECOMMENDATIONS REPORT

Prepared for  
PCC Farmland Trust

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## 1.0 Introduction

This report is the final deliverable for Phase 2 of the Farming in the Floodplain Project (FFP). The report summarizes the purpose of the FFP, work conducted as part of the FFP to this point, and how information developed under the FFP will be used moving forward. The report also summarizes key findings and recommendations documented in technical memorandums developed as part of the FFP. All technical memorandums developed as part of Phase 2 of the FFP are included as appendices to this report and are available online at [www.farminginthefloodplain.org/resources](http://www.farminginthefloodplain.org/resources).

## 2.0 Study Area

The study area for the FFP is the Clear Creek area, part of the Clear Creek Subbasin of the Puyallup River Watershed (Figure 1). The Clear Creek Subbasin is within the Puyallup River Watershed and is located south of the Puyallup River, north of 128th Street East, west of 66th Avenue East, and east of McKinley Avenue East. The Clear Creek area is roughly 1,140 acres in size and bounded by the Puyallup River to the north, Pioneer Way East to the south and west, and 52nd Street East to the east.



## 3.0 What Is the Farming in the Floodplain Project?

### 3.1 Purpose of the FFP

The FFP is a collaboration led by PCC Farmland Trust with contributions from the Pierce County Agricultural Program and the Pierce Conservation District. The purpose of the FFP is to advance progress toward a collectively agreed-upon plan for the Clear Creek area that improves agricultural viability in the area while also meeting the goals of flood risk reduction and salmon habitat enhancement. The FFP is intended clarify the needs and interests of the agricultural community in the Clear Creek area.

The FFP is one of four components of the Floodplains for the Future: Puyallup, White, and Carbon Rivers project, which is funded by a Floodplains by Design grant from the Washington Department of Ecology (Ecology). The other components are:

- A capital program that includes a broad suite of floodplain reconnection projects throughout the Puyallup River Watershed and includes the Clear Creek Floodplain Reconnection Project, which has an overlapping project area with the FFP and is described in more detail below.
- A monitoring plan and goal-setting process for the watershed.
- An agricultural conservation easement program to conserve active farmland within the broader Puyallup River Watershed.

The FFP is related to, but independent from, the Clear Creek Floodplain Reconnection Project proposed by Pierce County Surface Water Management (SWM). As conceived, the proposed Clear Creek Floodplain Reconnection Project involves the construction of a ring levee around low-lying portions of the Clear Creek area to protect farms, homes, and infrastructure from backwater flooding from the Puyallup River, followed by the removal of two tide gates where Clear Creek enters the Puyallup River. The project is intended to reduce flood risks, improve salmon habitat, and potentially improve agricultural viability and is anticipated to take 10 to 15 years or more to implement.

Farmers in the Clear Creek area have expressed concerns about the proposed reconnection project's potential impacts on farmland, which could include the loss of farmland and disruption of agricultural drainage, among other impacts. In addition to analyzing the potential impacts on farmland of the reconnection project, the FFP has also taken a broader look at agricultural viability in the Clear Creek area in order to develop a better understanding of the needs of agriculture. Ideally, the needs of agriculture will be integrated into the proposed Clear Creek Floodplain Reconnection Project so that it can achieve benefits for farming as well as for salmon habitat and flood risk reduction.

## 3.2 Work Completed Under the Farming in the Floodplain Project Thus Far

The FFP has included both farmer/landowner engagement activities and a suite of technical work. Because this report is a component of the technical work, this section focuses on that work and does not summarize landowner engagement activities.

Work on the FFP has been conducted in phases. Phase 1 lasted from February to August 2016. Phase 2 began in September 2016 and is ending in July 2017.

At the beginning of the FFP, a **Technical Advisory Group (TAG)** was formed to provide input on the technical work. The original concept for the TAG was to convene regional technical experts. However, when discussing who to invite to participate, it was determined that farmers and landowners in the Clear Creek area should also be included. The scope of the TAG was expanded to become a forum for shared learning and discussion about conditions in the Clear Creek area. In 2016 and 2017, six TAG meetings were held on the following topics:

- TAG #1 (April 2016): Agriculture in the Clear Creek area; agricultural viability; concerns, opportunities, and information needs in the Clear Creek area; and observed trends and projections
- TAG #2 (June 2016): Hydraulic modeling conducted for the Clear Creek Floodplain Reconnection Project, agricultural viability, and work plan elements for future phases of the FFP
- TAG #3 (July 2016): The Existing Conditions Report and Phase 2 of the FFP
- TAG #4 (November 2016): Sediment conditions in the Puyallup River and in Clear Creek
- TAG #5 (February 2017): The agricultural drainage inventory, the Snoqualmie Valley Watershed Improvement District, and agricultural conservation easements
- TAG #6 (May 2017): The agricultural drainage inventory, the Clear Creek tide gates, the farmland impacts of the proposed Clear Creek Floodplain Reconnection Project, and work plan items for the FFP in 2018 and 2019

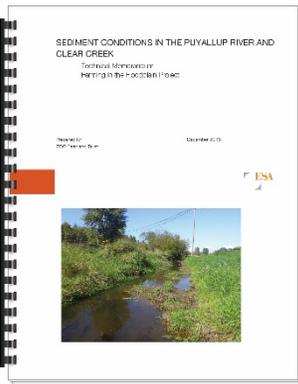
TAG meeting reports are available online at: <http://farminginthefloodplain.org/resources/>.



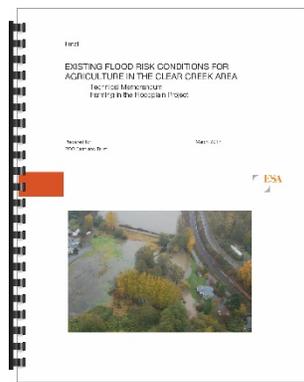
In addition to forming the TAG, Phase 1 of the FFP focused on understanding existing conditions. In August 2016, the FFP released an [Existing Conditions Report](#) (ECR). The ECR summarizes existing information about physical conditions and trends in the Clear Creek area, identifies information needs, and describes the relationship between physical conditions and the viability of agriculture in the area. Development of the ECR informed the work undertaken in Phase 2 of the FFP. The ECR has served as baseline information for additional technical work for the FFP. This Findings and Recommendations Report is intended as a follow-up to the ECR.

After completion of the ECR, the FFP began Phase 2, which included development of the following technical memorandums:

- Sediment Conditions in the Puyallup River and Clear Creek (December 2016)
- Existing Flood Risk Conditions for Agriculture in the Clear Creek Area (March 2017)
- Drainage Inventory Memorandum (May 2017)
- Clear Creek Tide Gate Assessment Technical Memorandum (July 2017)
- Farmland Impacts (July 2017)
- Upstream Development (May 2017)



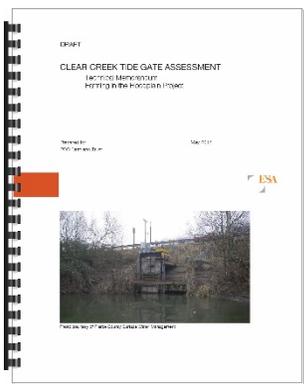
The fourth TAG meeting, held in November 2016, focused on the topic of sediment conditions in the Puyallup River and Clear Creek. The meeting included a presentation by Kris Jaeger of the U.S. Geological Survey (USGS) on sediment conditions in the Puyallup River, a presentation from ESA staff on sediment conditions in Clear Creek and its tributaries, and a group discussion of sediment questions and concerns. The [Sediment Conditions in the Puyallup River and Clear Creek Technical Memorandum](#) (Sediment Memorandum) summarizes the information presented and discussed at that meeting. The Sediment Memorandum is included in this report as Appendix A.



The [Existing Flood Risk Conditions for Agriculture in the Clear Creek Area Technical Memorandum](#) (Flood Risk Memorandum) provided information on existing flood risk conditions for farms in the Clear Creek area. The Flood Risk Memorandum includes sections on the relationship of flood risk to agricultural viability, flood risk to organic certification and crops, vulnerabilities in the Clear Creek area flood system, ongoing and planned actions to reduce vulnerabilities in the Clear Creek area, and findings. The Flood Risk Memorandum is included in this report as Appendix B.



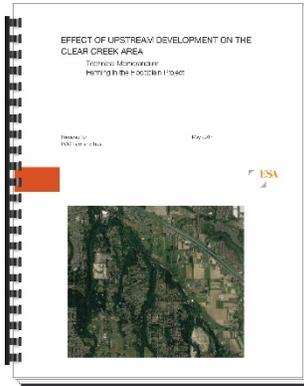
The [Drainage Inventory Memorandum](#) documents an inventory of the agricultural drainage system in the Clear Creek area conducted by ESA. The agricultural drainage inventory provides an improved map and qualitative information on the agricultural drainage system that can be used in the future to inform the planning and design of projects such as the proposed Clear Creek Floodplain Reconnection Project, projects undertaken by Drainage District 10 or individual landowners, and other multiple-benefit projects in the area, and to ensure that these projects improve agricultural drainage. The drainage inventory is for planning purposes only; it is not detailed enough to develop permit applications or design plans for actions that would modify or alter the drainage network. The Drainage Inventory Memorandum is included in this report as Appendix C.



The **Clear Creek Tide Gate Assessment Technical Memorandum** (Tide Gate Memorandum) describes the current operations of the tide gates at the mouth of Clear Creek and recommends potential actions to improve operations of the tide gates. The description of current operations of the tide gates in the Tide Gate Memorandum is based on water surface elevation data derived from water level loggers installed by SWM in Fall 2016; photographs of the tide gates; and as-built plans and other documentation of the tide gates. Recommended potential interim actions in the Tide Gates Memorandum are described at a conceptual level; additional analysis would be needed to determine the feasibility of the recommended actions before they could be implemented. The Tide Gate Memorandum is included in this report as Appendix D.



The **Farmland Impacts Memorandum** identifies the general types of impacts that could occur to farmlands from a levee constructed as part of SWM's proposed Clear Creek Floodplain Reconnection Project. The Farmland Impacts Memorandum also identifies issues that should be considered in the master planning process for the Floodplain Reconnection Project, such as considerations for design of the project and additional studies needed to understand potential impacts. The Farmland Impacts Memorandum is included in this report as Appendix E.



The [Effect of Upstream Development on the Clear Creek Area Technical Memorandum](#) (Upstream Development Memorandum) evaluates the impacts from upstream development on runoff delivered to the Clear Creek area. The evaluation was primarily conducted with a GIS exercise using historic and recent land cover data to describe the change in impervious surface over time. The evaluation also includes a summary of the change in stormwater regulations over time. The Upstream Development Memorandum is included in this report as Appendix F.

### 3.3 The Farming in the Floodplain Project Moving Forward

Phase 2 of the FFP ends in July 2017. At the time of writing of this report, the Washington State Legislature is considering funding the next phase of the Puyallup Watershed Floodplains for the Future initiative, which would likely include funding for an additional phase of the FFP, covering 2018 and 2019. Potential work plan elements for the next phase of the FFP are currently being discussed with farmers in the Clear Creek area and Floodplains for the Future stakeholders.

When the FFP began in early 2016, Pierce County was considering two possible levee alignments for the Clear Creek Floodplain Reconnection Project (one at roughly the 14 foot contour and the other at roughly the 18 foot contour NAVD<sup>1</sup>). However, since that time, the planning process for the Clear Creek Floodplain Reconnection Project has changed. Pierce County has agreed to revisit the conceptual design of the project with a facilitated and collaborative master planning process for the Clear Creek area. During this process, the alignment of the levee and other project elements will be open to revision. The hope of FFP project staff is that farmers in the Clear Creek area will be able to use the information developed by the FFP to advocate for the needs of agriculture in the collaborative master planning process for the Clear Creek area.

## 4.0 Findings and Recommendations Related to Existing Conditions

A number of findings and recommendations are included throughout the Existing Conditions Report and the technical memorandums developed as part of the FFP. This report includes 15 high level findings (with associated recommendations) summarized from the ECR and the technical memorandums. Additional detail on each can be found in the appendices to this report or in the ECR. The 15 findings are divided into those related to existing conditions (in this section) and those related to the potential impacts of the proposed Clear Creek Floodplain Reconnection Project (Section 5.0).

<sup>1</sup> NAVD stands for North American Vertical Datum of 1988. Pierce County Surface Water Management uses the NAVD 88 datum for all elevation data in the Puyallup Watershed.

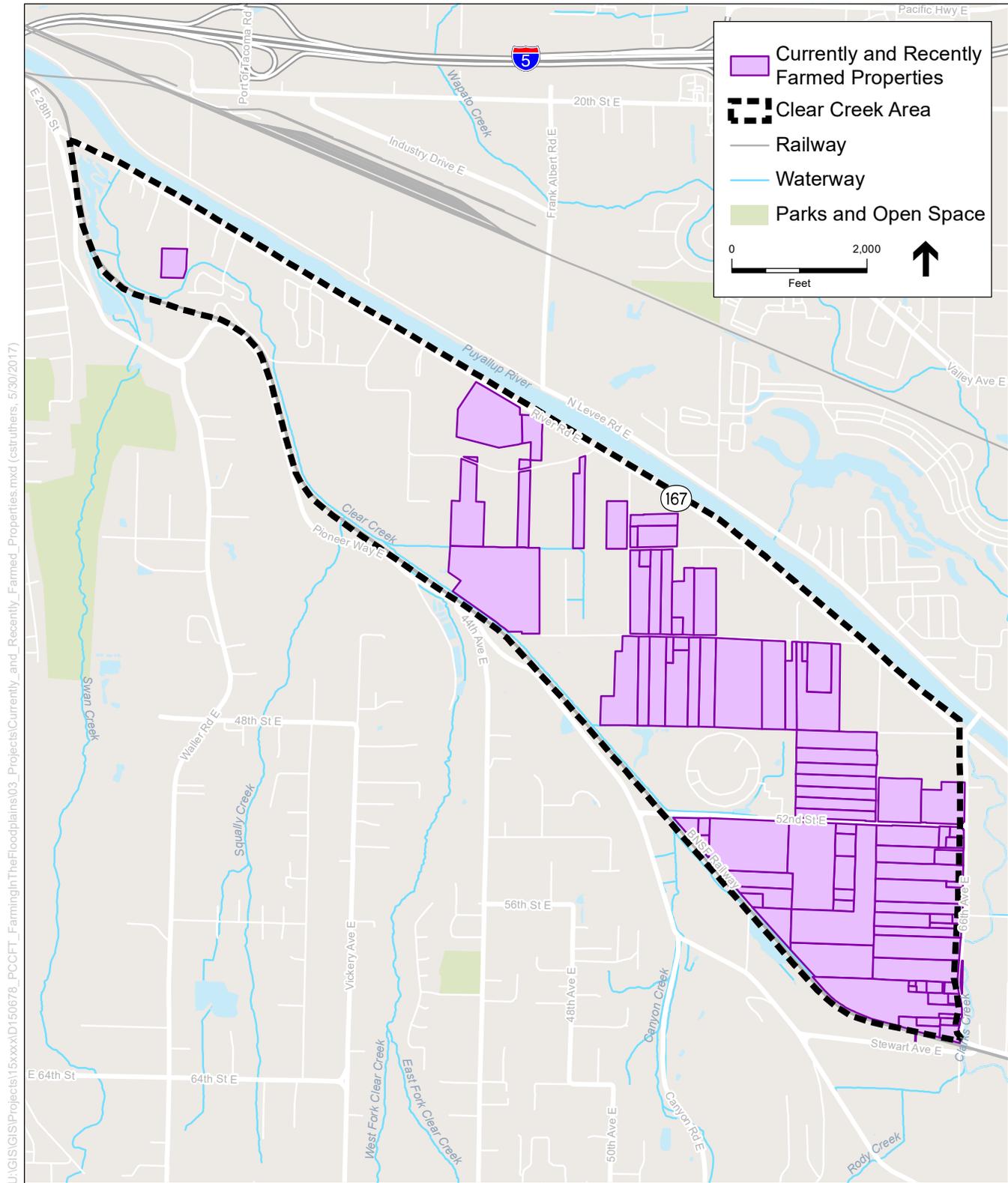
## 4.1 Agriculture in the Clear Creek area is important

Pierce County is home to almost 1,500 local farms that produce \$91 million worth of products, including vegetables, livestock, poultry, eggs, flowers and bulbs, and aquaculture (Pierce County, 2016b). Farmland throughout the county has historically been converted into residential and other uses and that trend is continuing. Remaining agricultural lands are often adjacent to residential or commercial structures. The Puyallup Valley in particular has experienced a rapid increase in development. As of the writing of the 2006 Pierce County Agriculture Strategic Plan, 25 percent of agricultural land in the Puyallup Valley was located within incorporated areas or urban growth boundaries as of 2006 (Pierce County, 2006b). In 2004, American Farmland Trust published a report titled: “The Suitability, Viability, Needs, and Economic Future of Pierce County Agriculture,” which found that agriculture in the county was shifting from industrial, wholesale agriculture to value-added, direct market “urban edge” farming. This shift was caused by the urbanization and fragmentation of the agricultural land base, but was made possible by the favorable climate and soil in the county (American Farmland Trust, 2004). More recent reports suggest that the trends identified in the 2004 report have continued throughout the Puyallup River watershed (WSU et al., 2015).

The Clear Creek area reflects the trend in Pierce County of a transition to smaller, local market-driven urban edge farming. The area also has several large wholesale farms that have been in the same family for generations. The area’s proximity to consumers and highly productive soils also are attracting new farmers to Pierce County, with new farmers starting farms or becoming owners of existing smaller farms. Farmers in the Clear Creek area note the value of their prime farmland soils, as defined by the Natural Resources Conservation Service (NRCS). Soils in the Clear Creek area produce high value crops and support small farms (Clear Creek Farmers, 2016).

As a Puyallup Valley lowland agricultural area not located within an urban growth area, the Clear Creek area is important for Pierce County agriculture as a whole. Farms in the Clear Creek area are close to consumers and local markets in the urban centers of Tacoma and Puyallup. Smaller acreage farms in the Clear Creek area, many of which are certified organic, sell vegetables, berries, eggs, meats, Koi fish, and other farm products direct to consumers on farm or through Community Supported Agriculture (CSA) subscriptions as well as through outlets such as the Tacoma and Proctor Farmers Markets, Marlene’s Market (a local grocery store chain), and the Tacoma Food Coop (Johnson et al., 2016). Larger scale farms also sell fresh produce direct to local consumers through their own on-farm stands, as well as to regional grocery retailers and food distributors. Many Clear Creek farms offer agritourism activities such as community potlucks, on-farm events, summer camps, pumpkin patches, and U-pick berries (Clear Creek Farmers, 2016).

Figure 2 shows currently and recently farmed properties in the Clear Creek Area. Information in the figure was gathered through PCC Farmland Trust’s landowner engagement effort.



SOURCE:  
 ESA 2016; Pierce County 2015;

PCCFT Farming in the Floodplain. 150678  
**Figure 2**  
 Currently and Recently Farmed Properties

The Strategic Conservation Partnership (SCP) is a collaborative group working to increase the pace and durability of agricultural conservation in Pierce County. SCP members include the Pierce County Agricultural Program, PCC Farmland Trust, Forterra, and the Pierce Conservation District. To help guide their work, SCP members funded a GIS-based prioritization of farmlands in Pierce County. Factors included in the prioritization included zoning and comprehensive plan designations; soil types and quality; parcel size; threat of conversion based on proximity to Urban Growth Areas; adjacency to other agricultural lands; and the presence of critical areas. The GIS prioritization identified many high-priority farms in the Clear Creek area. Maintaining agriculture in the Clear Creek area is important for meeting the SCP goal of conserving and increasing the farmland acreage base. Because many of the farmlands that are high priority for agricultural conservation are in the Clear Creek area, maintaining agriculture in the area is also critical for meeting the SCP's 10-year voluntary conservation goal of 6,000 acres. Figure 3 is a conservation funding heat map that shows the Clear Creek area as one of the County's biggest concentrations of high priority farmland conservation projects.



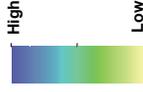
**PCC FARMLAND TRUST**  
Saving local organic farmland forever

**PCAR  
Conservation Funding  
Heat Map**

Pierce County, Washington

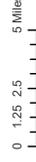
● PCCFT Projects

 Priority Areas for Farmland Conservation

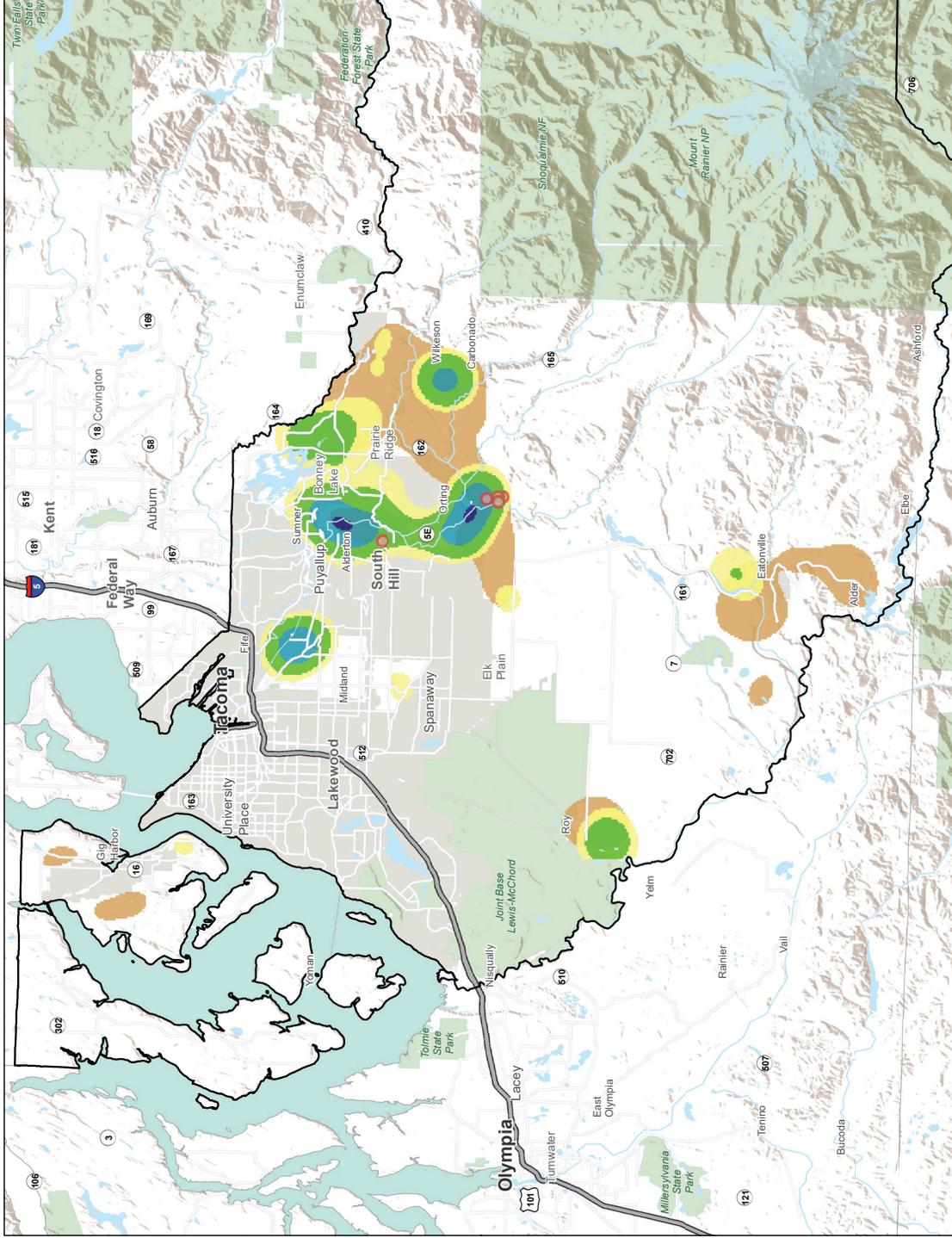


**Concentration of Highest Priority Projects**

Note: Concentration is a measure of the density of projects within a 2-mile radius of a given property.



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SOURCE: PCC Farmland Trust, 2017

PCCFT Farming in the Floodplain. 150678

**Figure 3**

Conservation Funding Heat Map



Additional information on this topic can be found in Chapter 2 of the ECR and in the Farmland Impacts Memorandum (Appendix E).

### **Recommendation**

Efforts should be made to protect agricultural viability in the Clear Creek area. Impacts and benefits to agriculture and to agricultural viability should be considered for proposed projects in the area. Impacts should be minimized or avoided where possible. Floodplain projects in the Clear Creek area should take a multiple-benefits approach and pursue actions that benefit agriculture as well as flood risk reduction and habitat improvements.

## 4.2 Agricultural viability is better understood through the concept of risk than through quantifiable thresholds

The FFP is focused on the concept of agricultural viability. Agricultural viability can be defined as the ability of a farmer or group of farmers to:

- Productively farm on a given piece of land or in a specific area,
- Maintain an economically viable farm business,
- Keep the land in agriculture long-term, and
- Steward the land so it will remain productive into the future.

At the outset of the FFP, several stakeholders expressed a desire to develop “thresholds” that would identify those physical conditions under which farms in the area would no longer be viable. However, farmers in the area expressed that conditions, crops, techniques, and plans vary so much between farms, even neighboring farms, that setting thresholds for farming as a whole would be neither possible nor useful. The same flooding conditions can be devastating for a farmer growing perennial crops but be a minor two-day nuisance for a farmer focusing on seasonal crops. Drainage conditions that render entire fields unusable for one farmer can be a benefit to a neighboring farm with a different soil type and different topography.

Farmers in the Clear Creek area explained that farmers constantly deal with risks, including weather, flooding and drainage problems, and market conditions. In any given year, some crops are successful and others are not. Farmers individually determine what an acceptable level of risk is and adjust their farming practices accordingly.

Current conditions in the Clear Creek area present a range of risks to agriculture each year, and future conditions are anticipated to increase some existing risks, present new risks, or in some cases reduce risks. A variety of actions (designed to meet agriculture, flood risk reduction, or salmon habitat objectives) could be undertaken in the area, and each could increase or decrease risks to agricultural viability.

Additional information on this topic can be found in Chapter 2 of the ECR and in the Farmland Impacts Memorandum (Appendix E).

### **Recommendation**

The Clear Creek Floodplain Reconnection Project and other projects in the Clear Creek area should consider agricultural viability broadly. Risks and ranges of potential impacts to agriculture should be considered as part of project planning.

## 4.3 Current and past property acquisitions by SWM are already impacting agricultural viability in the Clear Creek area

Pierce County SWM has been implementing a policy to purchase frequently flooded property from willing sellers (Pierce County, 2013). In the Clear Creek area, Pierce County has purchased over 20 flood prone properties in the last two decades. The property acquisition program has impacted agricultural viability by leaving properties in the area vacant and by affecting Drainage District 10 and the Riverside Fire District.

Criminal activity, trespass, and illegal dumping have been observed in the Clear Creek area, both on flood damaged and abandoned properties and on vacant properties owned by Pierce County. After purchasing properties, Pierce County has removed homes and infrastructure and left the properties vacant. As part of the Clear Creek Floodplain Reconnection Project, Pierce County is currently acquiring more properties in the Clear Creek area with grant funding from several sources, including the Floodplains by Design program. As the amount of vacant land in the area increases, observed impacts (such as criminal activity, trespass, and illegal dumping) could increase as well.

Pierce County SWM is currently exploring the possibility of renting vacant parcels it owns near 47<sup>th</sup> Avenue in the Clear Creek area for agricultural production. Compacted soils on these parcels would need to be tilled and rehabilitated, and all infrastructure (including 47<sup>th</sup> Avenue) would need to be removed. It is unclear at this time whether it is possible to farm these parcels because they may be regulated as wetlands. If possible, conducting agriculture on otherwise vacant parcels owned by SWM in the interim period before the Clear Creek Floodplain Restoration Project is constructed would reduce the threat of trespass, crime, and illegal dumping.

Property acquisition in the area has also affected the Riverside Fire District and Drainage District 10. Pierce County pays full assessments to both the Drainage District and the Fire District for the properties it owns within the districts' boundaries (Redmond, 2017). Therefore, the property acquisition program does not affect the tax base of either district. However, the uncertainty of the long-term future of the area has impacted the ability of each district to conduct its work. In December 2012, the Riverside Fire District stopped providing services and instead contracted with Central Pierce Fire & Rescue, in part due to the proposed floodplain reconnection project. A notice letter to the District's constituents stated that the District was contracting out services due

to a number of issues, including reduced revenue, increasing costs, flood problems, and future flood management plans (Riverside Fire District, 2012). In February 2014, the agreement with Central Pierce Fire & Rescue was canceled because the community was unhappy with the service provided by Pierce Fire & Rescue (Hugo, 2017). Because of the uncertainty of the long-term future of the Clear Creek area, Drainage District 10 (which is faced with a range of other difficulties) is currently having difficulty establishing support for assessing properties to fund drainage maintenance or development of a Drainage Management Plan. The property acquisition program has also reduced the pool of landowners available to be Drainage District 10 commissioners.

Additional information can be found in the Farmland Impacts Memorandum (Appendix E).

### **Recommendations**

SWM should identify strategies to discourage illegal activities on its properties in the Clear Creek area. Expansion of the boundaries of Drainage District 10 should be considered to increase the tax base and pool of landowners who can serve as commissioner. Whether to expand the boundaries of Drainage District 10 would need to be decided by the citizens within the new boundaries. Increasing the vitality of Drainage District 10 would help it better serve its constituents and help offset impacts of the property acquisition program.

## 4.4 Agricultural drainage in the Clear Creek area is poor and is the biggest current risk to agricultural viability

Agricultural drainage in the Clear Creek area is poor and ditch maintenance is needed. There are thick growths of reed canarygrass and other vegetation in the ditches, and there is evidence of sediment deposition in most ditches. Both the vegetation growth and sediment deposits restrict drainage in the area.

Ditches generally have stable banks, but there are some small areas of localized erosion. A general lack of native trees and shrubs on the banks of ditches limits shading, which is a factor in vegetation grown in the channels. The lack of bank vegetation may also increase sediment runoff into ditches. Bankside vegetation could trap and filter sediment in runoff from adjacent farmland.

Some trash debris was observed in the Clear Creek channel just upstream of the culvert under Gay Road. Trash was also observed in the Clear Creek channel downstream of the historic intersection with South Ditch.

Because Drainage District 10 was inactive in recent years, most drainage ditch maintenance for the large collector ditches was deferred. The Drainage District has recently been reactivated and is beginning to address deferred maintenance.

Additional information on this topic can be found in the Existing Conditions Report and the Drainage Inventory Memorandum (Appendix C).

## **Recommendations**

Drainage District 10 should develop a Drainage Management Plan to guide maintenance activities in the Clear Creek area. A Drainage Management Plan would provide the foundation for maintaining drainage infrastructure and would help the Drainage District with budgeting and with permitting.

A Drainage Management Plan typically includes an inventory of the drainage system that identifies existing problems and thresholds for triggering maintenance actions in the future. The information in the Drainage Inventory Memorandum could be used as a starting point for developing a Drainage Management Plan. Additional information, such as survey data and documented water levels over time, should be gathered. The inventoried drainage features, along with district easements, roads, parcels, and other available information should be compiled in a base map that can be used as the basis for discussions within the District and with permitting agencies and other stakeholders.

The Drainage Inventory Memorandum identified several significant drainage problems in the Clear Creek area. These should be addressed soon and can be implemented prior to finalizing the Drainage Management Plan. These include:

- Remove reed canarygrass from drainage ditches and Clear Creek where it interferes with drainage.
- Remove debris that is trapped at obstructions.
- Culverts should be cleared of sediment, vegetation, or debris where appropriate.

Addressing these problems are short-term actions. Long-term approaches to these issues, such as potential culvert replacements, should be included in a Drainage Management Plan. More information on potential long-term approaches and on Drainage Management Plans is included in the Drainage Inventory Memorandum (Appendix C).

Some actions that would improve drainage are currently being pursued. PCC Farmland Trust, the Conservation District, landowners, and the county are currently collaborating on a project to plant vegetation along the banks of Nancy's Ditch. Shade from vegetation can reduce some noxious weeds, and vegetation can reduce sediment and pollutants from entering ditches. Actions such as the Nancy's Ditch planting project should be supported.

## 4.5 Relying on Clear Creek for agricultural drainage is a barrier to agricultural viability

Currently, all agricultural drainage from the Clear Creek area flows into Clear Creek before eventually draining to the Puyallup River. Relying on Clear Creek to drain agricultural fields creates several problems for agriculture in the Clear Creek area. Clear Creek is a salmon-bearing stream, which leads to higher regulatory barriers and permitting requirements for drainage maintenance. Clear Creek receives substantial sediment and stormwater inputs from its four major tributaries. During wet-season conditions, discharge from the tributaries raises the water

level in Clear Creek, reducing the ability of the channel to drain agricultural ditches. Because of aggradation in Clear Creek, South Ditch no longer flows directly into the stream. Regulatory hurdles to removing sediment from the Clear Creek channel make it difficult to correct drainage issues like those affecting South Ditch. Downstream of agricultural drainage areas, Clear Creek flows through two Port of Tacoma wetland mitigation sites which are not maintained for the purpose of drainage. Clear Creek drains into the Puyallup River through two tide gates that are not controlled by Drainage District 10 or other agricultural interests in the area. These factors all limit the ability to improve drainage in Clear Creek. A major constraint on the agricultural drainage system is that it relies on a stream which is affected by many factors not controlled by Drainage District 10 or others interested in agricultural drainage.

Additional information on this topic can be found in the Drainage Inventory Memorandum (Appendix C).

### **Recommendations**

Because relying on Clear Creek for drainage poses several problems for farms in the Clear Creek area, large-scale options to alter the agricultural drainage system should be considered as part of the master planning process for the Clear Creek Floodplain Reconnection Project. One option could be the recommendation in the Drainage Inventory Memorandum to evaluate options to separate the agricultural drainage system from the stream system. If the agricultural drainage system in the Clear Creek area had a separate outlet to the Puyallup River, with fish screens installed, it would be easier to permit maintenance activities because most if not all of the ditches would likely be considered non-fish-bearing. Drainage District 10 and individual farmers would have more control over the drainage system. There would be less input flow into the system that the agricultural drainage relies upon. Separating the drainage system from Clear Creek would also allow options for restoring the stream to more natural conditions.

Separating the agricultural drainage system from Clear Creek would be a large capital project requiring new infrastructure. It would also be a complex project to permit because it could require a new outlet to the Puyallup and would have to meet water quality criteria. Because of topography, the new river outlet would ideally be located as far downstream as possible to maximize gravity drainage. The drainage channel leading to the new outlet would need to be excavated as far as feasible toward the outlet, but may need to be piped as the elevation of the ground rises.

Pursuing this recommendation would present several challenges:

- Studies would be required, including a survey of the entire area, hydrologic and hydraulic modeling, and wetland delineation.
- Permitting would be complex, including an HPA, Corps permits, Endangered Species Act consultation, State Environmental Policy Act and National Environmental Policy Act compliance, and local permits (such as critical areas, shoreline, grading, and stormwater permits). Wetland and other mitigation could potentially be required as well.
- A complex set of agreements with landowners (including Pierce County SWM, the Port of Tacoma, and WSDOT) would be required.

- A new ditch system would need to be constructed.
- The new outlet to the Puyallup River would require piping or a pumping system to route water through the River Road Levee. Pumping would require a power source and funding to pay power costs.
- A new culvert under River Road with tide gates would be required for the new outlet.

The Puyallup Tribe has expressed concerns about this idea. A separate direct discharge to the Puyallup could be a problem for water quality. More information on the volume of discharge would be needed. These are issues that need to be addressed when exploring the feasibility of this recommendation.

This scale of large-scale actions to alter the drainage system is currently beyond the ability of Drainage District 10 to pursue. However, the feasibility study and design could be included as part of other projects proposed for the area, such as the Clear Creek Floodplain Reconnection Project. The Clear Creek Floodplain Reconnection Project is intended to be a multiple-benefit project that would improve flood management, habitat, and agriculture; a large-scale action to improve drainage would provide the benefit to agriculture needed to make it a successful multiple-benefit project.

## 4.6 The flood system in the Clear Creek area is not resilient

Flood events are inevitable and, with climate change, are expected to increase in frequency and magnitude in the future. Because there will be flood events on the Puyallup River and Clear Creek, a resilient flood system is needed to protect the viability of agriculture in the Clear Creek area.

Resilience concepts applied to flood risk management strategies is a relatively new use of the resilience planning framework. Using a definition that can be described as “engineering resilience,” a resilient flood system can be defined as one that can “bounce back and recover” from the disturbance of a flood event (Zevenbergen, 2016). According to this concept, resilient flood risk strategies aim to reduce flood risk through a combination of protection, prevention, and preparedness spanning a wide range of flood probabilities (Zevenbergen, 2016). A resilient flood system relies on the following attributes:

- Robustness (the capacity to withstand a disturbance without functional degradation),
- Redundancy (the extent to which system components are substitutable), and
- Rapidity (the capacity to restore the system in a timely manner) (Zevenbergen, 2016).

In a truly resilient flood environment, floodwaters can rise and fall without excessive damage. A truly resilient flood environment will also not have catastrophic failure if one component of the system fails during a flood.

The Clear Creek area does not have a resilient flood system. It is not robust – when the area floods, homes flood and are damaged, farm businesses are threatened, and people need to be evacuated. There is no redundancy – there are a number of vulnerable components of the flood management system (such as the Clear Creek tide gates and River Road Levee) that, if they fail,

would cause significant flood damage. Some farms in the Clear Creek area may be able to rapidly restore their farm after a flood event, but that depends on the time of year the flood occurs and would not be the case if barns, equipment, or crops are inundated.

As described in Section 4.3, Pierce County has purchased over 20 flood prone properties in the Clear Creek area in the last two decades, which has helped to reduce the damage caused by flood events when they occur. Removing homes and other infrastructure in a floodplain increases robustness because there are fewer structures to be damaged in a flood event.

Additional information on this topic can be found in the Flood Risk Memorandum (Appendix B) and the Farmland Impacts Memorandum (Appendix E).

### **Recommendations**

Pursuing a project that would increase flood resilience in the Clear Creek area would be a benefit to agricultural viability. However, any flood risk reduction projects would have to be evaluated to ensure that they would not increase other risks to agriculture. Alternatives to address flood risk in the area should be considered. Potential actions that could be taken include:

- Constructing structural flood control structures, such as the proposed levee associated with the Clear Creek Floodplain Reconnection Project, that would increase the level of flood protection for farms in the Clear Creek area,
- Reducing runoff from upstream areas of the Clear Creek Basin,
- Improving freeboard on River Road Levee,
- Altering the tide gates to improve the reliability of their operation and increase conveyance of flows from Clear Creek to the Puyallup River,
- Replacing undersized culverts in the area, particularly those under 44<sup>th</sup> Street East and Gay Road,
- Elevating homes, farm structures, and farm equipment in the floodplain, and
- Constructing “critter pads,” elevated areas where livestock can gather during flood events.

## 4.7 River Road levee overtopping and/or breaching is currently the biggest flood-related threat to farms in the Clear Creek area

The levees on the Puyallup River upstream of River Mile 2.8 are owned and operated by Pierce County, including the River Road Levee (Pierce County, 2013). River Road Levee reduces flood risk to the Clear Creek area from Puyallup River. The levee was constructed before there were federal standards for levees. Current standards adopted by Federal Emergency Management Agency (FEMA) require 3 feet of freeboard (height of levee above the 100-year flood elevation) for accredited levees. During flood modeling conducted in 2004, it was discovered that River Road Levee does not provide adequate freeboard, and FEMA subsequently de-accredited the

levee. A Corps of Engineers General Investigation that would address this issue is currently underway.

There is no available information on the probability of River Road Levee overtopping. However, in 2006 and 2009, flood levels were projected to overtop the River Road Levee, and Pierce County called for an evacuation of the Clear Creek area (Pierce County, 2016a; Hunger and Schmidt, 2016). Fortunately, in both events, precipitation patterns changed and the levee was not overtopped. In recent events, such as the 2009 flood, floodwaters have reached the edge of the Highway 167 road surface (Hunger and Schmidt, 2016).

The potential exists for River Road Levee to overtop or breach. This represents the biggest flood-related threat to farms in the Clear Creek area. Overtopping of the levee could significantly affect farms (as well as human health and safety) in the Clear Creek area. Homes, barns, fields, and equipment throughout the Clear Creek area could be inundated. People in the area could be physically at risk and evacuations could be called for by Pierce County based on flood forecasts. Livestock would also be threatened by an overtopping flood event.

Regardless of whether the levee overtops or otherwise fails to protect the area, the vulnerability of the levee currently affects agricultural viability because it causes the area to be mapped as a floodway, which restricts the building of new structures.

Additional information on this topic can be found in the Flood Risk Memorandum (Appendix B).

### **Recommendations**

The Corps of Engineers is evaluating approaches to addressing the freeboard issues of River Road Levee. Pierce County SWM and Clear Creek residents should continue to be involved in the General Investigation process and encourage the Corps of Engineers to address the River Road Levee problems.

## 4.8 Sediment levels are high in the Puyallup River and Clear Creek and are a risk to agricultural viability in the area

While erosion and sedimentation are natural river processes, current and projected sediment inputs into and transported by the Puyallup River and Clear Creek threaten agricultural viability by increasing flood risk and by compromising the ability of the system to drain agricultural lands. Specific risks include:

- Aggradation in the Puyallup River channel increases flood risk to the Clear Creek area because overtopping of River Road Levee would occur at lower flows.
- Aggradation in the Puyallup River near the mouth of Clear Creek would cause the water surface elevation to be higher under most river flow conditions, thereby increasing backwater conditions for Clear Creek.

- As the river bed of the Puyallup River rises due to aggradation, the river level rises relative to the land elevation in the Clear Creek area, which could limit the ability of the Clear Creek area to drain even during low river flow conditions.
- Sediment deposition and aggradation in Clear Creek create problems during high flow and low flow conditions.
  - During high flow, the reduced hydraulic conveyance capacity from sedimentation causes the channel to be overtopped sooner.
  - During low flow, sedimentation in the stream causes higher water levels, which create backwater conditions in the drainage system where the drainage channels join Clear Creek.

Additional information on this topic can be found in the Sediment Memorandum (Appendix A).

### **Recommendations**

Projects designed to reduce sediment inputs to the low-lying Clear Creek area could improve drainage and increase flood storage capacity in the channel. Both the Clear/Clarks Creek Basin Plan (Pierce County, 2006a) and the Swan Creek Watershed Characterization and Action Plan (Pierce County, 2015) include recommended actions to address sediment sources, including stormwater detention to control peak flows, control of direct discharges to the creeks, sediment source control, and installing log jams in the ravine portions of creeks to store sediment in the creeks and reduce down-cutting. Additional projects could be identified through research on sediment sources and dynamics on Squally Creek, Clear Creek, and Canyon Creek.

Sediment loading evaluations should be done for Squally Creek, Clear Creek, and Canyon Creek in order to understand the risk to agriculture viability. A range of approaches to study sediment sources on the tributaries could be undertaken. Some examples include:

- The Swan Creek evaluation was funded in part by an Ecology grant and included review of existing data and models, field work to identify sediment sources, collection of sediment samples, and modeling.
- The Puyallup Tribe recently completed a study of sediment sources on nearby Clarks Creek and its tributaries. That study, which included a stakeholder process, cost approximately \$500,000 and identified bank stabilization projects that can be undertaken to address sediment sources from eroding banks.
- A less resource-intensive approach could involve hiring a geomorphologist to do field reconnaissance to identify areas of bank erosion, estimate the quantity of sediment supplied by these sources, and develop proposed solutions.

These approaches represent two ends of a range of approaches; depending on available resources, an appropriate approach could be developed somewhere between these two levels of effort.

## 4.9 The wooden flap gate appears to be in poor condition and likely does not maximize agricultural drainage

There are two tide gates at the end of two large culverts under the River Road Levee where Clear Creek enters the Puyallup River. One of the tide gates is a wooden flap gate, and the other is a newer metal slide gate installed by the Port of Tacoma. The tide gates prevent water from flowing backwards through the culverts and into the Clear Creek area when the Puyallup River level is higher than the water level on the Clear Creek side of the culverts and the slide gate is down. The tide gates provide critical flood protection to farmers and residents in the Clear Creek area.

The wooden flap gate set at an angle of approximately 10 to 15 degrees, with the top set back and the bottom set forward. The angled position of the gate increases the amount of force required to open it, so there will be some minimum head difference required to push the gate open. Head is defined as the difference in elevation between two points in a body of water – in this case between the water in the culvert draining from Clear Creek and the water in the Puyallup River. The greater the head difference and the faster the outflow, the wider the gate will open. When the differences in water levels are small, the gate opens only slightly, resulting in small outflow rates and little to no opportunity for fish passage. Since this type of gate remains in the water at all times, flow through this barrel of the culvert is never entirely unobstructed.

Ownership of this gate is unclear, and there is no evidence of recent maintenance. The gate is old and, based on photographs, appears to be in poor condition. From photographs, there appears to be a hole in the top edge of the gate, possibly caused by a beaver chewing the gate. It is unclear whether the age and lack of maintenance of the gate have led to impairment in the function of the gate because there has been no known recent assessment of the gate's condition. It is possible that its function is impaired, and uncertainty about its condition has created concern that it could fail in a flood event. Due to its weight and the angle at which it is installed, it is unlikely that this gate opens frequently under current conditions. Even when the wooden flap gate does open (most likely only during high flows on Clear Creek) it is unlikely to open very wide. For this reason, the tide gate does not provide optimal drainage for water from the Clear Creek area (including agricultural drainage) to flow into the Puyallup River.

More information on this topic is included in the Tide Gate Memorandum (Appendix D).

### **Recommendations**

The Tide Gate Memorandum makes two recommendations for the wooden flap gate: assess the condition of the gate and modify the gate.

Assessment of the flap gate should include evaluation of the water tightness of the gate and seal against opening, the structural condition of the gate itself, and the condition of the hinges. Assessing the physical condition of the wooden flap gate would need to be conducted by a qualified structural engineer who could make recommendations for repairing any weaknesses, including a discussion of the risk of delaying repair actions. Based on the recommendations, any urgent repairs should be conducted to ensure the continued reliability of flood protection and tide

gate operations. This action could identify needed repairs that could improve the reliability of flood protection, improve the ability of water to drain out through the tide gate, and improve fish passage. Assessing the current condition of the wooden tide gate is a relatively simple action that should be undertaken in the short term.

The efficiency of the existing wooden flap gate could be increased by modifying it to make it “lighter” so that less force would be required to open it and hold it open. This would result in a wider gate opening for the same head difference, reduce head loss, and promote better drainage. Lightening the gate could be accomplished by removing some of the counterweights from the gate if it is weighted (many wooden gates are) or by adding an additional opening force. The most common approaches for applying a supplemental opening force to a tide gate involve some type of device, such as a winch and elastic cord that support a portion of the gate’s weight. These modifications would allow the gate to open more easily from the closed position but to still close promptly when water levels rise on the Puyallup River. Feasibility analysis for this action could include modeling to determine whether the modification would provide measurable benefits to drainage in agricultural areas. Modifying the wooden tide gate so that less force is needed to open the gate and keep it open is a relatively low-cost action that could be implemented as an interim measure even if the tide gates were eventually removed as part of the Clear Creek Floodplain Reconnection Project.

## 4.10 Current conditions and operations of the metal slide gate are not ideal for agricultural viability

The metal slide gate is owned and maintained by the Port of Tacoma and was installed in 1997 to replace a previous wooden flap gate at the same location. It operates using a float-trigger system, which triggers raising and lowering of the slide gate when water levels in the Puyallup River meet certain, pre-set elevations.

Based on analysis of water level logger data, it appears that the set point for the slide gate to be raised or lowered is approximately river elevation 8.2 feet NAVD 88. Design documents from the Port of Tacoma indicate that the slide gate was not originally intended to be lowered daily (Port of Tacoma, 1995). These documents indicate that the gate should close during the 2-year instantaneous peak flow, but not during the annual maximum daily-average flow, even if concurrent with a high tide. Consequently, if operating as originally envisioned, the slide gate should be lowered less than once per year. The preferred closing and opening elevations listed in the design report are when the river reaches 12.5 and 12.0 feet NAVD 88, respectively – significantly higher than the observed lowering of the slide gate at elevation of 8.2 feet NAVD 88 (Port of Tacoma, 1995). The design documents note that gate settings might need to be adjusted lower in response to observations by the local landowners of impacts to their properties, but no record could be found of the actual settings applied during gate installation or any subsequent adjustments (Port of Tacoma, 1995; Stebbings, 2016).

In late December 2016 or early January 2017, ice buildup jammed the slide gate during regular operations, causing the motor to burn out and damaging a gear in the gate assembly. The slide gate was stuck partially open due to difficulties in obtaining replacement parts. In May 2017, the

slide gate was repaired, and it is now functioning (Myers, 2017). The repairs did not change the opening and closing elevations of the slide gate.

Additional information on this topic is included in the Tide Gate Memorandum (Appendix D).

### **Recommendations**

The Tide Gate Memorandum (Appendix D) discusses two potential actions that include changes to the operation of the slide gate to increase the amount of time the slide gate is open, allowing greater drainage and fish passage. One would use a period of calibration to determine the ideal open/close set point for the slide gate while the other would install a programmable logic controller to make the slide gate operations more dynamic. Both actions would be a benefit to agricultural viability as well as habitat. These actions would need to be undertaken by the Port of Tacoma, the owner and operator of the slide gate. The slide gate could also be modified so that the flap gate mounted on the slide gate does not lock when the slide gate is fully lowered. The Port of Tacoma is receptive to modifying operations of the slide gate if the actions are consistent with the Port's Consent Decree with EPA (Port of Tacoma, 2017). Floodplains for the Future partners should discuss these potential actions with the Port of Tacoma and encourage the Port to consider implementing them.

## **5.0 Findings and Recommendations Related to the Clear Creek Floodplain Reconnection Project**

Findings in this section are related to the potential impacts of the proposed Clear Creek Floodplain Reconnection Project. These findings are primarily from the Farmland Impacts Memorandum (Appendix E). Additional information on the approach to identifying potential impacts is available in that memorandum.

5.1 The Clear Creek Floodplain Reconnection Project is likely to negatively impact agricultural viability in the Clear Creek area, but could be designed to minimize or avoid impacts and provide benefits

The Clear Creek Floodplain Reconnection Project is intended to be a multiple-benefit project that improves conditions for flood protection, salmon habitat, and agriculture. The Farmland Impacts Memorandum (Appendix E) discusses potential impacts, both positive and negative, to agricultural lands in the Clear Creek area from the proposed Clear Creek Floodplain Reconnection Project. The memorandum is concerned with the concept of "farm function." A letter from the Clear Creek Farmer's Collective to PCC Farmland Trust states, "Our collective has united around a platform that emphasizes 'no net loss of farm function'" (Clear Creek Farmer's Collective, 2016). The concept of farm function is broader than direct loss of farm acreage and includes potential impacts to physical conditions that relate to agricultural viability (such as drainage, sediment, and groundwater) and other factors that impact farming (such as

illegal activities on vacant lands or continued viability of Drainage District 10). These topics are addressed in the memorandum.

Depending on the levee alignment selected, the Clear Creek Floodplain Reconnection Project could require conversion of a substantial amount of agricultural lands. The project could also negatively impact farm function by increasing the risk to structures and livestock if River Road Levee were to overtop, by reducing agricultural drainage, potentially by changing groundwater conditions, by increasing the number of vacant parcels near agricultural properties, and by reducing the viability of Drainage District 10 and the Riverside Fire District. The project could also benefit farm function by reducing general flood risk.

Many of these potential impacts could be avoided or minimized through project design. For example, the Drainage Inventory Memorandum recommends exploring the feasibility of separating the agricultural drainage system from Clear Creek. This action could be considered for incorporation into the Clear Creek Floodplain Reconnection Project to help offset the potential impacts to agricultural drainage and to provide benefits to agriculture. The master planning process for the project should consider this idea and other potential ideas to improve agricultural viability as part of the project.

While the Clear Creek Floodplain Reconnection Project could negatively impact agricultural viability, it is also an opportunity to pursue large-scale actions that could improve conditions for agricultural viability as part of a multiple-benefit project.

Additional information on this topic can be found in the Farmland Impacts Memorandum (Appendix E).

### **Recommendation**

Farmers should participate fully in the master planning process for the project to encourage design elements that minimize or avoid negative impacts to agriculture and provide benefits. SWM should incorporate the needs of agriculture into the project design and should work to avoid or minimize negative impacts to agriculture from the project. The documents produced by the Farming in the Floodplain Project, particularly the Farmland Impacts Memorandum (Appendix E), have identified information needs and potential impacts of the proposed project. Clear Creek area farmers should use this information to advocate for project design elements that would avoid the potential impacts.

## 5.2 Farming on the wet side of the proposed levee is not likely to be feasible

Pierce County SWM has suggested that, depending on the levee alignment, it may be possible to farm on the wet side of the levee. For example, if the levee were constructed at the 18-foot contour, lands between elevations of about 15 to 18 feet NAVD could potentially be farmed. It is unclear at this point exactly what conditions would be on the wet side of the levee with the tide gates removed and a levee constructed. If more information is developed, it may be possible to determine that agriculture would be feasible on the wet side of the levee. However, with current

information, there appear to be several challenges to agriculture on the wet side of the levee that suggest it would not be feasible. This section details those potential challenges. At the end of the section, a list of conditions that would make agriculture on the wet side of the levee feasible is presented.

This section refers only to potential farming on the wet side of the proposed levee. The discussion in this section does not apply to farming on the dry side of the proposed levee.

One of the purposes of the Clear Creek Floodplain Reconnection Project is to open the Clear Creek area to tidally-influenced inundation. Currently, the tide gates close once or twice daily, suggesting that tidally-influenced inundation would enter the Clear Creek area up to twice a day if the tide gates were removed. If the tide gates were removed now, the Clear Creek area would be inundated with freshwater because the saltwater wedge in the Puyallup River only extends to the I-5 crossing. However, with anticipated sea level rise, the saltwater wedge will likely move upstream, potentially reaching the outlet of Clear Creek. The combination of removal of the tide gates and sea level rise could potentially cause the Clear Creek area to be inundated with saltwater, which would cause agriculture in the inundated area to no longer be viable.

The wet side of the levee would likely become a depositional area for sediment from the Puyallup River. In high water events, sediment could potentially be deposited on agricultural fields. More analysis of sediment dynamics on the wet side of the levee is needed to understand the extent of potential sediment deposition. Sediment deposition would likely affect agricultural drainage for farms on the wet side of the levee as channels are filled in with sediment and new channels are formed. Agricultural drainage for farms on the wet side of the levee would require maintenance, which would likely be incompatible with best stewardship practices for a habitat restoration area.

Farms on the wet side of the levee would be subject to more frequent inundation from tidally influenced water than under current conditions. Modeling conducted by NHC shows that, with the tide gates removed and a levee at the 18-foot contour, the 10-year flood stage would reach an elevation of approximately 18.6 feet NAVD (NHC, 2016). This means that all agricultural lands on the wet side of the levee would be fully inundated by at least 0.5 foot of water approximately once every 10 years. This modeling analysis does not consider increased winter stream flows or sea level rise under climate change, which would likely increase the frequency that these lands would be inundated.

Many farmers rely on cover crops to increase soil fertility and to protect soil from erosion in winter months. Inundation on the wet side of the levee could threaten the viability of cover crops and could cause farmers to use chemical methods to maintain or enhance soil fertility and health. These chemicals are unlikely to be compatible with a habitat restoration area.

Because of the frequency of flood inundation on the wet side of the levee, it would be inadvisable to build farm infrastructure, including farm houses, or to store equipment on the farms. This could limit the area to being farmed by large-scale farmers who rent and own fields in various locations. Smaller-scale, direct market farmers who live on their farms would not be inclined to farm properties on the wet side of the levee. Farms currently operating in the Clear Creek area between the 14 and 18 foot contours are primarily smaller-scale farms, so they could be displaced by the

Clear Creek Floodplain Reconnection Project even if areas on the wet side of the levee could be farmed.

Because storing equipment on the wet side of the levee would risk damage to the equipment, farmers would regularly need to transport equipment to and from farms on the wet side of the levee. Access to the wet side of the levee would likely be limited. The more access points were included in the project design, the larger the footprint the project would have. Roads and other impervious surfaces on the wet side of the levee would likely be incompatible with a habitat restoration area.

Farmers on the wet side of the levee could also face regulatory hurdles to farming. Farming could not occur on the parcels during the multi-year construction period of the project. While existing farms in the Clear Creek area (and elsewhere) are not subject to critical area regulations, new farms on the wet side of the levee would likely have to comply with regulations to protect wetlands and other critical areas. Large portions of the area on the wet side of the levee would likely be designated as wetland or as fish habitat, and the required buffers around these areas would further reduce the area available to be farmed.

Some stakeholders in the Clear Creek Floodplain Reconnection Project have suggested that farmers could adapt their crop choices to allow farming on the wet side of the levee and have suggested crops such as rice or cranberries. Neither of these specialized crops is suited to the tidal fluctuations that would occur on the wet side of the levee. Cranberries need to be grown in specific conditions with acidic peat soil. Cranberries are not grown underwater; instead, cranberry bogs are flooded with water only before harvesting. Rice needs to be grown in conditions where uniform flooding and controlled drainage are possible. This is often achieved through use of diking, machinery, and irrigation. Fertilizers are typically used to grow rice. The practices and conditions required for growing rice and cranberries could not be achieved on the wet side of the levee nor would they be compatible with the proposed habitat restoration area.

Due to the frequency of inundation, the potential for saltwater inundation in the future, access issues, and potential regulatory hurdles, farming on the wet side of the levee is unlikely to be feasible. In addition, some agricultural activities, such as use of chemicals, would not be compatible with a habitat restoration area.

The idea of farming on the wet side of the levee could be revisited in the future if the following conditions are met:

- The levee alignment chosen would allow adequate areas on the wet side of the levee at suitable elevations to be farmed;
- Access to the fields could be provided;
- The frequency with which the dry areas would be inundated by floodwaters was known;
- Sediment deposition on the wet side of the levee was well understood and adequate drainage could be ensured;

- It was known that the saltwater wedge would not travel far enough upstream to inundate the area with saltwater; and
- The habitat area on the wet side of the levee would not be adversely impacted by agricultural practices.

Additional information on this topic can be found in the Farmland Impacts Memorandum (Appendix E).

### **Recommendation**

The master planning process for the Clear Creek Floodplain Reconnection Project should assume that farming on the wet side of the levee would not be feasible. Other ways to create benefits for agriculture should be identified in the master planning process. Including a large-scale action to improve agricultural drainage, such as separating the agricultural drainage system from Clear Creek, could provide a clear benefit to agriculture and make the Floodplain Reconnection Project a multiple-benefit project.

## 5.3 The proposed Clear Creek Floodplain Reconnection Project would increase the risk to agricultural viability if River Road Levee were to overtop or breach

As described in Section 4.7, the potential exists for River Road Levee to overtop or breach. If the proposed Clear Creek ring levee were constructed and River Road Levee were to overtop or breach, the land between the two levees could potentially be substantially damaged because floodwaters from the Puyallup River would be impounded between the two levees. Under existing conditions, if River Road Levee were to overtop, the floodwaters would flow across farmlands while draining to Clear Creek. However, if the Clear Creek ring levee were in place, it would slow the floodwaters from draining into Clear Creek, so the land would be inundated by higher water and for a longer period of time, thus increasing the amount of damage in the area. In this scenario, Puyallup River waters would be high enough to close the Clear Creek tide gates and Clear Creek would back up, flooding lower-lying portions of the Clear Creek area. This could limit the ability of floodwaters overtopping River Road Levee to drain to lower elevations regardless of whether a Clear Creek ring levee was in place or not. Additional analysis and modeling of overtopping scenarios for River Road Levee would help clarify this issue.

If flood projections suggest that River Road Levee could overtop, Pierce County would implement its evacuation protocol for the area (as was done in 2006 and 2009). The presence of the ring levee would not alter the triggers for an evacuation. Therefore, construction of the ring levee would not increase the threat to human safety from an overtopping event. However, the higher water levels and increased length of inundation could increase the threat to livestock, farm infrastructure, and soils.

High velocity flood waters that could result from a breach or overtopping of River Road Levee could cause substantial scour in the area, which could have detrimental effects such as damaging

transportation routes and removing topsoil. For agricultural fields, impacts caused by flood waters coming from a breach or the overtopping of River Road Levee would be partially dependent on how recently the soil was tilled and what crop was providing land cover (Morton and Olson, 2014). If River Road levee were to fail with the proposed ring levee in place, these impacts (which are a risk regardless of whether a ring levee is built or not) would be focused on the agricultural land between the two levees. With less area for the Puyallup River floodwaters to disperse, the agricultural land protected by the two levee systems could experience a higher degree of detrimental impacts such as land scour, sediment deposition, and topsoil removal.

Additional information on this topic can be found in the Farmland Impacts Memorandum (Appendix E).

### **Recommendations**

The timeline of the Corps of Engineers General Investigation needs to be considered as part of the Clear Creek master planning process. Pierce County SWM and the Clear Creek area farmers should coordinate with the Corps to ensure that a solution to the River Road Levee freeboard issue is implemented prior to constructing the Clear Creek Floodplain Reconnection Project.

## 5.4 Groundwater elevations and gradients in the Clear Creek area are not well understood and could have impacts for agricultural viability, particularly with proposed projects and/or climate change

Groundwater in the Clear Creek area is important to agricultural viability because it can affect both water supply and drainage. Some farmers in the Clear Creek area rely on groundwater for irrigation. Any actions that would alter the surface water flow, such as removing tide gates or building a levee, could alter groundwater-surface water interactions and could cause changes to the groundwater table. The most likely effect on groundwater levels is that a levee could block groundwater flow if the groundwater flow direction is toward the levee. This could result in higher groundwater levels, especially in the area near the levee. Any factor that raises the already-shallow groundwater levels could further impede agricultural drainage and increase the frequency of groundwater ponding on the ground surface in some areas (ESA, 2016a). The higher groundwater levels near the levee could increase soil saturation and ponding on the dry side of the levee. Sea level rise associated with climate change could also raise groundwater levels in the Clear Creek area, further impeding agricultural drainage. The potential for saltwater intrusion into groundwater with sea level rise should also be considered.

Additional information on this topic is included in the Existing Conditions Report and in the Farmland Impacts Memorandum (Appendix E).

### **Recommendations**

Additional studies would help to understand and minimize the impacts to groundwater:

- An evaluation of hydrogeologic properties (hydraulic conductivities, flow directions, etc.) in the Clear Creek area to establish baseline conditions
- Determination of the current interaction of Clear Creek surface water and alluvial aquifer groundwater throughout the year (relative to seasonal agriculture timing)
- An analysis of the impact of sea level rise on groundwater levels in the Clear Creek area

## 5.5 The lack of specific climate change information for the Clear Creek area makes it difficult to plan for agricultural viability in the future and to understand the potential impacts of the proposed Clear Creek Floodplain Reconnection Project

Climate change will affect the physical conditions that impact agricultural viability in the Clear Creek area, including hydrology, water supply, groundwater, sediment, and sea level rise. Regional climate change projections can suggest a range of potential impacts (there is no climate information specific to the Clear Creek area), which makes it challenging to identify impacts, to plan for long-term agricultural viability, and to incorporate climate change into design of the Clear Creek Floodplain Reconnection Project.

### **Hydrology and Flood Risk**

Hydrology in the Puyallup River Watershed and in the Clear Creek Subbasin is expected to change as snowpack is reduced and precipitation patterns shift. The depth of snowpack on April 1 (the approximate current timing of peak annual snowpack in Northwest mountains) in the Puyallup River Watershed is projected to decline between 52 and 58 percent by the 2050s. Winter streamflows in the Puyallup River are projected to increase by 27 to 34 percent by the 2050s (CIG, 2015a).

Flood risk is projected to increase in the Puyallup River watershed and across Puget Sound. Peak river flows are projected to increase between 18 and 55 percent by the 2080s, and heavy rainfall events will become heavier (CIG, 2015b). The volume of the 10-year flood in the Puyallup River is projected to increase by 12 to 85 percent by the 2080s (CIG, 2016). Increased flooding would increase the cost of flood protection and stormwater management. Highways and other roads adjacent to rivers would flood more frequently. Existing flood control infrastructure, such as levees and tide gates, would likely be less effective as more frequent and larger floods exceed the events the infrastructure was designed for (CIG, 2015b). Flood risk on Clear Creek and its tributaries can also be expected to increase with climate change.

Increasing flood risk with climate change increases the importance of projects that would make the flood system in the Clear Creek area more resilient, such as the Clear Creek Floodplain Reconnection Project and addressing deficiencies in River Road Levee. Increased winter flows

will also affect drainage in the Clear Creek area. Pursuing improvements to the agricultural drainage system as part of the Clear Creek Floodplain Reconnection Project could help offset these impacts. Conversely, if the project were constructed in a way that negatively impacted agricultural drainage, climate change could magnify those negative impacts in the future.

### **Surface and Groundwater Supply**

While winter streamflows are expected to increase, summer streamflows would decrease. Summer streamflows in the Puyallup River are projected to decrease by 18 to 20 percent by the 2050s (CIG, 2015a). Most agriculture in the Clear Creek area relies on groundwater for irrigation rather than the Puyallup River. Flows in the Clear Creek area are also likely to decrease in the summer, which could potentially affect groundwater. Changes in sea level and hydrology would also impact groundwater in the Clear Creek area. As described in Section 5.4, there is currently limited information about groundwater in the Clear Creek area and more information is needed to characterize these potential changes. More information about how changes in summer streamflows could affect water supply in the Clear Creek area would help farmers develop strategies to protect agricultural viability in the long-run.

The Clear Creek Floodplain Reconnection Project is not anticipated to affect surface water supply in the Clear Creek area, but could affect groundwater wells. More information on existing groundwater conditions is required to understand this potential impact. Studies of groundwater should include climate change projections.

### **Sediment**

Erosion and the transport of sediment from the upper Puyallup River Watershed are both expected to increase in the future as heavy rainfall causes increased erosion and sediment transport and as higher streamflows and larger floods transport more sediment downstream. Changes in hydrology are also expected to change erosion rates and sediment in Clear Creek and its tributaries. Increased sediment in the Puyallup River and in Clear Creek and its tributaries could cause additional channel aggradation. Aggradation of the Puyallup River could increase flood risk in the Clear Creek area and could raise groundwater levels because the carrying capacity of the river would be reduced. Aggradation of Clear Creek could reduce drainage capacity. Any analysis of how the proposed Clear Creek Floodplain Reconnection Project would affect agricultural drainage should also consider the fact that sediment levels in the drainage system could increase with climate change.

### **Sea Level Rise**

Sea level is projected to rise an additional 14 to 54 inches in the Puget Sound region by 2100 (compared to 2000), although changes at specific locations will vary (CIG, 2015b). Sea level rise and reduced summer flows are projected to increase the risk of saltwater intrusion into groundwater, especially if groundwater extraction increases (CIG, 2015b). Sea level rise could slow the drainage of agricultural lands across Puget Sound. Currently, the saltwater wedge in the Puyallup River is downstream from the mouth of Clear Creek. Sea level rise could cause the saltwater wedge to extend farther up the Puyallup River, potentially reaching the Clear Creek area. Sea level rise could also cause saltwater intrusion into groundwater in the area, affecting groundwater quality. Sea level rise could also increase the surface elevations of the Puyallup

River, adjacent to the Clear Creek area. Understanding sea level rise is key to identifying the impacts of the proposed Clear Creek Floodplain Reconnection Project on groundwater, drainage, and flood risk and needs to be considered in project design.

### **Recommendations**

Climate change projections and modeling should be developed for the Clear Creek area. This should include:

- Dynamic downscaling of predicted precipitation patterns to provide a more accurate forecast of heavy rainfall statistics than provided by the statistical downscaling methods used for the Puyallup River watershed.
- Translating precipitation projections into streamflow levels.
- Developing a flood projection model for the Puyallup River watershed and the Clear Creek area.
- Analyzing the implications of projected increases in sediment transport from the tributaries of Clear Creek.
- Analyzing water availability in the summer during low flows under climate change scenarios.
- Analyzing the impact of sea level rise on groundwater including salinity impacts in the Clear Creek area.
- Analyzing sediment loading on the Puyallup River to project changes in the depositional and erosional environment in the Puyallup River near Clear Creek.

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## **APPENDIX A**

### **Sediment Conditions in the Puyallup River and Clear Creek Technical Memorandum**



# SEDIMENT CONDITIONS IN THE PUYALLUP RIVER AND CLEAR CREEK

Technical Memorandum  
Farming in the Floodplain Project

Prepared for  
PCC Farmland Trust

December 2016





# SEDIMENT CONDITIONS IN THE PUYALLUP RIVER AND CLEAR CREEK

Technical Memorandum  
Farming in the Floodplain Project

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December 2016

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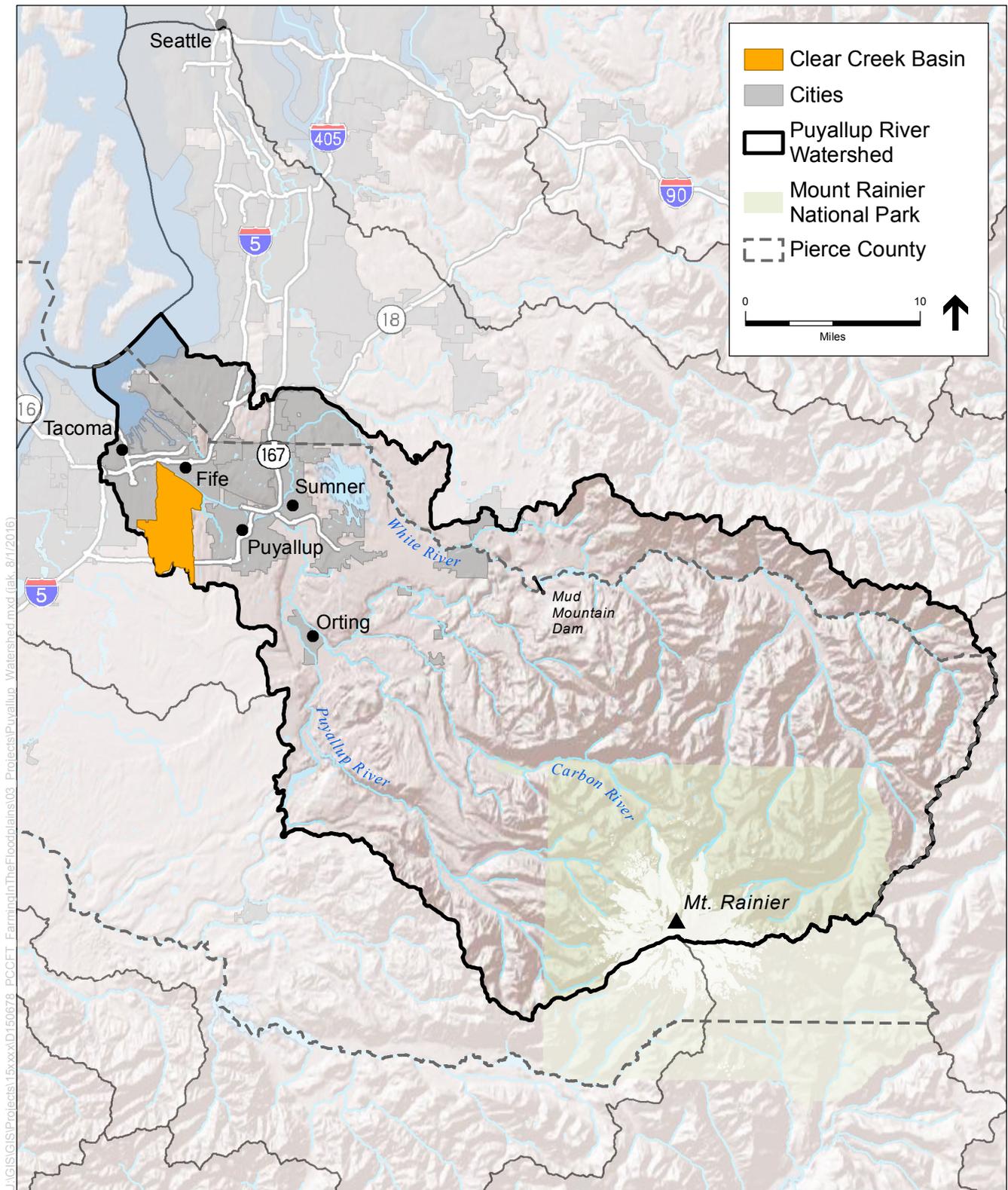
## 1.0 Project Background and Description

This technical memorandum has been prepared as part of Phase 2 of the Farming in the Floodplain Project (FFP). The FFP is one of four components of the Floodplains for the Future: Puyallup, White, and Carbon Rivers project, which is funded by a Floodplains by Design grant from the Washington Department of Ecology (Ecology). The purpose of the FFP is to advance progress toward a collectively agreed upon plan for the Clear Creek area that improves agricultural viability in the area while also meeting goals for flood risk reduction and salmon habitat enhancement. The FFP is intended to clarify the needs and interests of the agricultural community within the Clear Creek area.

As part of Phase 2 of the FFP, ESA facilitated a Technical Advisory Group (TAG) meeting on November 2, 2016 focused on the topic of sediment conditions in the Puyallup River and Clear Creek. The meeting included a presentation by Kris Jaeger of the U.S. Geological Survey (USGS) on sediment conditions in the Puyallup River, a presentation from ESA staff on sediment conditions in Clear Creek and its tributaries, and a group discussion of sediment questions and concerns. This technical memorandum summarizes the information presented and discussed at that meeting. Kris Jaeger of USGS and Judi Radloff of Geoenvironmental Engineers both reviewed a draft of this memo and provided comments and edits.

## 2.0 Study Area

The study area for the FFP is the Clear Creek area, part of the Clear Creek Subbasin of the Puyallup River Watershed (Figure 1). The Clear Creek Subbasin is within the Puyallup River Watershed and is located south of the Puyallup River, north of 128th Street East, west of 66th Avenue East, and east of McKinley Avenue East. The Clear Creek area is roughly 1.5 square miles (990 acres) in size and bounded by the Puyallup River to the north, Pioneer Way East to the south and west, and 52nd Street East to the east.



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SOURCE:  
 ESA, 2016; King County, 2015; Pierce County, 2013; Ecology, 2007;  
 OSM, 2016; WDNR, 2010

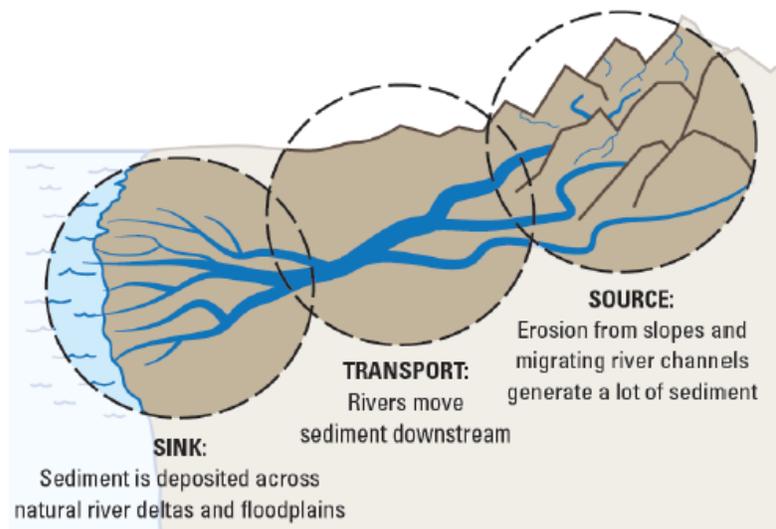
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**Figure 1**  
 Puyallup Watershed

### 3.0 What Is Sediment?

In the context of river and floodplain management, sediment refers to the soil, mud, sand, and gravel moved by rivers and streams. Sediment enters river systems through a variety of pathways that can include erosion from hillslopes, upland areas, or along the river and its floodplain. Examples of sediment delivery processes include landslides in steep terrain, gully and sheet runoff that can occur in agricultural lands, and bank erosion or bed incision within the river channel. Sediment, once delivered to the channel, is typically mobilized during periods of high streamflow and may either travel short distances before temporarily depositing in the channel or the adjacent floodplain, or may travel longer distances to a downstream receiving waterbody such as Puget Sound. Temporary sediment deposition on gravel bars or on the floodplain eventually will transit downstream during successive high flow events.

Figure 2, provided courtesy of the Skagit Climate Science Consortium, shows how sediment enters and moves through a river system. Buildup of deposited sediment is called aggradation. Downtcutting in a river bed is called incision. Erosion and sediment transport in rivers and streams are part of a natural process. Coarse sediment deposited in rivers and streams creates spawning habitat; finer grained sediment deposited beyond the channels builds floodplains and forms beaches, deltas, and offshore habitats (Jaeger, 2016). Adding flood control measures and modifying the river system has changed how sediment moves through the river system. Natural erosion and sediment transport processes continue in this modified system although sediment movement can pose a range of challenges for people and aquatic organisms, including increased flood risk, damage to spawning habitat, buried vegetation and habitat, and turbid water (Jaeger, 2016).



**Figure 2. Sediment transport. Source: Skagit Climate Science Consortium.**

## 4.0 Puyallup River Sediment Conditions

### 4.1 Sources of Information

The USGS operates streamflow gages throughout the Puyallup River system, including its major river tributaries, and has conducted numerous studies to understand sediment transport processes and how channel morphology (the shape of the river) has changed through time. The USGS uses the gage sites to evaluate sediment sources and movement in the system. The sediment-focused reports generated from these studies include *Channel-Conveyance Capacity, Channel Change, and Sediment Transport in the Lower Puyallup, White, and Carbon Rivers, Western Washington* (2010) and *Geomorphic Analysis of the River Response to Sedimentation Downstream of Mount Rainier, Washington* (2012). Findings from these reports were summarized by Kris Jaeger of USGS in a presentation for the Farming in the Floodplain Project Technical Advisory Group on November 2, 2016. Information in this section of the technical memorandum is based on Kris Jaeger's presentation (Jaeger, 2016). The USGS datasets referenced in the presentation include sediment and streamflow monitoring data, river cross sections, and aerial imagery for the Puyallup River Basin.

### 4.2 Established Information

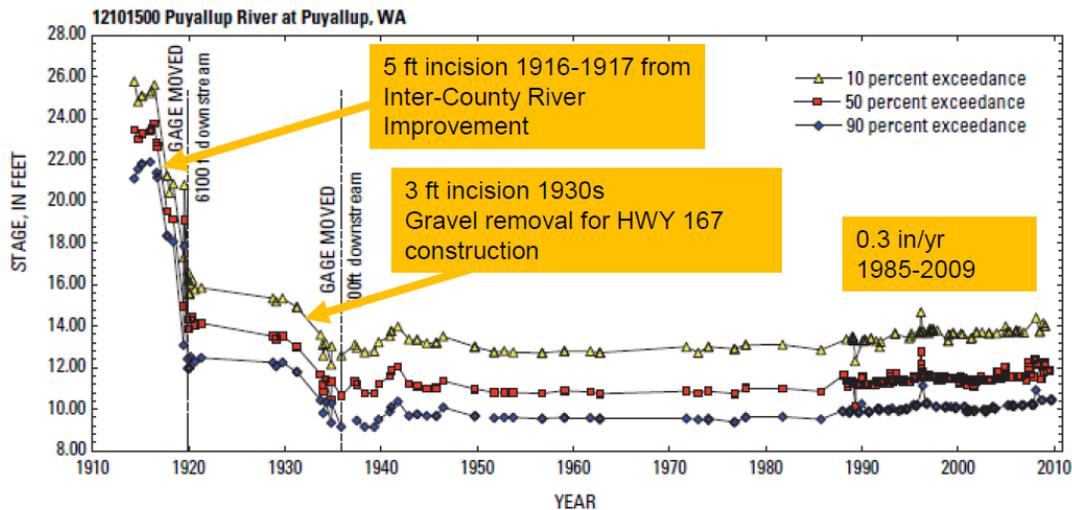
Sediment loads in the Puyallup River system are naturally high. At 980,000 tons, the average annual suspended sediment load from the Puyallup River ranks third in suspended sediment load among the major rivers that drain to Puget Sound. This sediment load varies significantly from year to year. Between 1978 and 1994, the estimated suspended sediment load each year varied from a low of 250,000 tons to a high of 1,700,000 tons. High suspended-sediment loads in the Puyallup River system occur because the river's headwaters drain Mount Rainier, a glaciated stratovolcano that produces a prodigious amount of sediment. The USGS estimates that 58 to 98 percent of the sediment volume entering the Puyallup River each year comes from Mount Rainier National Park. Weathering, rockfall, avalanches, and debris flows on Mount Rainier are all major sediment sources into the Puyallup River and its two major tributaries, the Carbon River and White River (Jaeger, 2016). Sediment loads in Puyallup River system rivers draining Mount Rainier after 1990 are elevated relative to sediment loads from the 1960s to the 1980s, but are not unusually large relative to loads over the 20th century period.

Coarse sediment coming from Mount Rainier initially deposits in the upper reaches of the river system, including the Upper Puyallup, White, and Carbon River. Smaller grained coarse sediment such as gravel and cobbles are also transported to the lower reaches of the system. Channels in the upper reaches of the Puyallup River have widened, presumably in response to observed increases in sediment loads (Czuba et al., 2010). Channels in the lower reaches have adjusted primarily through aggradation (Czuba et al., 2010). From 1985 to 2009, portions of the White River have experienced up to 7 feet of aggradation in the channel, which has reduced conveyance capacity and increased flooding risk. Reaches in the lower Puyallup River upstream of the confluence with the Carbon River have experienced up to 4 feet of aggradation over the same time period (Jaeger, 2016). The most downstream reaches of the lower Puyallup River

(from the City of Puyallup downstream), have experienced more moderate aggradation rates. From 1985 to 2009, aggradation in the Lower Puyallup River was approximately 0.3 inches per year, or about 7 inches total over the approximately 25-year period (Czuba et al., 2010). Portions of the lower Carbon River and lower White River experienced channel bed incision over the same time period, with up to 3 feet of degradation.

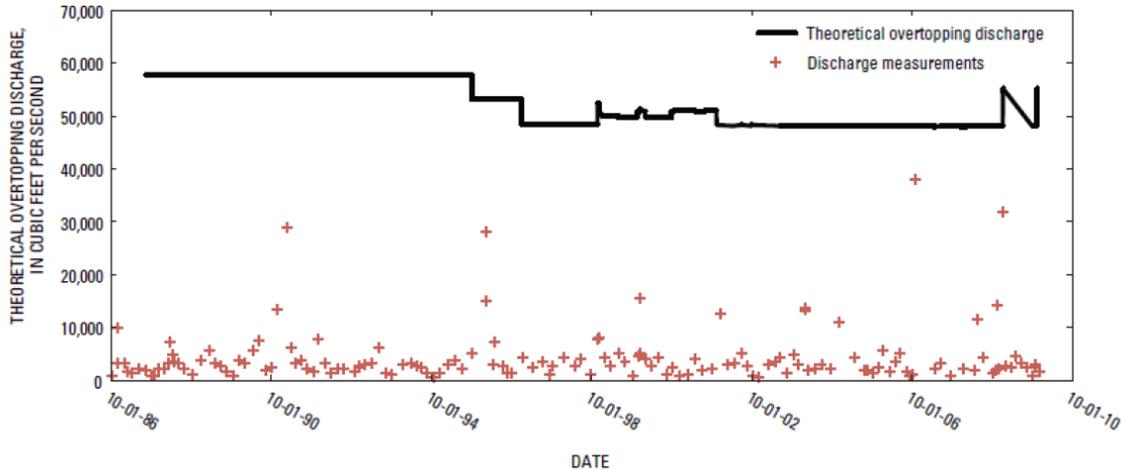
Upper channel reaches in the Puyallup River system are dominated by larger sediment, primarily gravel and cobbles, but the substrate of the lower channel reaches is characterized by sand and smaller sediment particles. The riverbed substrate in the Puyallup River transitions from gravel to sand at the approximate extent of tidal influence from Puget Sound near City of Puyallup. The USGS estimated that the time it takes medium-sized sediment to move through the Puyallup and White Rivers is 80 and 60 years, respectively. However, there is a long-term sediment storage reach just upstream of Mud Mountain Dam on the White River. The Carbon River transports medium-sized sediment more slowly, with an average transport time of 300 years (Jaeger, 2016).

Figure 3 shows the stage of three different high flow events in the Puyallup River channel modeled at the river gage near the City of Puyallup and how these elevations changed from around 1915 to 2010. The figure shows a 5-foot drop in the modeled water elevations between 1916 and 1917, due to the changes in the river bed associated with the Inter-County River Improvement project, which permanently diverted the White River into the Puyallup River. The figure also shows a 3-foot drop in the modeled water surface elevations in the 1930s associated with gravel removal in the river for the construction of Highway 167. Starting in the mid-1980s, the figure shows an increase in modeled water surface elevations of around 0.3 inches per year, which is attributed to aggradation of the river bed.



**Figure 3.** Stage for the period of record at 10, 50, and 90 percent exceedance for gaging station 12101500, Puyallup River at Puyallup, Washington. Source: Czuba et al., 2010.

Figure 4 shows changes over time in the theoretical discharge at which the Puyallup River starts overtopping at the river gage near Puyallup. The theoretical overtopping discharge was estimated by USGS based on changes in the stage-discharge rating curves at the river gage. The theoretical overtopping discharge has decreased by about 9,700 cubic feet per second since 1987 due to aggradation in the river channel (Czuba et al., 2010).



**Figure 4. Long-term trends in the theoretical overtopping discharge and discharge measurements at USGS streamflow-gaging station 12101500, Puyallup River at Puyallup, Washington. Source: Czuba et al., 2010.**

### 4.3 Information Gaps

The primary information gaps for sediment conditions in the Puyallup River relate to the effects of climate change on sediment regimes. Studies and models across the U.S. show preliminary evidence for increased magnitudes of high flow events, which in turn can increase sediment transport. Other studies show that as glaciers shrink, sediment supply increases from the newly exposed areas, but more research is needed to understand how that would affect actual sediment transport (Jaeger, 2016). The *State of Knowledge: Climate Change in Puget Sound* report states that erosion and transport of sediment are both expected to increase in the future (CIG, 2015). More information is needed on how sediment supply could increase, what changes in sediment transport can be anticipated, and how these changes would likely affect channel conveyance, flood risk, salmon habitat, and other features in the Puyallup River system.

## 5.0 Sediment from Clear Creek and its Tributaries

### 5.1 Sources of Information

The two best sources of information on sediment conditions in Clear Creek and its tributaries are the 2006 *Clear/Clarks Creek Basin Plan* (Basin Plan) and the 2015 *Swan Creek Watershed Characterization and Action Plan* (Swan Creek Action Plan). The Basin Plan is one of ten Basin Plans Pierce County developed to identify capital improvement, maintenance, and repair projects. The Basin Plan addresses flooding, erosion, water quality, and habitat conditions. The Swan

Creek Action Plan was developed because Swan Creek is one of the County's "Raise the Grade" streams identified in the Annual Stream Health Report Card. The Swan Creek Action Plan was funded in part through an Ecology Watershed Protection and Restoration Grant and is intended to improve identified water quality problems. The Swan Creek Action Plan process included a Sediment Loading Evaluation Study which describes sediment issues in Swan Creek.

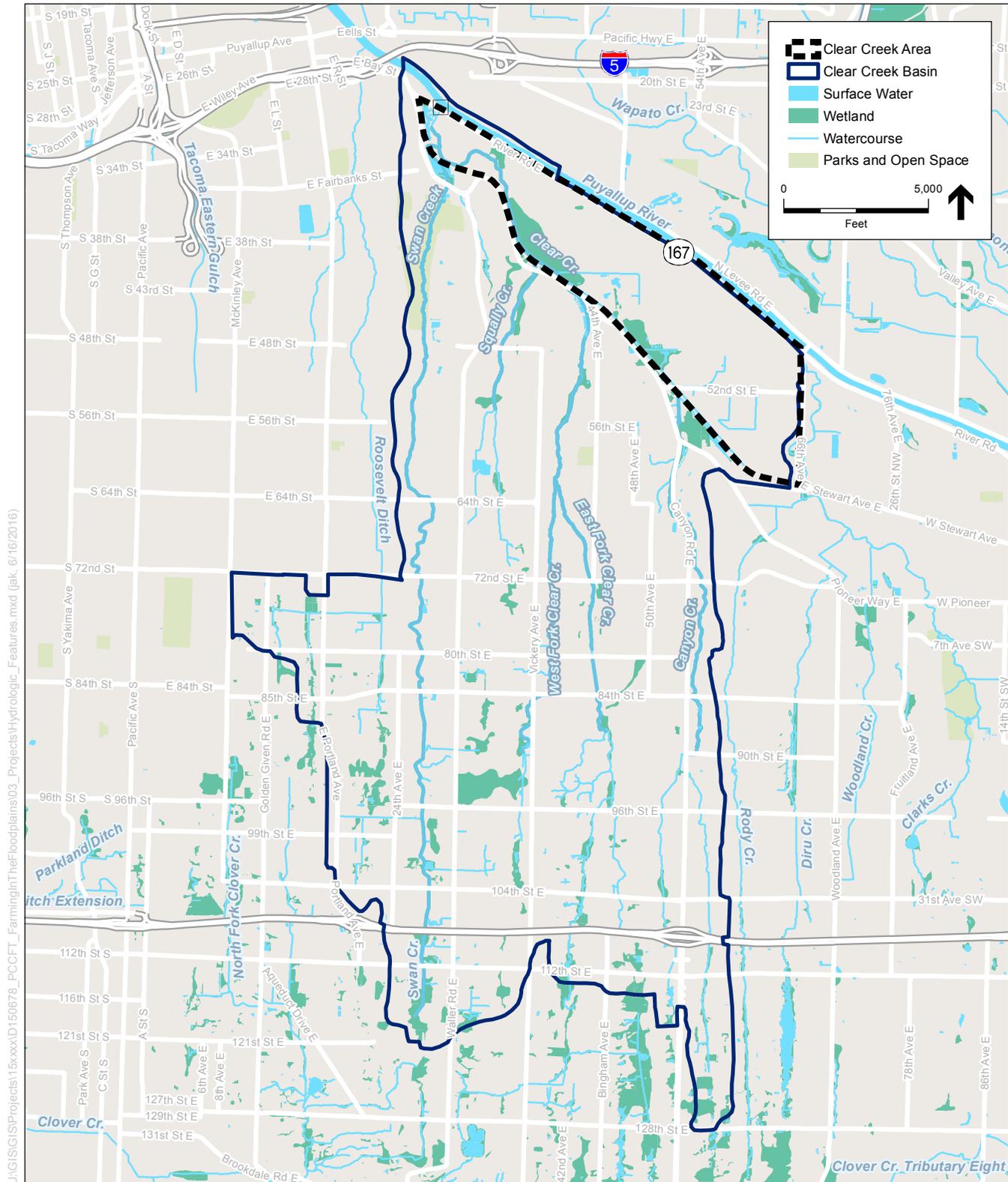
## 5.2 Established Information

Erosion and sedimentation are concerns in Clear Creek and its tributaries. Deposits of fine sediment in Clear Creek and in the drainage ditches in the Clear Creek area are documented in the *Drainage Inventory Preliminary Findings Memorandum* (ESA, 2016). ESA field staff recorded sediment deposits up to 3 feet deep in Clear Creek. Sediment deposits like this reduce the hydraulic capacity of the channel, contribute to more frequent overbank flooding, and provide a growth medium for invasive vegetation.

In general, the upper portion of the Clear Creek Basin is a large sediment source. During fieldwork for the Basin Plan, active stream bank and channel bed erosion were observed in all of the tributaries to Clear Creek. Erosion was observed in the form of channel downcutting, channel sidecutting, and hillslope mass wasting caused largely by excessive peak flows coupled with the geologic conditions of large, unconsolidated glacial outwash deposits, which are fine-grained and easily erodible. The Basin Plan states that urbanization has led to an increase in peak flows on these streams. The increased flows have in turn increased erosion (Pierce County, 2006).

All four streams draining into Clear Creek (Swan Creek, Squally Creek, upper Clear Creek, and Canyon Creek) would be eroding naturally, especially given the erodible soils and steep topography. However, development has altered conditions and increased sediment loads and increased the flows that transport this sediment (Pierce County, 2006). In general, the sediment is deposited in the low-gradient, slow moving, floodplain reach, which is the low-lying Clear Creek area where agriculture land uses are located. All four streams have stormwater or sediment facilities that allow for some reduction in peak flows and/or capture and removal of sediment.

Figure 5 shows hydrologic features in the Clear Creek Basin, including the four tributaries of Clear Creek.



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SOURCE:  
Pierce Co. 2016; ESA 2016

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**Figure 5**  
Hydrologic Features in the  
Clear Creek Basin

## Swan Creek

The 2015 Swan Creek Action Plan provides the most available information about sediment for any of the Clear Creek tributaries. Swan Creek is the most modified of the four tributaries. The upland wetlands on Swan Creek have been channelized, increasing peak flows. Swan Creek is also the longest of the four tributaries, which means it has the longest eroding reach contributing sediment to the system (Pierce County, 2015).

Swan Creek has a relatively flat uplands reach with low stream energy. Around 72<sup>nd</sup> Street East, the stream cuts down the hill. The upper valley reach is predominantly eroding, adding sediment to the stream. Around the lower valley reach, and particularly into the floodplain reach, sediment starts depositing. The Swan Creek Action Plan states that some of the primary erosion issues are caused by current conditions at the Pipeline Road Culvert and 64<sup>th</sup> Street culvert outlet (Pierce County, 2015).

Under natural conditions, Swan Creek would be receiving sediment inputs from the upland areas, eroding sediment in and near its channel, and transporting it downstream. The stream would be eroding the glacial outwash soils from the stream valley walls and banks, and depositing them onto the lower reach of the stream in what is called an alluvial fan. The channel would migrate back and forth across the fan as sediment was deposited. Because the alluvial fan portion of the stream has been modified and constrained where crossed by roads (Pioneer Way) and a railroad and where residences have been built, the fan is no longer functional as a depositional area without impacting these developments. The County constructed a sediment retention pond on the lower portion of the stream in 1991 and maintains it by regularly removing accumulated sediment. The sediment pond retains much of the sediment transported from upstream, preventing it from depositing over the entire former alluvial fan area. The pond is effective because it is located on the alluvial fan, a transition area between the high gradient and low gradient portions of the stream. It is low enough in the system to catch most sediment and does so just before it deposits in the floodplain (Pierce County, 2015). Pierce County Surface Water Management (SWM) staff has stated that the purpose of the sediment pond is to keep the Pioneer Way bridge from being overtopped. The Swan Creek Action Plan states that the current management of the sediment pond also protects habitat in the floodplain reach where both the City of Tacoma and Port of Tacoma wetland sites are located because sediment currently trapped by the pond would otherwise be deposited in the wetlands (Pierce County, 2015).

The County removes sediment from the pond every 2 to 3 years. In 2011, for example, 2,400 cubic yards (cy) of sand and gravel plus 600 cy of silt were removed after 2 years of buildup (Pierce County, 2015). Figure 6 shows sediment removed from the sediment pond in 2016. Judi Radloff, the geomorphologist at GeoEngineers who did the sediment loading evaluation study, has stated that the sediment pond catches most of the sediment from Swan Creek, and much of the additional sediment that moves downstream of the pond is likely deposited in the City of Tacoma wetland site before reaching Clear Creek (Radloff, 2016). Primarily fine sediment suspended in the stream would be transported downstream of the wetland.



**Figure 6. Sediment removed from the Swan Creek sediment pond in 2016.**

The Sediment Loading Evaluation Study for Swan Creek describes the stages of adjustment that an urbanizing or otherwise disturbed stream goes through, based on study by two researchers from the National Sediment Laboratory (Simon and Rinaldi, 2006). The stages are:

- 1 – pre-disturbed (a largely natural system);
- 2 – initially disrupted stage;
- 3 – rapid channel degradation with erosion and incision;
- 4 – channel widening, characterized by mass wasting along banks
- 5 – aggradation
- 6 – quasi equilibrium

According to the sediment loading evaluation study, the upland reach of Swan Creek is currently in Stage 2 – an initially disrupted state with a channelized stream and stormwater runoff from urbanizing land use. The upper valley reach is in stages 3 and 4 – incision and widening, as banks are subject to failure and more frequent, higher flow volumes come through, causing erosion. The lower valley reach is in stages 4 and 5 – the channel is still widening, but there is also aggradation as sediment is deposited and stored in bars. The floodplain reach is in stage 5. It is aggrading as sediment is deposited (Pierce County, 2015).

Swan Creek sediment information is not directly relevant to conditions for agriculture in the Clear Creek area because Swan Creek enters Clear Creek downstream of the agricultural lands. In addition, the sediment pond prevents excessive sediment from entering Clear Creek. However, because more information has been developed for sediment conditions on Swan Creek, this

information may be useful to better understand conditions on the other tributaries of Clear Creek, which have similar soils and topography.

## **Squally Creek**

The best source of information on sediment conditions in Squally Creek, Clear Creek, and Canyon Creek is the Basin Plan. The Basin Plan describes several sources of sediment on Squally Creek, including easily eroded roadside ditches along 57th Street East and 64th Street East, as well as the portion of Squally Creek downstream of the 48th Street East crossing. The Basin Plan also states that there is sediment deposition in Squally Creek immediately upstream of Pioneer Way East, caused by backwatering from large amounts of road fill placed in the channel during construction of Pioneer Way East. A SWM-operated stormwater detention facility was constructed on Squally Creek in 1995, which reduces erosion and sedimentation in the basin (Pierce County, 2006).

## **Clear Creek**

The Basin Plan identified the worst areas of erosion on upper Clear Creek as being immediately downstream of the 72nd Street Culvert, where the channel has incised 10 feet with vertical exposed banks on both sides of the channel, and between 45th Street East and Pioneer Way (Pierce County, 2006). Downstream transport of coarse sediment from upper Clear Creek is retained behind the privately-owned hatchery weir upstream of Pioneer Way and periodically removed.

## **Canyon Creek**

Similar to Clear Creek, the Basin Plan identifies an area of Canyon Creek with 10-foot-high exposed banks for 1,000 feet downstream of the second Canyon Road crossing (Pierce County, 2006). There is a SWM-operated stormwater detention facility on Canyon Creek at 84th Street and Canyon Road, which reduces peak flows and therefore likely reduces downstream erosion and sediment transport in Canyon Creek.

## **5.3 Information Gaps**

Sediment loading evaluation studies, similar to what was done on Swan Creek, should be done for these three tributaries. In addition, information is needed on the portion of sediment in lower Clear Creek originating from upstream areas in the Clear Creek Basin and the portion originating in runoff from properties within the Clear Creek area.

USGS maintains a seasonal gage on Swan Creek, which records flows from October 1 to April 30. There are no other streamflow gages on Clear Creek or its tributaries. Additional streamflow gages on Squally, Clear, and Canyon creeks would increase the understanding of hydraulic conditions on the tributaries and how they relate to sediment transport.

## 6.0 Relationship to Agricultural Viability and Conclusions

Information and conclusions in this section are based on the discussion at the Technical Advisory Group (TAG) meeting on November 2, 2016.

### 6.1 Risks to Agricultural Viability Caused by Increased Sediment

While erosion and sedimentation are natural river processes, current and projected sediment inputs into and transported by the Puyallup River and Clear Creek threaten agricultural viability by increasing flood risk and by compromising the ability of the system to drain agricultural lands. Specific risks include:

- Aggradation in the Puyallup River channel increases flood risk to the Clear Creek area because overtopping of River Road Levee would happen at lower flows.
- Aggradation in the Puyallup River near the mouth of Clear Creek would cause the water surface elevation to be higher under most river flow conditions, which would cause the tide gates to close more frequently, thereby raising backwater conditions for Clear Creek.
- As the river bed of the Puyallup River rises due to aggradation, the river level rises relative to the land elevation in the Clear Creek area, which could limit the ability of the Clear Creek area to drain even during low river flow conditions.
- Sediment deposition and aggradation in Clear Creek create problems during high flow and low flow conditions.
  - During high flow, the reduced hydraulic conveyance capacity from sedimentation causes the channel to be overtopped sooner.
  - During low flow, sedimentation in the stream causes higher water levels, which create back-water conditions in the drainage system where the drainage channels join Clear Creek.

### 6.2 Research and Projects to Address Sediment Risks

Projects designed to reduce sediment inputs to the low-lying Clear Creek area could improve drainage and increase flood storage capacity in the channel. Both the Basin Plan and the Swan Creek Action Plan include recommended actions to address sediment sources, including stormwater detention to control peak flows, control of direct discharges to the creeks, sediment source control, and installation of log jams to store sediment in the creeks and reduce down-cutting. Additional projects could be identified through research on sediment sources and dynamics on Squally Creek, Clear Creek, and Canyon Creek.

Sediment loading evaluations should be done for Squally Creek, Clear Creek, and Canyon Creek in order to understand the risk to agriculture viability. A range of approaches to study sediment sources on the tributaries could be undertaken. Some examples include:

- The Swan Creek evaluation was funded in part by an Ecology grant and included review of existing data and models, field work to identify sediment sources, collection of sediment samples, and modeling.
- The Puyallup Tribe recently completed a study of sediment sources on nearby Clarks Creek and its tributaries. That study, which included a stakeholder process, cost approximately \$500,000 and identified bank stabilization projects that can be undertaken to address sediment sources from eroding banks.
- A less resource-intensive approach could involve hiring a geomorphologist to do field reconnaissance to identify areas of bank erosion.

These approaches represent two ends of a range of approaches; depending on available resources, an appropriate approach could be developed somewhere between these two levels of effort.

Uncertainty associated with the effects of climate change is another risk to agricultural viability. The ability to plan for agricultural viability long-term would be enhanced by a greater understanding of how climate change could affect sediment dynamics in the Clear Creek area.

### 6.3 Sediment and Other Projects in the Study Area

Pierce County is currently pursuing a Habitat and Flood Capacity Creation project, which is a pilot study that will evaluate the effectiveness for combining habitat restoration treatments with selective sediment removal on the Puyallup River near the confluence with the White River. Depending on the outcome of the project, targeted and strategic sediment removal on the Puyallup River could reduce aggradation and increase flood storage capacity in the channel while simultaneously improving habitat conditions. The project is intended to be one in a suite of several risk reduction strategies currently ongoing in Pierce County to address moderate flood events.

Construction of the proposed Clear Creek Floodplain Reconnection Project would hydraulically reconnect a portion of the Clear Creek area (contained on the wet side of a new ring levee) to the Puyallup River. At the TAG meeting, the possibility that the wet side of the levee would become a depositional area for sediment from the Puyallup River was discussed. Tidal water level fluctuations in this would tend to cause channels to form and be maintained within this depositional area. At a nearby Puyallup Tribe restoration site on the Puyallup River, which opened up a subsided area to intertidal flow, approximately 4 feet of vertical aggradation was observed in the first three years, though the site has now reached equilibrium, according to comments from Russ Ladley of the Puyallup Tribe at the TAG meeting. At the TAG meeting, farmers in the Clear Creek area requested that modeling be completed to predict sediment dynamics on the wet side of the proposed levee, including a determination of how the

combination of sediment deposition and fluctuating water levels on the wet side of the levee would affect agricultural drainage from the dry side of the levee. Farmers also requested additional information on what type of habitat would be constructed on the wet side of the levee and whether drainage channels through the habitat area could be maintained to support drainage from the agricultural areas on the dry side of the levee.

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## **APPENDIX B**

### **Existing Flood Risk Conditions for Agriculture in the Clear Creek Area Technical Memorandum**



Final

# EXISTING FLOOD RISK CONDITIONS FOR AGRICULTURE IN THE CLEAR CREEK AREA

Technical Memorandum  
Farming in the Floodplain Project

Prepared for  
PCC Farmland Trust

March 2017





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## 1.0 Project Background and Description

This technical memorandum has been prepared as part of Phase 2 of the Farming in the Floodplain Project (FFP). The FFP is one of four components of the Floodplains for the Future: Puyallup, White, and Carbon Rivers project, which is funded by a Floodplains by Design grant from the Washington Department of Ecology (Ecology). The purpose of the FFP is to advance progress toward a collectively agreed upon plan for the Clear Creek area that improves agricultural viability in the area while also meeting goals for flood risk reduction and salmon habitat enhancement. The FFP is intended to clarify the needs and interests of the agricultural community within the Clear Creek area.

In Phase 1 of the FFP, ESA prepared an Existing Conditions Report which identified physical conditions in the Clear Creek area that limit agricultural viability. The report found that flood risk in the Clear Creek area is complicated and is not well understood by all stakeholders involved in the Floodplains for the Future project. As part of Phase 2, ESA has conducted additional research on flood risk, including coordination with Pierce County Surface Water Management (SWM).

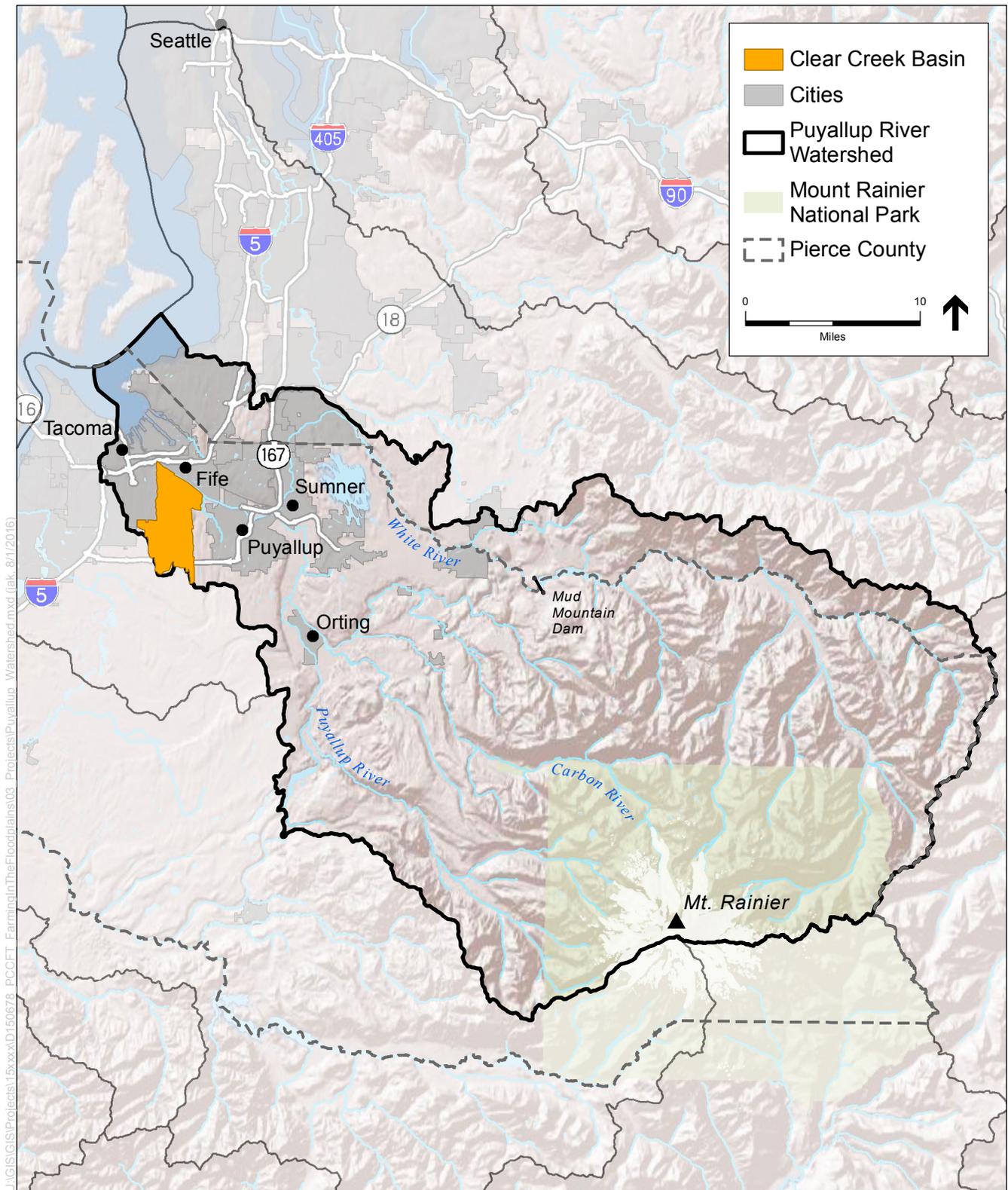
The purpose of this memorandum is to provide information on existing flood risk conditions for farms in the Clear Creek area.

The Clear Creek area faces both flooding and drainage issues. ESA is also preparing a Drainage Inventory Memorandum which will focus on drainage issues. For the purposes of these memorandums, drainage refers to conveyance of water through the area and to the Puyallup River and includes topics related to ditches and culverts. Flooding refers to events where water levels are ponded and are generally above the surfaces of local roads.

This memorandum includes sections on the relationship of flood risk to agricultural viability, flood risk to organic certification and crops, vulnerabilities in the Clear Creek area flood system, ongoing and planned actions to reduce vulnerabilities in the Clear Creek area, and findings.

## 2.0 Study Area

The study area for the FFP is the Clear Creek area, part of the Clear Creek Subbasin of the Puyallup River Watershed (Figure 1). The Clear Creek Subbasin is within the Puyallup River Watershed and is located south of the Puyallup River, north of 128th Street East, west of 66th Avenue East, and east of McKinley Avenue East. The Clear Creek area is roughly 1.5 square miles (990 acres) in size and bounded by the Puyallup River to the north, Pioneer Way East to the south and west, and 52nd Street East to the east.



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SOURCE:  
 ESA, 2016; King County, 2015; Pierce County, 2013; Ecology, 2007;  
 OSM, 2016; WDNR, 2010

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**Figure 1**  
 Puyallup Watershed

### 3.0 Relationship of Flood Risk to Agricultural Viability

As described in the Existing Conditions Report, flooding presents a risk to agricultural viability in the Clear Creek area (ESA, 2016b). Several farmers in the area have stated that recent incidences of high water from Clear Creek flooding low-lying areas did not represent a threat to their farms. However, recent high water events were well below record high water elevations and therefore do not represent the maximum potential extent, duration, or depth of floodwater inundation of farms in the Clear Creek area. The greatest risk of flood damage would come from the unlikely but possible chance of River Road Levee being breached because of the erosive water velocities and the resulting rapid rise in water elevation within the Clear Creek area. Overtopping of the River Road Levee without a breach would be a less disastrous but more likely risk.

The level of risk at each individual farm varies due to differences in elevation, topography, the crops grown, the location, and the techniques used. In general, the types of risks that flooding poses to farms include:

- Human health and safety is threatened for farmers who live on their farms in the floodplain;
- Crops can be killed or their growth stunted from standing water;
- Edible crops coming into contact with floodwaters are not suitable for human consumption (flooding typically does not occur during the growing season for most crops, but some perennial crops, such as blueberries, are grown in the Clear Creek area);
- Flooding can also prevent or discourage farmers from planting cover crops, which are an important tool for soil health and pest management;
- Flooding can inundate and damage agricultural equipment and structures, such as barns; and
- Flooding is a risk to livestock.

### 4.0 Flooding Risk to Organic Certification and Crops

During Phase 1 of the FFP, farmers in the Clear Creek area expressed concerns that flooding represented a risk to a farm's organic status. A number of farms in the Clear Creek area use organic growing practices. For small, direct-market farms in the Clear Creek area that rely on selling produce at farmers markets and through Community Supported Agriculture (CSA) subscriptions, maintaining organic certification is an important element of their viability as a farm business. Clear Creek area farmers expressed concern that flooding could trigger an inspection that could lead to loss of organic certification due to contaminants carried by floodwaters that are deposited on their crops or soils.

The Washington State Department of Agriculture (WSDA) Organic Program is accredited to certify organic farms in Washington State in accordance with the United States Department of Agriculture (USDA) National Organic Program (NOP). A certification fact sheet released by the WSDA in January 2012 states clearly that flooding of a farm does not jeopardize the farm's organic certification (WSDA, 2012).

The certification fact sheet states that crops that have come into contact with floodwaters are considered adulterated and cannot be sold for human consumption. It also states that USDA NOP standards are based on proper practices and do not mandate zero tolerance for residues of prohibited materials in soils. In some cases, the WSDA Organic Program may test crops grown on organically-certified farms following a flood event. If the samples show residues of prohibited materials over certain thresholds (the U.S. Food and Drug Administration (FDA) action level or above 5% of the EPA tolerance), the crops cannot be sold as organic and the farm must develop a plan to prevent additional contamination in the future (WSDA, 2012). Therefore, while flooding does not threaten the organic certification of a farm, it does threaten the viability of the farm business by potentially requiring crops grown after a field was inundated to be sold at lower prices as conventional produce.

After the December 2007 flood on the Chehalis River, the WSDA visited 17 organic farms that had been inundated to walk the fields and observe flood impacts. Inspectors found no signs of synthetic contaminants. Several months later, WSDA staff collected plant samples from the farms and tested them, but did not find any evidences of contamination that would threaten organic status of produce grown that season (WSDA, 2012).

Contaminants in floodwaters still represent a risk to food safety. Any crops that have come into contact with floodwaters are considered “adulterated” by the FDA and cannot be sold for human consumption. The FDA recommends waiting 60 days before replanting flooded fields and keeping a 30 foot buffer between areas that have been flooded and adjacent areas to be harvested for human consumption to prevent cross contamination between flooded and non-flooded areas (FDA, 2011).

The WSDA has produced a video on flood preparation and recovery as part of its “Farm Wisdom” video series on managing risk on small farms. The video is available at <https://www.youtube.com/watch?v=NLcTCI9JxD4>.

## **5.0 Vulnerabilities in the Clear Creek Area Flood System**

Flooding in the Clear Creek area is caused by a complex interaction of flows in the Puyallup River and Clear Creek and its tributaries. The flood control system in the area consists of levees, an upstream dam, tide gates, and stormwater detention ponds on Swan, Squally, and Canyon creeks. The flood system includes several vulnerabilities. These vulnerabilities, each of which is described below, include:

- Flooding from the Puyallup River
- River Road Levee
- Mud Mountain Dam
- Flooding from Clear Creek and its four tributaries
- The Clear Creek tide gates
- Climate change

The Clear Creek Floodplain Reconnection Hydrologic and Hydraulic Modeling Final Report, prepared by Northwest Hydraulic Consultants Inc. (NHC) for Pierce County in 2015, identifies four sources of floodwaters in the Clear Creek area:

- Discharges from Swan, Squally, Clear, and Canyon creeks,
- Precipitation falling directly on the floodplain,
- Floodwater entering Canyon Creek via overflow from Clarks Creek during extreme flood events, and
- Floodwaters from the Puyallup River, which enter the Clear Creek floodplain when allowed to by operations of the tide gates (NHC, 2015).

Floodwaters could also enter the Clear Creek area from the Puyallup River by overtopping or breaching River Road Levee, which was not included in NHC's modeling.

Various components of flooding in the Clear Creek area have been described as “backwater flooding” in the NHC report, previous reports prepared by ESA, and conversations between stakeholders. The National Weather Service glossary defines backwater flooding as “upstream flooding caused by downstream conditions such as channel restriction and/or high flow in a downstream confluence stream” (NOAA, 2017). Based on this definition, this memorandum uses the term backwater flooding to describe flooding in the Clear Creek area caused by the inability of water in the Clear Creek channel to flow into the Puyallup River due to high water levels in the river.

## 5.1 Puyallup River Flooding

The Clear Creek area is in the Lower Puyallup reach of the Puyallup River. It was historically part of the floodplain of the Puyallup River, but was disconnected from the floodplain when River Road Levee was constructed in the 1910s. Disconnecting the area from the Puyallup River protected it from Puyallup River flooding, but also cut off the supply of sediment that historically was deposited in the area and built up the agricultural soils.

According to the Pierce County Flood Plan, major flooding in the Lower Puyallup River occurred in 1906, 1917, 1919, 1921, 1932, 1933, 1934, 1965, 1977, 1986, 1990 (twice), 1996, 2006, and 2009 (Pierce County, 2013). The Clear Creek area also flooded three times in 2015. The 2009 flood, with a flow of 48,200 cubic feet per second (cfs), was the largest on record since completion of Mud Mountain Dam in 1948 (Pierce County, 2013). The 2009 flood (in the Puyallup River Watershed and throughout Western Washington) was caused by heavy rainfall, warm temperatures, and melting snowpack (Corps, 2016). Runoff in the watershed has increased since 2005 and extensive sediment deposition has reduced the capacity of the Puyallup River channel, which the Corps considers the primary driver of changes in flood risk in the area (Corps, 2016). Additional information on sediment conditions in the Puyallup River can be found in the Sediment Memorandum prepared for the FFP (ESA, 2016c).

The majority of rainfall in the Puyallup River Watershed (approximately 75 percent) occurs between October and March, and the majority of floods occur between November and February. Larger floods typically occur due to atmospheric rivers. Atmospheric rivers are concentrated but

relatively narrow streams of moisture that carry significant volumes of water vapor. The storms that bring atmospheric rivers to the Pacific Northwest from the tropics are also known as “Pineapple Express” events. The average duration of floods in the Puyallup River Watershed is typically 1 to 2 days, which can be extended by several days in the lower White and Puyallup rivers by flow regulation at Mud Mountain Dam.

As described in the “River Road Levee” section below, flooding of the Puyallup threatens to overtop River Road Levee, which would inundate farm businesses and residences in the Clear Creek area. If the Clear Creek tide gates are not properly functioning, they may not close, which would cause Puyallup River water to back up into the Clear Creek area, also inundating farm businesses and residences. This occurred in the 2006 and 2009 floods (Hunger and Schmidt, 2016). Even if River Road Levee does not overtop, increased flooding levels on the Puyallup River directly lead to flooding in the Clear Creek area. While the Puyallup River is flooding, the Clear Creek tide gates shut, causing Clear Creek to back up, flooding farm businesses and residences. The more frequently the Puyallup River floods, the more frequently the Clear Creek area floods due to this backwater flooding. The higher flood levels are on the Puyallup River, the longer the tide gates will be closed, increasing the level and duration of backwater flooding from Clear Creek.

## River Road Levee

The levees on the Puyallup River upstream of River Mile (RM) 2.8 are owned and operated by Pierce County, including the North Levee Road Levee and the River Road Levee (Pierce County, 2013). North Levee Road Levee, located on the right bank of the Puyallup River, reduces flood risk to the City of Fife and other areas north of the Puyallup River. River Road Levee reduces flood risk to the Clear Creek area from Puyallup River. Potential damage to the levees is considered the highest flood risk on the Puyallup River system (Pierce County, 2013). If the levees were not in place, annual damage from flooding in the Lower Puyallup River would be an estimated \$7.6 million, with damages of \$78.7 million estimated from a 100-year flood event.

According to the Pierce County Rivers Flood Hazard Management Plan (Flood Plan), both levees are in good condition and are structurally sound (Pierce County, 2013). However, the levees were constructed before there were federal standards for levees. Current standards adopted by Federal Emergency Management Agency (FEMA) require three feet of freeboard (height of levee above the 100-year flood elevation) for accredited levees. During flood modeling conducted in 2004, it was discovered that both levees do not provide adequate freeboard, and FEMA subsequently de-accredited both levees.

FEMA requires the following standards be met for accredited levees:

- **Freeboard.** A minimum freeboard of 3 feet above the base flood elevation all along the length of the levee, with an additional 1 foot within 100 feet of structures (such as bridges) or wherever the flow is restricted, and an additional 0.5 foot at the upstream end of a levee.
- **Closures.** All openings must be provided with closure devices that are structural parts of the system during operation and designed according to sound engineering practices.

- **Embankment Protection.** Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability.
- **Embankment and Foundation Stability Analyses.** Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided must evaluate expected seepage during loading conditions associated with the base flood and must demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability.
- **Settlement Analyses.** Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained.
- **Interior Drainage.** An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than 1 foot, the water-surface elevation(s) of the base flood (FEMA, 2016b).

River Road Levee was de-accredited due to lack of freeboard. No analysis of whether River Road Levee would meet the other accreditation standards has been conducted at this time.

In 2009, a study of the levees conducted for Pierce County by TetraTech found that a 100-year flood event would overtop the North Levee Road Levee at RM 3.3, but would not overtop the River Road Levee (Pierce County, 2013). The simulation found that a 500-year flood event would overtop the North Levee Road Levee at RM 3.3 and would also overtop the River Road Levee at RM 3.1, causing flooding in adjacent areas for over 24 hours. River Road Levee was also simulated to overtop at RM 4.5, 5.55, and 7.2 for shorter durations (Pierce County, 2013). Specific river mile locations at overtopping locations are based on modeling; due to dynamic flood conditions, overtopping in an actual flood event could vary in location. In 2006 and 2009, flood levels were projected to overtop the River Road Levee, and Pierce County called for an evacuation of the Clear Creek area (Pierce County, 2016a; Hunger and Schmidt, 2016). Fortunately, in both events, precipitation patterns changed and the levee was not overtopped. In recent events, such as the 2009 flood, floodwaters have reached the edge of the Highway 167 road surface (Hunger and Schmidt, 2016).

The potential exists for River Road Levee to overtop or breach. This represents the biggest potential flood risk to farms in the Clear Creek area. Overtopping of the levee could significantly affect farms (as well as human health and safety) in the Clear Creek area. Homes, barns, fields, and equipment throughout the Clear Creek area could be inundated. Humans in the area could be physically at risk and evacuations could be called for by Pierce County based on flood forecasts. Livestock would also be threatened by an overtopping flood event.

Regardless of whether the levee overtops or otherwise fails to protect the area, the vulnerability of the levee currently affects agricultural viability because it causes the area to be mapped as a floodway. This is discussed in more detail below in Section 6.2.

## Mud Mountain Dam

The White River flowed north to the Duwamish River until an avulsion (an incident in which a river rapidly abandons its channel and forms a new channel) in 1906 rerouted the river into the Puyallup River Watershed, doubling the size of the basin. Mud Mountain Dam is located on the White River and is operated by the Corps to provide flood control for the Lower Puyallup River. The dam was authorized by Congress after the 1933 flood, which destroyed levee systems in the Lower Puyallup River valley. The operation of the dam, completed in 1948, is intended to keep the peak flood flow on the Lower Puyallup River to less than 45,000 cfs by holding back flows on the White River. After the peak flow on the Puyallup River passes, the water stored behind Mud Mountain Dam is released into the White River (Corps, 2016). In recent years, sedimentation in the White River channel, encroachment into the floodplain by development, and other factors have required changes in the operation of Mud Mountain Dam (Pierce County, 2013). After the November 2008 flood, a flow of 12,000 cfs was released from Mud Mountain Dam without incident. For comparison, the average November flow in the White River downstream of Mud Mountain Dam at the USGS gaging station in Auburn is 1,870 cfs. In January 2009, a release of the same flow rate of water caused flooding in the town of Pacific. It was determined that the channel capacity in the area had been reduced to approximately 6,000 to 8,500 cfs. In 2015, a release of 6,000 cfs from the dam again caused flooding in Pacific, indicating that the channel capacity continues to decrease (Corps, 2016). The loss of channel capacity in the White River causes the Corps to release floodwaters held behind Mud Mountain Dam more slowly when possible, reducing the ability to draw down the reservoir in anticipation of future flood events. Flows on the Lower Puyallup exceeded 45,000 cfs (up to 48,200 cfs) in the January 2009 flood despite the operation of Mud Mountain Dam. For comparison, average January flows on the Puyallup River at the USGS gaging station in the City of Puyallup are 4,375 cfs.

### Flooding Terminology

**cfs** (or cubic feet per second) is a measurement of flow in a river or stream.

The **base flood** and **100-year flood** are two synonymous terms for a flood event that has a 1 percent chance of occurring in any given year.

The **flood elevation** is the height above sea level that floodwaters reach in a given event. The **base flood elevation** is the height that floodwaters reach in the 100-year flood.

Changes in the operation of Mud Mountain Dam affect agricultural viability in the Clear Creek area. Because of the loss of channel capacity, floodwaters from Mud Mountain Dam are released more slowly. Therefore, it takes longer to move floodwaters through the system, causing the Lower Puyallup River to be at elevated levels for longer. This in turn delays water draining from the Clear Creek tide gates, during which time Clear Creek and its tributaries continue to drain into the area, increasing the water levels in the Clear Creek area.

## Climate Change and Puyallup River Flooding

Flood risk throughout Puget Sound is projected to increase with climate change. Heavy rainfall events are projected to become heavier, increasing peak flows. Sea levels are projected to rise. At

the same time, sediment loads are projected to increase and the Puyallup River is predicted to aggrade, reducing channel capacity to handle the increased peak flows.

The Puyallup River Watershed is a “mixed rain and snow” watershed, meaning that about 30 percent of the total volume of precipitation in the basin falls as snow while the rest falls as rain (CIG, 2015b). The percentage of precipitation that falls as snow is relatively high because the headwaters of the rivers include high elevation areas on Mount Rainier. Accumulated snowpack within a watershed effectively stores water through the winter until it starts to melt in the spring, shifting a portion of streamflow to later in the year. The Puget Sound region as a whole is projected to see a decrease in snowpack and an associated increase in the percentage of precipitation falling as rain. Mixed rain and snow watersheds are projected to see the largest changes in flooding as they transition to a greater balance of rain relative to snow (CIG, 2015b).

Flood risk is projected to increase in the Puyallup River Watershed and across Puget Sound. Peak daily river flows are projected to increase between 18 and 55 percent by the 2080s, and peak daily rainfall events are projected to become 5 to 34 percent more intense (CIG, 2015b). Under a climate change projection based on a moderate greenhouse gas emissions scenario, the volume of the 10-year flood in the Puyallup River is projected to increase 12 to 85 percent by the 2080s (CIG, 2016). Increased flooding would increase the cost of flood protection and stormwater management. Highways and other roads adjacent to rivers would flood more frequently. Existing flood control infrastructure, such as levees and tide gates, could be stressed by more frequent floods and from floods that exceed the magnitude of events the infrastructure was designed for (CIG, 2015b).

In addition, sea level is projected to rise an additional 14 to 54 inches in the Puget Sound region by 2100, although changes at specific locations will vary because of local variations in the rates of land subsidence and uplift (CIG, 2015b).

As flood water levels on the Puyallup River increase with climate change, the probability of River Road Levee overtopping and inundating farms in the Clear Creek area will also increase. Increased water levels from sea level rise and river flooding will also delay drainage from the Clear Creek tide gates, increasing backwater flooding of Clear Creek area.

## 5.2 Clear Creek Flooding

Large portions of the Clear Creek area are mapped as being within the 100-year floodplain. Mapped flood elevations within the floodplain are at about 18 feet NAVD in a 100-year flood (Pierce County, 2013). In addition, each of the four tributaries to Clear Creek (Swan Creek, Squally Creek, Clear Creek, and Canyon Creek) has a mapped floodplain along these creeks going upstream through their respective canyons.

The 100-year flood flows in Clear Creek are over 700 cfs (Schmidt, 2016), as compared to a mean December flow of 15.4 cfs. The Pierce County Flood Plan shows over 20 repetitive loss properties (i.e., properties with more than one flood insurance claim within a 10-year period) in the Clear Creek area. Other properties without flood insurance also have had repetitive flooding (Dixon, 2017). Floodwaters reached an elevation of 18 feet above sea level in the Clear Creek

area in the 2009 flood and over 10 people had to be rescued (Pierce County, 2013). Flooding of this elevation in the Clear Creek area inundates approximately 400 acres of land (Pierce County, 2013).

SWM staff have stated that, in the 2015 flood, water came from the south and flowed over 44<sup>th</sup> Street south to north, which they stated is the opposite direction of typical flood flows in the area (Hunger and Schmidt, 2016). It is unclear why this occurred, but the County speculates that it could be connected to South Ditch being blocked from draining directly into Clear Creek, as reported in the Agricultural Drainage Inventory Preliminary Findings Memo (ESA, 2016a). Drainage District 10 has speculated that this occurred due to overgrowth of reed canarygrass in the channel of Clear Creek (Neville, 2017).

Clarks Creek is directly to the east of the Clear Creek subbasin and the Clear Creek area. According to SWM staff, some landowners in the Clear Creek area believe that, in the 2009 flood, floodwaters from Clarks Creek overflowed into the Clear Creek area (Hunger and Schmidt, 2016).

## **Tide Gates**

ESA is currently conducting an assessment of the Clear Creek tide gates for an upcoming technical memorandum. The following description of the tide gates is based on information gathered for that effort, including the Pierce County Rivers Flood Hazard Management Plan (Pierce County, 2013); Port of Tacoma technical information, construction plans, and as-built plans (Port of Tacoma, 1995; Port of Tacoma, 1997a; Port of Tacoma 1997b); and Pierce County's tide gate fact sheet (Pierce County, 2016b).

There are tide gates at the end of two large rectangular concrete conduits under the River Road Levee where Clear Creek enters the Puyallup River. These rectangular tide gates are both located at the river-side end of the conduits and are hinged at their tops. This configuration prevents water from flowing backwards through the conduit and into the Clear Creek area when the river level is higher than the water level on the other side of the tide gates. Any time the water level in the river is lower than in the Clear Creek area, the difference in water elevation pushes the gates open to let water out. In the mid-1990s, the Port of Tacoma replaced one of the tide gates with a top-hinged tide gate mounted on a sliding frame. The intent of this configuration is to slide the tide gate assembly up away from the conduit most of the time. An actuator slides the tide gate assembly back down into place when the water elevation in the river rises to a set elevation. The tide gates may act as a barrier to fish passage during high flow events on the Puyallup River, when juvenile salmon need refuge from high velocity flows.

In the 2006 and 2009 floods, the newer tide gate assembly was slid up away from the end of the conduit, which allowed Puyallup River floodwaters to flow into the Clear Creek area (Hunger and Schmidt, 2016). Flood elevations in the Clear Creek area in the 2009 flood topped out at approximately 18 feet above sea level. In the 2015 floods, the tide gate was slid into position at the end of the conduit, and consequently the flood water elevation in the Clear Creek area during this event only reached 14.5 feet (Hunger and Schmidt, 2016).

Modeling conducted by NHC for the Clear Creek Floodplain Reconnection Project included a variety of scenarios for the outlet of Clear Creek into the Puyallup River. The modeling results

allow comparison of existing conditions to conditions with two open culverts (i.e., removal of the tide gates) (NHC, 2016). Model results indicate that removal of the tide gates would:

- increase the 10-year flood stage from approximately 16.9 feet to approximately 18.6 feet (1.7 foot increase);
- increase the 50-year flood stage from 19 feet to approximately 20 feet; and
- increase the 100-year flood stage from approximately 20.1 feet to approximately 20.4 feet (NHC, 2016).

These results indicate that the tide gates, when operating properly, protect agricultural properties (particularly those at elevations between 17 and 21 feet) from more frequent flood inundation.

The Clear Creek tide gates contribute to agricultural viability in the Clear Creek area by preventing flooding from the Puyallup River. The largest recent flood event in the Clear Creek area occurred when the newer tide gate was slid up away from the end of the conduit during river flooding conditions, which is not the way it was intended to be operated (Hunger and Schmidt, 2016). Floodwater elevations in the Clear Creek area are lower when the tide gate is slid into position at the end of the conduit to prevent flow of water from the river into the area. However, increases in the Puyallup River water levels, such as from higher tides or larger river flows due to climate change or from changes in the operation of Mud Mountain Dam as discussed below, result in longer periods of time when the water from the Clear Creek area collects, waiting to flow out through the tide gates. Anything that would increase the flow of water into the Clear Creek area compounds the problem and would result in higher water levels there.

If the newer sliding tide gate were positioned up away from the end of the conduit when the river levels are high, Puyallup River water would back up into the Clear Creek area, possibly inundating farm businesses and residences. This occurred in the 2006 and 2009 floods (Hunger and Schmidt, 2016).

Additional information on the operation of the tide gates is being researched as part of ESA's work on Phase 2 of the Farming in the Floodplain Project. A technical memorandum on this topic, including information needs for understanding the relationship of the tide gates to flood risk, will be released in spring 2017. In addition, Pierce County has installed water elevation recorders on both sides of the tide gates. This data will confirm how the newer sliding tide gate assembly is being operated, which will be described in ESA's memo on the tide gates.

## **Climate Change and Clear Creek Flooding**

Climate change information specific to Clear Creek and its tributaries has not been developed. The Clear/Clarks Creek Basin Plan, written in 2006, does not refer to climate change. The more recent Swan Creek Watershed Action Plan (2015) also does not refer to climate change, though the sediment loading analysis included as an appendix does state that "As urbanization (and climate change) progress and the stream continues to see increased flow, the stream may be in a continual state of adjustment" (Pierce County, 2015). It is likely that all four tributaries of Clear Creek will be in a state of adjustment as climate change and development change streamflow and sediment dynamics. Unlike the Puyallup River, Clear Creek and its tributaries do not have glacial headwaters, so the impacts of climate change on flooding are likely to be less dramatic than on

the Puyallup. However, heavy precipitation events are projected to become more intense, meaning that climate change is likely to increase the frequency, volume, and duration of flood events on Clear Creek. In addition, increased sediment due to climate change could increase aggradation and reduce channel capacity in Clear Creek. Climate change could make inundation of farmlands in the Clear Creek area more likely in the future.

## **6.0 Ongoing and Planned Actions to Reduce Vulnerabilities in the Clear Creek Area**

### **6.1 Federal Regulations and Programs**

Pierce County is a participating community in the National Flood Insurance Program (NFIP), which provides affordable insurance to property owners in communities that join the NFIP. The County is also active in the Community Rating System (CRS), which is an incentive program for communities in the NFIP that provides discounts to the flood insurance rates for property owners when the community takes action to meet the floodplain management goals of the CRS, which are: (1) reduce flood damage to insurable property; (2) strengthen and support the insurance aspects of the NFIP; and (3) encourage a comprehensive approach to floodplain management (FEMA, 2016a).

Being a part of the CRS is voluntary and involves a high degree of effort on behalf of the communities that participate. Pierce County is one of the few communities that are within the highest levels (equating to the largest discounts on flood insurance premiums for property owners) of the CRS. The classes range from 1 (being the highest) through 10, and Pierce County is one of three Washington counties that have achieved a CRS class of 2 (out of a total of five communities nationwide), which results in a 40 percent discount on flood insurance premiums. Only one community in the U.S. is listed as a class 1 (FEMA, 2016a).

Other communities in the area are either not participating in the CRS or are listed in a lower class which does not afford discounts as high as Pierce County residents receive. The City of Fife, for example, participates in the NFIP but is not an active member of the CRS and therefore receives no discount. The Puyallup Tribe is not a participant in the NFIP and therefore is not subject to the same regulations for floodplain development.

Flood maps for Pierce County have recently been updated, and the current maps became effective on March 7, 2017. The new flood maps can be viewed online at [msc.fema.gov](https://msc.fema.gov). The flood maps show portions of the Clear Creek area as being within the 100-year floodplain of Clear Creek but protected from Puyallup River flooding by River Road Levee. As described above, River Road Levee has been de-accredited by FEMA, which means that it is no longer considered to provide 100-year flood protection. However, this is not reflected on the maps because the Clear Creek area is secluded from the map updates while FEMA works to determine a new method to map flood risk behind levees that do not provide 100-year flood protection. The areas secluded from FEMA map updates show the flood hazard information as depicted in previous FEMA flood maps – in this case 1987. FEMA intends to update secluded areas on flood maps “at a later time” (FEMA, 2015).

## 6.2 Local Regulations

Pierce County has codified its development regulations in Title 18E of the Pierce County Code (PCC). Chapter 18E.70 contains regulations related to Flood Hazard Areas, including standards that are applied to all development or new construction in the flood hazard areas throughout the county. Most of the Clear Creek area is in unincorporated Pierce County and is regulated by PCC 18E. The listed purposes of these regulations include protection of human life and health, minimization of net loss of ecological functions of floodplains, and qualification of Pierce County for participation in the NFIP. Adopting these regulations is a component of being a community that is participating in the NFIP, which allows for property owners to be eligible to receive subsidized flood insurance.

As described above, portions of the Clear Creek area are mapped as a floodplain, but none of the area is mapped by FEMA as a floodway. Under the NFIP, a regulatory floodway is defined as the area of the floodplain that must remain free of encroachments in order to prevent a rise in the 100-year flood elevation of greater than 1 foot. However, Pierce County Code defines a floodway as “an extremely hazardous area due to the depth and/or velocity of floodwaters which carry debris, potential projectiles, and have erosion potential” (PCC 18E.70.020 B). Pierce County regulates “Deep and/or Fast Flowing Water Areas” as floodways. This designation includes areas where flood depths would be greater than 3 feet, floodwaters would be moving faster than 3 feet per second, or a combination of the two. Pierce County has conducted an analysis of deep and/or fast flowing water of the Clear Creek area, which determined that some portions of the Clear Creek area would be regulated as a floodway based on the deep and/or fast flowing water criterion regardless of the accreditation of River Road Levee because flood depths in those areas would be greater than 3 feet (Pierce County, 2016a). Because the Clear Creek area is secluded from the recent updated maps, the most recent data from FEMA is from the 1987 Flood Insurance Study, which showed a base flood elevation in the Clear Creek area of 17.6 feet NAVD. Based on this information, areas at an elevation of 14.6 feet NAVD or lower would have flood depths of 3 feet or greater. If River Road Levee were to become accredited, FEMA would presumably remap the Clear Creek area with newer data and establish a new base flood elevation.

In general, no development, encroachment, filling, clearing, grading, new construction, or substantial improvement is permitted in a floodway area (PCC 18E.70.040 B). However, there are specific exceptions for agricultural activities in the Clear Creek area, and each property owner should contact Pierce County for specific review of the restrictions on their parcel. Exceptions include:

- Farmhouses and non-residential agricultural structures can be repaired, reconstructed, replaced, and improved if design considerations to minimize flood damage are followed.
- New agricultural accessory structures such as barns and storage buildings can be built if design considerations to minimize flood damage are followed.
- New buildings that are less than 120 square feet can be built since they do not trigger a building permit.
- Compost can be imported, stored, manufactured, or applied – with some conditions – without violating the County’s no fill regulations.

While the floodway designation makes it difficult to build farm infrastructure and reduces the value of the agricultural lands, it also follows best practices for resilient floodplain management by keeping new infrastructure and people out of high risk floodplain areas.

### 6.3 Emergency Management

During major flood events on the Puyallup River, Pierce County staff open an Emergency Operations Center to coordinate emergency response. The County has River Watch volunteers who observe flood levels in specific areas, including along the River Road Levee, in order to help inform emergency response. If flood projections show that River Road Levee could overtop, the Clear Creek area would be evacuated. Residents would be notified through reverse 911 and by police and firefighters going door to door through the area. Flood levels were projected to overtop the levee in 2006 and 2009, and the Clear Creek area was evacuated (Hunger and Schmidt, 2016).

### 6.4 Corps of Engineers General Investigation

The Corps is pursuing a Flood Risk Management General Investigation of the Puyallup River Watershed due to the frequent flooding and its resulting damage throughout the basin. Pierce County is the local sponsor for the General Investigation. The goal of the General Investigation is to identify, evaluate, and recommend solutions to flood risk in the basin. In March 2016, the Corps released a Draft Integrated Feasibility Report and Environmental Impact Statement, which includes details of a Tentatively Selected Plan (Corps, 2016). The Tentatively Selected Plan includes several actions throughout the Puyallup River Watershed to reduce flood risk, including two projects adjacent to the Clear Creek area. In one project, North Levee Road Levee, located across the Puyallup River from the Clear Creek area, would be set back approximately 100 to 1,000 feet between RM 2.7 and RM 8.1 (the portion of the project directly across the Puyallup River from the Clear Creek area). In the second project, floodwalls would be constructed along River Road Levee, which currently has insufficient freeboard. The floodwall height would range from 4 to 8 feet above the existing levee, with an average height of 6 feet. The floodwall would reduce the risk of River Road being overtopped by floodwaters (Corps, 2016). The Corps of Engineers web site for the General Investigation is accessible at <http://www.nws.usace.army.mil/Missions/Civil-Works/Programs-and-Projects/Projects/Puyallup-River-GI/>. The Corps is currently responding to comments from the Environmental Protection Agency (EPA) and others on the draft report and EIS, and plans to release a new scope for the project by the end of 2017.

### 6.5 Clear Creek Floodplain Restoration Project

Pierce County SWM is proposing to implement the Clear Creek Floodplain Reconnection Project as part of its Rivers Comprehensive Flood Hazard Management Plan (Pierce County, 2013). The purpose of the project is to relieve flooding issues, maximize agricultural use in the area, and improve habitat for wildlife. The Clear Creek Project would remove the tide gates to allow Puyallup River water to flow into the Clear Creek area, reconnecting the river to a portion of its historic floodplain. The reconnected floodplain would establish a more natural connection with

the Puyallup River and allow free passage for fish in and out of Clear Creek. To reduce property damage, Pierce County would acquire property from willing sellers and construct a ring levee between the reconnected floodplain and remaining properties in the Clear Creek area. NHC has conducted hydrologic and hydraulic modeling of the proposed project for Pierce County. Information on NHC's modeling efforts is included in the Clear Creek Floodplain Reconnection Hydrologic and Hydraulic Modeling Report (NHC, 2015). NHC is currently conducting additional modeling for Pierce County.

Because this memorandum focuses on existing conditions for flood risk to agriculture in the Clear Creek area, it does not evaluate the impacts of the proposed project on flood risk. An upcoming Farmland Impacts Evaluation Memorandum will evaluate this issue.

## 7.0 Findings

### 7.1 The Clear Creek Area and Flood Resilience

Flood events are inevitable and, with climate change, are expected to increase in frequency and magnitude in the future. Because there will be flood events on the Puyallup River and Clear Creek, a resilient flood system is needed to protect the viability of agriculture in the Clear Creek area.

Resilience concepts applied to flood risk management strategies is a relatively new use of the resilience planning framework. Using a definition that can be described as “engineering resilience,” a resilient flood system can be defined as one that can “bounce back and recover” from the disturbance of a flood event (Zevenbergen, 2016). According to this concept, resilient flood risk strategies aim to reduce flood risk through a combination of protection, prevention, and preparedness spanning a wide range of flood probabilities (Zevenbergen, 2016). A resilient flood system relies on the following attributes:

- Robustness (the capacity to withstand a disturbance without functional degradation),
- Redundancy (the extent to which system components are substitutable), and
- Rapidity (the capacity to restore the system in a timely manner) (Zevenbergen, 2016).

In a truly resilient flood environment, floodwaters can rise and fall without excessive damage. A truly resilient flood environment will also not have catastrophic failure if one component of the system fails during a flood.

The Clear Creek area does not have a resilient flood system. It is not robust – when the area floods, homes flood and are damaged, farm businesses are threatened, and people need to be evacuated. There is no redundancy – there are a number of vulnerable components of the flood management system that, if they fail, would cause significant flood damage. Some farms in the Clear Creek area may be able to rapidly restore their farm after a flood event, but that depends on the time of year the flood occurs and would not be the case if barns, equipment, or crops are inundated.

Pursuing a project that would increase flood resilience in the Clear Creek area would be a benefit to agricultural viability. However, any flood risk reduction projects would have to be evaluated to ensure that they would not increase other risks to agriculture. Alternatives should be looked at for how to address flood risk in the area. Potential actions that could be taken include:

- Directly protecting agricultural properties from flooding,
- Reducing runoff from upstream areas of the Clear Creek Basin,
- Improving freeboard on River Road Levee,
- Altering the tide gates to improve the reliability of their operation and increase conveyance of flows from Clear Creek to the Puyallup River,
- Replacing undersized culverts in the area, particularly those under 44<sup>th</sup> Street East and Gay Road,
- Elevating homes, farm structures, and farm equipment in the floodplain, and
- Constructing “critter pads,” elevated areas where livestock can gather during flood events.

## 7.2 Information Needs

Through the Floodplains for the Future program, farmers and residents in the Clear Creek area are being asked to participate in a collaborative process that may result in the construction of a large ring levee in the Clear Creek area. In the short term, residents are being asked to consider voluntarily selling their property to Pierce County to remove properties from flooding areas and for eventual construction of the levee project. Throughout the Farming in the Floodplain Project, farmers have made it clear that they do not have the information about both current and future flood risk to make decisions or collaborate in the Floodplains for the Future Program. In addition, more information is needed in order for farmers to be assured that any levee project in the area has fully accounted for both flood risk and agricultural needs.

In order to address these issues, the following information is needed:

- Information on stream flows and recurrence intervals for both the Puyallup River and Clear Creek during recent flooding events;
- Data on streamflow in Clear Creek and its tributaries;
- Information on the frequency of the Clear Creek tide gates closing and the average duration of closure;
- Future precipitation projections for the Puyallup River Watershed based on dynamic downscaling (current projections are based on statistical downscaling, which is not the most accurate method);
- Precipitation projections translated into projected seasonal streamflow levels for the Puyallup River and Clear Creek and its tributaries;
- Hydraulic model simulations of flood projections and sea level rise with climate change for the Puyallup River Watershed and the Clear Creek area;

- Analysis of climate vulnerabilities on Clear Creek and its tributaries affecting agriculture in the Clear Creek area;
- The flood frequency at which River Road Levee would be overtopped and future changes to that risk of flooding;
- The modeled elevation of floodwaters in the Clear Creek area if the levee is overtopped;
- The modeled velocity of floodwaters in the Clear Creek area if the levee is overtopped;
- A complete review of whether River Road Levee meets the FEMA accreditation standards other than freeboard, including a full geotechnical assessment of the levee;
- The portion of the Clear Creek area that would still be mapped as floodway if the River Road levee provided adequate 100-year flood protection;
- Future projections for operations of Mud Mountain Dam, considering current and projected future levels of aggradation in the channel downstream of the dam and future changes in peak flows;
- The likelihood of Clarks Creek floodwaters flowing into the Clear Creek area, including which flood events might trigger this and what areas could be vulnerable to this threat; and
- Whether changes in the drainage of South Ditch are affecting flooding conditions in the Clear Creek area.

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## **APPENDIX C**

### **Drainage Inventory Memorandum**



# FINAL DRAINAGE INVENTORY MEMORANDUM

Farming in the Floodplain Project

Prepared for  
PCC Farmland Trust

May 2017





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**Acronyms and Abbreviations**

Ecology	Washington Department of Ecology
ESA	Environmental Science Associates
FFP	Farming in the Floodplain Project
GPS	Global Positioning System
HPA	Hydraulic Project Approval
NPDES	National Pollutant Discharge Elimination System
PALS	Planning and Land Services
PCC	Pierce County Code
RV	recreational vehicle
SR 167	State Route 167
SWM	Pierce County Surface Water Management



## 1.0 Project Background and Description

ESA has prepared this Agricultural Drainage Inventory as part of the second phase of the Farming in the Floodplain Project (FFP). The FFP is one of four components of the Floodplains for the Future: Puyallup, White, and Carbon Rivers project, which is funded by a Floodplains by Design grant from the Washington Department of Ecology (Ecology). The purpose of the FFP is to advance progress toward a collectively agreed-upon plan for the Clear Creek area that improves agricultural viability in the area while also meeting goals for flood risk reduction and salmon habitat enhancement. The FFP is intended to clarify the needs and interests of the agricultural community within the Clear Creek area.

As part of the second phase of the FFP, ESA conducted an inventory of the agricultural drainage system in the Clear Creek area. The agricultural drainage inventory provides an improved map and qualitative information on the agricultural drainage system that can be used in the future to inform the planning and design of projects such as the proposed Clear Creek Floodplain Reconnection Project, projects undertaken by Drainage District 10 or individual landowners, and other multiple-benefit projects in the area, and to ensure that these projects improve agricultural drainage. The drainage inventory is for planning purposes only; it is not detailed enough to develop permit applications or design plans for actions that would modify or alter the drainage network.

This analysis includes the findings from field work conducted by ESA staff in September and October 2016 (referred to in this memorandum as the dry season field visit) and January 2017 (referred to in this memorandum as the wet season field visit) as part of the agricultural drainage inventory.

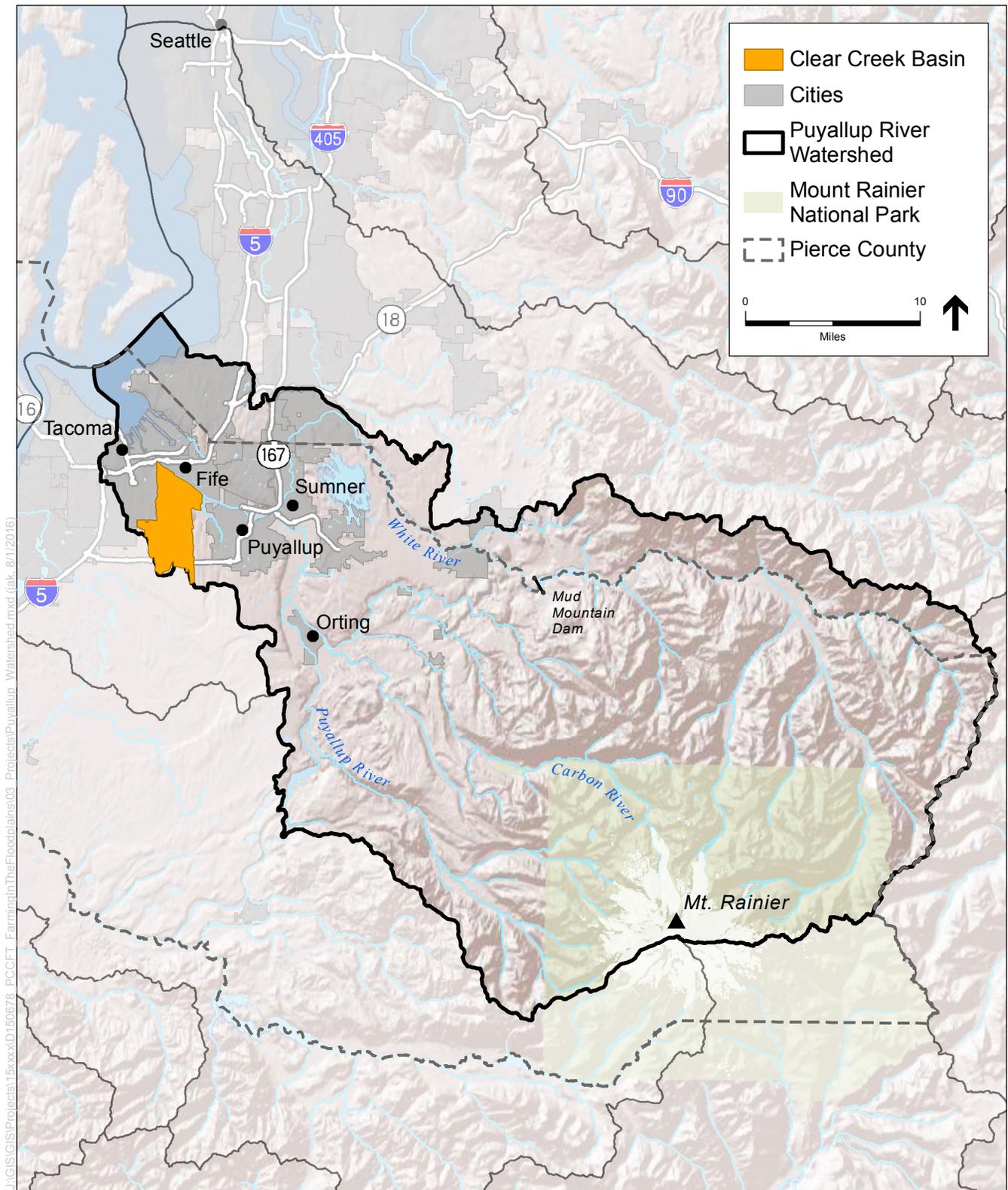
In November 2016, ESA prepared a *Drainage Inventory Preliminary Findings Memo* (ESA, 2016a). The Preliminary Findings Memo included information and general observations from the dry season field work. This memorandum updates the Preliminary Findings Memo with the following additional information:

- Information from the wet season field work.
- Information on ownership and maintenance responsibilities.
- Findings.
- Recommendations.

A draft of this memorandum was released in April 2017. This Final Drainage Inventory Memorandum includes revisions in response to comments received on the draft memorandum. These revisions include information provided by Drainage District 10 about culverts in the Clear Creek area.

## 2.0 Study Area

The study area for the agricultural drainage inventory is the Clear Creek area, part of the Clear Creek Subbasin of the Puyallup River Watershed (Figure 1). The Clear Creek Subbasin is within the Puyallup River Watershed and is located south of the Puyallup River, north of 128<sup>th</sup> Street East, west of 66<sup>th</sup> Avenue East, and east of McKinley Avenue East. The Clear Creek area is roughly 1.5 square miles (990 acres) in size and bounded by the Puyallup River to the north, Pioneer Way East to the south and west, and 52nd Street East to the east. The Clear Creek area is located primarily within unincorporated Pierce County, with the northern tip of the area within the City of Tacoma and the southern tip within the City of Puyallup. It encompasses a portion of State Route 167 (SR 167), a section of the BNSF Railway, agricultural lands, single-family residential neighborhoods, a recreational vehicle (RV) park, a few commercial properties, the Riverside Fire District, and two schools (Chief Leschi High School and ReLife School).



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SOURCE:  
 ESA, 2016; King County, 2015; Pierce County, 2013; Ecology, 2007;  
 OSM, 2016; WDNR, 2010

PCCFT Farming in the Floodplain. 150678

**Figure 1**  
Puyallup River Watershed

### 3.0 Ownership and Maintenance Responsibilities

Three entities own the drainage ditches in the Clear Creek area. Drainage District 10 owns a parcel which includes a portion of Clear Creek and may own other ditches in the area. The extent of Drainage District 10's ownership and maintenance responsibility for ditches in the area is unclear. Pierce County Roads owns the ditches along county roads. Others are owned by private landowners. As part of the drainage inventory, ESA researched the ownership and maintenance responsibilities for drainage features in the Clear Creek area.

To research ownership of the inventoried ditches, ESA reviewed recorded documents from 1900 through current day and found four agreements made by Drainage District 10; however, none of these documents clarified ownership or maintenance responsibilities for the ditches within the District's jurisdiction. Potential next steps to clarify ownership and maintenance responsibilities could include reviewing recorded plats at the auditor's office or requesting that a survey or title assessment be conducted. These tasks were outside of the scope of this technical memorandum. An alternate approach could be to pursue legal agreements clarifying ownership and maintenance responsibilities moving forward. Ownership and maintenance responsibilities for the tide gates at the confluence of Clear Creek and the Puyallup River are also unclear. Additional information about this will be provided in an upcoming Tide Gate Technical Memorandum.

Drainage District 10 was formed in 1912 under authority of Revised Code of Washington (RCW) 85.06, which authorized the formation and operation of special purpose districts. RCW 85.06.080 gives Drainage District commissioners the "*exclusive charge of the construction and maintenance of all drainage systems which may be constructed by said district.*" The Drainage District has the authority to purchase or condemn property on which to build drainage ditches. The District receives revenues from taxes assessed by the District based on the benefit that the property receives from the District and not based on the property value. The commissioners of the Drainage District are authorized to construct, straighten, widen, deepen, and improve existing drains or ditches in the District, as well as dig or construct additional drains or ditches. Additionally, the District may divert, dam, or carry off the waters of any stream or water endangering or causing damage in the District (RCW 85.06.640). In recent years, Drainage District 10 was inactive and was not conducting maintenance on ditches in the Clear Creek area. In 2016, the District was reactivated and elected new commissioners.

Drainage Districts typically focus on maintaining collector ditches that serve multiple properties. In the Clear Creek area, several larger collector ditches carry water from the feeder ditches and roadside ditches to Clear Creek and then to the Puyallup River. It is not known if these ditches are owned by Drainage District 10 or by another entity. A plat for the properties along 47<sup>th</sup> Avenue East (which are currently owned by Pierce County Surface Water Management (SWM)) shows a 20- to 40-foot wide drainage easement along the edge of several properties, but does not indicate the owner of the easement. It is possible that Drainage District 10 may have drainage easements on these properties. Drainage District 10 does not have a current Drainage Management Plan for the ditches in the area.

The smaller private ditches are owned and maintained by the landowners whose properties they serve. Drainage District 10 does not maintain these ditches. Roadside ditches in the public right-of-way are owned and maintained by Pierce County Roads. For example, the ditches along 44<sup>th</sup> Street South (identified as DD14 and DD17), are owned and maintained by Pierce County Roads. Roadside ditches are designed and maintained to protect the roadway foundation and to prevent water from flooding the roads. Pierce County Roads does not maintain roadside ditches for agricultural drainage.

Most maintenance activities would be subject to federal, state, and local permit requirements. Clear Creek is a modified natural water course (a historically natural system that has been diverted, dredged and/or straightened) and maintenance activities in Clear Creek would be subject to the following regulations:

- Section 404 of the Clean Water Act (Corps of Engineers)
- Endangered Species Act (National Marine Fisheries Service and U.S. Fish and Wildlife Service)
- National Pollution Discharge Elimination Permit (NPDES) (Ecology)
- Hydraulic Project Approval (HPA) (Washington Department of Fish and Wildlife)
- Shoreline Master Program (Pierce County Department of Planning and Land Services [PALS])—this only applies to the mouth of Clear Creek which is in a wetland mitigation site)
- Critical areas regulations (PALS)

Aside from Clear Creek itself, the drainage ditches in the Clear Creek area are constructed waterways (ditches with no headwaters or other natural water sources) and may be exempt from some of these regulations. Exemptions would have to be determined on a case-by-case basis. In particular, ditches constructed in historic wetlands may trigger federal permit review.

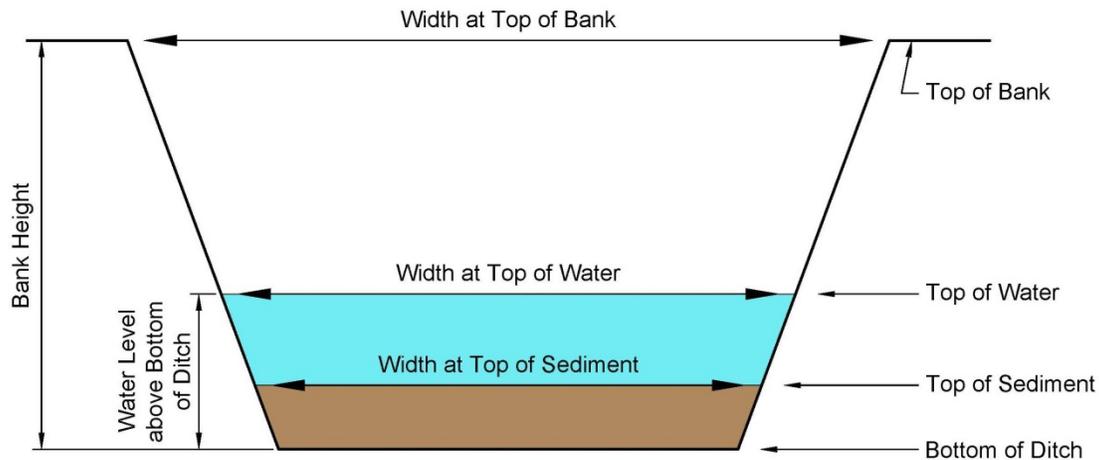
## 4.0 Field Investigation Methodology

During the dry season field work, ESA field investigators completed an inventory of drainage ditches and culverts in the Clear Creek area by taking measurements and recording information on channel size and condition. A Global Positioning System (GPS) unit was used to record drainage ditch and culvert locations and other points of interest, which included bends in the drainage channel, road crossings, and junctions with other ditches. All measurements were taken using a stadia rod and/or measuring tape and recorded to the nearest tenth of a foot. At each point of interest within a drainage ditch, the following data were recorded:

- **Channel Measurements** – width and depth of channel banks, surface water (if present), and sediment.

- **Channel Condition** – type of substrate and vegetation within the channel; type and density of vegetation adjacent to the channel; overall condition and stability of channel banks.

Figure 2 is a diagram of a ditch cross-section illustrating where measurements were taken by field investigators.



**Figure 2. Ditch Cross-section**

In addition to the information above, field investigators recorded any observed debris in the channel and noted potential maintenance needs in the surrounding area.

At culvert locations, field investigators recorded the following information at each culvert:

- Culvert diameter.
- Culvert type (corrugated metal, plastic, etc.) and shape (round, rectangular, etc.).
- Crossing type (e.g., road, railroad, etc.).
- Condition – presence of flow impediments at culvert entrance and material condition (rusted, corroded, etc.).
- If the culvert was perched above the channel.

Field investigators returned to the Clear Creek area in the wet season to observe key ditches and culverts when water levels were higher than they were during the dry season. Field investigators observed flow direction, took photographs, measured water depths, and recorded observations about drainage ditch conditions.

In this analysis, ditches were classified using the approach defined in the *Drainage Management Guide for Whatcom County Drainage Improvement Districts* (Whatcom Conservation District,

2009). The *Drainage Management Guide* classifies ditches as being natural, modified, or constructed, defined as follows (Whatcom Conservation District, 2009):

- **Natural watercourses** are those “that have not been significantly altered from their historical flow path or floodplain.”
- **Modified watercourses** are “historically natural systems that have been diverted, dredged, straightened, and/or diked.”
- **Constructed watercourses** are ditches with no headwaters or other natural water sources.

Ditches were assigned identification numbers in the field (Figure 3). Throughout this memorandum, ditches are referred to by name when a name is known. Roadside ditches are referred to by the name of the corresponding road. Other ditches are referred to by the identification number assigned in the field. Because some ditches are referred to by name or by corresponding road, the numbers of ditches described in this memorandum are not consecutive.

The inventory is not comprehensive and does not include all drainage ditches and culverts in the Clear Creek area due to constraints on the amount of field time available. Areas covered in the inventory were prioritized by importance to the overall drainage system, based on preliminary mapping and feedback from farmers and landowners in the area.

Local farmers and landowners provided critical assistance throughout the field investigation, including providing access, showing field investigators the locations of ditches and culverts, and providing additional information on drainage conditions.

## 5.0 Results of Field Investigation

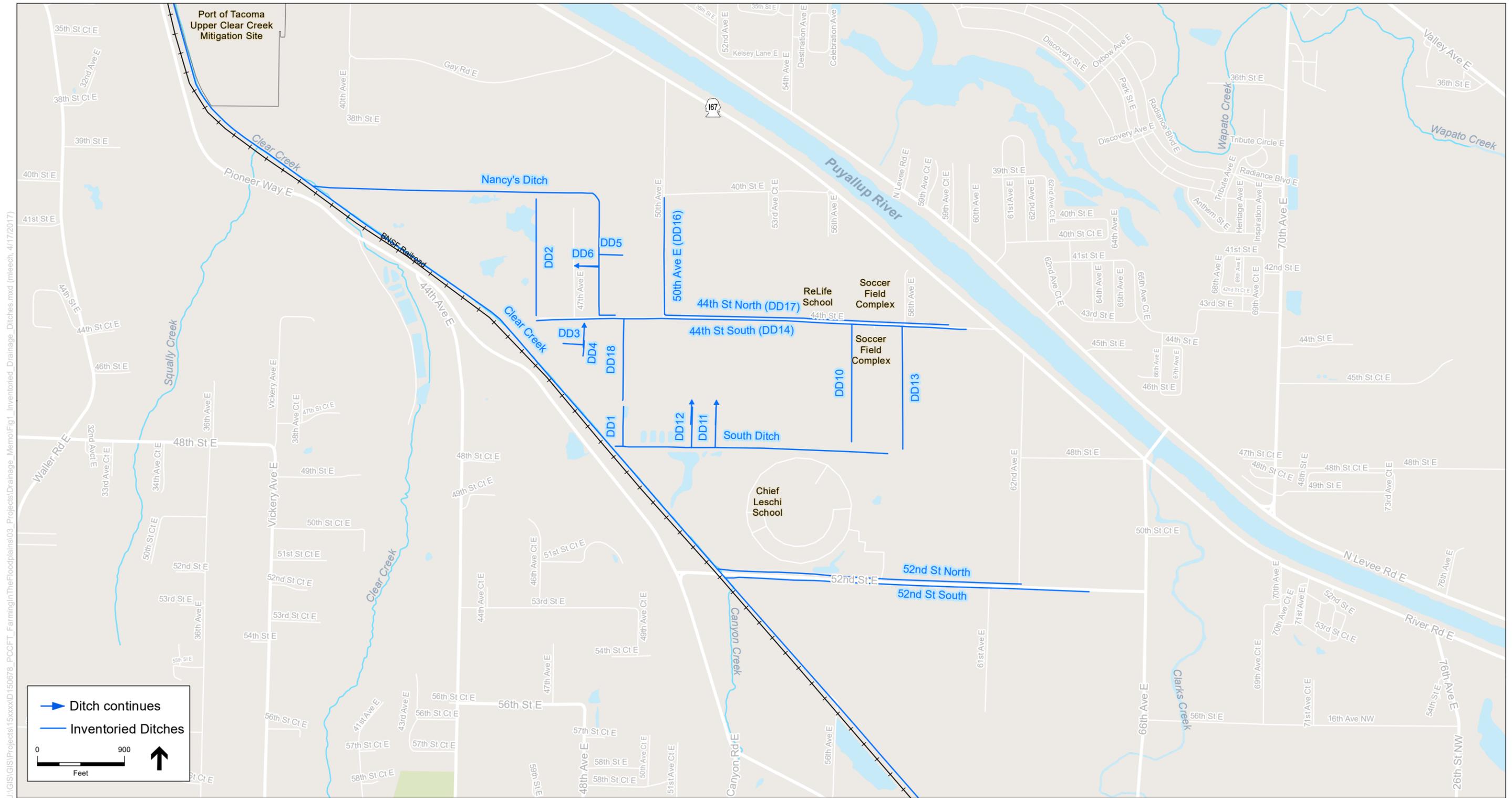
Field investigation for the agricultural drainage inventory took place September 20 through 24, September 27, October 12, 2016, and January 19, 2017. Observations from the field investigation are presented below by drainage ditch. Figure 3 shows the drainage ditches inventoried during the field investigation. Figure 4 shows the drainage ditches inventoried with flow direction arrows where flow direction is known. Figures 5a and 5b show the locations of inventoried culverts. The figures only show drainage features inventoried during the field work. They do not show other drainage features that ESA was informed about or those we observed in the field, but were not able to inventory (such as the roadside drainage ditch on the west side of 50<sup>th</sup> Avenue). The figures only show connections that were directly observed. Where one end of a ditch was inventoried but the end point of the ditch was not observed, the figures show an arrow to indicate that the ditch continues in that direction, but that the end point was not inventoried.

Results of the field investigation are summarized below, organized by the eight main drainage ditches identified during the inventory:

- Clear Creek

- Nancy's Ditch
- 44<sup>th</sup> Street North Ditch
- 44<sup>th</sup> Street South Ditch
- South Ditch
- 50<sup>th</sup> Avenue East Ditch
- 52<sup>nd</sup> Street East Ditches (North and South)

Information collected included observations of water flow, condition of the channel, presence of vegetation, connecting private ditches, and culverts.



SOURCE: ESA 2016; OSM 2015; Wa Ecology 2015

PCCT Farming in the Floodplain . 150678

**Figure 3**  
Inventoried Drainage Ditches





SOURCE: ESRI, 2016; ESA, 2016

PCCFT Farming the Floodplain . 150678

**Figure 5a**  
Inventoried Drainage Ditches and Culverts

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SOURCE: ESRI, 2016; ESA, 2016

PCCFT Farming the Floodplain . 150678

**Figure 5b**  
Inventoried Drainage Ditches and Culverts

## 5.1 Clear Creek

Overview. Clear Creek is a modified watercourse that serves as the primary agricultural drainage channel in the Clear Creek area. Drainage District 10 owns a narrow parcel that covers much of its length. It has four major tributaries: Canyon Creek, Upper Clear Creek, Squally Creek, and Swan Creek. Clear Creek flows north from its headwaters in the south portion of the Clear Creek basin to near 44<sup>th</sup> Avenue East. It then flows northwest along the western boundary of the Clear Creek area (Pioneer Way and the BNSF Railway line). At 52<sup>nd</sup> Street East, Canyon Creek flows into Clear Creek via a railroad crossing culvert (CC-Culvert 6). Upper Clear Creek enters Clear Creek near Pioneer Way and 44<sup>th</sup> Avenue East via a culvert (CC-Culvert 3). Squally Creek enters Clear Creek, approximately 500 feet downstream of Nancy's Ditch via a railroad crossing culvert (CC-Culvert 40). From this point, Clear Creek continues northwest through a largely residential area, before Swan Creek joins Clear Creek just upstream of the lower Port of Tacoma wetland mitigation site, north of Pioneer Way East. Clear Creek then flows approximately 0.15 mile to its confluence with the Puyallup River. The Puyallup River empties into Commencement Bay approximately 3 miles downstream from the Clear Creek confluence.

Water Flow Observations. At the time of the dry season site visits, field investigators observed continuous water flow in Clear Creek from the Canyon Creek confluence to Gay Road East. The presence of water varied in the reach of Clear Creek upstream from the Canyon Creek crossing. Field investigators did not observe water in the west and east ends of this reach of Clear Creek; however, they did observe standing water and limited flow in the central part of this reach. During the wet season site visit, the creek appeared to have flooded the Port of Tacoma Upper Clear Creek mitigation site, and standing water was observed from the mitigation site downstream to Gay Road East.

Channel Condition. Several stretches of the Clear Creek channel were observed to have stable banks. In other areas, unstable and undercut banks were observed. A majority of the channel bed was covered with a thick layer of soft, very fine sediment, 1 foot deep in some areas and over 3 feet deep in other areas. The bank height ranged from 3.8 feet to 10 feet, and the channel width ranged from 18 to 40 feet at the top of the bank. Water depth, measured from the top of the soft sediment, ranged from just under 1 foot to approximately 7 feet. During the wet season site visit, field investigators observed increased turbidity in Clear Creek from the Canyon Creek junction downstream to Gay Road East. In addition, water depths had increased to more than 11.5 feet.

Vegetation. Throughout Clear Creek, field investigators commonly observed dense reed canarygrass growth within the channel and on the channel banks. Within the channel, reed canarygrass was often so dense that it appeared to impede water flow. In other areas, recent maintenance activities had cleared the channel of reed canarygrass (Photo 1). Other vegetation species observed growing in the channel in moderate density included duckweed and another aquatic plant species assumed to be elodea. Himalayan blackberry was common on the channel banks and made areas of the channel inaccessible to investigators.

Along Clear Creek immediately downstream of where South Ditch formerly connected to it, dense patches of black twinberry, Pacific willow, Sitka willow, red-osier dogwood, red alder, and bigleaf maple were observed adjacent to the channel. Along the rest of Clear Creek downstream

of South Ditch, investigators observed very limited and scattered shrubs and trees. On the right bank, the width of the vegetated riparian area averaged approximately 40 feet. On the left bank, the width of the vegetated area was limited by the railroad tracks.



**Photo 1. Clear Creek facing downstream from the 52nd Street East culvert**



**Photo 2. Squally Creek flows through a culvert under the railroad tracks and into Clear Creek**



**Photo 3. Upper Clear Creek flows into Clear Creek via two culverts that cross under the railroad tracks (photo is of culvert outlets)**



**Photo 4. Canyon Creek (left) flows into Clear Creek**

Culverts. Canyon Creek, upper Clear Creek, and Squally Creek enter Clear Creek through several culverts under the BNSF Railway line (Photos 2 through 4). The majority of these culverts range between 4 and 6 feet in diameter. A number of culverts appeared to be partially obstructed by sediment and/or reed canarygrass. Another culvert under the BNSF Railway line, between the outlets of Canyon Creek and upper Clear Creek, drains a stormwater retention pond into Clear Creek. Based on information provided by Drainage District 10, the stormwater retention pond appears to drain stormwater from around 30 residential properties on the south side of the BNSF Railway line and Pioneer Way. This culvert was not inventoried during ESA's field work, but it was observed by ESA staff on April 24, 2017. Clear Creek flows through culverts under 52<sup>nd</sup> Street East and Gay Road East. At the inlets of the Gay Road East culverts, woody debris, a very large rock, and trash debris were observed. During the wet season field visit, water levels in Clear Creek were near the top of the Gay Road East culverts.

## 5.2 Nancy's Ditch

Overview. Nancy's Ditch is a constructed watercourse that originates at 44<sup>th</sup> Street East approximately 250 feet east of 47<sup>th</sup> Avenue East. It continues north for a quarter mile, then turns west and continues for approximately a half mile before draining into Clear Creek via four small culverts. Photo 5 shows the north end of the north-south reach of Nancy's Ditch, where it turns toward the west.

Water flows into Nancy's Ditch from the 44<sup>th</sup> Street roadside ditches and from at least two private drainage ditches. The 44<sup>th</sup> Street ditches convey flows from South Ditch and private ditches.

Water Flow Observations. Standing water depths in Nancy's Ditch ranged from 1.9 feet to 4.9 feet during the dry season field visits, but little to no water movement was observed. During the wet season field visit, Nancy's Ditch was near bankfull and visibly flowing into Clear Creek.

Channel Condition. The majority of the channel banks appeared to have limited areas of erosion and undercutting. Field investigators observed a thick layer of silty sediment along the channel bed, roughly 2.5 feet deep in places. The channel ranged between 15 and 26 feet in width at the top of the bank.



**Photo 5. North end of north-south reach of Nancy's Ditch, facing south.**

**Vegetation.** A high density of duckweed was observed on the water surface (Photo 6). Reed canarygrass was very dense along both banks for the entire length of Nancy's Ditch. In many areas of the channel, reed canarygrass was observed growing within the channel, impeding water flow and potentially increasing water levels upstream. During the wet season site visit, field investigators observed little to no duckweed on the water surface; however, reed canarygrass growth within the channel remained the same.



**Photo 6. East-west reach of Nancy's Ditch. Reed canarygrass is dense on the banks and edges of the channel. Duckweed dominates the water surface**

Most of Nancy's Ditch lacks a vegetated riparian corridor. However, there were points along the east-west portion of the channel where large shrubs and trees dominated an approximately 45-foot-wide zone on both banks. Dominant tree and shrub species observed at these points included red alder, black cottonwood, Oregon ash, Pacific willow, Sitka willow, and red osier dogwood. Dense reed canarygrass growth dominated the herbaceous cover at these points. Close to the south end of Nancy's Ditch, investigators observed dense Himalayan blackberry on the west bank of the channel.



**Photo 7. Water in western portion of 44<sup>th</sup> Street North Ditch and DD17-Culvert 5**

**Culverts.** Nancy's Ditch flows into Clear Creek via several small culverts. Drainage District 10 records suggest there are five culverts. However, only four culverts were observed during the field investigation. During the wet season site visit, the water surface was less than 0.3 feet from the top of these culverts.

Two culverts were observed at the south end of Nancy's Ditch. One culvert connects the 44<sup>th</sup> Street North Ditch to Nancy's Ditch (ND Culvert 5), and the other connects 44<sup>th</sup> Street South Ditch to Nancy's Ditch (DD14 Culvert 7).

Connecting Private Ditches. Two private drainage ditches, Drainage Ditch 5 and Drainage Ditch 6, flow into the north-south portion of Nancy's Ditch. Drainage Ditch 5 flows west from private property, and connects to the east bank of Nancy's Ditch. A culvert was observed in the ditch (DD5-Culvert 1), which appeared to be partially obstructed by sediment and dense reed canarygrass. No water flow was observed. Drainage Ditch 6 drains east through private property and connects to the west bank of Nancy's Ditch. Water was observed flowing into Nancy's Ditch from Drainage Ditch 6.



**Photo 8. Culvert partially obstructed by reed canarygrass in 44<sup>th</sup> Street North ditch**

Another private drainage ditch (Drainage Ditch 2) parallels the north-south portion of Nancy's ditch and ends approximately 12 feet south of the east-west portion of Nancy's Ditch. According to the owner of the property that includes Drainage Ditch 2, an unmaintained culvert connects Drainage Ditch 2 to Nancy's Ditch at this point. However, field investigators did not observe the culvert during the dry season site visits. Investigators did observe silty substrate and dense reed canarygrass growth in the channel. If a culvert is present, it is likely buried and not functioning properly. PCC Farmland Trust staff observed water in Drainage Ditch 2 flowing north toward Nancy's Ditch on March 24, 2017.

The other end of Drainage Ditch 2 is just north of the 44<sup>th</sup> Street North Ditch and west of 47<sup>th</sup> Avenue East.

### 5.3 44<sup>th</sup> Street North Ditch

Overview. The 44<sup>th</sup> Street North Ditch is a roadside drainage ditch (constructed watercourse) on the north side of 44<sup>th</sup> Street. The ditch begins near River Road East and flows west to a junction with the 50<sup>th</sup> Avenue East Ditch. From this point west, no ditch was observed on the north side of 44<sup>th</sup> Street, except for a short, separate portion of the ditch starting approximately 150 feet east of Nancy's Ditch.

Water Flow Observations. During the dry season site visits, field investigators did not observe any water in the east portion of the channel from River Road East to 50<sup>th</sup> Avenue East. During the wet season visit, field investigators observed standing water less than 1 foot deep in the channel just east of the 50<sup>th</sup> Avenue East intersection.

It was unclear where water in the 44<sup>th</sup> Street North Ditch would flow at the junction with 50<sup>th</sup> Avenue East. No culvert connecting this portion of the ditch to the west portion of the ditch was observed. However, very dense reed canarygrass was observed at the end of both segments of the ditch and may be obscuring a culvert. Unlike the east portion of the channel, water in the short, separate western portion of the channel was up to 1 foot deep. Flow was very slow and toward Nancy's Ditch.

Channel Condition. The channel had stable banks and ranged between 10 and 18 feet in width at the top of the bank. Silty sediment was observed on the channel bed. Increased turbidity was observed in the west portion of the channel during the wet season site visit.

Vegetation. Very dense reed canarygrass was growing in the channel and on the banks along the majority of 44<sup>th</sup> Street North Ditch (Photo 7). The separate, west portion of the ditch had lower densities of reed canarygrass, and duckweed was dominant where water was present. The channel appeared to be maintained from the front of the ReLife School to the east end of the ditch. There was short weedy vegetation in the channel, but little to no reed canarygrass along this reach.

Culverts. Ten culverts were observed in the 44<sup>th</sup> Street North Ditch, mostly under driveway and road crossings. All culverts ranged between 1 and 2 feet in diameter. Some culverts appeared to be partially obstructed by sediment and by dense reed canarygrass growing in the channel (Photo 8).

The culvert (ND-Culvert 5) at the west end of the 44<sup>th</sup> Street North Ditch drains this portion of the ditch into Nancy's Ditch. It was unclear during the dry season site visits if a culvert connects the east and west portions of the 44<sup>th</sup> Street North Ditch past 50<sup>th</sup> Avenue East.

## 5.4 44<sup>th</sup> Street South Ditch

Overview. The 44<sup>th</sup> Street South Ditch is a roadside drainage ditch (constructed watercourse) along the south side of 44<sup>th</sup> Street. It begins at River Road East and continues west to the end of 44<sup>th</sup> Street. Several adjacent agricultural and soccer fields likely drain through private ditches into 44<sup>th</sup> Street South Ditch. In addition, three private north-south oriented ditches likely drain South Ditch into the 44<sup>th</sup> Street South Ditch. Water drains from 44<sup>th</sup> Street South into Nancy's Ditch, eventually draining into Clear Creek.

Water Flow Observations. During the initial dry season site visit, no water was observed in most of the east portion of the 44<sup>th</sup> Street South Ditch, except for some stagnant water directly east of Nancy's Ditch. At a later site visit on October 12, 2016, following a short period of rain, water was observed in the channel farther east toward 50<sup>th</sup> Avenue East.

The water in the channel just west of Nancy's Ditch was approximately 1 foot deep, with little to no water flow. Water was observed entering Nancy's Ditch from the 44<sup>th</sup> Street South Ditch through the connecting culvert.

Channel Condition. In general, the channel appears to have stable banks. A layer of silty sediment was observed along the channel bed, measuring over 1 foot deep in some areas. The channel

ranged between 10 and 14 feet wide at the top of the bank. During the wet season site visit, increased turbidity was observed in the channel.

Vegetation. Similar to the 44<sup>th</sup> Street North Ditch, dense reed canarygrass was observed growing in the channel and on the banks for the majority of its length. In areas with less dense reed canarygrass and where standing water was present, duckweed was dominant. The ditch appeared to be maintained starting at the west side of the soccer field parking lot (Photo 9). There was short weedy vegetation in the ditch and little to no reed canarygrass from this point to the east end of the channel. During the wet season site visit, little to no duckweed was observed.

Culverts. Twenty-four culverts were observed along the length of the 44<sup>th</sup> Street South Ditch, mostly under driveways and the road shoulder. Photo 10 shows one of the culverts on the 44<sup>th</sup> Street South Ditch. Many culverts were partially obstructed by sediment, reed canarygrass, and/or Himalayan blackberry.

Field investigators observed two culverts that drain the 44<sup>th</sup> Street South Ditch. One culvert (DD14-Culvert 7) crosses north under 44<sup>th</sup> Street and drains into Nancy's Ditch. According to a local landowner, drainage issues south of 44<sup>th</sup> Street began when a larger culvert that drained into Nancy's Ditch was replaced with the current, much smaller culvert. This has not been confirmed by ESA staff. A second culvert (DD17-Culvert 5) crosses northwest under 44<sup>th</sup> Street from the 44<sup>th</sup> Street South Ditch and drains into the 44<sup>th</sup> Street North Ditch. Very little flow was observed at the inlet of either of these culverts. In addition, a perched culvert (DD14-Culvert 10) was observed on top of DD17-Culvert 5 approximately 1.9 feet above the channel bed (Photo 11). Unlike DD17-Culvert 5, DD14-Culvert 10 is oriented east-west. The fact that the culvert is perched likely impedes the westerly flow of water in the 44<sup>th</sup> Street South Ditch east of this point when the water level is below the culvert. However, DD17-Culvert 5 is located at the bottom of the channel below DD14-Culvert 10, so even when the water level is low, drainage of the east portion of the 44<sup>th</sup> South Ditch to the 44<sup>th</sup> North Ditch could still potentially occur. During the wet season site visit, field investigators observed water close to or above the tops of culverts on the 44<sup>th</sup> Street South Ditch between DD14-Culvert 10 and DD14-Culvert 14.

Connecting Private Ditches. As previously mentioned, adjacent agricultural and soccer fields drain to the 44<sup>th</sup> Street South Ditch via private ditches. These ditches include Drainage Ditches 3, 4, 10, 13, and 18. Drainage Ditches 10, 13, and 18 are oriented north-south and connect to the 44<sup>th</sup> Street South Ditch. Drainage Ditch 3 is oriented east-west and drains to Drainage Ditch 4, which is oriented north-south toward the 44<sup>th</sup> Street South Ditch through private property. Drainage Ditch 4 is presumed to connect to 44<sup>th</sup> Street South, although this connection was not observed. Water and limited flow were observed in Drainage Ditches 3 and 4 during the dry season visits. A culvert (DD4-Culvert 1) was observed in Drainage Ditch 4 approximately 45 feet north of the intersection with Drainage Ditch 3. Field investigators did not observe the other end of the culvert, but it is likely, due to its orientation and location, that Drainage Ditch 4 drains to the 44<sup>th</sup> Street South Ditch.



**Photo 9. 44<sup>th</sup> Street South Ditch adjacent to the soccer fields**



**Photo 10. 44<sup>th</sup> Street South Ditch and culvert, west of 50<sup>th</sup> Avenue East**



**Photo 11. Perched culvert in the 44<sup>th</sup> Street South Ditch. A second culvert that flows under the road and into the 44<sup>th</sup> Street North ditch is below it in the channel.**



**Photo 12. Water levels above the top of a culvert along the 44<sup>th</sup> Street South Ditch, observed during the wet season site visit.**

## 5.5 South Ditch

Overview. South Ditch is a constructed watercourse originating at the southeast corner of the River Jam Field soccer complex and ending approximately 100 feet east of Clear Creek. South Ditch is oriented east to west, with its west end directly north of Chief Leschi School.

South Ditch historically flowed into Clear Creek, but it no longer connects. Due to sediment deposition in Clear Creek, the creek is now higher than the ditch, preventing gravity drainage to the creek. Subsequently, the ditch outlet was filled. Instead of flowing west into Clear Creek, South Ditch now drains north to Drainage Ditch 18, a private drainage ditch. This ditch carries flows from South Ditch northwards into the 44<sup>th</sup> Street South Ditch. Water then flows into Nancy's Ditch and eventually enters Clear Creek approximately 4,000 feet downstream of the original outlet of South Ditch.

Water Flow Observations. During the dry season site visits, water was not observed at the east end of South Ditch. Toward the west end of the channel, water was approximately 3 feet deep. Little to no water flow was observed in the channel. During the wet season site visit, less than 0.5 foot of standing water was observed at the east end of South Ditch.

South Ditch is drained via a private north-south oriented ditch into the 44<sup>th</sup> Street South ditch. Adjacent agricultural fields drain into South Ditch via two north-south oriented ditches (DD11 and DD12). In addition, there are several man-made ponds just north of South Ditch, one of which is fed by a private ditch.

Channel Condition. The condition of South Ditch varied. Some areas of the channel had stable banks, and other areas had steep, eroding banks. The majority of the channel had silty sediment along the bed, and channel width ranged between approximately 6 and 20 feet at the top of the bank. During the wet season site visit, increased turbidity was observed in the channel.

Vegetation. South Ditch appeared to be maintained at the east end, south of the soccer fields. No vegetation was observed in the channel, and both banks were mowed. Reed canarygrass was the dominant species west of the soccer fields and was observed growing in dense mats within the channel and along the banks. Duckweed covered much of the water surface (Photo 13). Black cottonwood, red alder, Pacific willow, Sitka willow, Oregon ash, and Himalayan blackberry were observed along the south bank and adjacent to the channel. During the wet season visit, no duckweed was observed on the water surface.

Culverts. Field investigators did not observe any culverts along South Ditch. However, there could potentially be a buried and/or obstructed culvert given the observed dense vegetation and sediment in the channel at its west end.

A concrete footbridge crosses South Ditch at the west end of the soccer fields (Photo 13). The bridge is approximately 4 feet wide and positioned 1 foot above the channel bed, and could be an obstruction at higher flows.

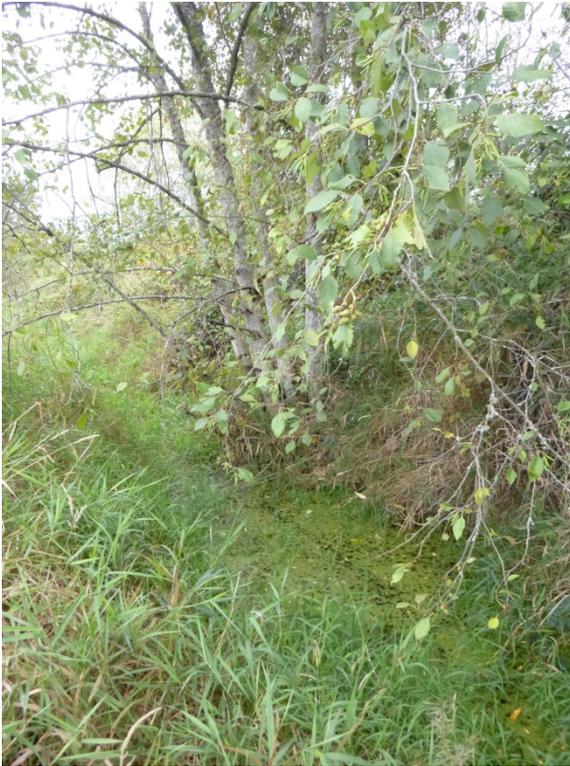
Connecting Private Ditches. As mentioned above, South Ditch connects to the 44<sup>th</sup> Street South Ditch via Drainage Ditch 18, a private, north-south oriented ditch. Drainage Ditches 11 and 12

originate at mid-points of adjacent agricultural fields and connect to South Ditch via narrow channels overgrown with reed canarygrass. Very little water flow was observed in these channels.

## 5.6 50<sup>th</sup> Avenue East Ditch

Overview. The 50<sup>th</sup> Avenue East Ditch (Drainage Ditch 16) is a roadside drainage ditch (constructed watercourse) oriented north-south on the east side of 50<sup>th</sup> Avenue. Field investigators collected data only on the portion of this ditch from East 40<sup>th</sup> Street to 44<sup>th</sup> Street East. Another ditch is located on the west side of 50<sup>th</sup> Avenue but was not inventoried. No connection was observed from the 50<sup>th</sup> Avenue West Ditch to 50<sup>th</sup> Avenue East Ditch.

Water Flow Observations. No water was observed in the ditch until just north of 44<sup>th</sup> Street East. At this point, field investigators observed very shallow standing water with no visible flow.



**Photo 13. South Ditch between Drainage Ditches 11 and 12. Dense reed canarygrass dominates both banks. Duckweed is dense in the channel. Red alder overhangs the channel.**



**Photo 14. South Ditch is maintained south of the soccer fields.**

Channel Condition. The banks of the channel appeared to be stable with no signs of erosion. However, the overall condition of the channel was difficult to assess due to dense reed canarygrass throughout the channel. The channel width remained relatively consistent, ranging between approximately 8 and 10 feet at the top of the bank.

Vegetation. The entire length of the channel was dominated by reed canarygrass, and no shrubs or trees were present (Photo 15).

Culverts. The 50<sup>th</sup> Avenue East Ditch flows through two culverts: one under a driveway along 50<sup>th</sup> Avenue (DD16-Culvert 1) and one at the corner of 44<sup>th</sup> Street East and 50<sup>th</sup> Avenue (DD16-Culvert 2). Both culverts had sediment and reed canarygrass partially obstructing their inlets and outlets. These obstructions prevented field investigators from measuring the culverts. DD16-Culvert 2 appeared to be directed east of 50<sup>th</sup> Avenue to connect the 50<sup>th</sup> Avenue East Ditch with the 44<sup>th</sup> Street North Ditch; however, the other end of the culvert was not found by field investigators.



**Photo 15. 50<sup>th</sup> Avenue East ditch facing south toward 44<sup>th</sup> Street**

## 5.7 52<sup>nd</sup> Street East Ditches (North and South)

Overview. Drainage ditches (constructed watercourses) were observed on both sides of 52<sup>nd</sup> Street East (52<sup>nd</sup> North Ditch and 52<sup>nd</sup> South Ditch). These ditches drain directly to Clear Creek at their western ends. Both the 52<sup>nd</sup> North Ditch and 52<sup>nd</sup> South Ditch are oriented east-west and end near a railroad crossing to the west. The 52<sup>nd</sup> South Ditch extends farther east than 52<sup>nd</sup> North Ditch, nearly to 66<sup>th</sup> Avenue East. The 52<sup>nd</sup> North Ditch ends at the intersection with 62<sup>nd</sup> Avenue East. GPS data points were only collected at the west ends of the ditches, but the general condition of the ditches was observed along their lengths.

Water Flow Observations. No water was observed at the east ends of the two channels. At the west end of the 52<sup>nd</sup> South Ditch, water was 1.5 feet deep with little flow. In the 52<sup>nd</sup> North Ditch, water was 2.5 feet deep with very low flow in the direction of Clear Creek.

Channel Condition. No signs of erosion were observed at the west ends of the channels but may have been obscured by the dense vegetation in the channel. The 52<sup>nd</sup> South Ditch was 18 feet wide at the top of the bank, and the 52<sup>nd</sup> North Ditch was 25 feet wide at the top of the bank. Both channels had a layer of silty sediment along the bed.

Vegetation. Dense reed canarygrass was observed growing on the banks as well as in the channel of the 52<sup>nd</sup> South Ditch (Photos 16 and 17). In open water areas without reed canarygrass, there was dense duckweed. East of the intersection of the ditch with Clear Creek, field investigators observed a patch of cattails. Other vegetation on the banks included blackberry, red alder, and black cottonwood. Farther east, some vegetation was observed in the channel but little to no reed canarygrass.

Similar to the 52<sup>nd</sup> South Ditch, the 52<sup>nd</sup> North Ditch had dense reed canarygrass on the banks and in the channel. Water pennywort was also observed growing in a dense mat across the channel at the west end. A dense patch of cattails was also observed to the east of where the 52<sup>nd</sup> North Ditch connects to Clear Creek.

Culverts. No data were collected for culverts on the 52<sup>nd</sup> Street East ditches.



**Photo 16. 52<sup>nd</sup> North Ditch near Clear Creek, facing east**



**Photo 17. 52<sup>nd</sup> South ditch near Clear Creek, facing east**

## 6.0 Findings

The following sections summarize the major findings drawn from the field investigations described in Chapter 6. The findings include general observations about conditions in the drainage system, maintenance needs, as well as observations about longer term needs.

### 6.1 Reliance on Clear Creek for Drainage

Currently, all agricultural drainage from the Clear Creek area flows into Clear Creek before eventually draining to the Puyallup River. Relying on Clear Creek to drain agricultural fields creates several problems for agriculture in the Clear Creek area. Clear Creek is a salmon-bearing stream, which leads to higher regulatory barriers and permitting requirements for drainage maintenance. Clear Creek receives substantial sediment and stormwater inputs from its four major tributaries. During wet-season conditions, stormwater volumes from the tributaries raise the water level in Clear Creek, reducing the capacity of the channel to drain agricultural ditches. Because of aggradation in Clear Creek, South Ditch no longer flows directly into the stream. Regulatory barriers to removing sediment from the Clear Creek channel make it difficult to correct drainage issues like those affecting South Ditch. Downstream of agricultural drainage areas, Clear Creek flows through two Port of Tacoma wetland mitigation sites which are not maintained for the purpose of drainage. Clear Creek drains into the Puyallup River through two tide gates that are not controlled by Drainage District 10 or other agricultural interests in the area. A major constraint on the agricultural drainage system is that it relies on a stream which is affected by many factors not controlled by Drainage District 10 and others interested in agricultural drainage.

### 6.2 Overall Drainage Conditions and Maintenance Problems

The overall conclusion about drainage conditions in the Clear Creek area is that ditch maintenance is needed. There are thick growths of reed canarygrass and other vegetation in the ditches, and there is evidence of sediment deposition in most ditches. Both the vegetation growth and sediment deposits restrict drainage in the area.

Ditches generally have stable banks, but there are some small areas of localized erosion. A general lack of native trees and shrubs on the banks of ditches limits shading, which is a factor in vegetation grown in the channels. The lack of bank vegetation may also increase sediment runoff into ditches. Bankside vegetation could trap and filter sediment in runoff from adjacent farmland.

Some trash debris was observed, including a television and car parts in the Clear Creek channel just upstream of the culvert under Gay Road. Trash was also observed in the Clear Creek channel downstream of the historic intersection with South Ditch.

Because Drainage District 10 was inactive in recent years, most drainage ditch maintenance for the large collector ditches was deferred. The Drainage District has recently been reactivated and is beginning to address deferred maintenance. Many of these problems could be remedied through regular maintenance implemented under a drainage management plan.

## 6.3 Noxious Vegetation

Invasive plants, including reed canarygrass, elodea, duckweed, and Himalayan blackberry, are a maintenance issue for the agricultural drainage system in the Clear Creek area. Most of the weeds identified in the Clear Creek area drainage ditches are listed by the state or Pierce County as noxious weeds, including elodea, reed canarygrass, bindweed, and Himalayan blackberry (Pierce County Noxious Weed Control Board, 2017; Washington State Noxious Weed Control Board, 2017). Removal of reed canarygrass, in particular, is the primary unaddressed maintenance need in the drainage system. Reed canarygrass encroaches on ditch channels, traps sediment in the channel, and impedes water flow. Reed canarygrass was also observed in floating mats in the channel of several ditches in the Clear Creek area. In summer 2016, a Washington Conservation Corps (WCC) field crew removed reed canarygrass from the Clear Creek channel, which improved drainage. However, these actions need to be repeated on a regular basis to be effective.

Reed canarygrass was observed in the channel at every data point surveyed on Clear Creek, although in most instances it was sparse. The drainage inventory field work was conducted approximately one month after WCC field crews removed reed canarygrass from the channel, which explains why only sparse reed canarygrass was observed. High density of reed canarygrass was observed in the channel between the outlet of upper Clear Creek and the intersection of Nancy's Ditch. In this reach, mats of reed canarygrass were observed, and field investigators noted that reed canarygrass was choking out the channel.

Duckweed and reed canarygrass were observed throughout the channel of Nancy's Ditch. At some points, duckweed was observed covering the entire surface of the channel. In some portions of the ditch, high density mats of reed canarygrass were observed to be choking the channel. Duckweed and reed canarygrass were also observed throughout the channel of South Ditch. Dense reed canarygrass was also observed in every roadside ditch inventoried, along with other vegetation (such as epilobium and equisetum) in the channel.

As noted above in Section 6.2, lack of shade on ditches is one factor contributing to growth of noxious vegetation. Water quality issues, such as nutrient pollution, could also be contributing to growth of noxious vegetation. This drainage inventory did not assess water quality.

## 6.4 Sediment

Accumulated sediment is an issue for agricultural drainage because it reduces the carrying capacity of ditches and stream channels. Accumulated sediment was observed in ditches throughout the Clear Creek area. Specific locations where sediment was observed are described below.

Sediment depths in Clear Creek ranged from approximately 0.1 foot to 3.6 feet. The highest depth (3.6 feet) was observed at the intersection of Clear Creek with Nancy's Ditch. Approximately 100 feet upstream of the intersection with Nancy's Ditch, sediment was 1.7 feet deep. Most points surveyed on Clear Creek between the outlets of Canyon Creek and upper Clear Creek had over 1

foot of accumulated sediment. Culverts along this reach of Clear Creek had up to 1 foot of accumulated sediment at the bottom of the culvert.

Most roadside ditches had no or little (up to 0.1 foot) accumulated sediment at the bottom of the ditch when inventoried in the dry season. The ditch on the north side of 52<sup>nd</sup> Street had 0.8 foot of accumulated sediment in the channel. The roadside ditch on the south side of 44<sup>th</sup> Street had 1.1 feet of accumulated sediment at the culvert conveying water from the roadside ditch to Nancy's Ditch. Accumulated sediment levels in the channel of Nancy's Ditch were high, ranging from 1.1 to 2.5 feet. Sediment levels in South Ditch were lower, ranging from 0 to 0.6 foot.

During the wet season field visit, at the culverts where upper Clear Creek and Squally Creek enter Clear Creek, field investigators observed that water entering from the tributaries was significantly less turbid than the water in Clear Creek (Photo 18).



**Photo 18. Culverts conveying upper Clear Creek into Clear Creek on January 19, 2017. Water from upper Clear Creek was substantially less turbid than water in Clear Creek.**

Addressing the accumulation of sediment would improve the agricultural drainage system. More information on sources of sediment and approaches to address sediment are included in the [Sediment Conditions in the Puyallup River and Clear Creek](#) Technical Memorandum (ESA, 2016b).

## 6.5 Culverts

The Clear Creek agricultural drainage system includes numerous culverts. Much of the system relies on roadside ditches, which flow through relatively small culverts under roadways. All agricultural drainage from areas north of Clear Creek and 52<sup>nd</sup> Street eventually flows into Nancy's Ditch, which flows through four relatively small culverts before entering Clear Creek. During the field investigation, culverts were generally observed to be in good condition, although vegetation and sediment partially obstructed many culvert inlets. During the wet season site visit, water was observed near or above the tops of several culverts. This could indicate downstream drainage problems and undersized culverts.

In the wet season field visit, water was observed at the top of the culverts conveying Clear Creek under Gay Road. In the dry season, a large rock was partially blocking the entrance to one of the culverts, and large woody debris was observed at the entrance to the other culvert. Several culverts conveying Clear Creek under driveways or access roads were partially obstructed by sediment.

Nancy's Ditch flows through four small culverts directly adjacent to each other before entering Clear Creek. Each culvert is 2.4 feet in diameter. During the dry season field visits, sediment was observed in the culverts. During the wet season field visit, the culverts had some debris at their inlets. While water was flowing through the culverts, water flow was faster on the outlet side of the culverts, suggesting that the culverts may be constricting water flow. Water was observed near the top of the culverts (approximately 0.3 inch from the top) but not overtopping the culverts. Water in Nancy's Ditch upstream of the culverts was at bankfull height (Photo 19).



**Photo 19. Nancy's Ditch flowing through four culverts before entering Clear Creek on January 19, 2017**

A culvert (DD14 Culvert 7) crosses under 44<sup>th</sup> Street, carrying water from the roadside ditch on the south side of 44<sup>th</sup> Street to Nancy's Ditch. The culvert is only 1.1 feet in diameter. When observed in the dry season, it was partially blocked by silty sediment. The culvert was submerged during the wet season field visit. No flow was visible from the south side of 44<sup>th</sup> Street into the culvert. Based on the small diameter of the culvert and the fact that it was submerged, this culvert is likely undersized.

There are eight culverts on the 44<sup>th</sup> Street South roadside ditch west of the intersection with 50<sup>th</sup> Avenue. Two of the culverts are 2 feet in diameter; the rest are 1 foot in diameter. Some of the culverts were partially obstructed by reed canarygrass, bindweed, or large cobbles. In the wet season field visit, these culverts were either submerged or nearly submerged. Based on the small size of the culverts and the fact that they were at or near overtopping, these culverts are likely undersized.

There are 15 culverts on the 44<sup>th</sup> Street South roadside ditch east of 50<sup>th</sup> Avenue. The majority are 1 foot in diameter, although some are up to 2.9 feet in diameter and two are only 8 inches in diameter. Two plastic culverts were cracked. Erosion was observed on the downstream end of one culvert. Many of the culverts were partially obstructed by reed canarygrass, sediment, gravel, cobbles, leaves, dense epilobium, trash, or debris.

Eight culverts were observed on the 44<sup>th</sup> Street North roadside ditch east of 50<sup>th</sup> Avenue. The culverts ranged from 1 to 2 feet in diameter. Sediment was observed in the culverts, in some cases leaving as little as 0.4 foot of culvert open above the top of the sediment. Culverts on both sides of 50<sup>th</sup> Avenue East were partially or mostly blocked with sediment and dense reed canarygrass, to the point that the culverts could not be fully investigated.

As described in this section, many of the culverts in the Clear Creek area appear to be undersized based on field observations. In order to determine whether an individual culvert is indeed undersized, a culvert backwater analysis could be conducted. The culvert backwater analysis

would require additional information on the physical conditions of the culvert (such as the exact size and slope of the culvert, the elevation of the culvert inlet, the shape of the ditch, the elevation of the bottom of the ditch, and the slope of the ditch). This information could be obtained through a survey. Ideally, a backwater analysis would also be based on information from logging water elevations on both sides of the culvert. However, if that information was not available, rainfall data from USGS could be used. Because the culvert and ditch system is so interconnected, however, it would be preferable to analyze the system as a whole to determine which culverts are undersized instead of analyzing culverts individually. Ideally, this would be done through a Drainage Maintenance Plan.

## 6.6 South Ditch Problems

A local landowner informed the ESA field crew that South Ditch no longer flows directly into Clear Creek, and the crew confirmed this during the field visit. Due to sediment deposits in Clear Creek, the creek is now higher than the ditch, preventing the ditch from draining into the creek. Subsequently, the ditch outlet to Clear Creek has been filled in. It is unclear how this occurred, though the ESA field crew was informed it was done to block backflow from Clear Creek into South Ditch during high flows and floods.

Instead of flowing west into Clear Creek, South Ditch now drains to several narrow private drainage ditches (Figure 4). These ditches carry flows from South Ditch north to the roadside drainage ditch on the south side of 44<sup>th</sup> Street. From there, water flows into Nancy's Ditch, where it flows north then west, entering Clear Creek approximately 4,000 feet downstream of the original outlet of South Ditch. The inability of South Ditch to drain directly into Clear Creek is a major impediment to agricultural drainage in the Clear Creek area.

During the wet season field visit, water was flowing faster at the west end of South Ditch than it was during the dry season. However, little to no flow was observed east from this point, likely due to reed canarygrass growth within the channel.

## 6.7 44<sup>th</sup> Street and 50<sup>th</sup> Avenue Flow Problems

During the wet season field visit, water was present but not moving in the roadside ditch on the west side of 50<sup>th</sup> Avenue. No water flow was observed in the roadside ditch on the east side of the 50<sup>th</sup> Avenue. A high density of reed canarygrass was observed, and approximately 3 inches of standing water was observed on the adjacent field. It was not clear where the roadside ditches on either side of 50<sup>th</sup> Avenue drained to.

The 44<sup>th</sup> Street North Ditch is long and has the potential to collect significant amounts of runoff from neighboring farms. During the wet season field visit, the 44<sup>th</sup> Street North Ditch east of the 50<sup>th</sup> Street intersection was completely overtopped with water, and no water flow was observed in the ditch. It was not clear where this roadside ditch drained to.

Landowners reported drainage issues along the south side of 44<sup>th</sup> Street to the ESA field crew. Drainage problems could be caused by the undersized culvert connection between the 44<sup>th</sup> Street

South Ditch and Nancy's Ditch. It is also likely that rerouting flows from South Ditch into Nancy's Ditch has contributed to the problem.

Additional investigation is needed to understand the drainage problems in these three roadside ditches. Confirming how water is routed would be an important step in assessing drainage in this portion of the Clear Creek area. The size of these ditches and culverts should also be checked for adequacy based on their drainage areas.

## **7.0 Recommendations**

Based on the observations and findings described in this report, ESA developed the following recommendations for improving agricultural drainage in the Clear Creek area drainage system. The primary recommendation is to separate the agricultural drainage system from the stream system. This would improve the long-term viability of agriculture in the area. Other recommendations are included to address more immediate drainage problems, as well as longer term recommendation to address drainage problems at South Ditch and along 44<sup>th</sup> Street and 50<sup>th</sup> Avenue.

The recommendations in this section vary in the degree of difficulty of implementation. Some of the recommendations, particularly the recommendation to separate the agricultural drainage system from the stream system and Recommendations 5 through 7, would require extensive study, permitting, and funding. However, these recommendations could be pursued as collaborative multiple-benefit projects where they would improve habitat or minimize flood risk as well as improve agricultural drainage, or where they could be included as a component of a larger multiple-benefit capital project like the Clear Creek Floodplain Reconnection Project. The Puyallup Watershed Floodplains for the Future initiative and the upcoming master planning process for the Clear Creek Floodplain Reconnection Project are opportunities to pursue these recommendations.

### **Recommendation for Long-term Agricultural Viability in the Clear Creek Area**

Because relying on Clear Creek for drainage poses several problems for farms in the Clear Creek area as described in Section 6 (Findings), ESA recommends separating the agricultural drainage system from the stream system. If the agricultural drainage system in the Clear Creek area had a separate outlet to the Puyallup River, possibly with fish screens installed, it would be easier to permit maintenance activities because most if not all of the ditches would likely be considered non-fish-bearing. Drainage District 10 and individual farmers would have more control over the drainage system. There would be less input flow into the system that the agricultural drainage relies upon. Separating the drainage system from Clear Creek would also allow options for restoring the stream to more natural conditions.

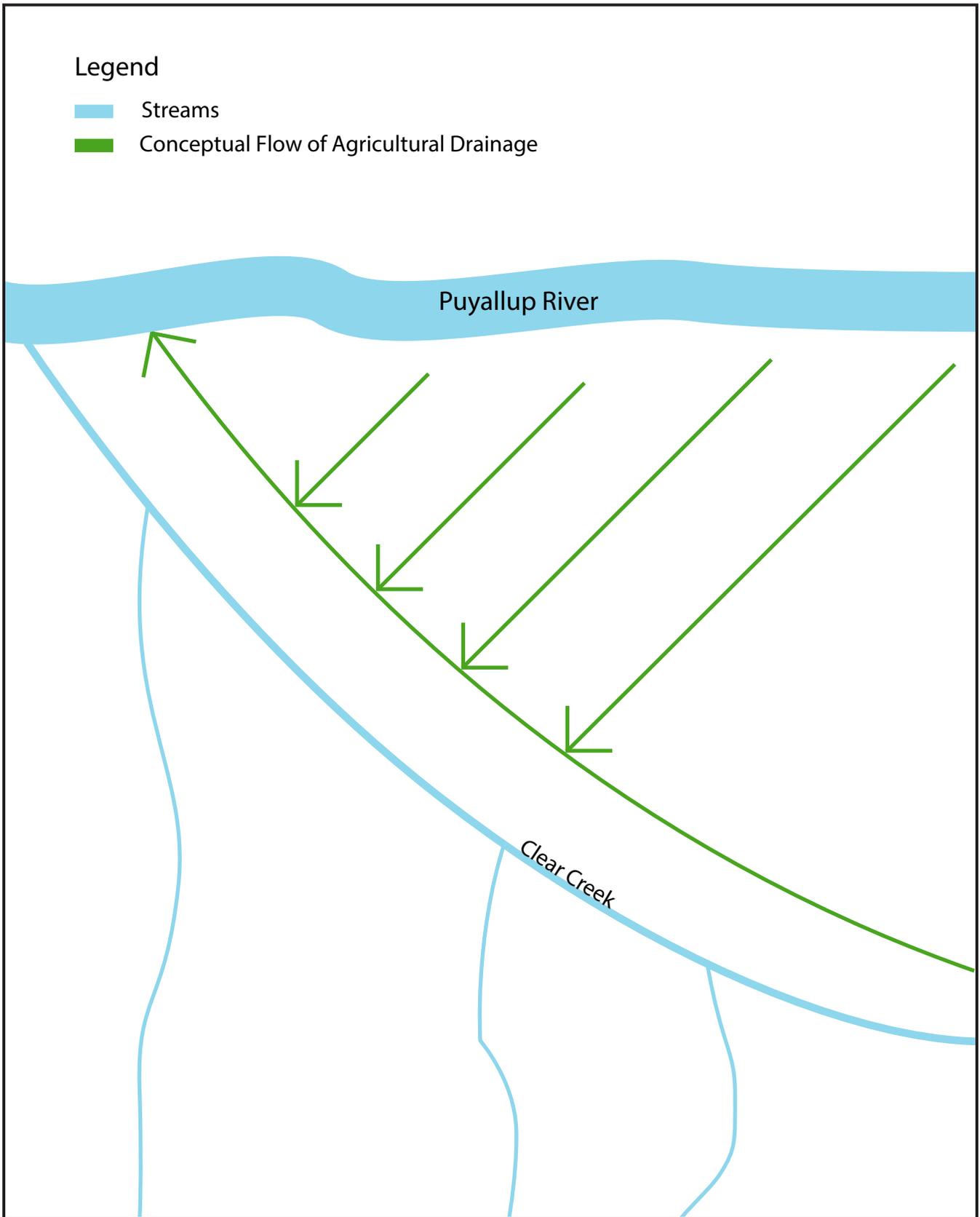
Separating the agricultural drainage system from Clear Creek would be a large capital project requiring new infrastructure. Because of topography, the new river outlet would ideally be located as far downstream as possible to maximize gravity drainage. The drainage channel leading to the new outlet would need to be excavated as far as feasible toward the outlet, but may need to be piped as the elevation of the ground rises.

Pursuing this recommendation would present several challenges:

- Studies would be required, including a survey of the entire area, hydrologic and hydraulic modeling, and wetland delineation.
- Permitting would be complex, including an HPA, an NPDES permit, Corps permits, Endangered Species Act consultation, State Environmental Policy Act compliance, and local permits (such as critical areas, grading, and stormwater permits). Wetland mitigation could potentially be required as well. A new outlet to the Puyallup River would difficult to permit, and additional information on anticipated discharges and potential water quality impacts would be needed.
- A complex set of agreements with landowners (including Pierce County SWM, the Port of Tacoma, and WSDOT) would be required.
- A new ditch system would need to be constructed.
- The new outlet to the Puyallup River would require piping or a pumping system to route water through the River Road Levee. Pumping would require a power source and funding to pay power costs.
- A new culvert under River Road with tide gates would be required for the new outlet.

Figure 6 shows a conceptual diagram of this recommendation.

This scale of project is currently beyond the ability of Drainage District 10 to pursue. However, the feasibility study and design could be included as part of other projects proposed for the area, such as the Clear Creek Floodplain Reconnection Project.



SOURCE: ESA, 2016

PCCFT Farming in the Floodplain

**Figure 6**

Conceptual Sketch of Separation of  
Drainage Systems From Stream System

## Recommendations for Ongoing Maintenance and Long-term Drainage Improvements

The following recommendations would address the maintenance and major drainage problems in the Clear Creek area. The near-term actions are described first, followed by the longer term actions.

### **Recommendation #1: Develop a Drainage Management Plan**

Drainage District 10 should develop a Drainage Management Plan to guide maintenance activities in the Clear Creek area. A Drainage Management Plan would provide the foundation for maintaining drainage infrastructure. Having a Drainage Management Plan would help the District with budgeting and with permitting.

A Drainage Management Plan typically includes an inventory of the drainage system that identifies existing problems and thresholds for triggering maintenance actions in the future. The information in this agricultural drainage inventory analysis could be used as a starting point for developing a Drainage Management Plan. Additional information, such as survey data and documented water levels over time, should be gathered. The inventoried drainage features, along with district easements, roads, parcels, and other available information should be compiled in a base map that can be used as the basis for discussions within the District and with permitting agencies and other stakeholders.

The Whatcom Conservation District has developed a Drainage Management Guide that, while tailored to Whatcom County, includes resources that could help Drainage District 10 develop a Drainage Management Plan (Whatcom Conservation District, 2009). A number of the steps recommended in the guide are inventory processes such as:

- Map and classify the watercourses, including identifying constructed watercourses, modified natural watercourses, and natural watercourses.
- Inventory and map other infrastructure, including bridges and culverts, sediment traps, floodgates, tide gates, and other unique drainage infrastructure.
- Map significant natural features, including fish distribution and wetlands.

The majority of these inventory steps are included in this agricultural drainage inventory analysis. The mapping data are available electronically and can be provided to Drainage District 10. Other information may be available from other existing sources. For example, a GIS data layer on Chinook presence is available on the Pierce County Open GeoSpatial Data Portal (<http://gisdata-piercecowa.opendata.arcgis.com/>). Additional information is needed to understand flow conditions at the 44<sup>th</sup> Street and 50<sup>th</sup> Avenue ditches as identified in Section 6.7.

Other steps involved in developing a Drainage Management Plan relate specifically to implementing maintenance activities, including:

- Divide the watercourses into reaches.
- Schedule drainage maintenance work by reach.

- Adopt BMPs.
- Adopt monitoring, reporting, and adaptive management plans.

Adopting BMPs for maintenance activities will facilitate the issuance of permits. Examples are available in the guide and through other sources. Monitoring and adaptive management plans will guide the overall maintenance activities and help the District respond to unforeseen events.

There are other issues that Drainage District 10 needs to pursue outside the scope of this agricultural drainage inventory. The District should consider these issues prior to developing the Drainage Management Plan. These include:

- Consider if the Drainage District boundary should be expanded.
- Find existing drainage easement documents and/or apply new drainage easements for ditches that the District desires to maintain.
- Develop interlocal agreements with the Port of Tacoma and Pierce County regarding drainage responsibilities.

### **Recommendation #2: Address Acute Maintenance Issues**

This agricultural drainage inventory identified several significant drainage problems in the Clear Creek area. These should be addressed soon and can be implemented prior to finalizing the Drainage Management Plan. These include:

- Remove reed canarygrass from drainage ditches and Clear Creek where it interferes with drainage. Dense mats of reed canarygrass were observed on most drainages and impede flows in many places. The reed canarygrass removal conducted by WCC field crews in Clear Creek in summer 2016 appears to have been successful in improving drainage conditions; however, this removal is not a permanent solution. Reed canarygrass should continue to be removed from the Clear Creek channel on a regular basis. Similar removal efforts should be undertaken for Nancy's Ditch, South Ditch, and key roadside ditches.
- Remove sediment deposits where feasible. Sediment removal in Clear Creek would be difficult to permit, and is unlikely to be feasible in the short term. Short-term efforts to remove sediment deposits should focus on Nancy's Ditch; the roadside ditch on the south side of 44<sup>th</sup> Street adjacent to the culvert conveying water in the ditch to Nancy's Ditch; the four culverts where Nancy's Ditch enters Clear Creek; the culvert conveying water from the 44<sup>th</sup> Street South Ditch to Nancy's Ditch; and culverts on the roadside ditches alongside 44<sup>th</sup> Street and 50<sup>th</sup> Avenue.
- Remove debris that is trapped at obstructions, including at the following locations:
  - Clear Creek channel upstream of the Gay Road culvert.
  - Inlets of the Gay Road East culverts.
  - Culverts on Nancy's Ditch.
  - Culverts on the 44<sup>th</sup> Street South Ditch.

- Culverts should be cleared of sediment, vegetation, or debris where appropriate. Culverts should be tall enough to provide a free water surface to avoid racking up floating debris. Priority should be given to fixing the culvert problems at Gay Road, Nancy's Ditch, and 44<sup>th</sup> Street South.

Addressing these problems are short-term actions. Long-term approaches to these issues should be included in the Drainage Management Plan.

### **Recommendation #3 Develop Plan for Weed Control**

The District should develop a plan for controlling weeds in and along the drainage ditches. The Pierce County Noxious Weed Control Board offers information on appropriate weed control methods. Many of these methods will require permits, especially those that involve chemical applications. Water quality in ditches should be assessed to determine whether water quality issues, such as nutrient pollution, are contributing to growth of noxious vegetation. If so, addressing water quality issues could help with weed control.

Ongoing plans for weed removal and prevention should be included in the Drainage Management Plan.

### **Recommendation #4: Plant Desirable Vegetation along Drainage Ditches**

Shade from shrubs and trees can effectively reduce some noxious weeds including reed canarygrass and elodea. In addition, vegetation strips can reduce sediment and pollutants entering ditches from adjacent land. PCC Farmland Trust and the Pierce Conservation District are currently developing a planting project for Nancy's Ditch. This could serve as a pilot project for planting along other drainage ditches in the Clear Creek area. Plantings could be undertaken by Drainage District 10 as part of its Drainage Management Plan or could be implemented by individual landowners or other entities.

Some considerations for planting projects include:

- Selecting native vegetation species.
- Avoiding planting any species on the Washington State or Pierce County noxious weed list.
- Maintaining access to the ditches for future maintenance activities.
- Designing plantings so that they do not interfere with the stability of the ditches.
- Selecting plants with strong roots that add to bank stability.
- Not selecting aggressive plants that would encroach on channels, such as Hooker's willow.

### **Recommendation #5: Manage Sediment Sources**

Accumulated sediment, in some places 3 feet deep, is reducing the drainage capacity of agricultural ditches in the Clear Creek area. The [\*Sediment Conditions in the Puyallup River and\*](#)

*Clear Creek Technical Memorandum* describes a range of studies and actions that could be undertaken to manage sediment sources in the Clear Creek Subbasin (ESA, 2016b). These would focus on the tributaries to Clear Creek and include stormwater detention to control peak flows; control of direct discharges to the creeks; bank stabilization; installation of log jams to store sediment in the creeks and reduce down-cutting; and sediment loading evaluations for Squally Creek, Clear Creek, and Canyon Creek. Adoption of BMPs for soil management on agricultural fields could also reduce inputs of fine sediment to ditches in the area. Reduction of sediment inputs to the system would reduce long-term maintenance needs for the drainage system. Generally, the priority for sediment management should be to:

- Provide upland sediment source control.
- Create sediment traps or ponds at grade breaks where sediment-bearing tributaries enter the Clear Creek area.
- Remove accumulated sediment in the drainage network when the performance of the system is impacted.

Managing sediment sources should be included in the Drainage Management Plan. The plan should include steps for ongoing maintenance to control sediment, and BMPs that landowners should adopt to reduce sediment. It should also include plans to identify sources of funding for the studies needed to address the larger scale projects, such as the sediment loading evaluations for the tributaries.

#### **Recommendation #6: Improve Drainage at 44<sup>th</sup> Street and 50<sup>th</sup> Avenue**

As described in Section 6.7, the drainage patterns of the roadside ditches along 44<sup>th</sup> Street and 50<sup>th</sup> Avenue are unclear. The ESA field crew was not able to resolve how flows from the east portion of the roadside ditch on the north side of 44<sup>th</sup> Street and the roadside ditches along 50<sup>th</sup> Avenue are routed to Clear Creek. Additional study is needed to determine how these ditches connect, and to develop appropriate plans to address the problems. Addressing the problem is a long-term action requiring additional study, engineering, and funding. In the long term, it would be preferable if the agricultural drainage system did not rely on roadside ditches as collectors.

#### **Recommendation #7: Improve Drainage from South Ditch**

As described in Section 6.6, South Ditch no longer flows directly into Clear Creek. The inability of South Ditch to drain directly into Clear Creek is a major impediment to agricultural drainage in the Clear Creek area. One solution to the problem would be to dredge Clear Creek so that South Ditch is able to flow directly into the stream. Because Clear Creek is a salmon-bearing stream, it would be difficult to permit this action. Even if dredging could be permitted, it would not be a permanent solution because Clear Creek would likely continue to aggrade and block the outlet.

If South Ditch is not directly reconnected to Clear Creek, alternatives need to be developed to provide an appropriate outlet for South Ditch. Routing South Ditch through Nancy's Ditch adds to the drainage area of Nancy's Ditch, and therefore the amount of water flowing into Nancy's Ditch. Private ditches, roadside ditches, and road culverts are all part of the conveyance system for routing South Ditch flows to Nancy's Ditch. Alternatives to dredging would generally include

modifying the ditches and culverts that convey water from South Ditch to Clear Creek. A new connector ditch alignment should also be considered that would provide an outlet for South Ditch without tying into the roadside ditches or crossing under 44<sup>th</sup> Street.

Addressing this problem is a long-term action requiring additional study, engineering, and funding.

## 8.0 References

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- Whatcom Conservation District. 2009. *[Drainage Maintenance Guide for Whatcom County Drainage Improvement Districts](#)*. March 2009.

## **APPENDIX D**

### **Clear Creek Tide Gate Assessment Technical Memorandum**



# CLEAR CREEK TIDE GATE ASSESSMENT

Technical Memorandum  
Farming in the Floodplain Project

Prepared for  
PCC Farmland Trust

July 2017



Photo courtesy of Pierce County Surface Water Management



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## 1.0 Project Background and Description

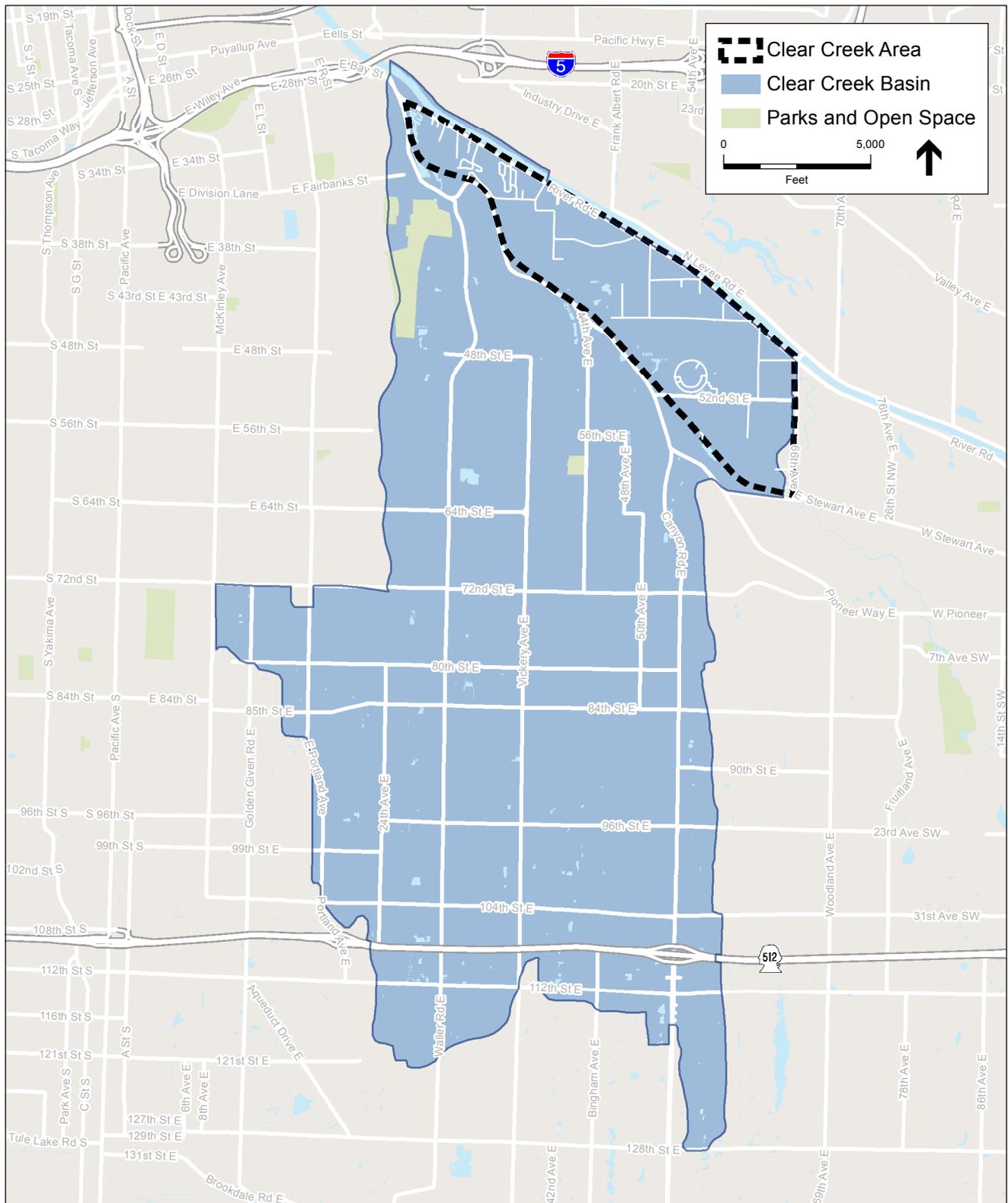
The purpose of this memorandum is to describe the current operations of the tide gates at the mouth of Clear Creek. This memorandum also reviews potential actions to improve operations of the tide gates and recommends some that could be implemented as interim measures. The potential actions described in this memorandum are not presented as alternatives to eventual removal of the Clear Creek tide gates, but as interim measures that could provide improvements in drainage and fish passage benefits in the near term. The description of current operations of the tide gates is based on water surface elevation data derived from water level loggers installed by Pierce County Surface Water Management (SWM) in fall 2016; photographs of the tide gates; and as-built plans and other documentation of the tide gates. It was not within the scope of this memorandum to conduct field work to assess the tide gates in person. Recommended potential actions are described at a conceptual level; additional analysis would be needed to determine the feasibility of the recommended actions before they could be implemented.

This technical memorandum has been prepared as part of Phase 2 of the Farming in the Floodplain Project (FFP). The FFP is one of four components of the Floodplains for the Future: Puyallup, White, and Carbon Rivers project, which is funded by a Floodplains by Design grant from the Washington Department of Ecology (Ecology). The purpose of the FFP is to advance progress toward a collectively agreed upon plan for the Clear Creek area that improves agricultural viability in the area while also meeting goals for flood risk reduction and salmon habitat enhancement. The FFP is intended to clarify the needs and interests of the agricultural community within the Clear Creek area.

## 2.0 Study Area

The study area for the FFP is the Clear Creek area, part of the Clear Creek Subbasin of the Puyallup River Watershed (Figure 1). The Clear Creek Subbasin is within the Puyallup River Watershed and is located south of the Puyallup River, north of 128th Street East, west of 66th Avenue East, and east of McKinley Avenue East. The Clear Creek area is roughly 1,140 acres in size and bounded by the Puyallup River to the north, Pioneer Way East to the south and west, and 52nd Street East to the east.

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SOURCE:  
ESA 2016, ESRI 2016

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**Figure 1**  
Clear Creek Basin and Area

### 3.0 Description of the Tide Gates

Clear Creek passes under River Road East (State Route (SR) 167) through a two-barrel, 120-foot long box culvert with an invert<sup>1</sup> elevation of 1.1 feet measured in North American Vertical Datum of 1988 (NAVD 88)<sup>2</sup> and no slope (flat). A trash rack on the upstream end prevents debris from entering the culvert and the tide gates are mounted on the downstream (river) side of the box culverts.

A tide gate is a gated opening through which water flows toward the tide water when the tide is low and which closes automatically when the tide is high, with the goal of preventing tidal waters from inundating the landward side of the gate. The two tide gates installed on the Clear Creek culverts are of different types, ages, and states of repair. The newer gate, which is shown in the raised position on the left in Figure 2, consists of a 6-foot wide by 7-foot tall metal slide gate assembly (Port of Tacoma, 1997b). This gate was installed in 1997 to replace a previous wooden flap gate at the same location. The slide gate was installed as part of the Port of Tacoma's Clear Creek Mitigation Project, a habitat restoration project located just upstream on Clear Creek. The tide gate is intended to improve fish passage at the culvert at the mouth of Clear Creek and allow a larger number of salmonids to access the mitigation area.

The older gate, shown on the right, is a top-hinged wooden flap gate approximately 8 feet wide by 7 feet tall in a wooden frame. The gate is set at an angle of approximately 10 to 15 degrees, with the top set back and the bottom set forward, as shown below in Figure 4 (Port of Tacoma, 1997a). This is a common design for flap gates to make them close more effectively. Ownership of this gate is unclear, and there is no evidence of recent maintenance.

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<sup>1</sup> The invert elevation is the elevation at the base of the interior of a culvert.

<sup>2</sup> NAVD 88 is a U.S. standard datum for elevation measurements. Pierce County Surface Water management uses NAVD 88 for all elevation data.

**Figure 2 Clear Creek Tide Gate (viewed from the Puyallup River)**

SOURCE: Mike Neville, 2016

## 4.0 History and Ownership

It is uncertain when the existing box culverts and original wooden tide gates at Clear Creek were installed and by whom. Records suggest that some type of control structure was in place at this location in the early 1930s, as one was mentioned in the original WSDOT right-of-way easement when State Road (SR) No. 5, the precursor of the existing SR 167, was constructed along the top of the levee (ICRIC, 1932).

In 1966, a letter from the Washington State Highway Commission to the Division of Flood Control regarding the Clear Creek tide gates stated that the commission had “accumulated considerable data... which indicates that we have a responsibility for this structure and maintenance” (State Highway Commission, 1966). The statement that they had to gather data to reach this conclusion implies that responsibility for the tide gates was unclear even in the 1960s.

A 1982 court decision in a case involving flood damages in the Clear Creek area described the tide gates’ origins as follows:

In 1933, at the confluence of the Puyallup River and Clear Creek, the State of Washington built two ‘tide gates’ which were designed to prevent the Puyallup’s water from backing up along the smaller tributary and flooding the adjoining land. The commissioners of Drainage District No. 10, established in 1912, had responsibility under RCW 85.06.080 and RCW 85.07.170 for maintaining drainage systems within their district. These commissioners routinely inspected the ‘tide gates,’ performed the necessary maintenance, and paid for expenses out of their annual budget of approximately \$4,000. (Geppert v. State of Washington, 31 Wn. App. 33)

The court's account of the tide gates' origins is based on the parties' testimony and is not necessarily complete or accurate. The lawsuit was brought by a group of landowners in the Clear Creek area against the commissioners of Drainage District 10, alleging that poorly executed repairs to the tide gates had caused flood damage to their properties. The lawsuit does indicate that in the early 1980s, Drainage District 10 maintained the tide gates.

A December 1996 letter from the Washington State Department of Transportation (WSDOT) to a commissioner of Drainage District 10 shows that, at that time, WSDOT's bridge maintenance crew performed regular maintenance on the tide gates (at that time, two wooden flap gates). The crew removed debris from the culvert trash rack and tires that were propping open the flap gates. The letter states that the crew had removed debris from the trash rack four times in 1996. The letter states that "[t]his six-person crew is responsible for maintaining almost 600 structures in seven counties and they are stretched very thin." This implies that the Clear Creek tide gates were among the structures that WSDOT considered itself responsible for maintaining at that time (WSDOT, 1996).

In a 2016 email to Puyallup Watershed Floodplains for the Future partners, Carl Ward of WSDOT stated that the north half of the SR 167 right-of-way at the Clear Creek crossing is owned by the Inter-County River Improvement Commission of King and Pierce County, which has granted a perpetual easement to WSDOT. According to Ward, WSDOT does not own the land the tide gates are on and is only responsible for "establishment, construction, and maintenance" of SR 167 as established in the easement. The email stated that, "in our opinion, WSDOT does not have ownership or jurisdiction over the tide gates or the land upon which the tide gates are constructed. Thus, WSDOT has no maintenance obligations" (Ward, 2016). At this time, it is unclear who owns and is responsible for maintenance of the culverts and the wooden flap gate.

In 1997, the Port of Tacoma replaced one of the wooden flap gates with a metal slide gate as part of its Clear Creek Mitigation Site Project. The Clear Creek Mitigation Site Project was required as part of a Consent Decree between the U.S. Environmental Protection Agency (EPA), the Port of Tacoma, and other parties to offset unavoidable environmental impacts related to cleanup of the Commencement Bay Nearshore/Tideflats superfund site. The Consent Decree does not specify the design or the operations of the slide gate, but does specify performance objectives for the mitigation site, including "improve fish passage at the culvert at the mouth of Clear Creek" (US District Court of Western Washington, 1993). While the open/close elevations are not explicitly stated in the Consent Decree, they may have been included in subsequent EPA-approved design submittals for the mitigation area, which would be equally legally binding. The Port is required to operate the slide gate in accordance with the Consent Decree, and changes to the open/close elevations would require EPA approval.

## **5.0 Description of Current Operations**

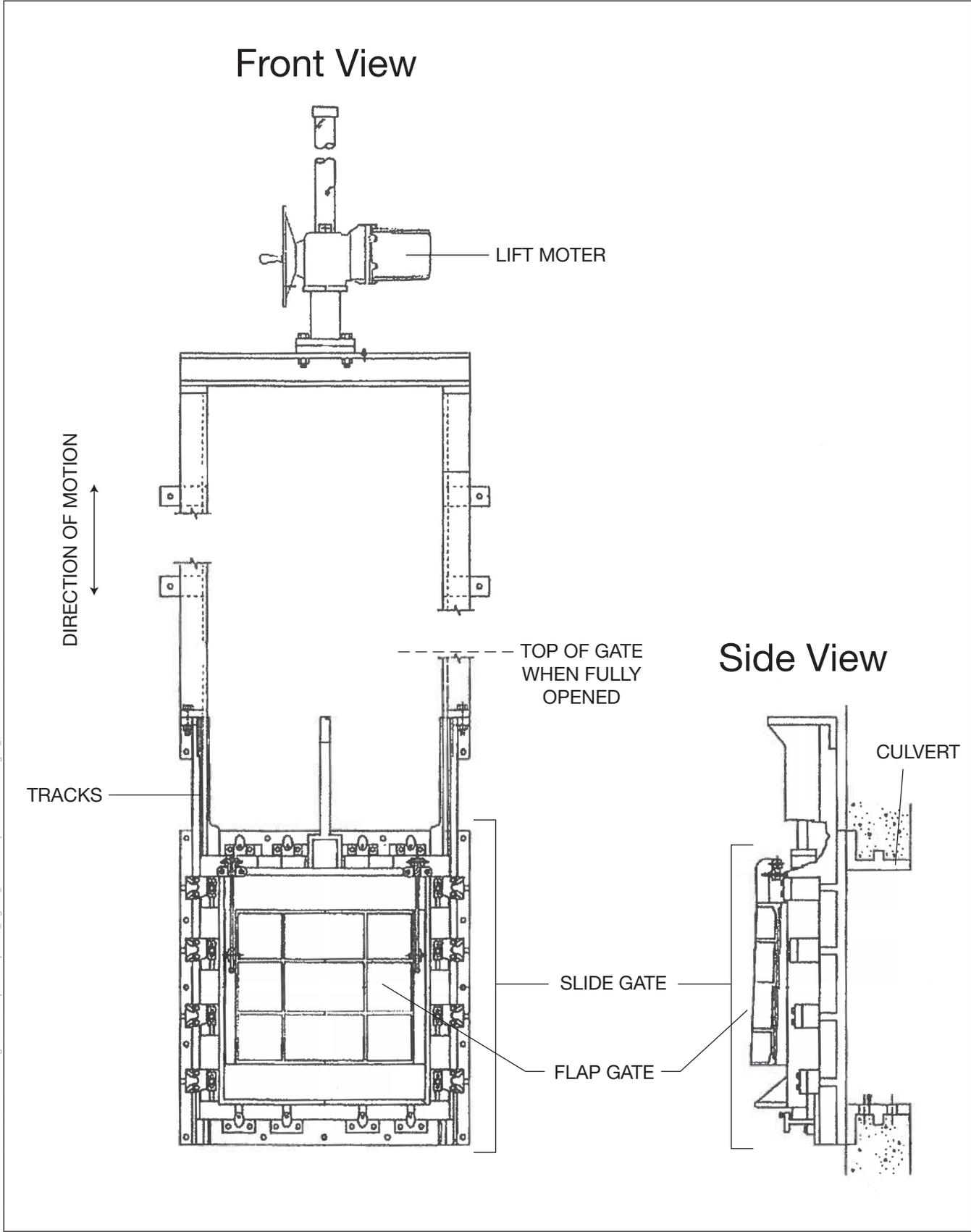
### **5.1 Metal Slide Gate**

The metal slide gate assembly (on the left in Figure 2) operates using a float-trigger system, which triggers raising and lowering of the slide gate when water levels in the Puyallup River meet

certain, pre-set elevations. A diagram of the slide gate is shown in Figure 3. The slide gate's default position is up, with the gate completely clear of the water to maximize the area of the opening so that the gate does not influence flows through the culvert. A generator-driven screw assembly closes the gate when river elevation exceeds the pre-defined threshold (Stebbing, 2016). The slide gate assembly is owned and maintained by the Port of Tacoma.

The metal slide (sluice) gate has a 5-foot by 5-foot flap gate inset into the front (Port of Tacoma, 1997b). This flap gate is designed to allow water to flow from Clear Creek to the Puyallup River when there is a head difference and the slide gate is lowered, allowing for greater drainage. Head is defined as the difference in elevation between two points in a body of water – in this case between the water in the culvert draining from Clear Creek and the water in the Puyallup River. However, according to Port of Tacoma staff, when the slide gate is fully lowered, the flap gate latches shut and cannot open (Myers, 2017b).

In late December 2016 or early January 2017, ice buildup jammed the slide gate during regular operations, causing the motor to burn out and damaging a gear in the gate assembly. Due to difficulties in obtaining replacement parts, the slide remained stuck partially open until May 11, 2017, when it was repaired. According to Port of Tacoma staff, they were unaware how far open the gate was from the time it was stuck until late April 2017 (Myers, 2017a). At that time the Port of Tacoma manually raised the slide gate to allow for better drainage and fish passage (Myers, 2017b). The gate is now functioning normally.



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SOURCE: Reference, 2017

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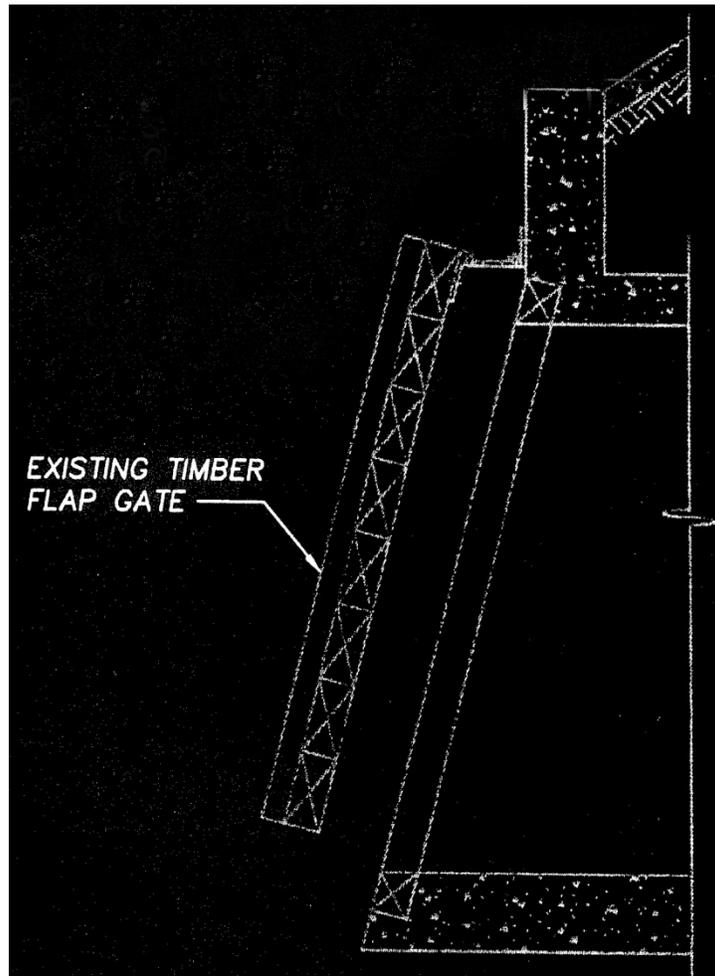


**Figure 3**  
Slide Gate Schematic

## 5.2 Wooden Flap Gate

The wooden flap gate (on the right in Figure 2) is a simple balance system that opens and closes based on head differences between the river and Clear Creek. A diagram of the wooden flap gate is shown in Figure 4. The gate is hinged at the top, and water pressure from the river pushes the gate closed when water levels in the river exceed water levels in Clear Creek. Then, when water levels in Clear Creek exceed water levels in the river, water pressure from Clear Creek pushes the gate open. The angled position of the gate increases the amount of force required to open it, so there will be some minimum head difference required to push the gate open. The greater the head difference, the faster the outflow and the more the gate will open. When there are small differences in water levels, the gate opens only slightly, resulting in small outflow rates and little to no opportunity for fish passage. Since this type of gate remains in the water at all times, flow through this barrel of the culvert is never entirely unobstructed.

**Figure 4 Wooden Flap Gate Schematic**



SOURCE: Port of Tacoma, 1997a

*Wooden Flap Gate Schematic showing angled gate and frame.*

The existing wooden flap gate is old and, based on photographs, appears to be in poor condition. From photographs taken by a Drainage District 10 commissioner in 2016, there appears to be a hole in the top edge of the gate, possibly caused by a beaver chewing the gate (shown on the upper left of the right gate in Figure 2). It is unclear whether the age and lack of maintenance of the gate have led to impairment in the function of the gate because there has been no known recent assessment of the gate's condition. It is possible that its function is impaired, and uncertainty about its condition has created concern that it could fail in a flood event. Due to its weight and the angle at which it is installed, it is unlikely that this gate opens frequently under current conditions. The slide gate side of the culvert provides less resistance, so water would preferentially flow out that direction. Even when the wooden flap gate does open (most likely only during high flows on Clear Creek) it is unlikely to open very much, which may impede drainage from Clear Creek.

### 5.3 Tide Gates and Flooding

Some reports characterize the tide gates as “causing” flooding when closed by preventing Clear Creek from draining freely to the Puyallup River during high flow events (Pierce County, 2013). However, as described above, the gates are only fully closed when water elevations in the Puyallup River are higher than water elevations in Clear Creek. Even in the absence of the tide gates, Clear Creek would not be able to drain into the Puyallup River under these circumstances. Instead, floodwaters from the Puyallup River would flow into the Clear Creek area, increasing the amount of local flooding.

As part of feasibility planning for the Clear Creek Floodplain Reconnection Project, Pierce County hired Northwest Hydraulics Consulting (NHC) to model a variety of scenarios for the outlet of Clear Creek into the Puyallup River. The results of the modeling show that the tide gates reduce flood levels in the Clear Creek area. The modeling results allow comparison of existing conditions to conditions with two open culverts (i.e., removal of the tide gates) (NHC, 2016). Model results indicate that removal of the tide gates would:

- increase the 10-year flood stage from approximately 16.9 feet to approximately 18.6 feet (1.7 foot increase);
- increase the 50-year flood stage from 19 feet to approximately 20 feet; and
- increase the 100-year flood stage from approximately 20.1 feet to approximately 20.4 feet (NHC, 2016).

NHC is currently updating this modeling, and flood stages could change by several inches. Generally, however, these results indicate that the tide gates, when operating properly, protect agricultural properties (particularly those at elevations between 17 and 21 feet) from more frequent flood inundation.

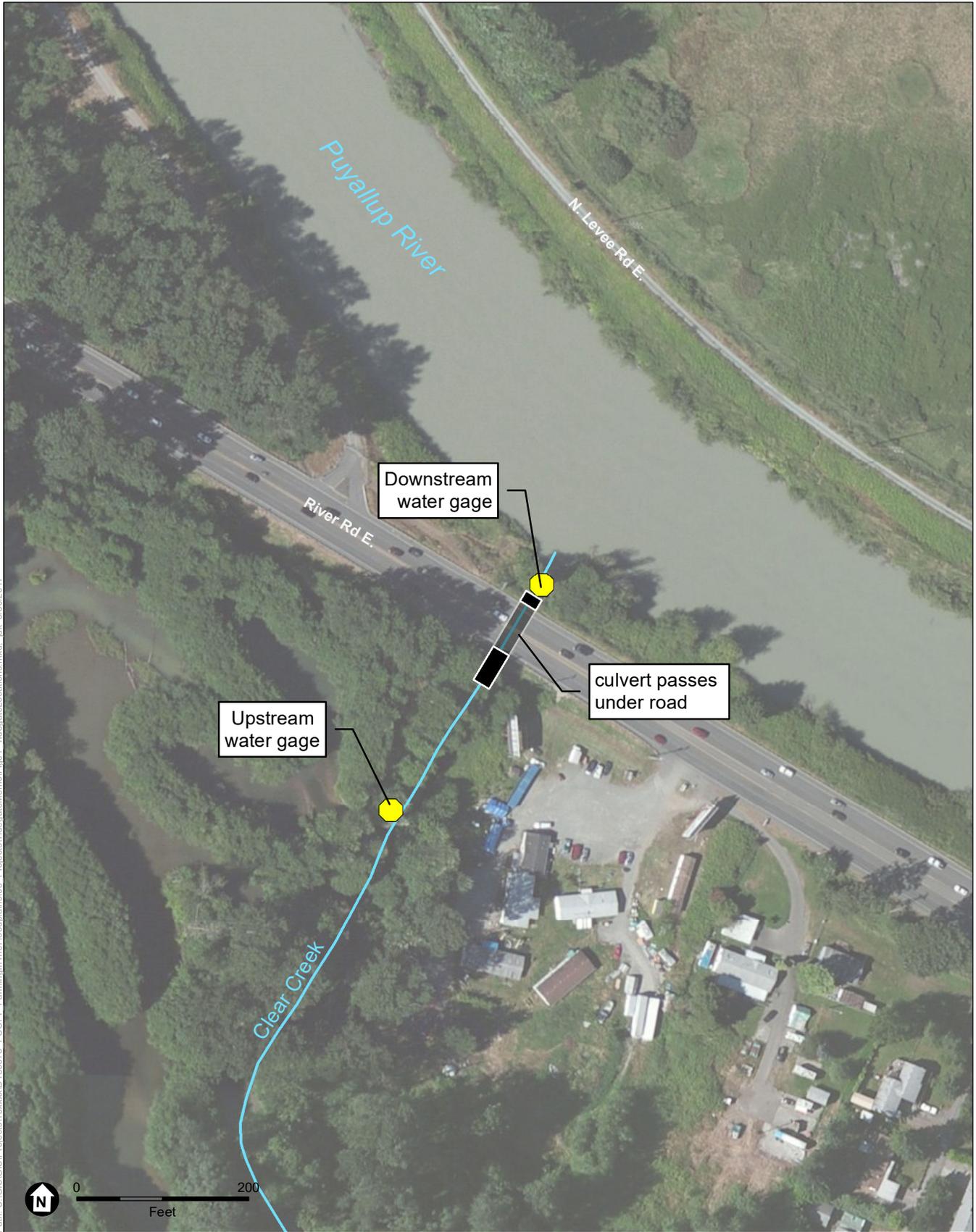
Pierce County SWM's understanding, based on information reported by Clear Creek area residents, is that one or both tide gates were not functioning properly during the 2009 flood event and that Puyallup River floodwaters were able to enter the Clear Creek area. While this cannot be confirmed, aerial photographs of the Clear Creek area show that floodwaters were brown,

suggesting that they included water from the Puyallup River. By comparison, floodwaters from the 2015 flood were clear (Hunger and Schmidt, 2017).

## **6.0 Analysis of Current Operations**

Pierce County staff installed several gages in the lower Clear Creek area in September 2016 to measure water levels on each side of the tide gates as shown in Figure 5. The discussion in this memorandum is based on 5 months of water level data from these gages. Pierce County installed the following gages:

- Water level gage on the Clear Creek side of River Road East, approximately 200 feet upstream of the culvert entrance (shown in the lower left in Figure 5).
- Water level gage on the Puyallup River side of River Road East, just outside of the tide gates (shown in the upper right in Figure 5).
- Uncalibrated pressure gage attached to the back of the slide gate that was used to detect gate opening and closing (not shown).



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SOURCE: NAIP 2016; ESA 2017

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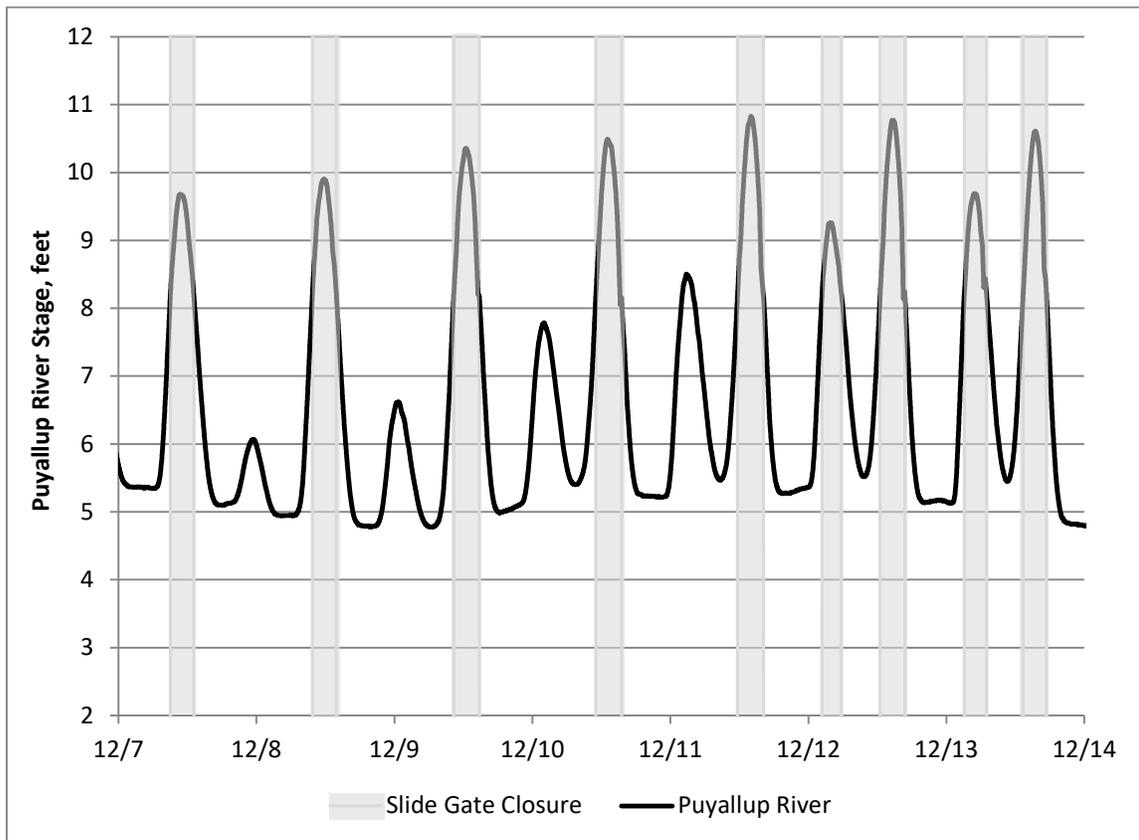
**Figure 5**

Gage Locations



ESA analyzed four months of rainy season gage data, a representative sample of which is shown in Figures 6 and 7, below. Rapid changes in the readings of the pressure gage attached to the gate indicate the times when the slide gate was raised or lowered. Cross referencing those times with the water levels in the Puyallup River, it appears that the set point for the slide gate to be raised or lowered is approximately river elevation 8.2 feet NAVD 88. Figure 6 shows one week of water level data from the Puyallup River gage, shown as a black line, superimposed over the periods of tide gate closure, shown as gray bars. During this time period, variations in tidal elevations due to the normal tidal cycle caused the slide gate to shift from closing once per day (12/7 to 12/11) to closing twice per day (12/12 to 12/13).

**Figure 6 Slide Gate Operations**



SOURCE: Pierce County water level logger data

*Water levels recorded in the Puyallup River at the Clear Creek tide gates are shown by the black line. Periods of time when the slide gate was closed due to high water are indicated by the shaded bars.*

Design documents from the Port of Tacoma indicate that the slide gate was not originally intended to be lowered daily (Port of Tacoma, 1995a). These documents indicate that the gate should close during the 2-year instantaneous peak flow, but not during the annual maximum daily-average flow, even if concurrent with a high tide. Consequently, if operating as originally envisioned, the slide gate should be lowered less than once per year. The preferred closing and opening elevations listed in the design report are when the river reaches 12.5 and 12.0 feet NAVD 88, respectively – significantly higher than the observed lowering of the slide gate at elevation 8.2

feet NAVD 88 (Port of Tacoma, 1995a). Design documents correlate the preferred gate closure trigger elevations to Puyallup River flows of approximately 16,000 cubic feet per second (cfs) (Port of Tacoma, 1995b). However, during the December 7 through December 14, 2016 period shown in Figure 6, Puyallup River flows were only 2,140 cfs to 3,040 cfs as measured at the USGS gauge at Puyallup, 3.7 miles upstream of the Clear Creek confluence. Puyallup River flows did not reach 16,000 cfs during winter 2016 – 2017, although they came close (15,200 cfs) in early February and again (15,600 cfs) in mid-March (USGS, 2017). If the slide gate was operating as originally envisioned, it would have lowered no more than twice, if at all, in the past year, as opposed to once or twice per day as observed.

The design documents note that gate settings might need to be adjusted lower in response to observations by the local landowners of impacts to their properties, but no record could be found of the actual settings applied during gate installation or any subsequent adjustments (Port of Tacoma, 1995a; 2016). The Port of Tacoma is investigating the discrepancy between the elevations proposed in the design document and observed trigger elevations (Stebbing, 2017).

The wooden flap gate operates much differently from the slide gate. It opens and closes based on differences in head between the stream and the river. It is closed when the water is higher on the river side. Because the gate is mounted at an angle 10 to 15 degrees from vertical, it likely remains closed until the water level in the culvert rises some amount above the water level on the river side of the gate. Due to significant variations in the stages<sup>3</sup> of the stream and river, the flap gate can open and close across a wide range of water levels. However, since there is no gage on the back of the flap gate to detect its motion, the operations of the flap gate cannot be measured with the current gage array. Additional gaging would be required to determine operation of the flap gate.

Given the current condition of the wooden flap gate, there is also a strong possibility of leakage when the gate is closed, which cannot be accounted for with the data available. The amount and potential importance of leakage could be assessed by physical examination of the flap gate at low water. This would include measuring the size of any gaps between the gate and its frame and holes in the surface and by observing the flow back through the culvert when both gates are in the closed position. With the gates closed, flow in either direction would be caused by leakage around or through the gates. This leakage is expected to be relatively trivial in relation to Clear Creek or Puyallup River flows and is not expected to contribute significantly to observed water levels in the Clear Creek area.

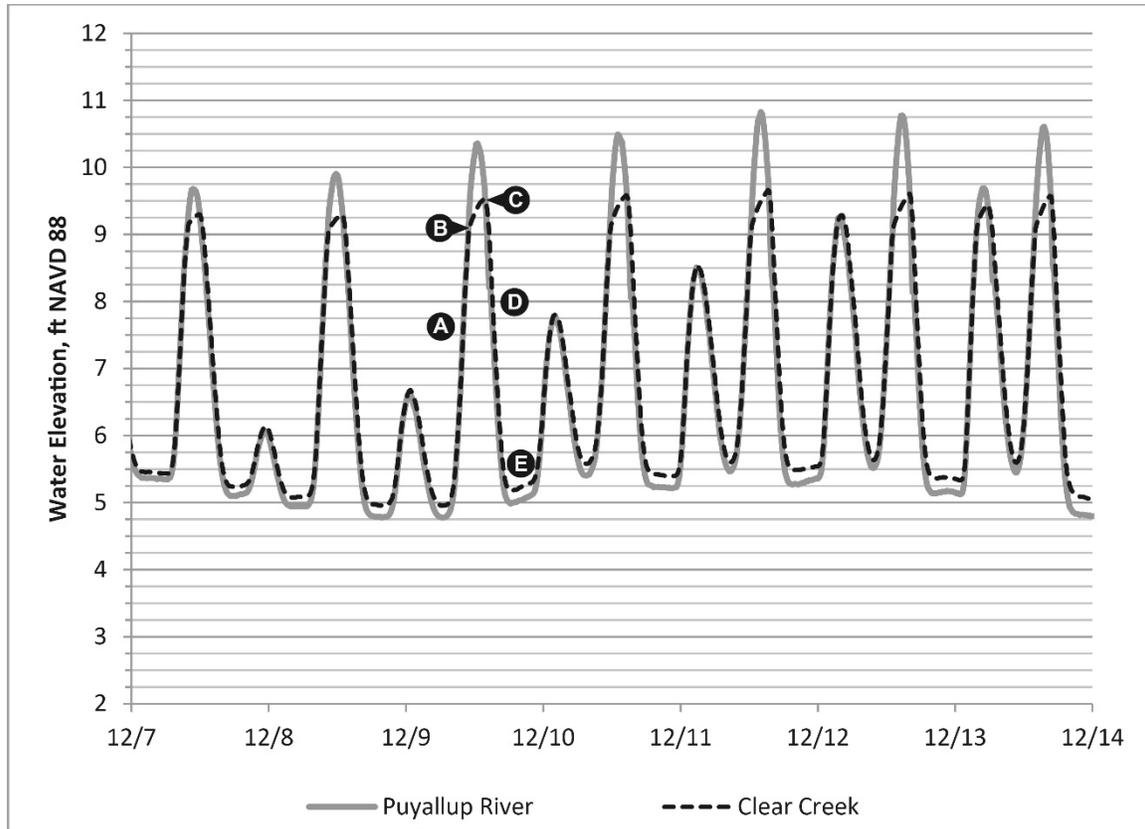
The tide gates are only effective at preventing Puyallup River water from entering Clear Creek when both the slide gate and flap gate are closed. Periods when both gates are closed can be identified by when water levels in the Puyallup River exceed levels in Clear Creek. Flap gate operations can be inferred by comparing these periods of total closure to the known operations of the slide gate, closing at river elevations of 8.2 feet NAVD 88. Fundamental differences in how the gates operate make comparisons difficult, but in general, the flap gate appears to close and reopen at a higher river stage than the slide gate. This indicates that the timing of the slide gate

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<sup>3</sup> Stage is defined as the height of the surface of a stream or river above an arbitrary zero point.

operations may be off, with the slide gate beginning to close while Clear Creek is still draining to the Puyallup River, potentially impeding drainage from the Clear Creek area.

**Figure 7 Water Levels in Clear Creek and Puyallup River**



SOURCE: Pierce County water level logger data

*Water Levels in Clear Creek and the Puyallup River over a representative one week period.*

Figure 7 shows the effects of the tide gates on water levels in Clear Creek. The solid line shows Puyallup River water elevation and the dashed line shows the Clear Creek water elevation. Water levels in Clear Creek and the Puyallup River rise in synchrony (A) with the rising tide until both gates close (B), blocking peak high tide from entering Clear Creek. After both gates close, Clear Creek can no longer drain, so water levels on the Clear Creek side of the gates slowly rise. The flap gate opens when the rising water level in the stream matches the elevation of the falling limb of the tide in the river (C). The slide gate opens at its preset point. Water levels then fall in synchrony (D) until a control on the base water elevation of Clear Creek prevents water levels in Clear Creek from falling further, creating a difference between the stream and river levels (E) at low tide.

The magnitude of this low tide difference ranged from less than 0.01 feet to approximately 0.75 feet during the monitoring period, with the larger differences correlated to lower stages in both Clear Creek and the Puyallup River. Given the distance between the two gages, the difference is most likely caused by the slope of the channel and differences in base water surface elevation when not backwatered by the tide. Other explanations for the difference could include:

- The inlet of the culvert or some other obstruction could be acting as a barrier at low flows.
- Debris accumulation on the trash rack may be impacting drainage.
- There may be a small survey error in the measured gage elevations.

The explanation for the difference could be resolved by surveying the area to derive accurate distance and elevation relationships or by observation of the culvert at low water.

## 7.0 Review of Potential Actions to Improve Tide Gate Function

Pierce County is currently pursuing the Clear Creek Floodplain Reconnection Project, which would include removal of the Clear Creek tide gates and construction of a ring levee to protect properties from flooding caused by removal of the tide gates. The timeline for implementation of the Clear Creek Floodplain Reconnection Project is at least 10 years. Because the project would not be constructed for at least 10 years, interim actions could be taken to improve tide gate function. ESA reviewed the feasibility of potential tide gate improvements to determine their feasibility as interim actions. The potential actions described in this section are not presented as alternatives to removal of the Clear Creek tide gates and the actions would not provide the same benefits to fish passage during high flows and flood events. The recommendations are presented at a conceptual level only. Further engineering design and analysis would be necessary to fully assess the suitability of any action for the Clear Creek area.

Potential actions to improve tide gate operations could include installation of new tide gates, structural modification of the existing tide gates, or modified operations of the existing tide gates. Actions could be undertaken to:

- Improve flood protection or the reliability of flood protection
- Increase drainage from Clear Creek into the Puyallup River
- Increase fish passage during normal conditions
- Increase fish passage during high flow conditions (flood events)

### 7.1 Flood Protection and Drainage Considerations

When the tide gates are functioning properly, they help to protect farms in the Clear Creek area from Puyallup River flooding. However, this area is also subject to flooding from Clear Creek and its tributaries. It should be noted that no modification to the tide gate would be able to completely prevent flooding in the Clear Creek area. In the 2009 flood event, it appears that the tide gates did not function properly and that Puyallup River floodwaters inundated the Clear Creek area. As described in Section 5, the slide gate was stuck partially open for a portion of winter 2016 - 2017; fortunately, no flood event occurred during that period. Potential actions could be undertaken to modify the tide gates in order to increase the reliability of the flood protection they provide.

Drainage through the Clear Creek tide gates could be improved by maximizing the amount of water flowing out from Clear Creek to the Puyallup River while limiting the amount of water

flowing back in from the Puyallup River to Clear Creek. The two most important factors in determining the amount of flow through a flap gate are the area of the gate opening and the head difference (difference in water level) from one side of the gate to the other. Studies have found that changes in the area of the opening are twice as effective at increasing flow as changes in the head difference (Repogle and Wahlin, 2003). Thus the most effective way to improve drainage through the tide gates would be to increase the amount of gate opening when Clear Creek is draining to the Puyallup River.

## 7.2 Fish Passage Considerations

Because the Farming in the Floodplain Project is focused on agricultural viability, this memorandum is primarily focused on flood protection and drainage for agricultural properties in the Clear Creek area. However, improvement to fish passage is also considered for each potential tide gate action discussed below. Tide gates affect fish passage in many ways. The most obvious effect is that when the gates are fully closed, fish access to potential refugia (i.e., shelter from high flows and predators) is blocked. Tide gates can also inhibit fish passage even when the gates are open and allowing water to pass. The two major considerations for fish passage through tide gates are the size of the gate opening and the water velocity. Studies have found that flap gates can remain fully closed up to 75 percent of the time (Giannico and Souder, 2005). Increasing the duration of gate opening would improve fish passage.

In addition, some types of tide gates, particularly older flap gate designs, may open only a few inches even when draining, which is insufficient for fish passage. The size of the opening required for unimpeded fish passage varies by species and life stage. For example, the Oregon Department of Fish and Wildlife (2015) recommends a minimum opening width of 4 feet. The existing wooden flap gate is unlikely to provide this large of an opening under almost any conditions.

High flow velocities coming out of the gate can also be a barrier, making it difficult for smaller fish to swim upstream. Larger gate openings also help to reduce flow velocity. Tide gates can also be predation hot spots where larger fish and birds wait for smaller fish forced through the narrow openings or disoriented by the sudden change in flow pattern.

## 7.3 Summary of Potential Interim Actions

This section describes the benefits, drawbacks, and feasibility considerations of the following potential actions:

- Modify operations of the slide gate by changing the open/close trigger
- Modify operations of the slide gate with a programmable logic controller
- Modify the wooden tide gate to reduce the amount of head needed to open the gate
- Replace the wooden tide gate with a new flap gate
- Install orifices for fish passage from the Puyallup River to Clear Creek

Section 7.3.6 includes descriptions of two additional potential actions which were considered but are not recommended.

### 7.3.1 Modify Operations of the Slide Gate by Changing the Open/Close Trigger Elevation

This action would modify the slide gate's set point to lower and raise the gate at higher river elevations. This is likely the simplest step that can be taken to improve both drainage and fish passage through the culvert. The current settings for the slide gate assembly cause it to lower while Clear Creek is still draining to the Puyallup River. The frequency of operation (once or twice daily) also contributes to unnecessary wear and tear on the slide gate assembly's mechanical components.

This action would keep the gate in the raised position longer. As suggested in the original 1995 design report, an iterative calibration period may be required to find the right balance between maximizing drainage and preventing flow from the Puyallup River from entering the Clear Creek area (Port of Tacoma, 1995a). During the monitoring period (described in Section 5), the river elevation at which the culverts switched from draining towards the Puyallup to filling towards Clear Creek was between 9.0 and 10.0 feet NAVD 88. This elevation range may provide a starting point for adjusting the slide gate assembly settings.

Alternatively, depending on the level of ongoing effort and maintenance desired, a schedule could be developed where maintenance staff would change the open/close set point seasonally to reflect variations in hydrology and drainage needs. During the dry season when water levels in the drainage ditches are down and the risk of flooding is low, the slide gate assembly could be left open longer. More protective settings could be implemented during the wet season. The slide gate could also be modified by preventing the flap gate mounted on the slide gate from latching shut when the slide gate is fully down.

This action could:

- Improve drainage from Clear Creek to the Puyallup River
- Allow for greater fish passage opportunities both into and out of Clear Creek
- Potentially reduce aquatic weed growth by providing greater flow circulation in the dry season
- Reduce wear and tear on slide gate components

A potential drawback of this action is that floodwaters from the Puyallup River could potentially enter the Clear Creek area. This would depend on the open/close set point elevation chosen and how quickly the river rises during flood stage. As described above, some iteration and calibration could be required.

Assuming that the mechanism is in good working order, resetting the open/close elevations for the slide gate should be simple and straightforward from a technical standpoint. More maintenance effort would be required to initially adjust the settings, and on an ongoing basis if a seasonally varying schedule were chosen.

As noted in Section 4, any alteration to the slide gate operations would require EPA concurrence to ensure the modifications are consistent with the Consent Decree. The Port and Pierce County would need to work closely together to ensure any changes do not increase flood risk.

### 7.3.2 Modify Operations of the Slide Gate by Installing a Programmable Logic Controller

Adding a programmable logic controller (PLC) and sensors to the slide gate assembly would provide a more complex and versatile option for controlling the raising and lowering of the slide gate assembly. A PLC is a simple computer which can be programmed to respond to preset schedules or triggers. This would allow for seasonal changes in slide gate operations without requiring a maintenance person to manually reset it. If paired with an array of water level sensors, the PLC could begin to make “smart” decisions about when to raise and lower the gate based on the time of year, how full the Clear Creek drainage ditches are, and tide predictions. This would make the system more complex, but would optimize the slide gate assembly’s operations by maximizing gate opening during periods when the risk or consequences of flooding are low and providing more protective gate closures when the drainage ditches are full or very high tides are predicted. This type of system may also have the capability to send notifications if the gate is not operating properly.

This action could:

- Allow the gate to be operated more flexibly based on real-time conditions
- Potentially allow for quicker repairs through automatic notification of problems
- Improve drainage by optimizing gate opening times and allowing Clear Creek to drain freely more frequently
- Improve fish passage into and out of Clear Creek by increasing gate opening durations

PLCs are relatively inexpensive, with the price depending on the level of complexity desired. PLCs are designed to be extremely durable. They require minimal training to program and are easy to reset.

Incorporating the PLC would add one more fallible part to the slide gate assembly because a reliable and persistent power supply and secure housing would be required. Also, the current gate components are 20 years old and may not be compatible with a modern PLC. There could be a learning curve for Port of Tacoma staff to learn how to program and troubleshoot the PLC. Developing a programming schedule could require significant physical data collection, analysis, and iteration. This would require ongoing engagement and cooperation from Drainage District 10, the Port of Tacoma, and SWM. As described in Section 4, any modification to the slide gate operations would require concurrence from EPA. Port of Tacoma staff have stated that the PLC may not be a viable option due to complications associated with operations and maintenance (Port of Tacoma, 2017).

### 7.3.3 Modify the Wooden Flap Gate

The efficiency of the existing wooden flap gate could be increased by making it “lighter” so that less force would be required to open it and hold it open. This would result in a wider gate opening for the same head difference, reduce head loss, and promote better drainage. Lightening the gate could be accomplished by removing some of the counterweights from the gate, if it is weighted (many wooden gates are); replacing the hinges to ensure it hangs level and opens without resistance; or adding an additional opening force, as described below.

The most common approaches for applying a supplemental opening force to a tide gate involve some type of device, such as a winch and cord that support a portion of the gate’s weight or by modifying the geometry of the hinges or gate itself to change the location of the center of mass relative to the hinge axis. These modifications would allow the gate to open more easily from the closed position, but to still close promptly when water levels rise on the Puyallup River.

This action could:

- Improve drainage by reducing the head difference required to open the gate, increasing the amount of time the gate is partially open and allowing Clear Creek to drain more effectively
- Potentially improve fish passage by causing the gate to open more widely and increasing the amount of time the tide gate was open

The retrofits discussed here would be relatively inexpensive and simple to implement, provided the wooden flap gate has sufficient structural integrity to be modified. Retrofits that apply an additional opening force can generally be easily adjusted to achieve the desired level of gate opening.

Since ownership of the wooden flap gate is uncertain, it is unclear who would undertake and maintain any modifications. Before the tide gate was modified, its condition would need to be assessed as described below in Section 8.1. Adding an opening force to the tide gate could require structural modifications to the tide gate to withstand the force. Additional maintenance and monitoring would be required in the period immediately following gate modification to ensure that it is functioning as desired and to identify and implement any needed adjustments.

### 7.3.4 Replace the Wooden Flap Gate with a New, Fish-Friendly Flap Gate

Flap gate design has advanced significantly since the existing wooden flap gate was installed on Clear Creek. Modern tide gates are lighter and come in a wide range of different geometries that allow for larger gate openings when the culvert is draining, but provide the same level of flood protection during high water events. This option may be the most appropriate if inspection finds the existing gate to be substantially deteriorated. Replacing the existing wooden flap gate with an aluminum gate would make the gate easier to open and more resistant to beavers and decay.

There are many types of tide gates available that might operate more efficiently than the existing flap gate, both for drainage and for fish passage. New tide gate designs that optimize fish passage

are widely available. New, fish-friendly flap gates operate passively and have a low probability of failure.

Revising the geometry of the existing flap gate to make the gate vertical instead of angled would reduce the amount of force required to open the gate and could lead to longer periods of opening wide enough to allow fish passage. This would require physical modifications to the downstream end of the culvert, likely adding additional concrete, to change its angle. This work would be similar to the modifications that were likely done to the other barrel of the culvert when the slide gate assembly was installed.

Side hinged tide gates have been shown to be effective at increasing drainage and fish passage, while providing equivalent flood protection (Giannico and Souder 2005). Because they are hinged on the side, like doors, they require very little head difference to open fully. Side-hinged tide gates require a vertical frame, so this option would also require physical modifications to the culvert.

The document *Tide Gates in the Pacific Northwest* (Giannico and Souder, 2005) includes a broad discussion of types of tide gates and the advantages and disadvantages of each. Selection of a specific tide gate design would need to be part of a collaborative process involving agricultural, fish habitat, and flood risk reduction stakeholders.

This action could:

- Improve drainage and fish passage by increasing how wide the gate opens and the duration of favorable conditions for fish passage
- Potentially reduce ongoing maintenance costs
- Likely increase the reliability of flood protection over the current wooden flap gate, which has not been maintained

Replacing the existing wooden flap gate would be more expensive than the other options discussed thus far. Modifications to the end of the culvert are likely to be a significant portion of the cost, so if cost is a controlling factor, it could be worth further exploring replacement options that work with the existing culvert geometry. Side hinged tide gates can be very sensitive to the geometry of the frame and the hinges and require more monitoring and maintenance than top-hinged designs to ensure proper functioning.

In-water work to revise the geometry of the gate would require a number of federal, state, and local permits. Acquiring these permits could be time consuming and expensive. Since ownership of the wooden flap gate is uncertain, it is unclear who would be the lead for permitting and who would have responsibility for installing a replacement gate and undertaking the required maintenance.

### 7.3.5 Orifices for Fish Passage

Another option to provide fish access to the Clear Creek area even when the tide gates are closed would be to add fish passage orifices to the tide gates. Fish passage orifices are small openings located beside or above the tide gates which are designed to allow juvenile fish passage during

high flow events. Juvenile salmon prefer to stay near the water's surface and the river edge, especially during floods. Consequently, the orifices should be positioned at appropriate elevations to be near the water surface during the design flood. Multiple orifices can be stacked vertically to provide fish passage at a range of water surface elevations. Because the orifices are small, they do not allow enough flow through to significantly increase water levels upstream of the tide gates.

This action was implemented by Drainage District 7 in King County, just north of Duvall, over 10 years ago as part of a larger fish passage retrofit of its tide gate system which also included a side-hinged tide gate and fish-friendly pump systems. The District installed three 4-inch wide by 8-inch tall orifices, each at a different elevation on their flood wall, so that the rising floodwaters would encounter them one by one.

Installing fish passage orifices on the Clear Creek culvert would require physical modifications to the end of the culvert. Because flood elevation is generally above the top of the tide gates, a riser would have to be added to the top of the culvert to allow water and fish to enter the culvert at higher water levels. The orifices would be stacked vertically on the front of the riser, and water would free-fall from the orifice to the water surface within the culvert. Because this option requires a physical modification to the culvert it is more likely to be cost effective when paired with one of the tide gate replacement options rather than as a stand-alone action.

This action could:

- Improve fish passage from the Puyallup River to Clear Creek during high flows (flood events)
- Create access to otherwise inaccessible flood refugia

This action would create small, likely insignificant, increases in water level in the Clear Creek area during floods. Modeling of the change in flood water levels during floods would be required. Because this method has not been widely implemented or studied, it is not known how effective it would be at providing fish passage. This action would not improve drainage.

The costs and complexity of physical modifications to the culvert and the uncertainties relating to ownership have been discussed above. However, incorporating fish passage orifices as part of a larger tide gate replacement project would not significantly increase the overall cost and effort involved.

It is unclear whether this approach has been implemented by other entities than King County Drainage District 7. In addition, no follow-up monitoring has been conducted to verify if fish are using the orifices installed by Drainage District 7. Before such an approach could be considered for the Clear Creek area, it would first need to be demonstrated that it could be effective. Follow-up monitoring of the Drainage District 7 fish orifices could be conducted. Alternately, observations of fish use of similar orifices could be conducted in a controlled setting, such as a hatchery.

### 7.3.6 Actions Considered But Not Recommended

Two additional actions were considered during the preparation of this memorandum, but are not described in detail or recommended because the review of potential interim actions determined

they are not feasible for the Clear Creek area. These actions include modifying operations of the slide gate by keeping the gate in a closed position at all times and replacing the wooden tide gate with a new slide gate.

Keeping the slide gate in a closed position at all times could improve the reliability of protection from Puyallup River flows entering the Clear Creek area through the tide gates during a flood and would also eliminate the risk of the slide gate becoming stuck in the open position. However, this action would also impair drainage, have a negative impact on fish passage, and be in direct conflict with the Consent Decree that governs operations of the slide gate. Therefore, the action would be infeasible and undesirable.

The wooden flap gate could be replaced with a slide gate assembly similar to the one on the other culvert barrel. This would improve drainage and fish passage. However, this action would also add to the complexity of maintenance and operation of the tide gates, be difficult to permit, and be expensive to install. If the wooden flap gate were to be replaced with a new tide gate, a fish-friendly flap gate (as discussed above in Section 7.4) would be preferable.

## 8.0 Recommendations

This section includes two general recommendations for the Clear Creek tide gates and four recommendations relating to the potential actions described in Section 7.

### 8.1 General Recommendations

#### **Recommendation #1: Determine responsibility for operation, ownership, and maintenance of the tide gates**

Pierce County Surface Water Management, Drainage District 10, the Port of Tacoma, EPA, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Puyallup Tribe, and potentially WSDOT should meet to determine the ownership and maintenance responsibilities for the tide gates. The entities should evaluate current operation of the tide gates to determine if they are operating as they should and develop a plan to provide the best flood protection, drainage, and fish passage. This plan should be captured in an interlocal agreement that defines responsibility for maintenance of the tide gates. Reaching an agreement on culvert and tide gate ownership would be a prerequisite to any successful improvement to the wooden flap gate.

#### **Recommendation #2: Assess condition of wooden tide gate and repair if needed**

The physical condition of the wooden flap gate should be assessed. The assessment should include evaluation of the water tightness of the gate and seal against opening, the structural condition of the gate itself, and the condition of the hinges. Assessing the physical condition of the wooden flap gate would need to be conducted by a qualified structural engineer. After assessing the gate, the engineer could prepare a memorandum with recommendations for repairing any weaknesses, including a discussion of the risk of delaying repair actions. Based on the recommendations, any urgent repairs should be conducted to ensure the continued reliability of flood protection and tide gate operations. This action could identify needed repairs that could

improve the reliability of flood protection, improve the ability of water to drain out through the tide gate, and improve fish passage.

Assessing the current condition of the wooden tide gate is a relatively simple action that should be undertaken in the short term. If the wooden tide gate is not in good structural condition, it would be helpful to know that as soon as possible. Information about the condition of the wooden tide gate would also provide useful information about the feasibility of modifications to the gate. This action should be considered for inclusion in the next phase of the Farming in the Floodplain Project.

## 8.2 Recommended Actions

Table 1 below summarizes the benefits, drawbacks, and feasibility considerations of the seven actions discussed above in Section 7. Recommendations 3 through 6 are based on the benefits and drawbacks of each potential action.

TABLE 1 SUMMARY OF POTENTIAL TIDE GATE ACTIONS

Section where Action is Described	Potential Action	Impacts				Feasibility Considerations
		Reliability of Flood Protection from the Puyallup River	Drainage (Clear Creek to Puyallup River)	Fish Passage (normal conditions)	Fish Passage (high flow conditions)	
7.3.1	Adjust Open/Close Set Point of the Slide Gate	Potential for minor negative or positive	Positive	Positive	Unchanged	More maintenance potentially required. Iterative calibration period required to set up. Adaptive management with local landowners and Drainage District 10 required.
7.3.2	Install Programmable Logic Controller for Slide Gate	Unchanged	Positive	Positive	Unchanged	Adds more mechanical parts to the slide gate that could fail. Minor costs and learning curve.
7.3.3	Modify Wooden Gate	Unchanged	Positive	Positive	Unchanged	Unclear ownership complicates implementation. Requires gate to be in good physical condition. Relatively inexpensive.
7.3.4	Replace Wooden Gate with New Flap Gate	Positive	Positive	Positive	Unchanged	Unclear ownership complicates implementation. More expensive than other options. Permitting and construction needs would be substantial.
7.3.5	Install Orifices for Fish Passage During High Flow Conditions	Minor negative	Unchanged	Unchanged	Positive	Examples of this approach have not been monitored to assess success. Relatively inexpensive if paired with other tide gate alterations.

**Recommendation #3: Modify wooden tide gate**

Modifying the wooden tide gate so that less force is needed to open the gate and keep it open is a relatively low-cost action that should be pursued. This action could be implemented as an interim measure even if the tide gates were eventually removed as part of the Clear Creek Floodplain Reconnection Project. The next phase of the Farming in the Floodplain Project could include feasibility analysis for this action. The feasibility analysis could include modeling to determine whether the modification would provide measurable benefits to drainage in agricultural areas.

**Recommendation #4: Discuss options to modify operations of the slide gate with the Port of Tacoma**

Two of the potential actions include changes to the operation of the slide gate to increase the amount of time the slide gate is open, allowing greater drainage and fish passage. One would use a period of calibration to determine the ideal open/close set point for the slide gate while the other would install a programmable logic controller to make the slide gate operations more dynamic. Both actions would be a benefit to agricultural drainage as well as fish passage by allowing the slide gate to be in a raised position more frequently and for longer periods of time. These actions would need to be undertaken by the Port of Tacoma, the owner and operator of the slide gate. The Port of Tacoma may be reluctant to pursue these actions, which would require an investment of staff time and could increase maintenance needs for the slide gate. Floodplains for the Future partners should discuss these potential actions with the Port of Tacoma and encourage the Port to consider implementing them.

**Recommendation #5: The Floodplains for the Future Habitat Group could explore the idea of adding orifices to the tide gates**

Installing orifices that could allow fish passage from the Puyallup River to Clear Creek during flood events could benefit fish passage, but would not improve agricultural viability. The Floodplains for the Future Habitat Group should explore this potential action. As described in Section 7.5, no follow-up monitoring has been conducted where fish orifices have been constructed. If this approach was to be implemented in the Clear Creek area, it would first need to be demonstrated that it could be effective. As with other potential actions discussed in this memorandum, installation of fish orifices would not achieve the level of fish passage benefits that would be realized by removal of the tide gates and is not recommended as an alternative to that action.

**Recommendation #6: Pursue replacing the wooden flap gate as a long-term option if the tide gates will not be removed**

Replacement of the wooden flap gate with a new, fish-friendly flap gate would improve drainage, fish passage, and the reliability of flood protection. However, the action would be expensive and the permitting and construction needs would be substantial. Therefore, this action is unlikely to be cost effective if the tide gate would be removed in the future as part of the Clear Creek Floodplain Reconnection Project. If that project is not pursued in the future, or if the project plans change and no longer include removal of the tide gates, this action should be considered as a long-term option to improve operation of the tide gates.

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## **APPENDIX E**

### **Farmland Impacts Memorandum**



# FARMLAND IMPACTS MEMORANDUM

## Farming in the Floodplain Project

Prepared for  
PCC Farmland Trust

July 2017





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## 1.0 Project Background and Description

The purpose of this technical memorandum is to identify the general types of impacts that could occur to farmlands from a levee constructed as part of Pierce County Surface Water Management's (SWM's) proposed Clear Creek Floodplain Reconnection Project. This memorandum also identifies issues that should be considered in the master planning process for the Floodplain Reconnection Project, such as considerations for design of the project and additional studies needed to understand potential impacts. Information in this memorandum is preliminary and is based on a general understanding of the current scope of the Clear Creek Floodplain Reconnection Project. Additional studies and impact analysis would be conducted as the project moves forward.

This technical memorandum has been prepared as part of Phase 2 of the Farming in the Floodplain Project (FFP). The FFP is one of four components of the Floodplains for the Future: Puyallup, White, and Carbon Rivers project, which is funded by a Floodplains by Design grant from the Washington Department of Ecology (Ecology). The purpose of the FFP is to advance progress toward a collectively agreed upon plan for the Clear Creek area that improves agricultural viability in the area while also meeting goals for flood risk reduction and salmon habitat enhancement. The FFP is intended to clarify the needs and interests of the agricultural community within the Clear Creek area.

## 2.0 Study Area

The study area for this memorandum is the Clear Creek area, part of the Clear Creek Subbasin of the Puyallup River Watershed (Figure 1). The Clear Creek Subbasin is within the Puyallup River Watershed and is located south of the Puyallup River, north of 128<sup>th</sup> Street East, west of 66<sup>th</sup> Avenue East, and east of McKinley Avenue East. The Clear Creek area is roughly 1,140 acres in size and bounded by the Puyallup River to the north, Pioneer Way East to the south and west, and 52nd Street East to the east. The Clear Creek area is located primarily within unincorporated Pierce County, with the northern tip of the area within the City of Tacoma and the southern tip within the City of Puyallup. It encompasses a portion of State Route 167 (SR 167), a section of the BNSF Railway, agricultural lands, single-family residential neighborhoods, a recreational vehicle (RV) park, a few commercial properties, the Riverside Fire District, and two schools (Chief Leschi High School and ReLife School).



### 3.0 Approach

When this technical memorandum was originally scoped in summer 2016, Pierce County had presented two proposed levee alignments for the Clear Creek Floodplain Reconnection Project (one at roughly the 14 foot contour and the other at roughly the 18 foot contour NAVD<sup>1</sup>). At that time, the proposed approach for this memorandum was to analyze the two levee alignments Pierce County had presented at a programmatic level and to qualitatively evaluate their potential impacts on farmland and agricultural viability. However, since that time, the planning process for the Clear Creek Floodplain Reconnection Project has changed. Pierce County has agreed to revisit the conceptual design of the project with a facilitated and collaborative master planning process for the Clear Creek area. During this process, the alignment of the levee and other project elements will be open to revision.

Because the direction of the Clear Creek Floodplain Reconnection Project is changing, the approach for this memorandum has changed. The proposed project is no longer defined in specific detail, so there are no specific impacts to evaluate. The purpose of this memorandum has evolved to be a tool to inform the master planning process and to help the County develop a project that avoids or minimizes impacts to farmland, and, ideally, improves agricultural viability in the Clear Creek area. This memorandum discusses impacts to farmland that could occur from a proposed project that would create aquatic habitat in the lower Clear Creek area by modifying the tide gates and constructing a ring levee. The extent, type, and degree of impacts will depend on the location, design, scope, scale, and timing of the Floodplain Reconnection Project; therefore, this assessment is preliminary because details of the Reconnection Project are not yet known. The memorandum identifies some of the issues that should be considered in the master planning process to address agricultural concerns.

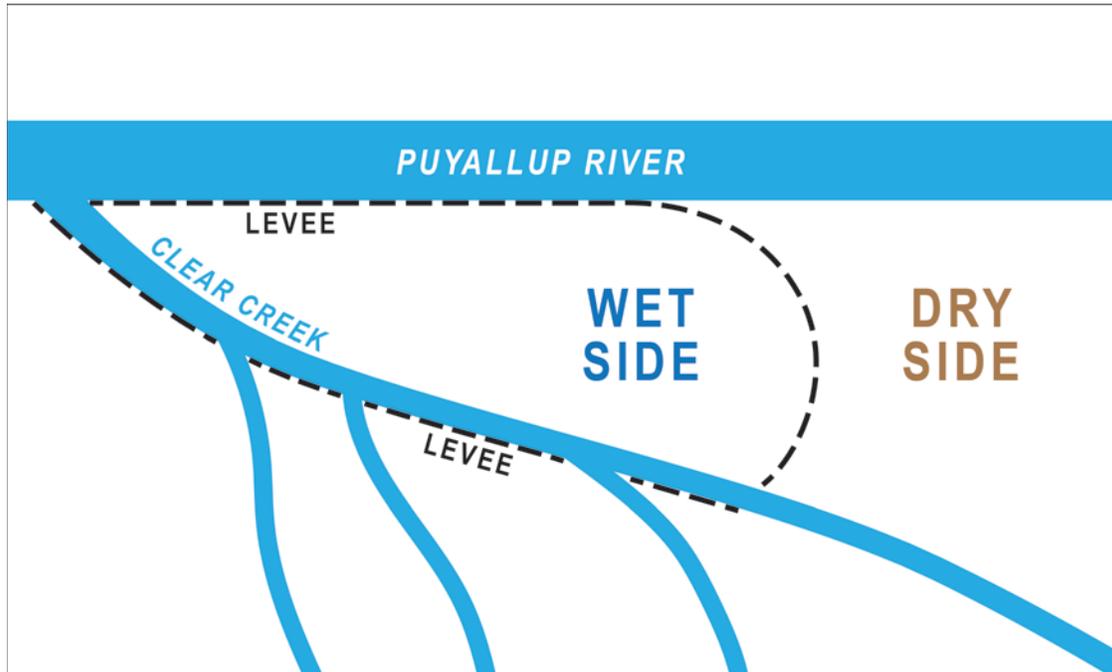
This memorandum documents questions about potential impacts of the Clear Creek Floodplain Reconnection Project raised by farmers in the Clear Creek area. These questions were raised in a letter to the Pierce County Executive (Johnson et al., 2016), in a letter to PCC Farmland Trust from the Clear Creek Farmer's Collective (Clear Creek Farmer's Collective, 2016), at Technical Advisory Group (TAG) meetings (TAG meeting reports are available [online](#)), and in direct conversations with PCC Farmland Trust and ESA staff. The letter from the Farmer's Collective states, "Our collective has united around a platform that emphasizes 'no net loss of farm function'" (Clear Creek Farmer's Collective, 2016). The concept of farm function is broader than direct loss of farm acreage and includes potential impacts to physical conditions that relate to agricultural viability (such as drainage, sediment, and groundwater) and other factors that impact farming (such as illegal activities on vacant lands or continued viability of Drainage District 10). These topics are addressed in this memorandum. The memorandum also addresses potential impacts that have arisen in the course of research conducted for the Farming in the Floodplain Project.

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<sup>1</sup> NAVD stands for North American Vertical Datum of 1988. Pierce County Surface Water Management uses the NAVD 88 datum for all elevation data in the Puyallup Watershed.

This memorandum describes the areas on the Clear Creek side of the ring levee as being on the “wet side” of the levee and areas on the landward side of the ring levee as being on the “dry side” of the levee. Figure 2 shows a conceptual diagram of the proposed levee with the wet side and dry side labeled.

**Figure 2. Levee Wet Side and Dry Side Diagram**



Pierce County has suggested that, depending on the alignment of the levee, it may be possible for some lands on the wet side of the levee to be farmed. This potential is assessed below in Section 6.17. All other sections of this memorandum focus on potential impacts to farmland on the dry side of the levee.

## 4.0 Clear Creek Floodplain Reconnection Project Description

Pierce County Surface Water Management is proposing to implement the Clear Creek Floodplain Reconnection Project (Clear Creek Project) as part of its Rivers Comprehensive Flood Hazard Management Plan (Pierce County, 2013) and the Puyallup Watershed Floodplains for the Future initiative. The purpose of the project is to relieve flooding issues, improve habitat for wildlife, and potentially improve agricultural viability. The proposed project would remove the tide gates at the mouth of Clear Creek to allow Puyallup River water to flow into the Clear Creek area, reconnecting the river to a portion of its historic floodplain. The reconnected floodplain would establish a more natural connection with the Puyallup River and allow free passage for fish in and out of Clear Creek. To reduce property damage, Pierce County would acquire property from willing sellers and construct a ring levee around the reconnected floodplain to protect property on the dry side of the levee.

The Clear Creek Project consists of three related components:

- Acquiring frequently flooded property in the Clear Creek area from willing sellers--the County has purchased over 20 properties in the area and is using grant funding (including Floodplains by Design funding) to acquire additional property that would be affected by the proposed Clear Creek Project,
- Modifying (potentially removing) the tide gates at the confluence of Clear Creek and the Puyallup River to allow the Puyallup River to flow into the reconnected floodplain area, and
- Constructing a ring levee around the area to protect properties that would be flooded by modifying the tide gates.

The Clear Creek Project is still in the early planning stages and the County has not yet conducted the necessary engineering studies or prepared design plans for the tide gate modifications or ring levee. The project would be implemented in phases and Pierce County anticipates that the project would take at least a decade to complete, largely because it is dependent on the acquisition of property from willing sellers and the availability of grant funding to purchase those properties. Pierce County is in the process of initiating a master planning process to determine the best approach to reconnect the floodplain in the Clear Creek area.

## 5.0 Agricultural Viability

This memorandum is based on two key concepts that set the context for evaluating potential impacts – agricultural viability and risks to agriculture.

The Farming in the Floodplain Project is focused on the concept of agricultural viability. Agricultural viability can be defined as the ability of a farmer or group of farmers to:

- Productively farm on a given piece of land or in a specific area,
- Maintain an economically viable farm business,
- Keep the land in agriculture long-term, and
- Steward the land so it will remain productive into the future.

This memorandum does not identify specific thresholds for physical conditions under which farms in the area would no longer be viable. During Phase 1 of the FFP, farmers in the area expressed that conditions, crops, techniques, and plans vary so much between farms, even neighboring farms, that setting thresholds for farming as a whole would be neither possible nor useful. The same flooding conditions can be devastating for a farmer growing perennial crops but be a minor two-day nuisance for a farmer focusing on seasonal crops. Drainage conditions that render entire fields unusable for one farmer can be a benefit to a neighboring farm with a different soil type and different topography (ESA, 2016a).

Instead, this memorandum uses the concept of risks to agricultural viability to identify potential impacts from the Clear Creek Floodplain Reconnection Project. Farmers in the Clear Creek area have explained that farmers constantly deal with risks, including weather, flooding and drainage problems, and market conditions. In any given year, some crops are successful and others are not. Farmers individually determine what an acceptable level of risk is and adjust their farming practices accordingly (ESA, 2016a). The Clear Creek Floodplain Reconnection Project would increase some risks to agricultural viability and would decrease other risks.

## 6.0 Potential Farmland Impacts

This section is divided into 17 questions related to potential effects of the Clear Creek Floodplain Reconnection Project on agriculture in the Clear Creek area. The questions have been raised by farmers and residents in the Clear Creek area or have arisen in ESA's research for the Farming in the Floodplain Project. For each question, the concern and potential impacts are described. Where applicable, considerations for the master planning process are described for each question.

Questions 6.1 through 6.4 address flood risk. Flood risk in the Clear Creek area is complex; farms face flood risk from several different directions. More information on flood risk is included in the [Existing Flood Risk Conditions for Agriculture in the Clear Creek Area Technical Memorandum](#) (Flood Risk Memorandum). Sections 6.1 through 6.4 of this memorandum address the following flood risks to farms:

- The risk of Puyallup River floodwaters entering the Clear Creek area at the outlet of Clear Creek (Section 6.1)
- The risk of River Road Levee overtopping (Section 6.2)
- The risk of Puyallup River flows increasing in the future (Section 6.3)
- The risk of Clear Creek flows increasing in the future (Section 6.4)

6.1 How would the new ring levee affect flood risk to agricultural properties from Puyallup River floodwaters entering the Clear Creek area at the outlet of Clear Creek?

### Existing Conditions and Trends

Currently, the tide gates at the Clear Creek outlet protect the Clear Creek area properties from Puyallup River flood flows. Modeling conducted by NHC for the Clear Creek Floodplain Reconnection Project included a variety of scenarios for the outlet of Clear Creek into the Puyallup River. The modeling results allow comparison of existing conditions to conditions with two open culverts (i.e., removal of the tide gates) (NHC, 2016). Model results indicate that removal of the tide gates would:

- Increase the 10-year flood stage from approximately 16.9 feet to approximately 18.6 feet (1.7-foot increase);

- Increase the 50-year flood stage from 19 feet to approximately 20 feet; and
- Increase the 100-year flood stage from approximately 20.1 feet to approximately 20.4 feet (NHC, 2016).

NHC is currently updating this modeling, and flood stages could change by several inches. Generally, however, these results indicate that the tide gates, when operating properly, protect agricultural properties (particularly those at elevations between 17 and 21 feet) from more frequent flood inundation.

Pierce County SWM's understanding, based on information reported by Clear Creek area residents, is that one or both tide gates were not functioning properly during the 2009 flood event and that Puyallup River floodwaters were able to enter the Clear Creek area. While this cannot be confirmed, aerial photographs of the Clear Creek area show that floodwaters were brown, suggesting that they included water from the Puyallup River. By comparison, floodwaters from the 2015 flood were clear (Hunger and Schmidt, 2017).

### **Considerations for the Clear Creek Floodplain Reconnection Project**

The proposed Clear Creek Floodplain Reconnection Project would remove the tide gates and construct a ring levee to protect agricultural and other properties from Puyallup River flood flows entering the area at the outlet of Clear Creek. Levees are designed to withstand specific flows, forces, and events and provide different levels of flood protection depending on the design criteria. The design criteria for the ring levee would likely account for how the levee would function under changing climate conditions such as increased precipitation and altered streamflows. The design criteria would also minimize the possibility of structural failures over time, though structural failures would be a possibility, especially if proper maintenance was not done. Also, agricultural land on the dry side of a levee is still at risk of flooding from other means (e.g., inadequate site drainage during a heavy storm event), so a ring levee would not guarantee that the remaining farmland would be unaffected by storm events in the future.

While residual flood risk would remain with the proposed ring levee, the levee would provide more reliable flood protection to the areas on the dry side of the levee than the existing tide gates. Therefore, the proposed project would increase the reliability of protection from Puyallup River floodwaters entering the area at the outlet of Clear Creek.

**Summary of Potential Impacts to Agriculture:** Construction of the Clear Creek levee would increase the reliability of protection for the dry side of the levee from Puyallup River floodwaters entering the area at the outlet of Clear Creek.

### **Considerations for the Master Planning Process:**

- The level of flood protection provided by the new levee depends on several components of the levee design, including, but not limited to, the levee alignment, the flow recurrence the levee is designed to (i.e., whether the levee designed for a 100-year flood or a 500-year flood), whether climate change is factored into the design, and the amount of freeboard provided.

- Updated hydrologic and hydraulic modeling would provide more detailed information on the benefits the proposed levee could provide to farmland in the Clear Creek area. Unlike the modeling already conducted by NHC, the modeling would need to focus on conditions on the dry side of the levee.

## 6.2 How would the proposed ring levee affect flood risk to farms if River Road Levee overtops or breaches?

### **Existing Conditions and Trends**

As described in the Flood Risk Memorandum, River Road Levee does not provide adequate freeboard for a 100-year flood event and has been de-accredited by FEMA for this reason. There is no available information on the probability of River Road Levee overtopping. No analysis of whether River Road Levee would meet other accreditation standards (such as stability analyses or settlement analyses) has been conducted at this time (ESA, 2017b). A process is in place through the Corps of Engineers General Investigation to evaluate options to increase freeboard on the levee and reduce the risk of levee overtopping.

The Flood Risk Memorandum concludes that the potential for River Road Levee to overtop or breach represents the biggest flood-related threat to farms in the Clear Creek area. Overtopping of the levee could significantly affect farms (as well as human health and safety) in the Clear Creek area. Homes, barns, fields, and equipment throughout the Clear Creek area could be inundated. People in the area could be physically at risk and Pierce County would be required to implement its evacuation protocol based on flood forecasts. Livestock would also be threatened by an overtopping flood event (ESA, 2017b).

### **Considerations for the Clear Creek Floodplain Reconnection Project**

As noted above, there is a Corps of Engineers General Investigation process currently underway to address the freeboard issues on River Road Levee. However, General Investigation processes tend to be lengthy and it is possible the proposed ring levee could be constructed before the freeboard problem on River Road Levee is solved. This question examines the potential risks to the agricultural area if the proposed ring levee is constructed prior to solving the River Road Levee freeboard problem.

If the proposed Clear Creek ring levee were constructed and River Road Levee were to overtop or breach, the land between the two levees could potentially be substantially damaged because floodwaters from the Puyallup River would be impounded between the two levees. Under existing conditions, if River Road Levee were to overtop, the floodwaters would flow across farmlands while draining to Clear Creek. If the Clear Creek ring levee were in place, it would slow the floodwaters from draining into Clear Creek, so the land would be inundated by higher water and for a longer period of time, thus increasing the amount of damage in the area. In this scenario, Puyallup River waters would be high enough to close the Clear Creek tide gates and Clear Creek would back up, flooding lower-lying portions of the Clear Creek area. This could limit the ability of floodwaters overtopping River Road Levee to drain to lower elevations

regardless of whether a Clear Creek ring levee was in place or not. Additional analysis and modeling of overtopping scenarios for River Road Levee would help clarify this issue.

If flood projections suggest that River Road Levee could overtop, Pierce County would implement its evacuation protocol for the area (as was done in 2006 and 2009). The presence of the Clear Creek levee would not alter the triggers for an evacuation. Therefore, construction of the Clear Creek levee would not increase the threat to human safety from an overtopping event. However, the higher water levels and increased length of inundation could increase the threat to livestock, farm infrastructure, and soils.

High velocity floodwaters that could result from a breach or overtopping of River Road Levee could cause substantial scour in the area, which could have detrimental effects such as damaging transportation routes and removing topsoil. For agricultural fields, impacts caused by floodwaters coming from a breach or the overtopping of River Road Levee would be partially dependent on how recently the soil was tilled and what crop was providing land cover (Morton and Olson, 2014). If River Road levee were to fail with the proposed ring levee in place, these impacts (which are a risk regardless of whether a ring levee is built or not) would be focused on the agricultural land between the two levees. With less area in which the Puyallup River floodwaters could spread, the agricultural land protected by the two levee systems could experience a higher degree of detrimental impacts such as land scour, sediment deposition, and topsoil removal.

**Summary of Potential Impacts to Agriculture:** The Clear Creek Floodplain Reconnection Project is not intended to address the biggest flood risk to agricultural properties in the Clear Creek area. That is being addressed through a separate Corps of Engineers process. Constructing the Clear Creek levee before adequate freeboard is provided on River Road Levee would likely increase the level of risk to agricultural structures (like barns and farmhouses), equipment, livestock, and soil if River Road Levee is overtopped.

**Considerations for the Master Planning Process:**

- The timeline of the Corps of Engineers General Investigation needs to be considered as part of the Clear Creek master planning process.
- Pierce County SWM and Clear Creek residents should continue to be involved in the General Investigation process and encourage the Corps of Engineers to address the River Road Levee problems.
- If the ring levee is constructed before the River Road Levee problems are addressed, design of flood gates in the ring levee should consider performance standards to reduce the amount of time floodwaters are impounded between the levees.

## 6.3 How would the proposed ring levee affect flood risk if Puyallup River flows increase in the future?

### **Existing Conditions and Trends**

Past flood events are not always reliable predictors of future events. Several factors could increase flood risks to the Clear Creek area in the future. These include events that would increase flows and flood levels in the Puyallup River such as climate change, changed operation of Mud Mountain Dam, and increased sediment aggradation in the Puyallup River. These events would increase water levels in the Puyallup River and likely keep them higher for longer. This would increase flooding in the Clear Creek area by backwatering Clear Creek for longer periods of time.

As described in the Flood Risk Memorandum, climate change could make inundation of farmland in the Clear Creek area more likely in the future as heavy precipitation events become more intense (ESA, 2017b). Sea level rise could also increase water levels on the Lower Puyallup River which could increase the duration of backwater flooding in the Clear Creek area. Additional information on potential risks from climate change is included in Section 6.15.

As described in the [Sediment Conditions in the Puyallup River and Clear Creek Technical Memorandum](#), aggradation (deposition of sediment) in the Puyallup River channel has raised the river bed and reduced the channel capacity for floodwaters, which can raise flood levels (ESA, 2016b). The Flood Risk Memorandum describes how aggradation in the channel of the White River has caused the Corps of Engineers to release floodwaters held behind Mud Mountain Dam more slowly, causing the Lower Puyallup River to be at elevated levels for longer, in turn delaying water from draining through the Clear Creek tide gates (ESA, 2017b).

### **Considerations for the Clear Creek Floodplain Reconnection Project**

All of the factors discussed above (modified operation of Mud Mountain Dam, projected climate change, and aggradation) could increase the duration and elevation of backwater flooding in the Clear Creek area, even if the tide gates are functioning properly. However, if the Clear Creek Floodplain Reconnection Project were constructed, the new ring levee would provide an extra level of protection from these risks. Backwater flooding would be contained on the wet side of the proposed ring levee.

**Summary of Potential Impacts to Agriculture:** Increased Puyallup River water levels in the future could increase flood risk to agriculture in the Clear Creek area. The proposed ring levee could help reduce these risks to the dry side of the ring levee.

### **Considerations for the Master Planning Process:**

- In order to provide flood protection, the proposed ring levee would need to meet design standards for flood protection as described in Section 6.1.

- Climate change information tailored to the Clear Creek area would provide more information on the benefits of the proposed levee. More detail on what climate change information is needed is provided in Section 6.15.
- Information about future operation of Mud Mountain Dam, which considers current and projected future levels of aggradation in the channel downstream of the dam and future changes in peak flow, would provide more information on the benefits of the proposed levee.

## 6.4 How would the proposed ring levee affect flood risk if Clear Creek flows increase in the future?

### **Existing Conditions and Trends**

Under current conditions, when water levels on the Puyallup River are high (such as during a flood event), the tide gates close and water from Clear Creek and its tributaries backwater, inundating the lower lying portions of the Clear Creek area. When the tide gates on Clear Creek have functioned properly to keep Puyallup River floodwaters out of the Clear Creek area, farm function in the Clear Creek area has not been affected by flooding in recent memory. Therefore, under current hydrologic conditions, farms in the Clear Creek area do not require additional protection from Clear Creek backwater flooding. However, past flood events are not always a predictor of future events.

Even without climate change, larger storm and flood events are possible. For example, the catastrophic flooding in the Chehalis River basin in December 2007 was from a flood event estimated to be a 500- to 800-year flood. And, as described in the Flood Risk Memorandum, climate change could make inundation of farmland in the Clear Creek area more likely in the future as heavy precipitation events become more intense (ESA, 2017b). Additional information on climate change is available in Section 6.15.

In the future, with larger flood events and/or climate change, more water would flow through Clear Creek and its tributaries, increasing the amount of water that would backwater and raising the elevation of floodwaters in the Clear Creek area. Without detailed climate change projections for Clear Creek and its tributaries, it is impossible to say whether increased backwater flooding would heavily inundate Clear Creek farms. However, it is a legitimate risk to farms in the area in the future that should be considered.

### **Considerations for the Clear Creek Floodplain Reconnection Project**

Higher flows in Clear Creek would increase flooding of the Clear Creek area both directly from flows overflowing Clear Creek and by slowing agricultural drainage. With the proposed Clear Creek Floodplain Reconnection Project, farms on the dry side of the levee would be protected from these flows by the proposed levee. Localized flooding where tributaries cross the levee could also be a concern and is discussed below in Section 6.5.

In the scenarios described above for high flows on Clear Creek (an extreme flood event or larger flood events due to climate change), flows on the Puyallup River would likely also be very high. This would prolong backwater flooding in the Clear Creek area and would increase the potential for River Road Levee to overtop. Potential impacts to farms from River Road Levee overtopping if the proposed ring levee were constructed before freeboard issues on River Road Levee are addressed are discussed above in Section 6.2. The proposed ring levee is unlikely to provide protection to the Clear Creek area in the event of increased future flooding on Clear Creek unless the issues with River Road Levee are also addressed.

**Summary of Potential Impacts to Agriculture:** Increased flood flows in the future could increase flooding of the Clear Creek area from Clear Creek. The proposed ring levee could help reduce this risk.

**Considerations for the Master Planning Process:**

- In order to provide flood protection from Clear Creek, the proposed ring levee would need to be designed to appropriate flood standards as described in Section 6.1. The design would need to include an outlet that would promote drainage of Clear Creek.
- Climate change information tailored to the Clear Creek area would provide more information on the benefits of the proposed levee. More detail on the climate change information needed is provided in Section 6.15.

## 6.5 Would flooding occur on the dry side of the levee where streams cross the levee?

**Existing Conditions and Trends**

The Clear Creek area generally slopes downhill from the Puyallup River and River Road Levee to Clear Creek. Therefore, floodwaters in the area drain to Clear Creek. While there are some localized impediments to drainage of floodwaters, currently there are no major barriers to floodwaters draining into Clear Creek as flooding subsides.

**Considerations for the Clear Creek Floodplain Reconnection Project**

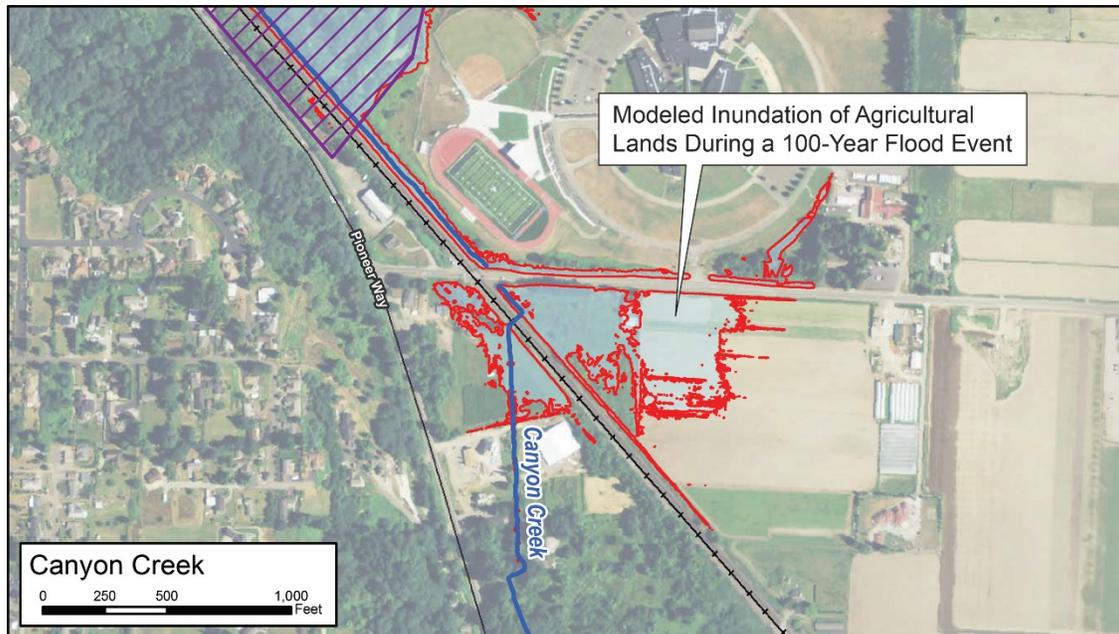
In a report released in March 2015, NHC summarized modeling conducted to determine how the stage and duration of flooding in the Clear Creek area would be impacted in the event the tide gates were removed and a ring levee were constructed. These findings are summarized in the *Clear Creek Floodplain Reconnection Hydrologic and Hydraulic Modeling Final Report* (NHC, 2015). Regardless of where it was constructed, the levee would need to allow for stream crossings for the four creeks that flow into Clear Creek. NHC modeled the potential for inundation on the dry side of the new ring levee at the stream crossings during a 100-year flood event if the levee were constructed at the 18-foot contour.

The NHC report found that there would be inundation on the dry side of the levee at the Clear Creek and Canyon Creek stream crossings during a 100-year flood. The inundation at the

crossing of Clear Creek would not affect farmland, though it could affect the Clear Creek hatchery. Inundation upstream of the crossing of Canyon Creek would inundate agricultural lands on the south side of 52<sup>nd</sup> Street.

Figure 3, adapted from NHC's report, shows the potential inundation at the Canyon Creek stream crossing.

**Figure 3. Potential Inundation at Canyon Creek Stream Crossing**



**Summary of Potential Impacts to Agriculture:** During a 100-year flood, there could be inundation of agricultural lands on the dry side of the levee where streams cross the levee.

**Considerations for the Master Planning Process:**

- Design of the ring levee could include measures to minimize or eliminate flooding at stream crossings, including constructing ponds or forebays where water from the streams could pond before flowing through the levee. Pumps could also be installed at stream crossings to reduce the time that streams would pond at the confluences.
- Modeling similar to that conducted by NHC for the 18-foot contour levee alignment should be conducted for any levee alignments considered during the master planning process. This modeling should incorporate climate change projections to account for projected increased flows from Clear Creek and its tributaries.

## 6.6 Would the proposed ring levee change the designation of the Clear Creek area as floodway?

### **Existing Conditions and Trends**

The Clear Creek area is currently regulated as a floodway by Pierce County because River Road Levee has been de-accredited by FEMA. While the floodway designation makes it difficult to build farm infrastructure, it follows best practices for resilient floodplain management by keeping new infrastructure and people out of high risk floodplain areas.

The lack of freeboard on River Road Levee is likely to be addressed in the future by the Corps of Engineers in a separate project. As described in the [Flood Risk Memorandum](#), some portions of the Clear Creek area would be regulated as a floodway based on the deep and/or fast flowing water criterion regardless of the accreditation of River Road Levee because flood depths in those areas would be greater than 3 feet (Pierce County, 2016a). Because the Clear Creek area was not included in FEMA's recently updated maps, the most recent flood data for the Clear Creek area are from the 1987 Flood Insurance Study. This study showed a base flood elevation in the Clear Creek area of 17.6 feet. Based on this information, areas at an elevation of 14.6 feet or lower would have flood depths of 3 feet or greater.

If River Road Levee were to become reaccredited, FEMA would presumably remap the Clear Creek area with newer data, establish a new base flood elevation, and update floodway mapping.

### **Considerations for the Clear Creek Floodplain Reconnection Project**

Because the floodway designation is based on deficiencies of River Road Levee, constructing the Clear Creek ring levee would not directly affect the floodway designation.

If lack of freeboard on River Road Levee was addressed in the future, areas with flood depths greater than 3 feet would still be regulated as floodway. In the Clear Creek area, this would include areas at an elevation of 14.6 feet or lower. Little agriculture occurs below this elevation in the Clear Creek area, and the majority of these areas would likely be within the footprint of the proposed Clear Creek Floodplain Reconnection Project. Therefore, construction of the proposed ring levee is unlikely to change the floodway designation for any agricultural lands in the Clear Creek area even if River Road Levee becomes reaccredited in the future.

**Summary of Potential Impacts to Agriculture:** Construction of the Clear Creek Floodplain Reconnection Project would not change the floodway designation for agricultural lands in the Clear Creek area.

**Considerations for the Master Planning Process:** This concern does not require major consideration during the master planning process.

## 6.7 Would modification of the tide gates and/or construction of a levee alter groundwater-surface water interactions in the Clear Creek area? Would those changes affect agriculture?

### **Existing Conditions and Trends**

Groundwater in the Clear Creek area is important to agricultural viability because it can affect both water supply and drainage. Some farmers in the Clear Creek area rely on groundwater for irrigation. Information on groundwater and on groundwater-surface water interaction in the Clear Creek area is limited.

### **Considerations for the Clear Creek Floodplain Reconnection Project**

Any actions that would alter the surface water flow, such as removing tide gates or building a levee, could alter groundwater-surface water interactions and could cause changes to the groundwater table. The most likely effect on groundwater levels is that a levee could block groundwater flow if the flow direction is toward the levee. This could result in higher groundwater levels, especially in the area near the levee. Any factor that raises the already-shallow groundwater levels could further impede agricultural drainage and increase the frequency of groundwater ponding on the ground surface in some areas (ESA, 2016a). The higher groundwater levels near the levee could increase soil saturation and ponding on the dry side of the levee. Sea level rise associated with climate change could also raise groundwater levels in the Clear Creek area, further impeding agricultural drainage. The potential for saltwater intrusion into groundwater with sea level rise should also be considered.

Because information on groundwater in the Clear Creek area is limited, it is not clear at this time how the proposed Clear Creek Floodplain Reconnection Project might affect groundwater.

**Summary of Potential Impacts to Agriculture:** The proposed project could affect groundwater levels in the area and increase drainage problems on the dry side of the levee.

### **Considerations for the Master Planning Process:**

- Several levee design options could minimize impacts to groundwater, including:
  - Locating the levee to minimize groundwater ponding by considering local topography
  - Positioning drainage ditches to intercept groundwater flow that may be blocked by the levee
- Additional studies would help to understand and minimize the impacts to groundwater:
  - An evaluation of hydrogeologic properties (hydraulic conductivity, flow direction, etc.) in the Clear Creek area to establish baseline conditions

- Determination of the current interaction of Clear Creek surface water and groundwater throughout the year
- An analysis of the impact of sea level rise on groundwater levels in the Clear Creek area

## 6.8 Would the new levee affect drainage from the Clear Creek agricultural area?

### **Existing Conditions and Trends**

The Existing Conditions Report identified poor drainage as the biggest current risk to agricultural viability in the Clear Creek area (ESA, 2016a). The [Drainage Inventory Memorandum](#) identified a number of conditions that impede agricultural drainage, including deferred maintenance, noxious vegetation in ditches, accumulated sediment, and undersized culverts (ESA, 2017a).

The Drainage Inventory Memorandum also identified reliance on Clear Creek for drainage as a major constraint on the drainage system. Currently, all agricultural drainage from the Clear Creek area flows into Clear Creek before eventually draining to the Puyallup River. Relying on Clear Creek, a natural waterway, to drain agricultural fields creates several problems for agriculture in the Clear Creek area.

### **Considerations for the Clear Creek Floodplain Reconnection Project**

The proposed Clear Creek Floodplain Reconnection Project could increase agricultural drainage problems by routing agricultural drainage through a levee and into a habitat project. How agricultural ditches could drain through the levee is a matter of project design (see Section 6.5). For example, pumps could be installed to pump water from agricultural ditches through the levee. If the pumps were properly maintained, agricultural drainage through the levee could be ensured. However, the habitat area and channels on the wet side of the levee would not be maintained for drainage. The Sediment Memorandum identified the potential for the wet side of the levee to become a depositional area for sediment from the Puyallup River (ESA, 2016b). The effect of increased deposition in the habitat area on drainage from the agricultural area is uncertain. Depending on how much sediment is deposited in the habitat area and how channels are formed in the area by tidal water fluctuations, drainage from the dry side of the levee could be impeded. More information is needed on how sediment dynamics and channel forming processes could affect the habitat area and drainage on the wet side of the levee.

If construction of the levee slows the rate of agricultural drainage, it could affect sediment deposition in the ditches. If sediment deposition increased aggradation in the ditches, the capacity of the ditches to move runoff would be reduced. Slowing agricultural drainage could also impact culverts, many of which appear to be undersized under current conditions (ESA, 2017a).

The Drainage Inventory Memorandum recommends separating the agricultural drainage system from the stream system. If the agricultural drainage system in the Clear Creek area had a separate outlet to the Puyallup River, with fish screens installed, it would be easier to permit maintenance

activities because most if not all of the ditches would likely be considered non-fish-bearing. Drainage District 10 and individual farmers would have more control over the drainage system. A new drainage system would have less flows since flows from the Clear Creek tributaries would continue to drain to Clear Creek and not the new system. A separate drainage system would reduce the impacts of the Clear Creek Floodplain Reconnection Project on agricultural drainage, and would improve agricultural drainage in the area above current conditions. A separate drainage system would also benefit the habitat project. Removing agricultural drainage from Clear Creek would reduce sediment and other pollutants entering the habitat area. Separating the drainage system from Clear Creek would also allow options for restoring the stream to more natural conditions. This action would be difficult to permit and would likely trigger water quality concerns.

**Summary of Potential Impacts to Agriculture:** Requiring the agricultural drainage system to flow through the Clear Creek levee and the habitat area on the wet side of the levee would likely exacerbate the largest current constraint to agricultural drainage in the Clear Creek area and would be a major impact to agricultural drainage. Incorporating a large-scale change to agricultural drainage system to improve drainage could eliminate or substantially reduce this potential impact. For example, creating a separate outlet to the Puyallup River for the agricultural drainage system could improve agricultural drainage over current conditions and improve habitat conditions in the stream.

#### **Considerations for the Master Planning Process:**

- Several issues related to agricultural drainage need to be considered in the master planning process, including:
  - How water would be drained through the levee, and whether pumps would be needed, should be determined during project design.
  - Ownership and maintenance responsibilities for any infrastructure (such as pumps) associated with draining agricultural ditches through the levee need to be determined.
  - The possibility of rerouting the agricultural drainage system so it would drain directly to the Puyallup River and not through the levee and habitat area should be considered as a potential component of the Clear Creek Floodplain Reconnection Project.
  - Modeling is needed to predict sediment dynamics on the wet side of the proposed levee. This should include a determination of how the combination of sediment deposition and fluctuating water levels on the wet side of the levee would affect agricultural drainage from the dry side of the levee.

## 6.9 How much would the project reduce farm acreage?

### **Existing Conditions and Trends**

Many of the farms in the Clear Creek area are located above the 18-foot elevation, particularly the larger wholesale farms. However, about a half dozen smaller, sustainable, direct-market farms are located or partially located between the 14- and 18-foot elevations in the area.

### **Considerations for the Clear Creek Floodplain Reconnection Project**

The Clear Creek Floodplain Reconnection Project would require substantial acreage for the habitat area and for the levee footprint. This land would no longer be available for agriculture or other uses (see Section 6.17 for a discussion of potential agricultural use of the wet side of the levee).

The amount of acreage required for the habitat area and for the levee footprint would depend on the levee design and alignment chosen. The portion of that acreage currently in use for agriculture would also depend on the design and alignment.

In order to provide examples of the amount of acreage the project could require, ESA used GIS to estimate the amount of acreage required for the two levee alignments originally presented by Pierce County. The original levee alignments were at approximately the 14-foot and 18-foot elevation contours.

For the purposes of the estimate, ESA made the following assumptions about the levee:

- The top of the levee would be at an elevation of 22 feet
- The top width of the levee would be 15 feet
- The slope of the dry side of the levee would be 5 to 1
- The slope of the wet side of the levee would be 3 to 1

Based on these assumptions, a levee at the 14-foot elevation would be 8 feet high and 79 feet wide. A levee built at this conceptual alignment (but tying into the River Road Levee and the BNSF Railway embankment where appropriate) would require approximately 25 acres for the levee footprint. The acreage of the wet side of the levee would be approximately 225 acres. A levee built at this alignment would cross through some parcels currently used for agriculture, and some agricultural parcels would be within the wet side of the levee.

Based on the assumptions above, a levee at the 18-foot elevation would be 4 feet high and 47 feet wide. A levee built at this conceptual alignment (but tying into existing levees where appropriate) would require approximately 11 acres for the levee footprint. The acreage of the wet side of the levee would be approximately 525 acres. This levee alignment would include many more acres of land currently in use as agriculture than a levee at the 14-foot elevation.

These estimates do not include the acreage that would be required for modifications to the system to ensure proper drainage, including new ditches following the levee alignment on the dry side, new storage areas, or infrastructure such as pumps to ensure drainage across the levee. It also

does not include any roads or paths constructed to provide maintenance access to the levee, which may be required. These needs should be considered in the master planning process.

**Summary of Potential Impacts to Agriculture:** The project could convert substantial acreage of land in the Clear Creek area. The amount of agricultural land converted to other uses would depend on the levee alignment chosen. Under any potential levee alignment, the project would likely require conversion of some agricultural lands to other uses. If conversion of agricultural land were minimized, other potential impacts to agricultural lands were avoided, and elements that improve key conditions for agriculture were included in the project design, the project could avoid loss of farm function.

**Considerations for the Master Planning Process:**

- This potential impact is entirely dependent on the levee alignment selected. Additional studies of impacts to agricultural lands should be undertaken as part of the master planning process when specific levee alignments are proposed.

## 6.10 How would the levee affect the viability of Drainage District 10?

**Existing Conditions and Trends**

Drainage District 10 is an agricultural drainage district in the Clear Creek area. It receives revenues from taxes assessed on properties in the District. Taxes are assessed on the benefit a property receives from the District and are not assessed on the property value. The commissioners of the Drainage District are authorized to construct, straighten, widen, deepen, and improve existing drains or ditches in the District, as well as dig or construct additional drains or ditches. Additionally, the District may divert, dam, or carry off the waters of any stream or water endangering or causing damage in the District (RCW 85.06.640). Because poor agricultural drainage is the biggest current threat to agricultural viability in the Clear Creek area, the viability of Drainage District 10 is critical to the viability of agriculture in the area.

Drainage District 10 faces a number of challenges in maintaining and improving agricultural drainage for the Clear Creek area. As described in the Drainage Inventory Memorandum, relying on Clear Creek for drainage is a concern because Clear Creek is a salmon-bearing stream with two wetland mitigation sites downstream of the agricultural areas, limiting maintenance activities that can be completed in the stream (ESA, 2017a). Drainage maintenance activities in Clear Creek are difficult to permit and have to be completed within a limited fish window. The boundary lines for Drainage District 10 do not include all areas that benefit from drainage maintenance activities within the District, and there are a number of issues with how areas responsible for paying assessments to the District are recorded. Drainage District 10 has recently reformed after being dormant for many years.

## **Considerations for the Clear Creek Floodplain Reconnection Project**

The Clear Creek Floodplain Reconnection Project requires acquisition of a large portion of the land base of Drainage District 10 as described in Section 6.9. The exact portion would depend on the levee alignments selected.

Pierce County's property acquisition in the Clear Creek area does not affect the tax base for Drainage District 10 because the county pays full assessments to Drainage District 10 for the property it owns (Redmond, 2017). However, each property purchased reduces the pool of landowners who can serve as commissioners of the District.

Because of the uncertainty of the long-term future of the Clear Creek area with the proposed Clear Creek Floodplain Reconnection Project, the District is currently having difficulty establishing support for assessing properties to fund drainage maintenance or development of a Drainage Management Plan. The uncertainty has impacted the ability of the District to tax its constituents.

The proposed project could include infrastructure designed to ensure agricultural drainage, such as pumps to improve ditch drainage through the levee. Ownership and maintenance responsibilities for the new infrastructure would need to be clarified. Drainage District 10 may not be able to assume ownership or maintenance responsibilities for this infrastructure.

Some landowners in the Clear Creek area are currently looking into the possibility of expanding the boundaries of Drainage District 10 in order to expand the District's tax base and area of service. If this action moves forward, the new District boundaries should be considered in the master planning process.

The Floodplains for the Future Program, which includes the proposed Clear Creek Floodplain Reconnection Project, has provided support to Drainage District 10 through funding of the Drainage Inventory Memorandum (conducted by the Farming in the Floodplain Project) and by supply WCC field crews to remove reed canarygrass from Clear Creek.

**Summary of Potential Impacts to Agriculture:** Property acquisition reducing the pool of landowners who can serve as commissioners of Drainage District 10 and uncertainty around the long-term future of the Clear Creek area due to the proposed Floodplain Reconnection Project has impacted the viability of the District, and therefore has impacted maintenance of agricultural drainage in the area. The fact that the county pays assessments to Drainage District 10 for the property it owns within the District helps offset these impacts, but the uncertain future of the area continues to impact the District.

### **Considerations for the Master Planning Process:**

- Considerations include:
  - Ownership and maintenance responsibilities for any drainage-related infrastructure installed as part of the proposed project would need to be clarified in advance.

- Whether drainage-related infrastructure, such as pumps, would be required as part of the proposed project.
- Whether the boundaries of Drainage District 10 will expand.

6.11 What are the impacts of vacant parcels adjacent to farms in the time between purchase of properties and construction of the project?

### **Existing Conditions and Trends**

Criminal activity, trespass, and illegal dumping have been observed in the Clear Creek area, both on flood damaged and abandoned properties and on vacant properties owned by Pierce County. As described above, Pierce County has been implementing a policy to purchase frequently flooded property from willing sellers (Pierce County, 2013). In the Clear Creek area, Pierce County has purchased over 20 flood prone properties in the last two decades. Pierce County has removed homes and infrastructure from the purchased properties and the properties have been left vacant. Vacant land is often a target for criminal activity, trespass, and illegal dumping. These activities have been observed in the Clear Creek area on vacant lands owned by Pierce County.

### **Considerations for the Clear Creek Floodplain Reconnection Project**

As part of the Clear Creek Floodplain Reconnection Project, Pierce County is currently acquiring more properties in the Clear Creek area with grant funding from several sources, including the Floodplains by Design program. As the amount of vacant land in the area increases, observed impacts (such as criminal activity, trespass, and illegal dumping) could increase as well.

Pierce County SWM is currently exploring the possibility of renting vacant parcels it owns near 47<sup>th</sup> Avenue in the Clear Creek area for agricultural production. Compacted soils on these parcels would need to be tilled and rehabilitated, and all infrastructure (including 47<sup>th</sup> Avenue) would need to be removed. It is unclear at this time whether it is possible to farm these parcels because they may be regulated as wetlands. However, if possible, conducting agriculture on otherwise vacant parcels owned by SWM in the interim period before the Clear Creek Floodplain Restoration Project is constructed would reduce the threat of trespass, crime, and illegal dumping.

Habitat projects can also be a target for trespass and dumping. For example, the Port of Tacoma Clear Creek Mitigation Site, located within the Clear Creek area, has been the location of homeless encampments. Locating a large habitat project adjacent to farms in the Clear Creek area could encourage trespass, which could reduce property values and create nuisances that could affect the farms. A plan should be in place to discourage trespass and dumping in the completed project.

**Summary of Potential Impacts to Agriculture:** Vacant parcels in the Clear Creek area that were acquired by SWM have been a target for criminal activity that has negatively affected farms and residences in the Clear Creek area. This activity will likely continue as long as the properties

are vacant. Opportunities to utilize those lands in the interim period before the Clear Creek Floodplain Restoration Project was constructed should be explored. A plan to discourage trespass in the completed project should be developed.

**Considerations for the Master Planning Process:**

- Elements that discourage trespass, criminal activity, and dumping should be included in the project design.

## 6.12 Would the new levee cause the loss of the Riverside Fire District?

**Existing Conditions and Trends**

Fire service for the Clear Creek area is provided by the Riverside Fire District. The Fire District extends from the city limits of Puyallup to the city limits of Tacoma, and from the Puyallup River to Pioneer Way. The Fire District also provides fire protection to the Chief Leschi Schools. It is funded by the Riverside Fire and Rescue tax district and by the Puyallup Tribal Nation. Most of the staff are volunteers.

In December 2012, the Fire District stopped providing services and instead contracted with Central Pierce Fire & Rescue. A notice letter to the District's constituents stated that the District was contracting out services due to "the economy, flooding problems, flood management future plans, lack of advanced life support services 'paramedics', reduced revenue, and increasing costs" (Riverside Fire District, 2012). The notice stated that revenue was reduced because of a reduction in the assessed value of properties within the District. The notice letter also stated that Pierce County's proposed floodplain reconnection project would further reduce the assessed value of the fire district. In February 2014, the Riverside Fire District terminated its interlocal agreement with Central Pierce Fire & Rescue and resumed operation. The agreement was canceled because the community was unhappy with the service provided by Pierce Fire & Rescue (Hugo, 2017).

**Considerations for the Clear Creek Floodplain Reconnection Project**

Pierce County pays a contractual rate to the Fire District for the property it owns within the District. The rate is reviewed on an annual basis (Redmond, 2017). Therefore, the Clear Creek Floodplain Reconnection Project has not affected the revenue of the Fire District and is not anticipated to in the future. However, the uncertainty around the long-term future of the area could potentially cause the Fire District to suspend services in the future, as happened in 2012.

**Summary of Potential Impacts to Agriculture:** The Clear Creek Floodplain Reconnection Project would not affect the revenue of the Fire District, but uncertainty around the long-term future of the area could potentially cause the Fire District to suspend services in the future.

**Considerations for the Master Planning Process:**

- Options to maintain the viability of the Fire District should be explored.

## 6.13 How would combining a trail with the levee affect farms in the area?

### **Existing Conditions and Trends**

Clear Creek area farmers presented information about their farms as part of a tour of the area on March 9, 2016. As part of that presentation, farmers presented a “Vision for the future of Clear Creek,” which included a trail system “that works with habitat, flood, and farm interests” (Clear Creek Farmers, 2016). At a Technical Advisory Group meeting, a Clear Creek area farmer stated that this idea represents an opportunity to connect the public with habitat and with local farms and to highlight Pierce County as an agricultural district in Washington (ESA, 2016a).

### **Considerations for the Clear Creek Floodplain Reconnection Project**

Combining a trail with the Clear Creek Floodplain Reconnection Project would provide a recreational amenity for farmers and other residents in the Clear Creek area. It could help bring residents of Tacoma, Puyallup, and other areas to Clear Creek, increasing the visibility of farms in the area. The trail could allow for educational opportunities as well. For direct market farms, particularly those with a focus on agritourism or with a farm stand, a trail could increase business.

Other farmers in the area might feel that bringing trail users to the area could interfere with farm activities. A trail on flat land adjacent to the levee would take up additional land, some of which may currently be used for agriculture. Locating a trail atop the levee would require additional design and safety considerations for the levee and could require a wider levee. Additional land could also be required for parking, restrooms, and other trail facilities.

**Summary of Potential Impacts to Agriculture:** A trail connecting habitat areas with farms could help increase the viability of agriculture in the Clear Creek area, but the footprint of the trail and its facilities could take up additional agricultural land.

### **Considerations for the Master Planning Process:**

- The idea of including a trail connecting habitat areas with farms should be considered as part of the master planning process.
- The idea of a trail through the Clear Creek area should be explored with Pierce County Parks and Recreation to determine its feasibility.
- A trail would need to meet trail design and safety standards.

## 6.14 Would the levee reduce agricultural viability in the Clear Creek area to the extent that agriculture in Pierce County as a whole is damaged?

### **Existing Conditions and Trends**

Pierce County is home to almost 1,500 local farms that produce \$91 million worth of products, including vegetables, livestock, poultry, eggs, flowers and bulbs, and aquaculture (Pierce County, 2016b). Farmland throughout the county has historically been converted into residential and other uses and that trend is continuing. Remaining agricultural lands are often adjacent to residential or commercial structures. The Puyallup Valley in particular has experienced a rapid increase in development. As of the writing of the 2006 Pierce County Agriculture Strategic Plan, 25 percent of agricultural land in the Puyallup Valley was located within incorporated areas or urban growth boundaries as of 2006 (Pierce County, 2006). In 2004, American Farmland Trust published a report titled: “The Suitability, Viability, Needs, and Economic Future of Pierce County Agriculture,” which found that agriculture in the county was shifting from industrial, wholesale agriculture to value-added, direct market “urban edge” farming. This shift was caused by the urbanization and fragmentation of the agricultural land base and was made possible by the favorable climate and soil in the county (American Farmland Trust, 2004). More recent reports suggest that the trends identified in the 2004 report have continued throughout the Puyallup River Valley (WSU et al., 2015).

As a Puyallup Valley lowland agricultural area not located within an urban growth area, the Clear Creek area is important for Pierce County agriculture as a whole. The Clear Creek area reflects the trend in Pierce County of a transition to smaller, local market-driven urban edge farming. The area also has several large wholesale farms that have been in the same family for generations. The area’s proximity to consumers and highly productive soils also are attracting new farmers to Pierce County, with new farmers starting farms or becoming owners of existing smaller farms.

The Strategic Conservation Partnership (SCP) is a collaborative group working to increase the pace and durability of agricultural conservation in Pierce County. SCP members include the Pierce County Agricultural Program, PCC Farmland Trust, Forterra, and the Pierce Conservation District. To help guide their work, SCP members funded a GIS-based prioritization of farmlands in Pierce County. Factors included in the prioritization included zoning and comprehensive plan designations; soil types and quality; parcel size; threat of conversion based on proximity to Urban Growth Areas; adjacency to other agricultural lands; and the presence of critical areas. The GIS prioritization identified many high-priority farms in the Clear Creek area. Maintaining agriculture in the Clear Creek area is important for meeting the SCP goal of conserving and increasing the farmland acreage base. Because many of the farmlands that are high priority for agricultural conservation are in the Clear Creek area, maintaining agriculture in the area is also critical for meeting the SCP’s 10-year voluntary conservation goal of 6,000 acres.

## Considerations for the Clear Creek Floodplain Reconnection Project

As described throughout this memorandum, the Clear Creek Floodplain Reconnection Project could negatively impact agriculture in the Clear Creek area in a variety of ways, including direct loss of agricultural acreage. There are no benchmarks for determining whether loss of agricultural lands reaches a “tipping point” for the agricultural industry in a county or region. However, it is important to note that the Clear Creek area is unique for farmland in the county due to its proximity to urban areas and to I-5.

**Summary of Potential Impacts to Agriculture:** If agriculture in the Clear Creek area were lost, it would have an impact on agriculture in the county as a whole. Therefore, it is important that the Clear Creek Floodplain Reconnection Project be designed to minimize impacts to agriculture.

### Considerations for the Master Planning Process:

- Designs that minimize impacts to farmland would help maintain agricultural viability in Pierce County as well as in the Clear Creek area.

## 6.15 How would the new levee and removal of the tide gates interact with climate change?

Climate change will affect the physical conditions that impact agricultural viability in the Clear Creek area, including hydrology, water supply, groundwater, sediment, and sea level rise. Regional climate change projections can suggest a range of potential impacts (there is no climate information specific to the Clear Creek area), which makes it challenging to identify impacts and to incorporate climate change into design of the Clear Creek Floodplain Reconnection Project.

### Hydrology and Flood Risk

#### Existing Trends and Projections

Hydrology in the Puyallup River Watershed and in the Clear Creek Subbasin is expected to change as snowpack is reduced and precipitation patterns shift. The depth of snowpack on April 1 (the approximate current timing of peak annual snowpack in Northwest mountains) in the Puyallup River Watershed is projected to decline between 52 and 58 percent by the 2050s. Winter streamflows in the Puyallup River are projected to increase by 27 to 34 percent by the 2050s (CIG, 2015a).

Flood risk is projected to increase in the Puyallup River watershed and across Puget Sound. Peak river flows are projected to increase between 18 and 55 percent by the 2080s, and heavy rainfall events will become heavier (CIG, 2015b). The volume of the 10-year flood in the Puyallup River is projected to increase by 12 to 85 percent by the 2080s (CIG, 2016). Increased flooding would increase the cost of flood protection and stormwater management. Highways and other roads adjacent to rivers would flood more frequently. Existing flood control infrastructure, such as levees and tide gates, would likely be less effective as more frequent and larger floods exceed the

events the infrastructure was designed for (CIG, 2015b). Flood risk on Clear Creek and its tributaries can also be expected to increase with climate change.

### Considerations for the Clear Creek Floodplain Reconnection Project

Increasing flood risk with climate change increases the importance of projects that would make the flood system in the Clear Creek area more resilient, such as the Clear Creek Floodplain Reconnection Project and addressing deficiencies in River Road Levee. Increased winter flows will also affect drainage in the Clear Creek area. Pursuing improvements to the agricultural drainage system as part of the Clear Creek Floodplain Reconnection Project could help offset these impacts. Conversely, if the project were constructed in a way that negatively impacted agricultural drainage, climate change could magnify those negative impacts in the future.

## **Surface and Groundwater Supply**

### Existing Trends and Projections

While winter streamflows are expected to increase, summer streamflows would decrease. Summer streamflows in the Puyallup River are projected to decrease by 18 to 20 percent by the 2050s (CIG, 2015a). Most agriculture in the Clear Creek area relies on groundwater for irrigation rather than the Puyallup River. Flows in the Clear Creek area are also likely to decrease in the summer, which could potentially affect groundwater. Changes in sea level and hydrology would also impact groundwater in the Clear Creek area. As described in Section 5.4, the information about groundwater in the Clear Creek area is currently limited and more information is needed to characterize these potential changes. More information about how changes in summer streamflows could affect water supply in the Clear Creek area would help farmers develop strategies to protect agricultural viability in the long-run.

### Considerations for the Clear Creek Floodplain Reconnection Project

The Clear Creek Floodplain Reconnection Project is not anticipated to affect surface water supply in the Clear Creek area, but could affect groundwater supply. More information on existing groundwater conditions is required to understand this potential impact. Studies of groundwater should include climate change projections.

## **Sediment**

### Existing Trends and Projections

Erosion and the transport of sediment from the upper Puyallup River Watershed are both expected to increase in the future as heavy rainfall causes increased erosion and sediment transport and as higher streamflows and larger floods transport more sediment downstream. Changes in hydrology are also expected to change erosion rates and sediment in Clear Creek and its tributaries. Increased sediment in the Puyallup River and in Clear Creek and its tributaries could cause additional channel aggradation. Aggradation of the Puyallup River could increase flood risk in the Clear Creek area and could raise groundwater levels because the carrying capacity of the river would be reduced. Aggradation of Clear Creek could reduce drainage capacity.

## Considerations for the Clear Creek Floodplain Reconnection Project

Any analysis of how the proposed Clear Creek Floodplain Reconnection Project would affect agricultural drainage should also consider the fact that sediment levels in the drainage system could increase with climate change.

### **Sea Level Rise**

#### Existing Trends and Projections

Sea level is projected to rise an additional 14 to 54 inches in the Puget Sound region by 2100 (compared to 2000), although changes at specific locations will vary (CIG, 2015b). Sea level rise and reduced summer flows are projected to increase the risk of saltwater intrusion into groundwater, especially if groundwater extraction increases (CIG, 2015b). Sea level rise could slow the drainage of agricultural lands across Puget Sound\.

Currently, the saltwater wedge in the Puyallup River is downstream from the mouth of Clear Creek. Sea level rise could cause the saltwater wedge to extend farther up the Puyallup River, potentially reaching the Clear Creek area. Sea level rise could also cause saltwater intrusion into groundwater in the area, affecting groundwater quality. Sea level rise could also increase the surface elevations of the Puyallup River adjacent to the Clear Creek area.

## Considerations for the Clear Creek Floodplain Reconnection Project

Understanding sea level rise is key to identifying the impacts of the proposed Clear Creek Floodplain Reconnection Project on groundwater, drainage, and flood risk and needs to be considered in project design.

**Summary of Potential Impacts to Agriculture:** Climate change will have many and varied effects on physical conditions that contribute to agricultural viability in the Clear Creek area, including flood risk, drainage, water supply, and groundwater. These conditions would also be affected by the Clear Creek Floodplain Reconnection Project. Existing climate change information for the Clear Creek area is based on regional datasets. No climate change information specific to the Clear Creek area has been developed. This information needs to be developed in order to better understand the impacts to agriculture of the proposed project, as well as habitat needs and future flood risk conditions in the area.

### **Considerations for the Master Planning Process:**

- Climate change projections and modeling need to be considered in the design of the proposed project. This should include:
  - Dynamic downscaling of predicted precipitation patterns to provide a more accurate forecast of heavy rainfall statistics than provided by the statistical downscaling methods used for the Puyallup River watershed.
  - Translating precipitation projections into streamflow levels.
  - Developing a flood projection model for the Puyallup River watershed and the Clear Creek area.

- Analyzing the implications of projected sediment transport increases from the tributaries of Clear Creek.
- Analyzing water availability in the summer during low flows under climate change scenarios.
- Analyzing the impact of sea level rise on groundwater including salinity impacts in the Clear Creek area.
- Analyzing sediment loading on the Puyallup River to project changes in the depositional and erosional environment in the Puyallup River near Clear Creek.

## 6.16 How will other proposed projects in the Clear Creek area combine with the Clear Creek Floodplain Reconnection Project to affect farms?

Other current and future projects in the Clear Creek area have the potential to impact agriculture and create cumulative impacts with the Clear Creek Floodplain Reconnection Project. This section addresses two known transportation projects proposed in the area: the extension of Canyon Road and the expansion of the BNSF Railroad line. Other future projects may also affect agricultural viability.

### **Existing Conditions and Trends**

Pierce County Roads plans to extend Canyon Road from Pioneer Way to 52<sup>nd</sup> Street and to build a new bridge over Clarks Creek and the Puyallup River. This would require construction of a four to five lane road that would cross agricultural fields in the Clear Creek area south of Chief Leschi Schools. Construction is scheduled for 2020 to 2022, depending on funding (Pierce County, 2017). The project would reduce the amount of agricultural land in the area and could bisect agricultural fields creating access problems

The BNSF Railway has indicated that it plans to expand its rail line through the Clear Creek area to the north, near where Clear Creek is located. Little is known about BNSF's plans at this time. Any impacts to Clear Creek would need to be mitigated, which could provide an opportunity to fund a realignment of the creek that could provide better habitat and drainage. However, expanding the railway line and potentially realigning Clear Creek could require use of land that is currently in agriculture. This potential action by BNSF needs to be tracked closely moving forward.

### **Considerations for the Clear Creek Floodplain Reconnection Project**

Impacts to agricultural lands from the Clear Creek Floodplain Reconnection Project need to be considered in context of the adjacent loss of agricultural land to the Canyon Road extension and the potential loss of agricultural land to the BNSF Railway.

**Summary of Potential Impacts to Agriculture:** Upcoming transportation projects would have a negative impact on farming in the Clear Creek area unless adequately mitigated. Any impacts to

agriculture from the Clear Creek Floodplain Reconnection Project need to be considered cumulatively with impacts from transportation projects.

**Considerations for the Master Planning Process:**

- The master planning process should track these projects and consider the cumulative impacts.

## 6.17 Would it be possible to conduct agriculture on the wet side of the levee?

Pierce County has suggested that, depending on the levee alignment, it may be possible to farm on the wet side of the levee. For example, if the levee were constructed at the 18-foot contour, lands between elevations of about 15 to 18 feet NAVD could potentially be farmed (though it is not clear at this time whether these areas would be frequently inundated). This presents an opportunity to preserve farmland or potentially to increase the acreage of farmland in the Clear Creek area. It is unclear at this point exactly what conditions would be on the wet side of the levee with the tide gates removed and a levee constructed. If more information is developed, it may be possible to determine that agriculture would be feasible on the wet side of the levee. However, with current information, there appear to be several challenges to agriculture on the wet side of the levee that suggest it would not be feasible. This section details those potential challenges. At the end of the section, a list of conditions that would make agriculture on the wet side of the levee feasible is presented.

This section refers only to potential farming on the wet side of the proposed levee. The discussion in this section does not apply to farming on the dry side of the proposed levee.

One of the purposes of the Clear Creek Floodplain Reconnection Project is to open the Clear Creek area to tidally-influenced inundation. Currently, the tide gates close once or twice daily, suggesting that tidally-influenced inundation would enter the Clear Creek area up to twice a day if the tide gates were removed. If the tide gates were removed now, the Clear Creek area would be inundated with freshwater because the saltwater wedge in the Puyallup River only extends to the I-5 crossing. However, with anticipated sea level rise, the saltwater wedge will likely move upstream, potentially reaching the outlet of Clear Creek. The combination of removal of the tide gates and sea level rise could potentially cause the Clear Creek area to be inundated with saltwater, which would cause agriculture in the inundated area to no longer be viable.

As described above in Section 6.8, the wet side of the levee would likely become a depositional area for sediment from the Puyallup River. In high water events, sediment could potentially be deposited on agricultural fields. More analysis of sediment dynamics on the wet side of the levee is needed to understand the extent of potential sediment deposition. Sediment deposition would likely affect agricultural drainage for farms on the wet side of the levee as channels are filled in with sediment and new channels are formed. Agricultural drainage would require maintenance, which would likely be incompatible with best stewardship practices for a habitat restoration area.

Farms on the wet side of the levee would be subject to more frequent inundation from tidally influenced water than under current conditions. NHC modeling shows that, with the tide gates removed and a levee at the 18-foot contour, the 10-year flood stage would reach an elevation of approximately 18.6 feet NAVD (NHC, 2016). This means that all agricultural lands on the wet side of the levee would be fully inundated by at least 0.5 foot of water approximately once every 10 years. This modeling analysis does not consider increased winter streamflows or sea level rise under climate change, which would likely increase the frequency that these lands would be inundated.

Many farmers rely on cover crops to increase soil fertility and to protect soil from erosion in winter months. Inundation on the wet side of the levee could threaten the viability of cover crops and could cause farmers to use chemical methods to maintain or enhance soil fertility and health. These chemicals are unlikely to be compatible with a habitat restoration area.

Because of the frequency of flood inundation on the wet side of the levee, it would be inadvisable to build farm infrastructure, including farm houses, or to store equipment on the farms. This could limit the area to being farmed by large-scale farmers who rent and own fields in various locations. Smaller-scale, direct market farmers who live on their farms would not be inclined to farm properties on the wet side of the levee. Farms currently operating in the Clear Creek area between the 14 and 18 foot contours are primarily smaller-scale farms, so they could be displaced by the Clear Creek Floodplain Reconnection Project even if areas on the wet side of the levee could be farmed.

Because storing equipment on the wet side of the levee would risk damage to the equipment, farmers would regularly need to transport equipment to and from farms on the wet side of the levee. Access to the wet side of the levee would likely be limited. The more access points that are included in the project design, the larger footprint of the project would need to be. Roads and other impervious surfaces on the wet side of the levee would likely be incompatible with a habitat restoration area.

Farming could not occur on the parcels on the wet side of the levee and in the construction zone during the multi-year construction period of the project. Farming throughout the area could be disrupted during construction.

Farmers on the wet side of the levee could also face regulatory hurdles to farming. While existing farms in the Clear Creek area (and elsewhere) are not subject to critical area regulations, new farms on the wet side of the levee would likely have to comply with regulations to protect wetlands and other critical areas. Large portions of the area on the wet side of the levee would likely be designated as wetland or as fish habitat, and the required buffers around these areas would further reduce the area available to be farmed.

Some Clear Creek Floodplain Reconnection Project stakeholders have suggested that farmers could adapt their crop choices to allow farming on the wet side of the levee and have suggested crops such as rice or cranberries. Neither of these specialized crops is suited to the tidal fluctuations that would occur on the wet side of the levee. Cranberries need to be grown in specific conditions with acidic peat soil. Cranberries are not grown underwater; instead, cranberry bogs are flooded with water only before harvesting. Rice needs to be grown in conditions where

uniform flooding and controlled drainage are possible. This is often achieved through use of diking, machinery, and irrigation. Fertilizers are typically used to grow rice. The practices and conditions required for growing rice and cranberries could not be achieved on the wet side of the levee nor would they be compatible with the proposed habitat restoration area.

**Summary of Potential Impacts to Agriculture:** Due to the frequency of inundation, the potential for saltwater inundation in the future, access issues, and potential regulatory hurdles, farming on the wet side of the levee is unlikely to be feasible. In addition, some agricultural activities, such as use of chemicals and drainage maintenance, would not be compatible with a habitat restoration area.

#### **Considerations for the Master Planning Process:**

- The master planning process should assume that farming on the wet side of the levee would not be feasible.
- The idea of farming on the wet side of the levee could be revisited in the future if the following conditions are met:
  - The levee alignment chosen would allow adequate areas on the wet side of the levee at suitable elevations to be farmed;
  - Access to the fields could be provided;
  - The frequency with which the dry areas would be inundated by floodwaters was known;
  - Sediment deposition on the wet side of the levee was well understood and adequate drainage could be ensured;
  - It was known that the saltwater wedge would not travel far enough upstream to inundate the area with saltwater; and
  - The habitat restoration area on the wet side of the levee would not be adversely impacted by agricultural practices.

## **7.0 Recommendations for the Master Planning Process**

This memorandum has identified several potential impacts of the Clear Creek Floodplain Reconnection Project that could negatively affect agricultural viability in the Clear Creek area. This memorandum has also identified design considerations for the Floodplain Reconnection Project that could reduce these negative impacts, and in some cases, provide benefits to agricultural viability. The master planning process for the project should take a comprehensive approach so that the issues affecting agriculture are considered along with the potential flood and habitat benefits. The master planning process should give special consideration to these issues in order to maintain agricultural viability:

- Design the project to minimize the conversion of agricultural land.
- Incorporate an effective agricultural drainage system into the project design. Projects that would benefit both agricultural drainage and fish habitat, such as separating agricultural drainage from Clear Creek, should be considered.
- Maximize the amount of flood protection provided to agricultural lands on the dry side of the ring levee. This should include consideration of climate change projections and factors such as the River Road Levee freeboard issues.
- Incorporate climate change projections into the project design so that the project provides long-term benefits for agriculture and other interests.
- Develop plans to minimize the indirect impacts of the project that could affect agricultural viability, including preventing criminal activity on vacant lands and maintaining the viability of Drainage District 10 and the Riverside Fire District.

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## **APPENDIX F**

### **Effect of Upstream Development on the Clear Creek Area Technical Memorandum**



# EFFECT OF UPSTREAM DEVELOPMENT ON THE CLEAR CREEK AREA

Technical Memorandum  
Farming in the Floodplain Project

Prepared for  
PCC Farmland Trust

May 2017

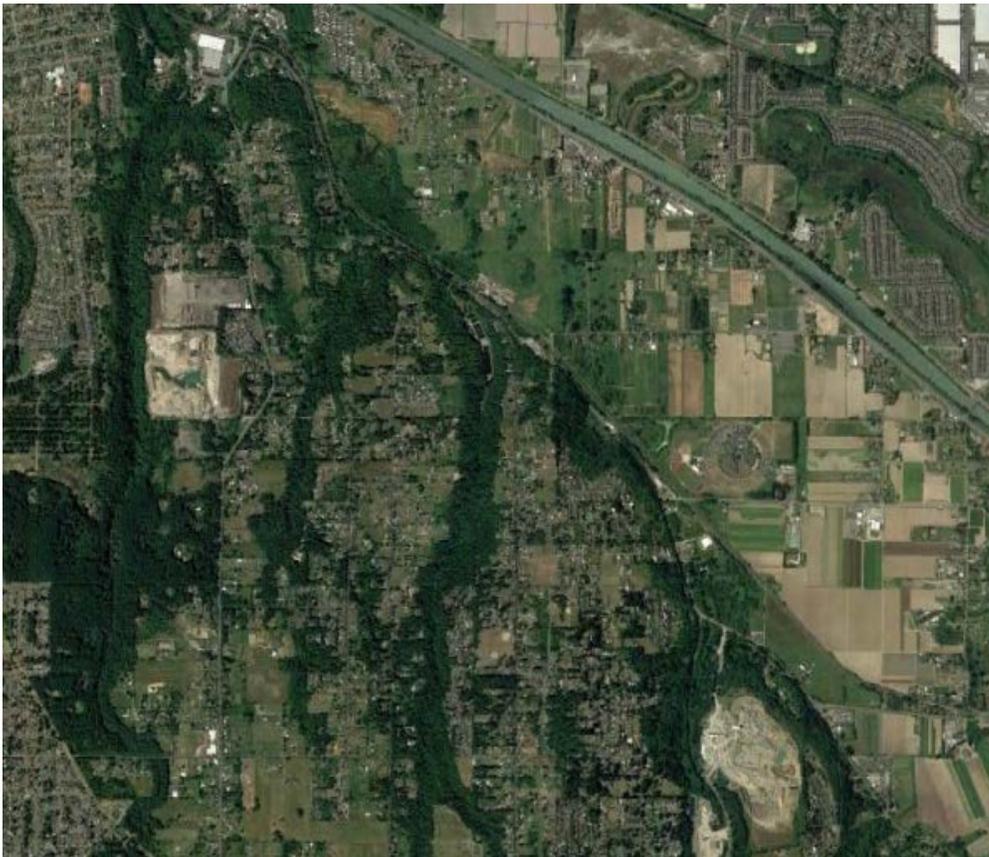


Photo credit: Google Earth



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## 1.0 Project Background and Description

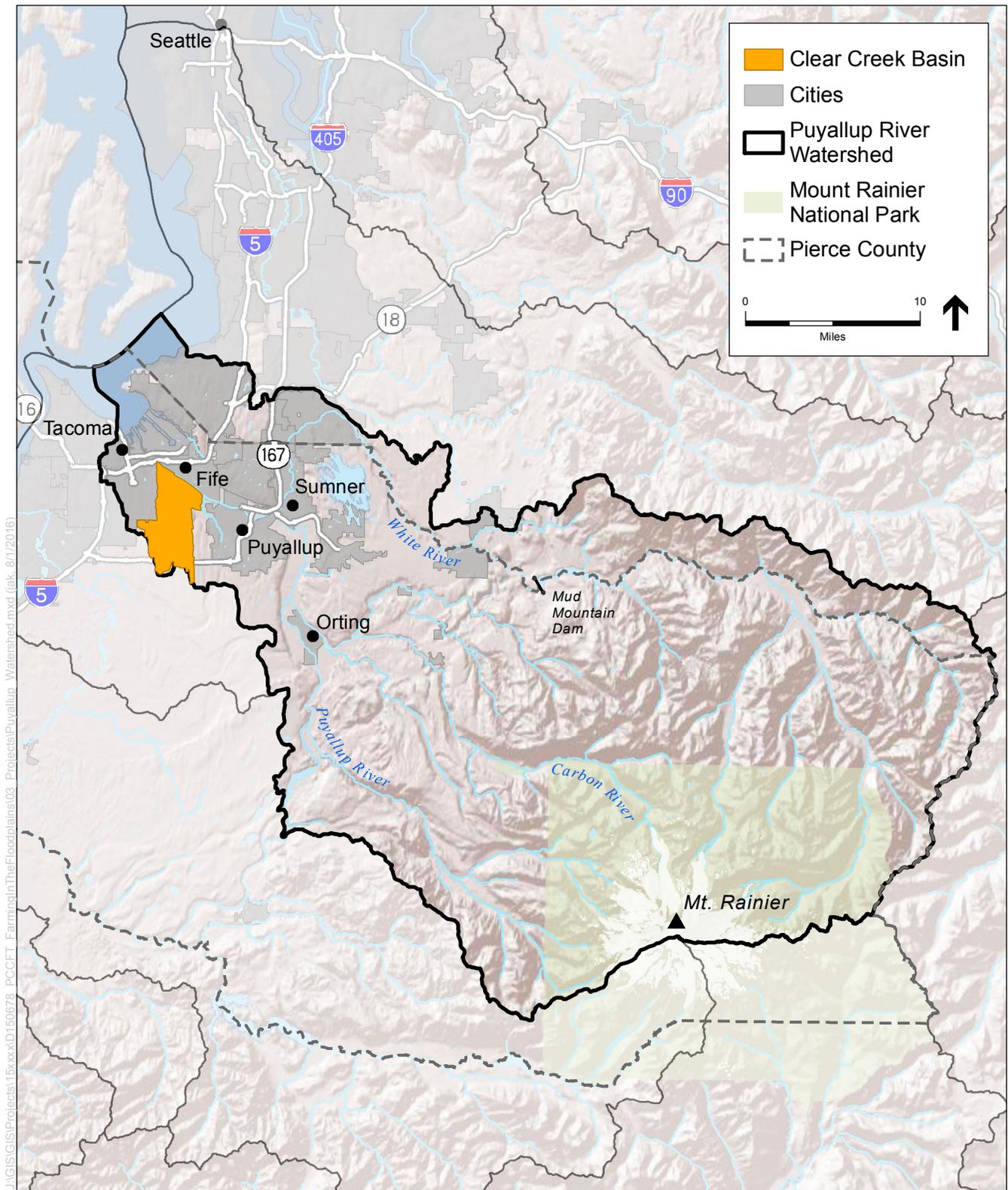
The purpose of this technical memorandum is to describe historic and recent land cover conditions in the Clear Creek area to increase understanding of how changes in impervious surface may be affecting the amount and timing of runoff delivered from upstream development. The evaluation was primarily conducted in GIS using readily available data from National Oceanographic and Atmospheric Administration (NOAA), Washington Department of Fish and Wildlife (WDFW), and Pierce County. The memorandum also describes changes in stormwater regulations over time.

This technical memorandum has been prepared as part of Phase 2 of the Farming in the Floodplain Project (FFP). The FFP is one of four components of the Floodplains for the Future: Puyallup, White, and Carbon Rivers project, which is funded by a Floodplains by Design grant from the Washington Department of Ecology (Ecology). The purpose of the FFP is to advance progress toward a collectively agreed upon plan for the Clear Creek area that improves agricultural viability in the area while also meeting goals for flood risk reduction and salmon habitat enhancement. The FFP is intended to clarify the needs and interests of the agricultural community within the Clear Creek area.

Throughout the first phase of the FFP, residents of the Clear Creek area asked how development in upstream areas of the Clear Creek Basin has affected flooding, drainage, and sediment conditions in the Clear Creek area. This memorandum has been written to summarize some of the available information on upstream development and consider how the upstream development may contribute to flooding and sediment conditions in the Clear Creek area. Available information regarding sediment in the tributaries of Clear Creek and in the lower Clear Creek area is documented in the [Sediment Conditions in the Puyallup Watershed and Clear Creek Technical Memorandum](#) (ESA, 2016). Therefore, this memorandum focuses on stormwater flows. The memorandum includes available information on the general impacts of upstream development, on stormwater regulations in Washington State and in Pierce County, on the history of development in the Clear Creek Basin, and on existing stormwater storage and treatment infrastructure.

## 2.0 Study Area

The study area for the FFP is the Clear Creek area, part of the Clear Creek Basin of the Puyallup River Watershed (Figure 1). The Clear Creek Basin is within the Puyallup River Watershed and is located south of the Puyallup River, north of 128th Street East, west of 66th Avenue East, and east of McKinley Avenue East. The Clear Creek Basin includes the four tributaries to Clear Creek: Swan Creek, Squally Creek, Clear Creek, and Canyon Creek. The Clear Creek area is roughly 1.5 square miles (990 acres) in size and bounded by the Puyallup River to the north, Pioneer Way East to the south and west, and 52nd Street East to the east.



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SOURCE:  
 ESA, 2016; King County, 2015; Pierce County, 2013; Ecology, 2007;  
 OSM, 2016; WDNR, 2010

PCCFT Farming in the Floodplain. 150678

**Figure 1**  
 Puyallup Watershed

### 3.0 Approach

GIS was used to document when development in the Clear Creek Basin occurred. Digital data sources included:

- National Oceanographic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) data
- Washington Department of Fish and Wildlife (WDFW) High Resolution Change Detection (HRCDD) data
- Pierce County parcel data

These data were compared over time to document when development occurred and the extent of that development. The results of the GIS analysis were used to produce the maps and tables in Section 7 of this memorandum that illustrate the history of development and the extent of impervious surfaces in the basin.

This memorandum also reviewed stormwater regulations in the State of Washington and Pierce County to identify regulatory changes over time. The focus of the review was on requirements for sizing stormwater conveyance systems and controlling flow rates from developments. Historic Pierce County regulations were provided by Pierce County Surface Water Management (SWM) and are listed in the References section of this memorandum.

A limitation in evaluating the effects of upstream development on the Clear Creek area is that stream flows have not been monitored continuously in the four tributaries of Clear Creek. The USGS has maintained a seasonal gage on Swan Creek at 80th Street East (Station 12102190) since 1989. This gage records water elevations from October 1 to April 30 which, with the use of a rating curve, allows the corresponding flows to be estimated. The USGS previously maintained a continuous stream gage on Clear Creek at Pioneer Way (Station 12102140), but that gage was removed in 1998. Without comprehensive and consistent records of stream data, comparing how streamflow has changed over time as patterns of urbanization and the stormwater regulations have changed cannot be done.

### 4.0 Relationship between Upstream Development and Stormwater Runoff

Stormwater runoff is defined as the portion of precipitation that does not naturally percolate into the ground or evaporate, but flows over the land surface or in pipes or other features of a stormwater drainage system into a surface water body or a constructed stormwater facility (Puget Sound Partnership, 2008). Development typically changes stream flows by increasing stormwater runoff and decreasing infiltration. This is generally caused by adding impervious surfaces (such as pavement and rooftops), compacting the soil, draining wetlands, and reducing vegetation. The following figures illustrate the changes in stormwater runoff caused by development.

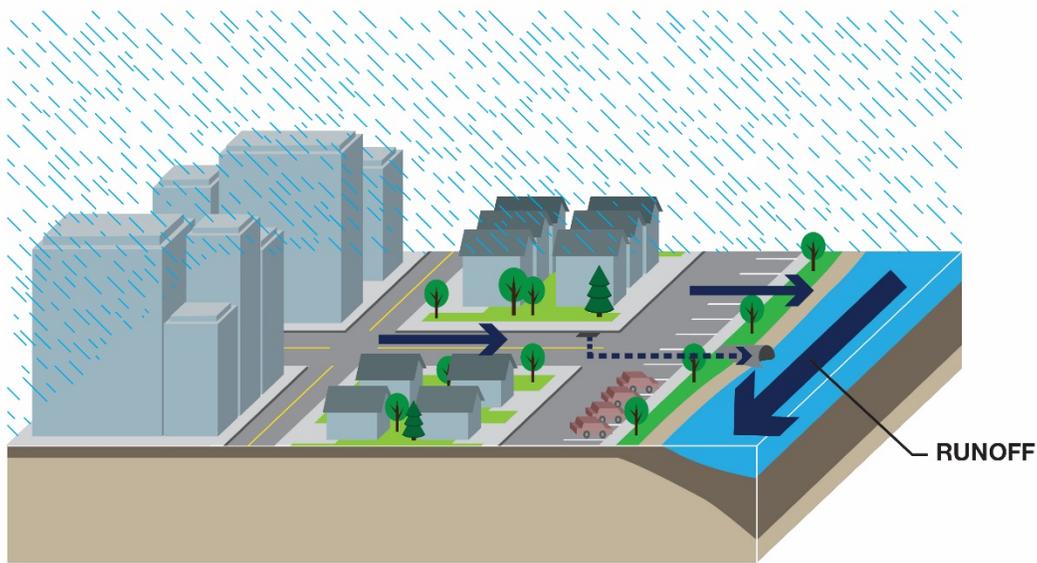
Figure 2a illustrates how precipitation moves through an undeveloped watershed. The dashed lines show precipitation infiltrating into the permeable soil where it flows below the surface.

Some of the water continues to percolate down to the groundwater level and some moves laterally to discharge to streams or other surface water bodies. The water that flows below the surface moves slowly through the system.



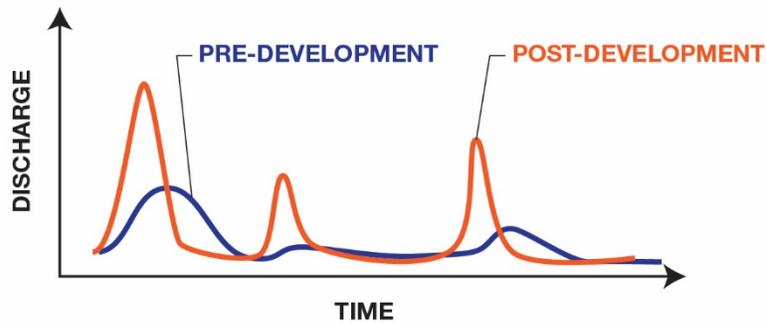
**Figure 2a.** Undeveloped Watershed.

Figure 2b shows how precipitation moves through a watershed where development (e.g., buildings, roads, and sidewalks) has removed vegetation, compressed the soil, and converted permeable areas to impervious surfaces. The increase in impervious surface reduces infiltration and subsurface flow and causes more of the precipitation to run over the surface. Water also flows through stormwater pipes which discharge directly to streams. The increased runoff causes water to reach surface water bodies more quickly and increases peak flows in streams following precipitation events.



**Figure 2b.** Developed Watershed.

These changes tend to not only increase the quantity of runoff, but to also reduce the time it takes for the runoff to become concentrated and flow into streams. This causes streamflows in developed areas to spike in response to precipitation as shown in Figure 2c. In undeveloped watersheds, streamflows (shown in blue) have flatter peaks following a storm event. In developed watersheds, streamflows (shown in red) peak more quickly and the peaks are higher.



**Figure 2c.** Hydrograph of Stormwater Peak Discharges

In the 1990s, increasing awareness of the relationship between development and changes to stream hydrology led to the development of stormwater regulations and guidelines that attempted to reduce the consequences of urbanization on aquatic resources. The following section describes how stormwater regulations have changed over time in response to changing understanding of the impacts of development on stormwater runoff.

## 5.0 Stormwater Management in Washington State and Pierce County

In the U.S., water quality and the discharge of pollutants into waters of the United States are regulated by the Environmental Protection Agency (EPA) under the Clean Water Act (CWA) of 1972 via the National Pollutant Discharge Elimination System (NPDES). Specifically, the NPDES permit program regulates pollutants discharged through a point source to waters of the United States. In 1973, EPA delegated authority to issue NPDES permits to the Washington Department of Ecology (Ecology). In 1987, the CWA was changed so that certain types of stormwater discharge were defined as a point source of pollution, and thus require a NPDES permit.

Stormwater management in Washington State is primarily regulated by Ecology, although local jurisdictions may implement their own stricter regulations. Ecology's permit program implements the requirements of EPA's stormwater programs, which cover discharges to surface water, as well as Washington's waste discharge permit program, which covers discharges to groundwater. As EPA rules change, Ecology's permit requirements must be updated.

Ecology publishes stormwater management manuals, which are not law, but rather guidance on how to meet permit requirements to control the quantity, quality, and timing of stormwater discharges resulting from development projects. The first manual was published in 1992 for the

Puget Sound Basin (Ecology, 1992). In 2001, Ecology published a Stormwater Management Manual for Western Washington, which was updated in 2005 and 2012. The 2012 manual was amended in 2014 (Ecology, 2001, 2005, 2014).

In Pierce County, stormwater is managed by the Surface Water Management division (SWM). Prior to 1997, Pierce County regulated stormwater through a series of ordinances and guidelines for development that included standards and requirements for drainage (Pierce County 1984, 1986, 1991). In 1995, Pierce County received an NPDES permit for stormwater, the terms of which required the County to adopt a stormwater management technical manual (PC Ordinance 96-46S2). Rather than adopt Ecology's Manual, Pierce County developed its own comparable manual in 1997, the Stormwater Management and Site Development Manual (Manual) (Pierce County, 1997). Pierce County has revised the Manual several times; the current Manual was adopted in December of 2015 (Pierce County 2005, 2008, 2012, 2015). The Manual offers general guidance as well as specific requirements that must be met to comply with county permit regulations.

Over time the requirements and guidelines for stormwater management have become increasingly strict, especially the requirements for limiting the peak rate of runoff from a site. Starting in 1997, the guidelines included conveyance and flow control standards that required stormwater systems to regulate the peak runoff rate from a site. The requirements were intended to reduce peak stormwater flows and delay when these peak flows reach streams to more closely mimic predevelopment conditions. Starting in 2005, the guidelines included requirements that the duration of stormwater discharge from a site match the duration modeled under predeveloped conditions. The purpose of these increasingly stringent requirements for stormwater management is to minimize the increase in erosion and peak streamflows caused by development.

## **6.0 Requirements for Redevelopment**

Pierce County stormwater regulations apply to new development and also to redevelopment, but there are exemptions. Minor development and redevelopment are not required to upgrade stormwater systems if they are exempt from a site development permit. Pierce County Code (PCC) 17A.10.070(C) lists the conditions under which a site development permit is not required. Some of the exemptions are based on the size of the cumulative development or redevelopment for each parcel of land. According to PCC 17A.10.070(C)(1)(h) exemptions include:

- Land disturbing activity that does not exceed 7,000 square feet
- The creation of less than 500 square feet of new impervious/hard surface
- The creation of less than 500 square feet of replaced impervious/hard surface
- The conversion of less than 0.75 acres of native vegetation to lawn
- The conversion of less than 2.5 acres of native vegetation to pasture
- Projects that cause a 0.10 cubic feet per second (cfs) increase in the 100-year discharge flow
- Grading of less than 50 cubic yards

To be exempt from a site development permit, minor new development and redevelopment projects must also meet other requirements, including compliance with construction stormwater requirements and restrictions on work in closed depressions and drainage courses, on steep

slopes, in critical areas and their associated buffers, and within County rights-of-way. Public and private utility work outside of the County right-of-way that that creates less than 2,000 square feet of new or replaced impervious/hard surface is also exempt from a site development permit. Installation of a new storm drainage system requires a site development permit and compliance with current stormwater standards.

## 7.0 History of Development in the Clear Creek Basin

The GIS exercise conducted for this technical memorandum evaluated the change in land cover in the Clear Creek area over time. The exercise is based on parcel data that indicates when development of a parcel occurred. A developed parcel is one on which some development, including vegetation clearing and construction of impervious surfaces has occurred; it does not imply that the entire parcel is impervious. Table 1 shows the percentages of parcels in the Clear Creek Basin developed in each decade between 1900 and 2010. As the table indicates, over 60 percent of parcels currently developed in the subbasin were developed prior to the 1990s when Pierce County adopted stormwater regulations that address peak flows and flow durations. The most active decades for development in the subbasin were the 1960s (13.8 percent), 1970s (10.4 percent), and 1990s (11.9 percent).

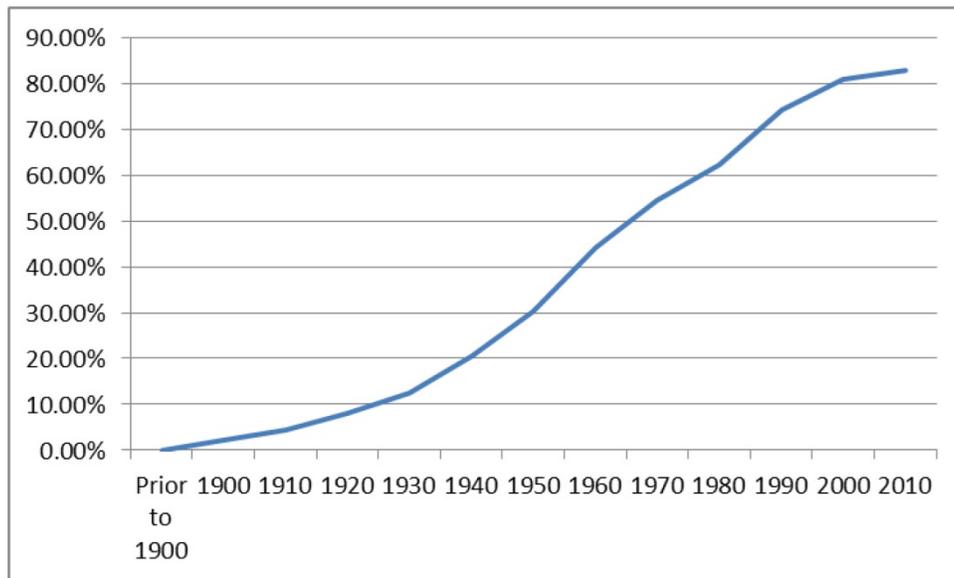
**Table 1. Progression of parcel development between 1900 and 2010**

Decade of Parcel Development	Percentage of Total Parcels	Dates of Stormwater Regulation Updates
No Date <sup>1</sup>	10.95%	
Prior to 1900	0.03%	
1900s	2.20%	
1910s	2.27%	
1920s	3.67%	
1930s	4.38%	
1940s	7.94%	
1950s	9.77%	
1960s	13.80%	
1970s	10.43%	
1980s	7.74%	1984
1990s	11.95%	1991, 1997
2000s	6.65%	2005, 2008
2010s	2.06%	2012, 2015
No structures on the parcel	6.17%	

<sup>1</sup> The date of development for some parcels is not included in the assessor's data.

Source: Pierce County Assessor data

The graph in Figure 3 shows the steady increase in development between the 1940s and 1990s. Only slightly over 6 percent of the parcels have not been developed. This number includes parks and other open space areas and also privately owned parcels that have no structures built on them.



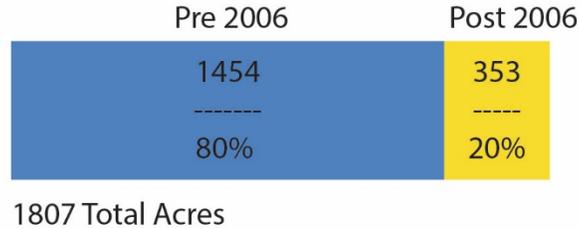
**Figure 3. Cumulative percent of developed parcels over time**

Figure 4 shows the year each parcel was developed in the Clear Creek Basin, grouped by the stormwater standards in place at the time. The figure clearly shows that most parcels (shown in light blue) were developed prior to 1991 before effective stormwater regulations were first put in place. A limited amount of development occurred after 1997 when stormwater guidelines first included conveyance and flow control standards that required stormwater systems to regulate the peak runoff rate from a site. Even less development has occurred since 2005 when stormwater regulations required that the duration of stormwater discharge from a site match the duration modeled under predeveloped condition. As shown in the pie chart in the legend of Figure 4, 58 percent of the development occurred prior to 1991 while only 4 percent has occurred since 2005 when stormwater regulations started requiring that the duration of stormwater discharge from a site match the duration of discharge modeled under predeveloped conditions.



Figure 5 further illustrates the percent of development that occurred prior to enactment of stormwater regulations aimed at matching the duration of discharge from a site to the duration modeled under predeveloped conditions. Approximately 20 percent (1,807 acres) of the Clear Creek Basin has been converted to impervious surface. Of the 1,807 acres of impervious surface in the Clear Creek Basin, 1,454 or 80 percent were developed prior to 2006.

**Figure 5. Percentage of Acreage Developed Before and After 2006**



## 8.0 Findings

### 8.1 Effective Impervious Surface Area

Effective impervious area (EIA) is the portion of the total impervious area that flows directly to a stream channel. The most recent calculation of EIA for the Clear Creek Basin was calculated in 2006 as part of the Clear/Clark's Creek Basin Plan (Pierce County, 2006). At that time the EIA for the entire Clear Creek Basin was 19 percent. Specific EIAs for each tributary basin were:

- Swan Creek: 21 percent
- Squally Creek: 11 percent
- Canyon Creek: 21 percent
- Clear Creek: 17 percent

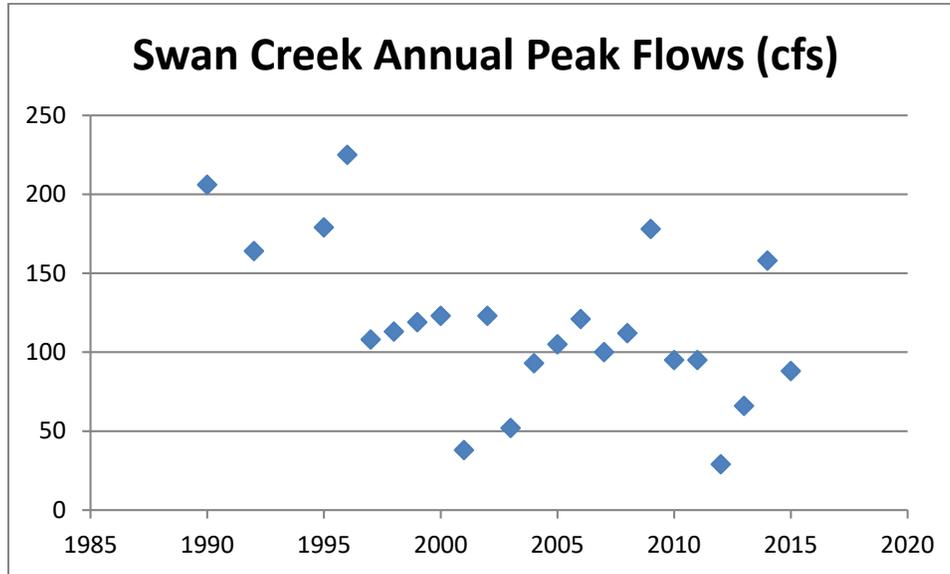
It is not possible at this time to update the EIA calculation because of a lack of available hydraulic data. However, it is likely that the EIA is somewhat higher now than in 2006 because of recent development. The trend of increasing development and EIA likely means that peak flows and erosion have increased in the Clear Creek Basin.

### 8.2 Ongoing Effects of Development

Figure 6 below shows the annual peak flows calculated from data recorded at the seasonal gage in Swan Creek. As shown in the graph, there is no indication that peak flows have increased since the gage was installed in 1989. As described in Section 7, the majority of development in the Clear Creek area occurred before 1989, so data from the Swan Creek gage cannot tell how current conditions differ from conditions before development occurred in the upstream areas. The data in

the graph represent a small sample size and only include data for one of the four tributaries. However, the data does not show an increasing trend in peak flows in recent years with ongoing upstream development.

**Figure 6. Swan Creek Annual Peak Flows**



Source: USGS, 2017.

### 8.3 Conclusions and Relationship to Agricultural Viability

As described in Section 7 of this memorandum, the majority of development in the Clear Creek Basin occurred before stormwater regulations were developed for Pierce County. The stricter stormwater requirements implemented since the 1990s have likely reduced the impacts of more recent development on runoff and peak flows. However, no studies have been conducted on the effectiveness of the stormwater regulations in the Clear Creek Basin. Retrofits of older stormwater facilities and installing regional detention facilities may be helpful in reducing impacts from prior development, but a lot of redevelopment is exempt from meeting current stormwater standards as discussed in Section 6.

It is likely that upstream development in the Clear Creek Basin that occurred before stormwater regulations were in place has increased streamflows in the Clear Creek area, particularly peak flows. With the stormwater regulations that are currently in place, it is unlikely that new development is a major cause of increased in flooding in the Clear Creek area.

Other factors are the more likely causes of drainage and flood risk issues for Clear Creek area farms. These factors include flooding from improperly operating tide gates at the mouth of Clear Creek, changes in Puyallup River flooding conditions, and climate change. Historic lack of drainage maintenance is likely the biggest cause of agricultural drainage problems in the Clear Creek area.

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