Return on Investment Analysis of Flood Risk Management Solutions for Pierce County

EARTH ECONOMICS

Prepared with data provided by:

Pierce County
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Earth Economics is responsible for the content of this report.

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Table of Tables

Table of Figures

Table of Abbreviations

BCA	**Benefit-Cost Analysis**
CMZ	**Channel Migration Zone**
USACE	**U.S. Army Corps of Engineers**
CRS	**Community Rating System**
CSR	**Compensatory storage requirements**
DFF	**Deep and/or fast-flowing floodway**
DNS	**Declaration of Non-Significance**
ESV	**Ecosystem Service Valuation**
FCZD	**Flood Control Zone District**
FEMA	**Federal Emergency Management Agency**
LWM	**Large Woody Material**
NPV	**Net Present Value**
SWM	**Surface Water Management**
ROI	**Return on Investment**

Executive Summary

Much of Pierce County's economic might and 22,100 residents reside squarely in the path of potentially catastrophic flooding in the Puyallup River Watershed.[1] The Tacoma, Puyallup and Sumner municipal wastewater treatment plants also lie in the floodway. The total losses from a 100-year flood could exceed $725 million.[2]

The Puyallup River is unique in the United States. Originating on the slopes of Washington State's Mount Rainier at a height of 14,410 feet, it flows to sea level within a few dozen miles, which creates significant flood hazards.

The county's existing flood-protection infrastructure, especially its aging levees, are inadequate to withstand flood events expected to be more frequent and more severe in the future due to climate change. Most levees within Pierce County are no longer accredited by the Federal Emergency Management Agency (FEMA).[3] Most of the levees and revetments in the upper parts of the watershed were never intended to meet the 100-year level of protection required by FEMA.[4]   In order to meet FEMA's accreditation standards, more than $300 million in upgrades on flood levee and bank stabilization projects are required.[5]

In recent years, Pierce County has adopted one of the most progressive flood risk reduction strategies in the U.S., establishing a strong regulatory structure to keep new development out of harm's way. While past construction has left a legacy of structural issues preventing sustainable flood management and buildings at high risk of flooding, actions to remedy these problems have been identified and are being pursued.

Despite the existing and future risks to people, homes and infrastructure, the county's financial resources to deal with the flooding issue are very limited. The total cost of proposed flood projects contained in the county's 2013 Flood Hazard Management Plan is $300 million to $400 million.[6] The cost of building a new setback levee along North Levee Road between Tacoma and Puyallup alone would cost $104 million.[7]   The revenue to be generated by a newly created Pierce County Flood Control Zone District is only $6.89 million a year.[8]

The limited financial resources available makes purely structural flood risk management solutions less cost effective without additional revenues.

As the new flood district gets off the ground, its leaders face key policy and spending decisions. Achieving the best long-term outcome for the citizens of the county depends on recognizing all the benefits that are achieved by making good floodplain management policy and spending decisions. Recognizing these benefits necessitates accounting for the natural assets of Pierce County – its green infrastructure – and must be an integral part of the solution.

Simply stated, "fighting the river" by building new, highly constraining levees and continually rebuilding damaged levees in the same places is an outdated and wasteful strategy that gives a false sense of security to citizens. It is also a strategy that county residents can no longer afford.

Alternate strategies such as restoring natural floodplains, setting back levees, allowing rivers to naturally change their course and protecting sensitive wetlands and riparian buffers can mitigate flood damage, reduce public capital and operations and maintenance costs, provide better public safety, and operate more resilient communities. A critical and complementary strategy to reduce future flood risk is the adoption and enforcement of proactive land-use regulations to guide development away from highly dangerous flood areas and valuable natural resource areas. Protecting open space and sensitive natural areas and reconnecting the river to portions of the floodplain reduces the damage of severe flooding. This strategy could be called "Making Room for the River," and it would reduce flood risk and provide space for sustainable development.

The Rivers Flood Hazard Management Plan and several floodplain development regulations support these nonstructural strategies. This report focuses on three regulations in particular: Channel Migration Zones, Deep and/or Fast Flowing Floodways, and Compensatory Storage. Three case studies examining flood-prone locations in the Puyallup Watershed are used to demonstrate the value of the regulations that facilitate good floodplain management. The case studies are summarized below.

Alward Road and Neadham Road Case Studies

The Alward Road and Neadham Road reaches of the Carbon and Puyallup Rivers are two examples where the county has spent millions over the years repairing damaged levees, removing debris and providing emergency services. This is in addition to federal expenditures from FEMA, private insurance payments, and losses by home owners. In both areas the county has been acquiring land from willing property owners and moving to restore much of the natural river processes. In the Alward Road reach, acquiring the remaining private property and building a new setback levee would cost approximately $29.6 million. In the Neadham Road reach, acquiring property, constructing a revetment at the base of Brooks Road and eventually abandoning Neadham Road would cost approximately $8.1 million.

An examination of the traditional "fight the river" approaches that the county employed in the past reveals the costs the county could have avoided had Channel Migration Zones and Deep and/or Fast Flowing Floodway designations existed when these reaches were developed. Using well-established methods of economic analysis, an economic value of the natural benefits that would have accrued had no development occurred can be ascertained.

For Alward Road, a conservative estimate for the costs incurred and the ecosystem benefits lost, using a zero percent discount rate, ranges from $51.6 million to $407.9 million. Using a 4 percent discount rate yields an estimate of $50.7 million to $203.7 million.

For Neadham Road, a conservative estimate for the costs incurred and the ecosystem benefits lost, using a zero percent discount rate, ranges from $32.1 million to $433.4 million. Using a 4 percent discount rate yields a conservative estimate of $29.8 million to $202.2 million.

The zero percent discount rate best demonstrates the value of natural capital since unlike built assets natural assets generally do not deteriorate and often increase in value over time. The discount rate methodology is explained later in this report.

Clover Creek Case Study

A 2.98-acre undeveloped property in the urbanized Spanaway area of southeast Pierce County, just a short distance from busy State Route 7, provides a third case study. In this case, a proposal was made to build seven homes on existing 1930's era lots on the east bank of Clover Creek in an area frequently subject to flooding. The applicant has obtained a wetland variance, which makes the project feasible by reducing the streamside buffer from 150 feet to 35 feet. To address flood risk, the homes would have to be built on soil mounds to raise their elevation above the 100-year flood level. However, during routine flooding it is very possible that the homes would become islands or suffer damage from the high moisture content of the soil under and around the homes. It is very likely that after the first few floods the homeowners would request that the County buy them out using the flood buyout program for high-risk homes.

For this reason the county's Surface Water Management Division has proposed a property swap that would preserve the property as an open space buffer.

This study calculates the ecosystem benefits of leaving the property, which lies in the regulated Deep and/or Fast Flowing Floodway, undeveloped. This demonstrates how properly enforced land-use regulations would be more economically beneficial to the community than allowing development.

For the Clover Creek Open Space, a conservative estimate for the added value of restoration, using a zero percent discount rate, ranges from $52,000 to $2.7 million. Using a 4 percent discount rate yields a conservative estimate of $23,000 to $1.2 million.

Conclusions and Next Steps

Conclusions of this report are:

1. The Channel Migration Zone, Deep and/or Fast Flowing Floodway, and Compensatory Storage Requirement regulations are extremely valuable to Pierce County and its residents. These regulations save taxpayers and private homeowners money.

2. The value of any regulation depends on decision makers who decide whether or not to enforce them. Exemptions can be extremely costly in terms of public safety and property loss both now and in the long run.

Next steps to consider are:

1. Pierce County can improve records of flood and disaster-related costs. As it is, too much of the cost estimates of flooding events rest on the value of federal aid provided to Pierce County. There is not enough tracking of local money spent by the county or local organizations on disaster costs to different departments such as the roads division.

2. Once one of the proposed non-structural capital projects is completed, before and after monitoring will be important to demonstrate the effectiveness of floodplain restoration on reducing both direct and indirect flood impacts.

3. More federal funding mechanisms are needed for proactive investment. Currently, the majority of funding for federal flood mitigation comes after disaster events. The more funding can be directed to pre-disaster grants or proactive investments, the more improved floodplain management strategies can actually be implemented.

4. Determine the value of all Pierce County floodplains. Because of the case study approach, this study does not calculate a value for all county floodplains. In doing so, Earth Economics and Pierce County could apply lessons learned on the three sites valued in this report to the 32 potential floodplain restoration sites identified in the Rivers Flood Hazard Management Plan.

Introduction

Natural systems provide flood risk reduction and protect human safety and property. Not locating people and infrastructure in flood prone areas contributes to economic vitality and resilience. Thus, both natural systems and the regulations that keep development out of harm's way have economic value. This value can be estimated. Traditionally, only built structures have been considered flood mitigation assets. Recognizing the economic benefits of natural systems and their "asset value" allows them to be combined with built assets when determining how to provide sustainable and resilient flood risk reduction. It also improves traditional benefit-cost analysis. Overlooked ecosystem services, including salmon habitat, flood attenuation and others, can be included in benefit-cost analysis improving the effectiveness of flood project analysis.

The Pierce County Council adopted its Rivers Flood Hazard Management Plan in February 2013 to guide the county's efforts to reduce damage from floods and channel migration and protect public safety and habitat by addressing several large rivers including the Puyallup, Carbon, White, Nisqually, and Mashel as well as South Prairie Creek. The plan recommends regional policies, programs, and projects that reduce the risks to public health, safety and property from river flooding and channel migration, lower river maintenance costs and maintain or improve river corridor habitat conditions. The plan was developed over several years using the best available technical information, an inclusive stakeholder process, and careful analysis of level-of-service and funding options.

The plan considers economic, social and cultural contexts, the existing regulatory framework, and relevant legal agreements. This report is designed to support the implementation of the county Plan.

The plan is a major step forward. Implementation will give these relentless rivers more room, provide for more flood storage space, and increase the floodway's capacity to carry larger volumes of water. Levees are still necessary to reduce flood risk to capital assets and critical structures such as port facilities and water treatment plants, but attempting to completely confine the rivers into small channels would actually increase the likelihood of catastrophic flooding. The nature of these powerful rivers combined with existing and anticipated changes in the climate will result in more frequent and larger flood events. Thus, Pierce County is moving toward a stronger systems approach of including both built and natural capital, as well as regulations and policies that will reduce the direct costs and economic disruptions of future flood events.

This requires better economics. Accounting for ecosystem services in Benefit-Cost Analysis provides a more realistic accounting of economic benefits, especially when project alternatives preserve or restore floodplains instead of relying on built infrastructure. In addition, this report demonstrates the economic, social, and environmental value of regulations that prevent development in flood hazard areas and thus provide greater future flood risk reduction. Toward this end, Pierce County Surface Water Management (SWM) and Earth Economics have conducted this return on investment analysis on SWM non-structural flood risk management solutions.

Case Study Approach

To better understand the financial impacts of nonstructural flood management, the project team analyzed three key land use regulations in three specific locations. Economic valuations were performed using ecosystem service valuation and avoided costs methodology.

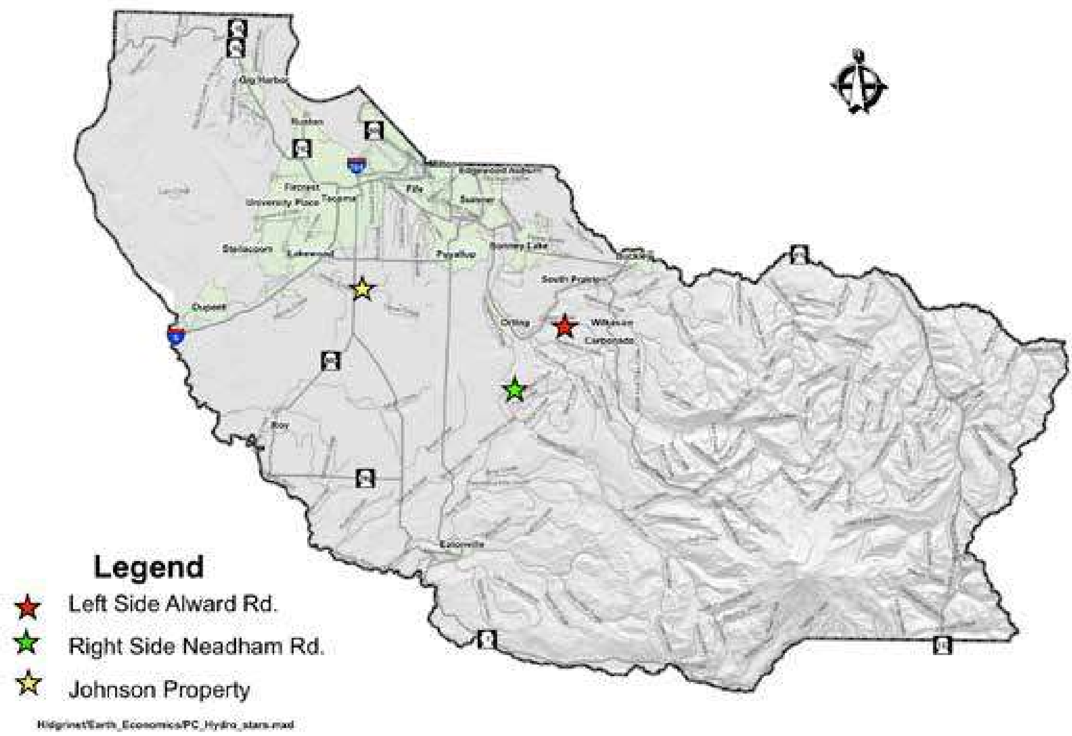
Land-use regulations analyzed:

• Channel Migration Zones (CMZ): Covered by Title 18E.70, severe CMZ hazard areas allow the county to predict where the river might migrate over time and regulate development on properties that may become flood-prone in the near future.

• Compensatory Storage Requirements (CSR): Initiated by Pierce County Ordinance 90-132, CSR compliance requires developers to replace flood storage to offset the flood storage lost by developing in the floodplain.

• Deep and/or Fast-Flowing Floodway (DFF): Designated but unmapped from 1987 to 2007, DFF hazard areas are now mapped for many of the major waterways in the Puyallup Watershed. This allows the county to regulate development in areas with the highest risk to life and property - the sections of river where the water is either a minimum of three feet deep, or where the current is moving at least three feet per second.

Figure 1: Case Study Locations
Source: Pierce County



Case studies selected:

Alward Road
This stretch of the Carbon River is located along the 177th Street East reach, near Orting. This case study will demonstrate the cost of developing in the floodplain. This area is regulated by CMZ, CSR and DFF.

Neadham Road
This reach of the Puyallup River is located a few miles above Orting. This case study will demonstrate the cost of older regulations which did not keep up with the channel zone migration of the river. This area is regulated by CMZ, CSR and DFF.

Clover Creek Open Space
Located on Clover Creek in Parkland, this case offers an argument for the benefits of pre-development property acquisition to enforce riparian buffers. This area is regulated by CSR and DFF.

Objectives of this Study

The objectives of this study are to:

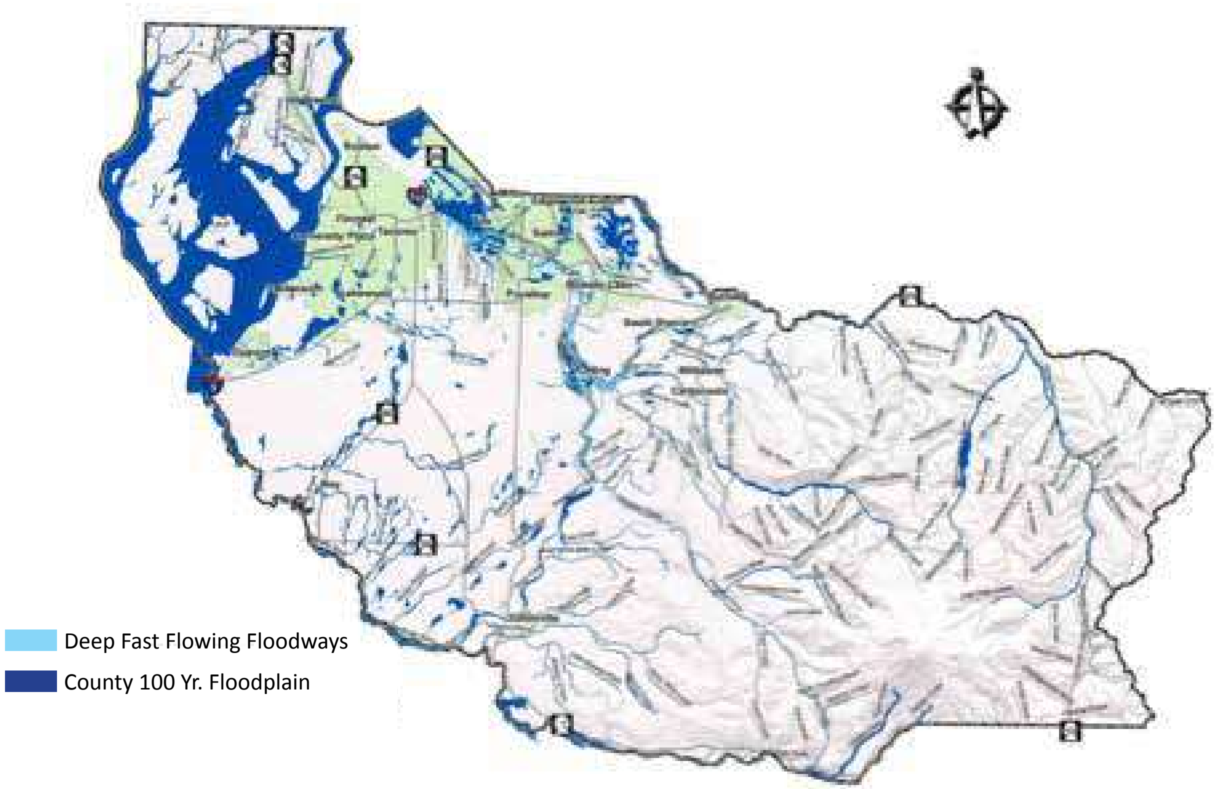
1. **Determine whether or not well-formulated land-use regulations reduce public and private costs by preventing or mitigating damage from flooding.** This analysis focuses on three land-use regulations: Channel Migration Zones, Deep and/or Fast Flowing Floodways, and Compensatory Storage Requirements.

2. **Demonstrate measureable benefits to enforcing those land-use regulations by examining real-life case studies.** Three case studies in the Puyallup and Clover Creek watersheds will be examined to illustrate the importance and economic benefits of the land use regulations: the Alward Road project will demonstrate the cost of developing inside the known floodplain; the Neadham Road project will demonstrate the value of Channel Migration Zoning; and the Clover Creek Open Space project will be used to present an argument about the benefits of acquisition to prevent floodplain development.

3. **Inform future mitigation project implementation to achieve the best possible value at the lowest cost for Pierce County residents.** By including ecosystem services in the return on investment analysis, planners and decision makers will have better information on the economic rationale behind flood risk reduction, economic development and floodplain restoration.

Overall, this study makes the case that well-designed and implemented land-use regulation and mitigation techniques can save lives and reduce costs associated with flooding for citizens, businesses, and government alike.

Figure 2: Flood Hazard Areas in Pierce County



Source: Pierce County

Flood Risk Management in Pierce County

History

Although it is not the sole watershed in the county, the Puyallup River Watershed is certainly the most prominent and destructive. This Watershed drains an approximately 1,040-square-mile area extending from the glaciers of 14,410-foot Mount Rainier to sea level in Puget Sound. This drop in elevation over a relatively short distance results in powerful flows in the watershed's main rivers and tributaries – the Puyallup, White, Carbon, and Greenwater rivers and South Prairie Creek. These circumstances concentrate flood events and damages at the downstream end of the watershed. The regulatory floodplains of Pierce County, shown in Figure 2, demonstrate this concentration. Most of the watershed lies within Pierce County.

Between 2006 and 2009, Pierce County experienced three of the 15 largest flood events that have occurred since the early 1900s.[9] An extraordinary flood event occurred in 2006 when 18 inches of rain fell in 36 hours on Mount Rainier. The resulting flood event caused a three-month closure of the national park and $30 million in damage to the park alone.[10] The event permanently closed the road to the park's Ipsut Creek Campground. Flooding during the 2006 flood event resulted in $10.4 million in additional damage to the county (Figure 3). The severe floods in 2008 and 2009 caused millions more in property damage.[11] Of the 15 federally declared disasters in Pierce County since 1964, nine of them have occurred since 1990.[12] Flood frequency and damages seem to be accelerating.

The Chambers-Clover Creek watershed is one of the county's smaller watersheds and runs through much of the developed area in the county. Clover Creek is rock-lined throughout the lower sections, and its ecological functions have been greatly impacted by development.

Changing Flood Conditions

While flooding in Pierce County is part of the natural climatic cycle, physical changes within the Puyallup Watershed are resulting in the increased frequency of severe flooding experienced in recent decades. Significant change has occurred at the head of the basin: Fourteen percent of the ice and permanent snow on Mount Rainier has melted in the past four decades, increasing the amount of alluvial sediment deposited within riverbeds and floodplains. Such buildup in streams and riverbeds contributes to flooding. Scientists report that the glaciers on Mount Rainier are melting at an accelerating rate; the rates of sedimentation in the Puyallup watershed can be expected to increase as well.[13,14]

Due to its long history of flooding and its urban location, the Puyallup River is the most leveed and armored river in the state. The lower reaches first began to be heavily developed with levees and revetments to control flooding as early as 1913, when the White River was permanently diverted into the Puyallup River.[15] The Mud Mountain Dam on the White River built in 1948 was largely constructed to manage flooding on the White and Lower Puyallup Rivers.[16]

As the result of continued flooding in the 1940s and into the 1950s, levees were constructed in the mid-1960s on the Alward and Neadham reaches of the Carbon and Puyallup rivers. These levees will be examined later in this report.

The Chambers-Clover Creek Watershed was also channelized in the early part of the 20th century to manage flooding. This channelization has had a profound effect on the natural functions of the lower part of the watershed. The area surround the Clover Creek Open Space case study has had a long history of flooding despite the structural efforts to manage it.

Economic Impacts of Flooding

It is hard to overstate the actual and potential economic consequences of severe flood events in the Puyallup River floodplain. This, as well as public safety concerns, is largely why the Pierce County Council in 2012 approved a countywide Flood Control Zone District and authorized a property tax to fund flood control and mitigation measures.

The April 3, 2012, council ordinance creating the district describes at length the historic and potential economic impacts of severe flooding in the Puyallup River Watershed.[17] The potential cost of what is commonly called the 100-year-flood event – the flood with a one percent probability of being equaled or exceeded in any given year – could be as high as $725 million. Because this value was calculated based upon the current estimate of the flood that has a one percent chance of occurring in a given year and does not take into account any potential changes in the climate or hydrologic regime, future flood damages could be higher than projected. The floodplain covers more than 60 square miles, includes all or parts of 17 cities and towns, and perhaps most significantly, the Port of Tacoma, the so-called “economic engine” of Pierce County.[18] The total assessed value of property within the floodplain as of 2012 was $1.2 billion.[19] The economic activities at risk include shipping, rail and interstate transportation corridors, manufacturing, oil and chemical industries and agriculture.

“Built” Infrastructure

At least 14 critical facilities, such as police and fire stations and schools, lie in the 100-year floodplain of Pierce County.[20] The Tacoma, Puyallup and Sumner municipal wastewater treatment plants lie within the floodplain. If flooding overwhelmed these plants, raw sewage would mix with floodwaters, posing serious public health and environmental risks. It could take as long as six months to restore normal operation and complete large-scale disinfection.

If flooding closed Interstate 5 and the rail lines that cross the Puyallup River in Tacoma, the economic impact could be felt statewide. Operations at the Port of Tacoma and traffic on major rail lines could be halted. The 2007 flood-caused closure of Interstate 5 near Chehalis for six days caused $47 million in lost economic output to the state.[21]

All told, about 22,100 people in 9,340 homes (as of 2009) live within the Puyallup River floodplain. Nearly 12,000 people work at jobs located there. The range of personal property losses in catastrophic flooding could be as high as $521 million.[22] Due to incomplete record keeping, the total costs of historic flooding in Pierce County are not known. But it is safe to say that due to the residential and economic development currently anticipated within the county floodplain, the potential overall costs of major flooding can only increase – unless effective and sustainable floodplain management measures are successfully implemented.

“Green” Infrastructure

In a 2011 study, Earth Economics calculated the economic worth of the ecosystem services currently provided within the Puyallup River Watershed, most of which falls within the borders of Pierce County. Ecosystem services are the physical and/or nonphysical processes of natural systems that support human activities and sustain life. They require input from natural capital such as a forest or marine ecosystem. For example, wetlands and forests are natural capital assets that provide the ecosystem service of filtering water without need of a costly filtration plant. The study concluded that those services have a net present value between $13 billion and $120 billion at a 4.125 percent discount rate.[23] This calculation, as we will explain later, does not take into account the fact that natural assets, if left intact, do not deteriorate over time in the way built infrastructure does. The resilient nature of green infrastructure provides long-term operations and maintenance savings in comparison to built infrastructure.

A common criticism leveled against nonstructural floodplain management solutions that leverage green infrastructure is that they stifle development and suppress tax revenue to the county. The reality is that regulations only prohibit specific locations for development, and this is to the greater benefit of the county and its residents. When development is located in the floodplain it eventually becomes a revenue sink for the county rather than a contributor. Better to encourage development elsewhere.

Figure 3: Flooding on the Puyallup River, 2006

Flood Risk Management

The history of flood hazard management in Pierce County can be said to have moved through three phases. First, in the early days, it was every man for himself! Floods happened. And the Puyallup Tribal members, the early settlers and the people who followed as Pierce County grew just had to cope with unrestrained floods. Then, in the 1910s, authorities began building levees along the Lower Puyallup. In the 1960s, the Army Corps of Engineers and the State of Washington actively promoted levee construction to "channelize" flood-prone rivers – a policy now widely questioned. Today, Pierce County is pursuing a third strategy: Where feasible, let the river occupy a larger portion of its natural floodplain, while still protecting critical infrastructure, human life, and property.

Land-Use Change

Levee construction along the Lower Puyallup River during the mid-60s allowed for rapid residential and commercial development in the floodplain behind the levee, where previously the risk of flooding limited land use primarily to agriculture. Development within the floodplain was promoted as economic growth and development, but in many parts of the US flooding has taken a toll on development in these types of flood-prone areas. Pierce County's newer approach is to regulate development in the floodplain by requiring development to occur outside of the floodplain where there is room, to prohibit development in the highest-risk areas of CMZs and DFFs, and to require development in the lower-risk floodplains to mitigate their impacts by providing compensatory storage.

Community Rating System

Pierce County's leading-edge approach to flood hazard management is also reflected in its high ranking in the Federal Emergency Management Agency's Community Rating System (CRS). Pierce County entered the CRS program in 1995 and became the first county in the U.S. to earn a Class 5 rating by virtue of its risk reduction efforts. Today, the county holds one of the highest ratings in the nation, a Class 2 rating; only two other jurisdictions in the nation have the same rating. (Only one jurisdiction, Roseville, CA, has the top Class 1 rating.) The Class 2 rating entitles local property owners in flood zones to as much as a 40 percent reduction in premiums for the flood insurance generally required by mortgage companies. A Class 1 rating would raise the discount to 45 percent.

A National Model

Today, Pierce County government, in comparison to many of its peers, is taking a more enlightened approach to flood risk reduction, which is now the preferred term. The old terms, flood "control" or "management," are used less often and not at all by the U.S. Army Corps of Engineers these days. The new terminology reflects a timely recognition that the old strategy of simply "fighting the river" is neither the least costly nor the most effective way to protect human life and property. The county's new thinking has resulted in greater efforts to limit development that is highly vulnerable to floods. The county frequently seeks to reduce future flood damage with property buyouts or acquisitions in flood-prone areas because they cost less than constantly rebuilding the channel-constraining levees that protect these properties. Since 1990, the county has spent nearly $28 million on such buyouts.[24]

Pierce County's vision for its watersheds is admirably innovative and could well serve as a national model. The new Rivers Flood Hazard Management Plan, adopted by the County Council on February 19, 2013, replaces the previous plan adopted in 1991. The new plan's Guiding Principles reflect a new awareness that simply fighting the river is not sustainable or economically prudent. The 13 principles demonstrate evidence-based pragmatism rather than merely heightened environmental consciousness. For example, river flooding and channel migration are recognized as natural, beneficial processes. Principle No. 8 states:

> *Protecting and working with, rather than trying to control, natural riverine processes generally will reduce flood risks to people and property in a less costly manner than traditional structural approaches to flood hazard management, while also benefiting native fish and wildlife and preserving aesthetic landscapes.*

Principle No. 5 recognizes that constructive land-use regulation is necessary. It states:

> *Future development within Pierce County, including cities and unincorporated areas if guided away from flood-prone areas, can reduce future risks to life and property. Adverse impacts of development both inside and outside the floodplain can be minimized by development practices that reduce future risks through appropriate regulation and land use, open land preservation and acquisition, multi-objective planning, relocation or elimination of high hazard structures, prohibiting unacceptable encroachments, and establishing ongoing maintenance practices that preserve and enhance environmental functions.*

Key Partnerships

The residents of Pierce County benefit from well-integrated government agency efforts to inform flood risk management and planning. Agencies that play key roles in addressing flood risks in the Pierce County include:

Pierce County Surface Water Management (SWM)
A division of the county's Public Works and Utilities Department, the agency owns the majority of the levees and revetments. It was responsible for developing the new flood plan and will share with the newly created Flood Control Zone District the responsibility for implementing the plan. The county's Permitting and Land-Use Services division, which issues development permits, also plays a key role.

Pierce County Flood Control Zone District (FCZD)
Created primarily to generate tax revenue for flood risk reduction efforts beyond those the county can afford with limited existing revenues, the district has signed an inter-local agreement with the county. In effect, SWM and Public Works will do most of the operational work of the district. The County Council will also govern the district.

U.S. Army Corps of Engineers (USACE)
Under Public Law 84-99, the Corps will aid flood-stricken communities in fighting floods by rebuilding levees after a flood event that meets Corps guidelines. Levees owned by communities must meet certain preparedness guidelines to be eligible for such aid. In addition, the Corps owns about three miles of levees upstream of the mouth of the Puyallup River.

Federal Emergency Management Agency (FEMA)
FEMA administers the National Flood Insurance Program. Property owners in participating communities may be required by their lender to obtain flood insurance through the program. If the local community participates in the agency's Community Rating System, property owners can obtain discounts on their premiums, depending on their community's rating. FEMA also provides grants to local communities and states for local property acquisitions intended to reduce potential flood damage.

Pierce County Department of Emergency Management
The agency distributes flood warning information to the public, conducts local disaster preparedness activities, updates continuous flood alerts and responds to local disasters, including flooding.

State Salmon Recovery Program
The relatively new Washington state program, created in 1999, is a potential source of funding for restoration and acquisition of riparian habitat, which is one objective of the county's new flood management plan.

Puyallup Tribe of Indians
The Puyallup Tribe co-manages with the state the migratory fish resources within the Puyallup River basin. It has considerable influence in state and local government actions affecting salmon runs and provides funding for some habitat protection and restoration efforts. The Tribe actually owns the Puyallup riverbed from the mouth to approximately river mile 7.2, and it has also signed agreements with the county on how the county maintains and operates its existing levees and revetments.

Reactive Investments

Insanity, Albert Einstein supposedly said, is "doing the same thing over and over and expecting different results." Economists and money managers have a different term for this: reactive investment. At the risk of oversimplifying, it means spending money on things that failed in the past but hoping that they will work in the future. Reactive investments are often triggered by failures.

The concept of reactive investment enters the discussion of flood risk reduction because it describes much of the public money spent responding to severe and repetitive flooding in the United States. For decades, levees along rivers like the Mississippi have been overwhelmed and destroyed by major floods. More often than not, they were simply rebuilt, stronger perhaps, but often damaged again in subsequent flood events. Homes and businesses in flood-prone areas were – and still are – repaired or rebuilt as they were with government aid following flood disasters, only to be damaged again by a new disaster a few years later.

The Corps has begun to rethink its strategy of automatically rebuilding or repairing levees. The disaster that befell New Orleans during Hurricane Katrina – and more recently Hurricane Sandy's destruction in New York and New Jersey – created a new awareness of the critical role of natural ecosystems in protecting against major storms and floods.[25,26] FEMA is also shifting toward more relocation rather than reconstruction in areas of frequent flooding. Critical to this shift is getting the economics right. Restoring developed residential areas to natural floodplains actually protects infrastructure downstream by providing greater flood storage. This is especially true when river-constraining levees can be allowed to breach or are removed, activating a much larger floodplain area for flood storage even during the smaller flood events. FEMA has adopted values provided by Earth Economics to calculate the economic value of "ecosystem services" and better estimate the benefits of mitigation actions that move infrastructure out of repetitive flood areas in the U.S.

Forests, natural floodplains, wetlands, estuaries, barrier islands, rock reefs and kelp forests, for example, all help absorb and store large amounts of rainwater, runoff, or act as a buffer against storm surges and coastal wave action. These natural assets reduce the damage caused by storms or flooding and lessen the need for costly infrastructure to protect against them. For example, wetlands in Louisiana reduce the height of hurricane storm surge waves. Natural systems protect houses, businesses and infrastructure. They save money and provide real economic benefits. Natural systems promote resilient communities and healthy economies. The value of ecosystem services should be part of the cost-benefit analysis that public officials use to make spending decisions related to flood hazard management.

Emergency services

In the typical flood disaster scenario, reactive investment is the usual response. Emergency rescue and relief services, repairing damaged levees, roads and other infrastructure, building additional levees or revetments, allowing people to rebuild homes and businesses as they were – are all reactive investments. Some are absolutely necessary, but they are reactive investments nonetheless. Since 1990, Pierce County has received more than $59 million in flood-related federal disaster relief and reconstruction funds. The epic 1996 flood event alone drew $25.8 million in federal aid. Federal aid is only available following a federal disaster declaration, although some state aid may be available for these smaller events. Flood insurance payments to individual property owners are available anytime there is damage to their structures due to flooding and are not included in these totals. Table 1 represents estimates of emergency assistance funds for the six largest flood events since 1990 in Pierce County.

Part of the difficulty in trying to convince communities and citizens to make less flood-prone land use decisions is that when a decision to build a structure in a high-risk area is made, the money used to rebuild it, buy it out, or repair the flood control structure to repair it is usually all or partly federal or state funds. These reactive investments are not so painful because they can be viewed as bringing money and sometimes jobs into the community. But at the same time there is a tremendous amount of suffering and anxiety for those who are affected, and there is no guarantee the state and federal money will be available. Most people would rather not suffer the flooding; if less money was needed for emergency services, more proactive investments could be made.

Table 1: Damage Costs for the Six Largest Federally Declared Disasters Since 1990

Year	Disaster	Stafford Act Obligated Funds in Pierce County	Total Individual FEMA Assistance in Pierce County	Corps of Engineers Funding*	Disaster Total
Nov. 1990	WA DR 852	N/A	N/A	$350,000	$350,000
Nov.-Dec. 1995	WA DR 1079	$387,000	$30,000	$2,500,000	$2,917,000
Feb. 1996	WA DR 1100	$18,760,000	$3,543,000	$3,500,000	$25,804,000
Dec. 1996 - Feb. 1997	WA DR 1159	$6,527,000	$831,000	$2,000,000	$9,358,000
Nov. 2006	WA DR 1671	$8,472,000	$1,284,000	$1,065,000	$10,822,000
Jan. 2009	WA DR 1817	$4,731,000	$1,529,000	$3,928,000	$10,188,000
TOTAL		**$38,877,000**	**$7,217,000**	**$13,343,000**	**$59,439,000**

***Emergency Response and PL 84-99 repairs and rehabilitation**

Adapted from Pierce County Flood Plan

Repairing Repeatedly Failed Levees

Reactive investments often don't make sense in cases of repetitive loss. Consider a homeowner who keeps parking his car on the street in front of his house even though it is regularly clipped by careless drivers. The owner keeps paying the deductible on his car insurance; perhaps his car insurance rate goes up. Eventually the homeowner will decide that he should park the car around the corner where there is less traffic. Repetitive loss, then, is something to be avoided if possible.

For this reason, FEMA is more willing to help pay for buyouts of property owners in cases of repeated insurance claims for property damaged by flooding to end the cycle of repetitive loss and reduce the potential for future damage.

This same principle is not applied to the public infrastructure built for flood protection. Even if they fail repeatedly, levees and revetments are almost always rebuilt, usually with the help of federal funds. When a federal disaster declaration is issued for a flood event, many of Pierce County's rebuilding costs are reimbursed, up to 75 percent, through FEMA. All damaged levees that are part of the Corps PL84-99 program can be rebuilt with up to 80 percent federal funding.

FEMA Emergency Disaster Grants

The Hazard Mitigation Grants Program funded by FEMA (and administered by the state) follow severe flooding. These funds, however, are not allowed for the purpose of rebuilding infrastructure where it was damaged. These grants are used for work to mitigate for flood damage and are allocated at 15 percent of the total disaster cost. Mitigation grants offer long-term value by reducing risk to property but may not yet represent the best use of funds to address future flooding. For example, a mitigation grant might help a homeowner in a flood-prone area raise his home. But that doesn't change the fact that the home, and the infrastructure serving it, remain in an area that could more logically be given over to floodplain restoration.

There are other available mitigation grants that are not tied to specific disaster events and that can be used for investment that is not merely reactive. These include Pre-Disaster Mitigation Grants, Repetitive Flood Claims Grants, Severe Repetitive Loss Grants, and Flood Mitigation Assistance.

Proactive Investments

Because reactive investments, like emergency aid and reconstruction, come as an immediate response to disasters that cause widespread damage and impact many people and businesses, few people question their value. It is part of government's role to help victims of disasters get back on their feet and help communities rebuild in instances where local sources of support are overwhelmed. The dilemma of proactive vs. reactive investment concerns whose money is being spent. Often reactive money is considered to be the "other people's" money if it comes from the federal government, whereas proactive investment is usually thought of as primarily local funding. The county has had to commit to a General Investigation through the Corps of Engineers, a long and costly process, in order to potentially have the Federal government partially fund a project. The General Investigation does commit significant local funds to the project.

Proactive investments should be viewed as equally important. The adage, "An ounce of prevention is worth a pound of cure," is highly relevant to the discussion of flood-risk reduction. The problem, however, is that local government officials have trouble funding the day-to-day operations of their cities and counties, much less looking to the future. Immediate needs and returns tend to crowd out more long-term investments, even when those proactive investments – in flood risk reduction, for example – have a higher return on investment for the taxpayers in the long run.

Pierce County deserves credit for creating a countywide Flood Control Zone District in 2012 and exercising the district's taxing authority to generate an estimated $6.89 million a year to fund projects addressing flood risks. The next step is deciding which projects in the county's new flood plan to fund first. The anticipated revenue is dwarfed by the $300 million to $400 million flood management costs for all of the proposed measures.

The largest project, constructing a new setback levee where North Levee Road runs along the Puyallup River between Tacoma and Puyallup, would cost $104 million.[27] Nonetheless, the new funding will allow the county to carry out additional proactive projects to address the increasing threat of severe flooding.

Going forward, the challenge for county decision makers is to strike the right balance between reactive investments and proactive investments. The county's decision to implement the programs that allow it to obtain a high classification in FEMA's Community Rating System is one example of a proactive investment. Some of these programs include steps to preserve the flood-mitigating benefits of natural areas (or at least mitigating for the loss of such areas); consistent operation and maintenance of flood-related infrastructure such as levees and revetments, and implementing policies and regulations that help prevent or reduce flood damage. Making extensive use of available proactive federal funding such as hazard mitigation grants has allowed Pierce County to do much more than would have been possible with local funding only.

Mitigation, when used properly as a flood risk reduction tool, fixes or minimizes past mistakes rather than repeating them. Research has shown that FEMA-funded mitigation programs have a 4-to-1 benefit-to-cost ratio.[28] This is without even considering the economic value of ecosystem services outlined earlier in this report. Because the benefits of mitigating flood damage far outweigh the costs, mitigation proposals should be given a high priority in allocating limited resources.

Operations and Maintenance

It is important not to overlook basic operation and maintenance as an essential proactive investment. Such work keeps levees and other built infrastructure functioning the way they are intended to function. Inspections and routine maintenance are critical, but Pierce County has found it difficult to properly maintain all of its aging levees. In 2004, FEMA officially decertified the levee system along the lower eight miles of the Puyallup River, declaring it inadequate to meet current standards for protection against a 100-year flood event.[29]

FEMA Community Rating System

Nationwide there are over 20,000 communities participating in the National Flood Insurance Program. Of those, approximately 1,200 participate in the Community Rating System. The CRS, as noted previously, has awarded Pierce County a Class 2 rating (Class 1 is highest), a distinction held by only two other jurisdictions in the U.S. The rating is a reward for good floodplain management and measures taken to potential flood damage, and earns Pierce County property owners up to a 40 percent discount on their flood insurance premiums if they live within the Special Flood Hazard Area (SFHA); outside of the SFHA, savings are only 10 percent. Table 2 shows the savings communities in Washington realize by participating in the CRS program, in October 2012. Pierce County property owners save nearly $350,000 a year on the cost of flood insurance thanks to the county's high rating. In CRS national rankings (Table 3) Pierce County and King County, along with Tulsa, Oklahoma, are tied for second. Only the City of Roseville, California, ranks higher with the nation's sole Class 1 rating.

Table 2: Participating CRS Communities in Washington State

Community Name	County	CRS Class	# Policies	Community Savings
Pierce County	Pierce	2	2154	$349,717
King County	King	2	2667	$873,517
Skagit County	Skagit	4	3033	$1,015,223
Snohomish County	Snohomish	4	1925	$504,398
Auburn, City of	King	5	1028	$20,329
Bellevue, City of	King	5	250	$21,733
Burlington, City of	Skagit	5	1335	$325,820
Centralia, City of	Lewis	5	1000	$160,434
Chehalis, City of	Lewis	5	266	$87,806
Clark County	Clark	5	712	$89,505
Fife, City of	Pierce	5	91	$3,788
Issaquah, City of	King	5	237	$57,236
Monroe, City of	Snohomish	6	77	$9,619
Snoqualmie, City of	King	5	521	$197,620
Thurston County	Thurston	5	760	$76,791
Index, Town of	Snohomish	6	31	$5,992
Kent, City of	King	6	1548	$143,276
North Bend, City of	King	6	574	$129,769
Orting, Town of	Pierce	6	324	$33,484
Renton, Town of	King	6	283	$21,670
Westport, City of	Grays Harbor	6	228	$34,714
Whatcom County	Whatcom	6	1412	$192,053
Ephrata, City of	Grant	7	282	$55,215
Everson, City of	Whatcom	7	194	$24,589
La Conner, Town of	Skagit	7	167	$32,588
Lewis County	Lewis	7	1326	$92,699
Mount Vernon, City of	Skagit	7	982	$208,606
Sultan, Town of	Snohomish	7	275	$38,897
Sumas, City of	Whatcom	7	258	$38,046
Lower Elwah Indian Reservation	Clallam	8	5	$35
Lummi Nation	Whatcom	8	173	$22,909
Wahkiakum County	Wahkiakum	8	192	$11,229
Yakima County	Yakima	8	705	$51,664
Total				**$4,955,951**

Table 3: National CRS Rankings

Community Name	State	County	Class
Roseville, City of	California	Placer	1
Pierce County	Washington	Pierce	2
King County	Washington	King	2
Tulsa, City of	Oklahoma	Tulsa	2
Maricopa County	Arizona	Maricopa	4
Sacramento County	California	Sacramento	4
Fort Collins, City of	Colorado	Larimer	4
Louisville-Jefferson County ME	Kentucky	Jefferson	4
Charleston County	South Carolina	Charleston	4
Skagit County	Washington	Skagit	4

Policy and Regulation

Local government policies and regulation are an essential foundation for a proactive approach to flood risk reduction. Effective policies and regulations, faithfully implemented and enforced, can prevent flood damage and eliminate or greatly reduce the need for mitigation or costly long-term infrastructure investments. Three of the key land-use regulations at work in Pierce County are Channel Migration Zones (CMZ), Compensatory Storage Requirements (CSR) and Deep and/or Fast Flowing Floodways (DFF).

Channel Migration Zones

Pierce County first mapped channel migration zones in 2003 for the Puyallup, Carbon and White Rivers.[30] CMZ mapping is currently underway for other rivers in the watershed. This designation serves to identify for regulatory purposes local areas at high risk for channel avulsion or migration. Channel avulsion occurs when a stream rapidly abandons an existing channel and takes a new course.[31] Channel migration is a change of course that occurs more gradually over a period of time. These zones are ranked as high, medium or low hazard areas. In the high-hazard CMZs, most development is prohibited.[32]

Because many of the rivers in Pierce County are short and extremely steep, they naturally and dynamically migrate from one side of their valley walls to the other over time. Channelization with levees or revetments hampers such movement, but the rivers powerfully attack their restraints during major floods. When levees that constrain rivers too tightly are breached in major floods, vast damage can occur because more investment is placed next to a river where a levee provides perceived protection. Mapping CMZs and using them in conjunction with FEMA floodplain maps gives the county a far more accurate picture of flood hazard zones than using either method alone. (Title 18E.70)

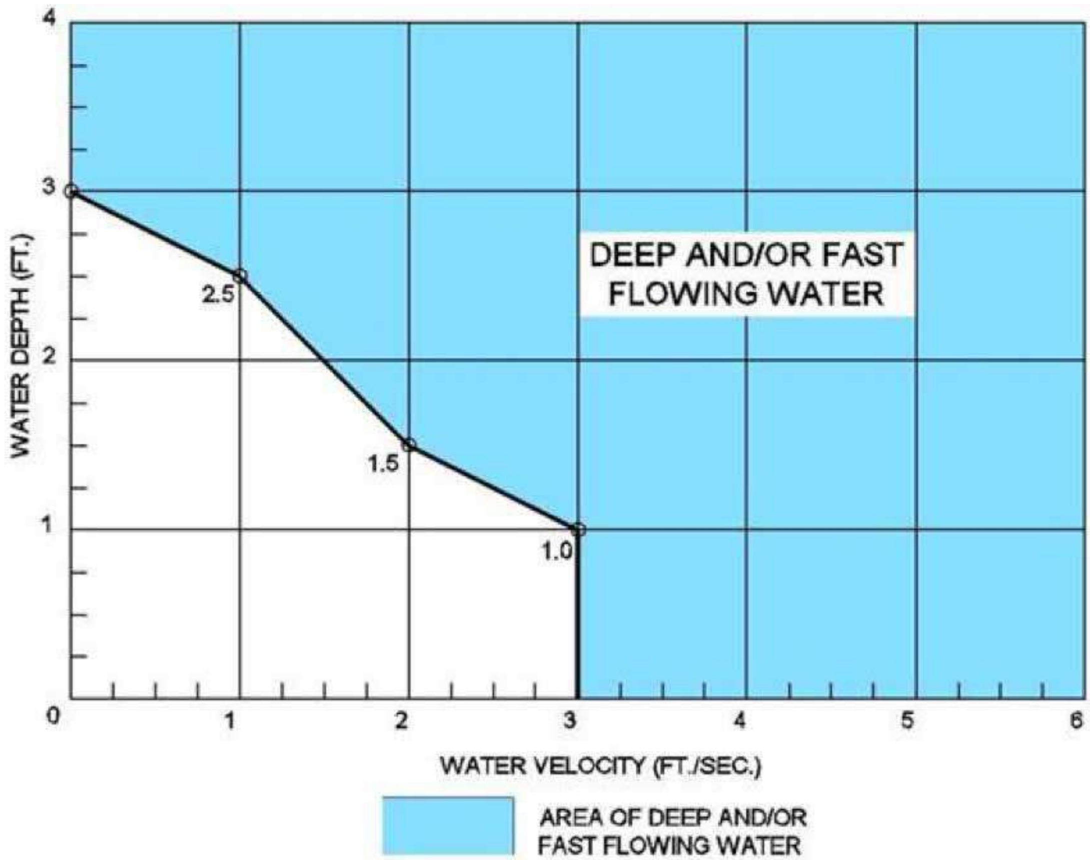
Compensatory Storage Requirements

Pierce County enacted CSRs in 1991 with Ordinance 90-132. The requirements are intended to prevent the loss of flood storage capacity due to new development. Loss of storage capacity increases the velocity intensity of flooding at that site and increases flooding downstream. The CSR policy requires proposed development within flood hazard areas to compensate for loss of storage capacity by providing an equivalent capacity nearby in the floodplain.[33] These requirements are efficient because they force the developer or builder who increases the risk of flood damage to other properties to pay the cost of compensation, rather than transferring the greater potential cost of flood damage to the community and property owners downstream.

Deep and/or Fast Flowing Floodways

DFFs have been designated and regulated in one way or another since the county enacted Ordinance 87-121S in 1987.[34] DFF designation identifies flood hazard areas with the highest risk to life and property. The designation generally restricts development in reaches where the rivers are either a minimum of three feet deep or the current moves at least three feet per second during the 1% annual chance flood. The county adopted its first truly accurate DFF maps in 2007 with the help of outside consultants.[35,36]

Figure 4: Deep and/or Fast Flowing Water Designation



Source: Dennis Dixon, Pierce County

Leveraging Green Infrastructure

Green Infrastructure

Green infrastructure is the life-sustaining natural capital of a watershed – its mountains, forests, rivers, lakes, wetlands, floodplains, aquifers and estuaries. It includes biological diversity from large game animals to tiny microorganisms, from soaring cedars and Douglas firs to specks of algae. It is no secret that the Puyallup River Watershed, extending from Mount Rainier to Puget Sound, is particularly rich in natural beauty and natural assets. These assets are key components of the region's exceptional quality of life.

The concept of green infrastructure includes the natural processes that occur within ecosystems. These ecosystem services include flood risk reduction, water supply, water quality, waste treatment, nutrient regulation, soil formation and retention, wildlife habitat and recreation, as well as intangibles such as spiritual and religious values. There is widespread consensus that ecosystem services are economic assets with measurable economic benefits. Earth Economics and other organizations have done substantial work to help quantify these benefits so they can be incorporated into public and private decision-making.

In our broader discussion of flood hazard management, green infrastructure includes the natural floodplain itself, vegetation, wetlands and upland forests that absorb rainwater and reduce runoff. In both urban and rural settings, investments in both built and green infrastructure are more cost-effective than investments in built infrastructure alone.

The flood-related benefits of green infrastructure can be substantial, and are inextricably linked to ecosystem services. Preserving, restoring or facilitating natural functions can often eliminate or reduce the need to construct and maintain built infrastructure. For example, a "green" floodplain can provide flood attenuation and reduce peak flood flows, thereby preventing the need to dredge – which is a costly and ecologically destructive investment. Restoring natural river flows and reconnecting old floodplains to the river enhances people's quality of life within the watershed: Community safety is improved, property values can go up as property becomes more attractive to buyers because of the perceived environmental amenities, the natural surroundings and views are improved, and recreational opportunities are enhanced. The same "green" measures taken to enhance flood protection can also provide or improve salmon habitat, improve water quality and contribute to climate stability.

Ecosystem Services, Flood Protection and Climate Change

Climate change must be considered in any discussion of flood protection. Regardless of the debate over the causal role human activities have played in climate change, the fact that climate is changing is not in dispute. Global air and water temperatures are rising. Storms are larger and more frequent, powered by heat in the atmosphere. Consider: 2012 was the hottest year on record for the continental United States. Worldwide, the 13 hottest years have all occurred since 1998. The nation experienced a record flood in the Mississippi Basin in 2011, followed by a drought in 2012. Hurricane Sandy, the ferocious storm that devastated coastal parts of New York and New Jersey in 2012, cemented a growing realization that climate change will bring more extreme weather and rising sea levels – and the risk of ever more destruction.

Like most areas in Western Washington, Pierce County can expect more frequent and extreme flooding events as a result of climate change. Summers will be drier; winters will be warmer and wetter. If climate change predictions prove accurate, annual precipitation changes projected through 2050 in the region range from an annual decrease of 7 percent, (2 inches) in summer to a significant increase of 13 percent (4 inches) in winter. Although projections show increases in total yearly precipitation, summer water supplies will decrease.   Winter snowpack levels will decrease as warmer temperatures bring more rain and less snow; this will mean more winter flooding and more drought conditions in summer. Increased costs and other adverse effects of flooding will be felt by many sectors of our society and economy.

Twenty-First Century Thinking

This report is, above all, about the need to update 20th century flood policies for the 21st century. Pierce County followed a traditional flood-fighting or "wall in the river" path for most of the past century, relying on manmade structures like levees and revetments to hold back surging rivers. This was the most advanced thinking of its time, but it has been costly and often unsuccessful. A record of nine federally declared flood disasters in the past 22 years speaks for itself. And we know there is more and likely worse flooding to come.

Pierce County is now a national leader in floodplain management. It pays close attention to river migration zones, floodwater velocities and the complementarity benefits of preserving natural floodplain functions; to the stability of non-structural flood management projects for flood risk reduction, and to the preservation and restoration of salmon habitat. Yet county government, even following the creation of the FCZD, lacks the financial resources to mount a truly comprehensive flood protection strategy. Little more than $6 million a year will be available for capital projects, including land acquisition, to address current needs of over $300 million, much less address the increased danger posed by climate change. As noted earlier, one of the new flood management plan's highest capital priorities, an eight-mile-long setback levee on North River Road, would cost $104 million by itself.[37]

At a time of rising concern over federal budget deficits, the chances for major federal contributions for Pierce County's projects are not great. These circumstances make it imperative for county officials to adopt the most cost-effective strategies for implementing restoration, acquisition and other needed actions that are available to achieve adequate flood risk reduction. Regulations that prevent building in flood hazardous areas are the most inexpensive solutions that avoid high future costs. Therefore, Pierce County is interested in determining if its existing ordinances help to reduce future costs of flood response and protection.

Three local case studies have been selected to determine the economic effects of these ordinances. All three involve on-the-ground numbers and rationales in the county's proposed capital improvement plan for the flood control zone. The Alward Road and Neadham Road sites are both subject to heavy flooding. The analysis shows that these costs that could have been avoided had current land-use regulations been in effect when development first occurred. The Clover Creek site will analyze a pending situation in which development permits have been granted that will allow a developer to skirt existing flood protection regulations. If the residential development proceeds, the county and the taxpayers will likely incur avoidable flood-related costs. All three sites are in Deep and/or Fast Flowing zones; Alward and Neadham are in Channel Migration zones, and Clover Creek will require compensatory storage if development is constructed.

Case Studies
Alward Road

History and Context

This very active and partially developed flood area extends for eight miles along the Carbon River above its confluence with the Puyallup River, near the town of Orting (Figure 5). South and east from the town of Orting on State Route 162 lies Alward Road, also known as 177th Street East. The road parallels the left bank (facing downstream) of the Carbon River. Above the Alward Road reach, the Carbon is confined in steep, narrow channels. At the eastern end of the reach, the river begins to broaden into a wider valley with channel splitting (braiding) and formation of large gravel bars.[38] Residential homes lie on the left side of the river. The right bank is a steep bluff.

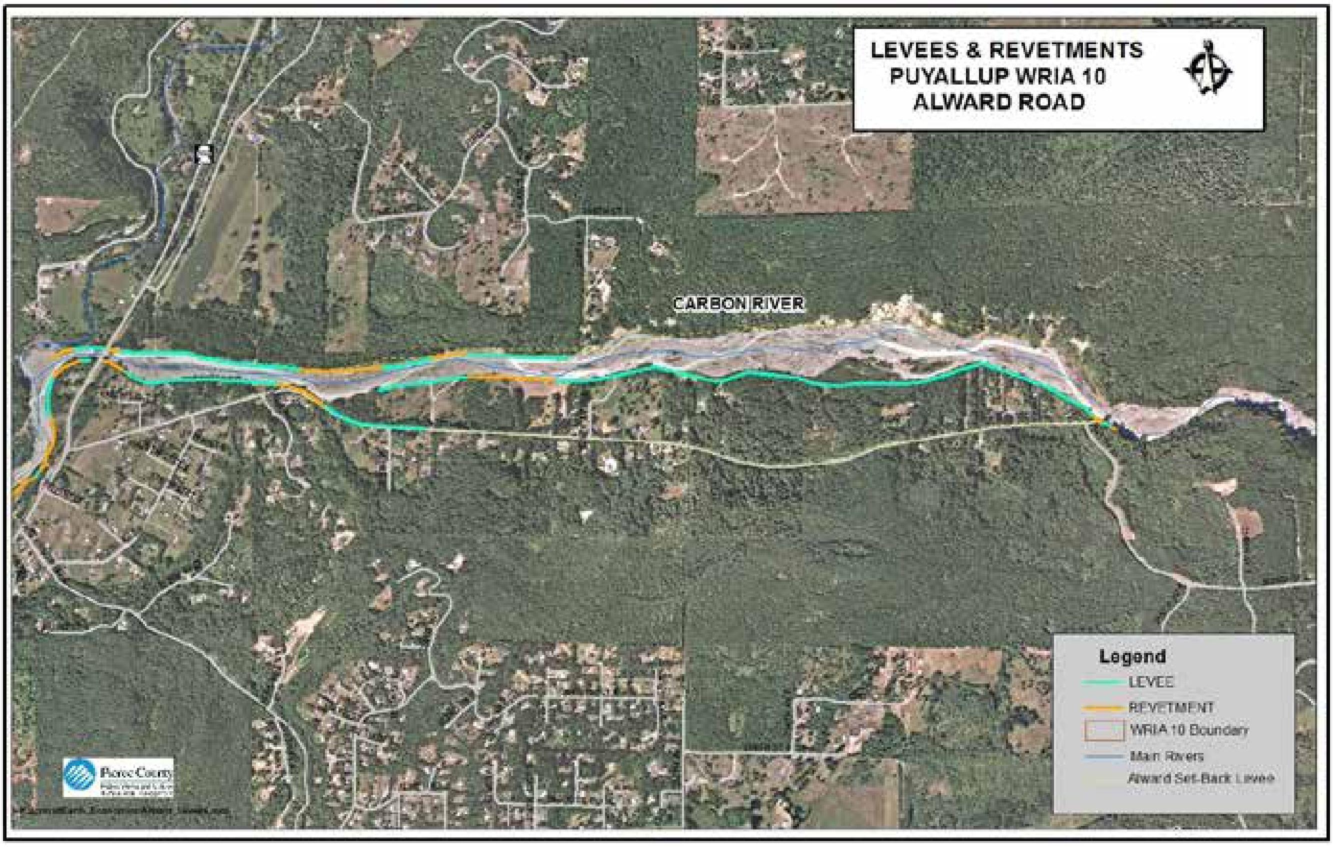


Figure 5: Alward Road Reach Levees and Revetments
Source: Pierce County

Almost the entire length of the reach is armored; both banks host levees and revetments and the right bank is lined by steep bluffs. These steep bluffs used to have an armored revetment at their base to prevent the river from eroding the base and leading to large landslides filling the river channel and pushing the river to the Alward road side. Floods have washed away that armoring, and it was too expensive to replace. Although Pierce County has been slowly acquiring land in this reach since 1991, 41 privately owned properties remain to be purchased.[39] The reach is within the 100-year mapped floodplain and lies in both DFF and CMZ flood hazard areas (Figure 6).

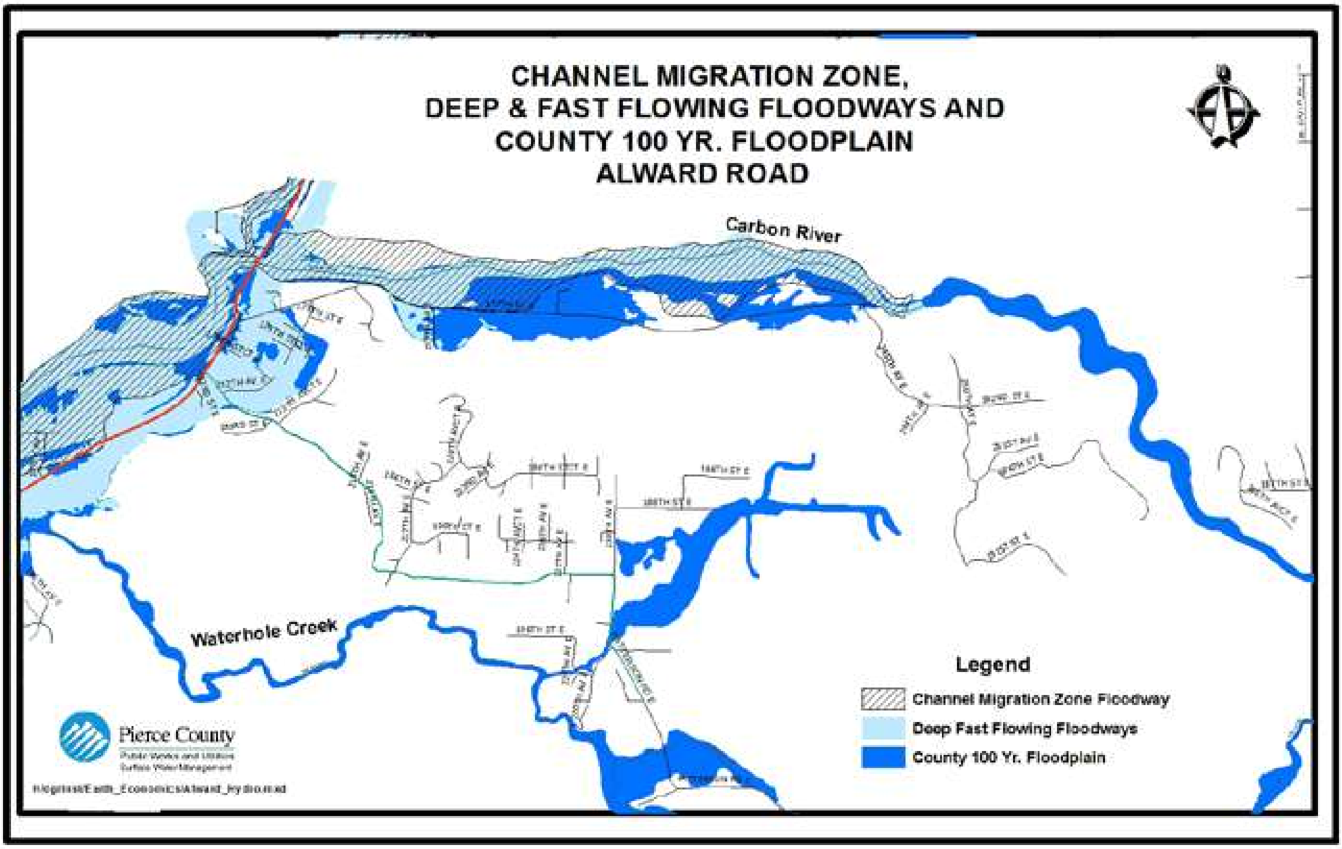


Figure 6: Flood Hazard Areas at Alward Road
Source: Pierce County

The Carbon River contains the most productive spawning habitat in the Puyallup River basin for all species of salmon.[40] The most productive areas are located along the unconfined right bank within the case study site, which allows the river to meander and create side-channel habitat, Figure 7. Because the right bank in the reach is a steep bluff, any levee setback to minimize flood damage and improve habitat would have to be on the left bank.

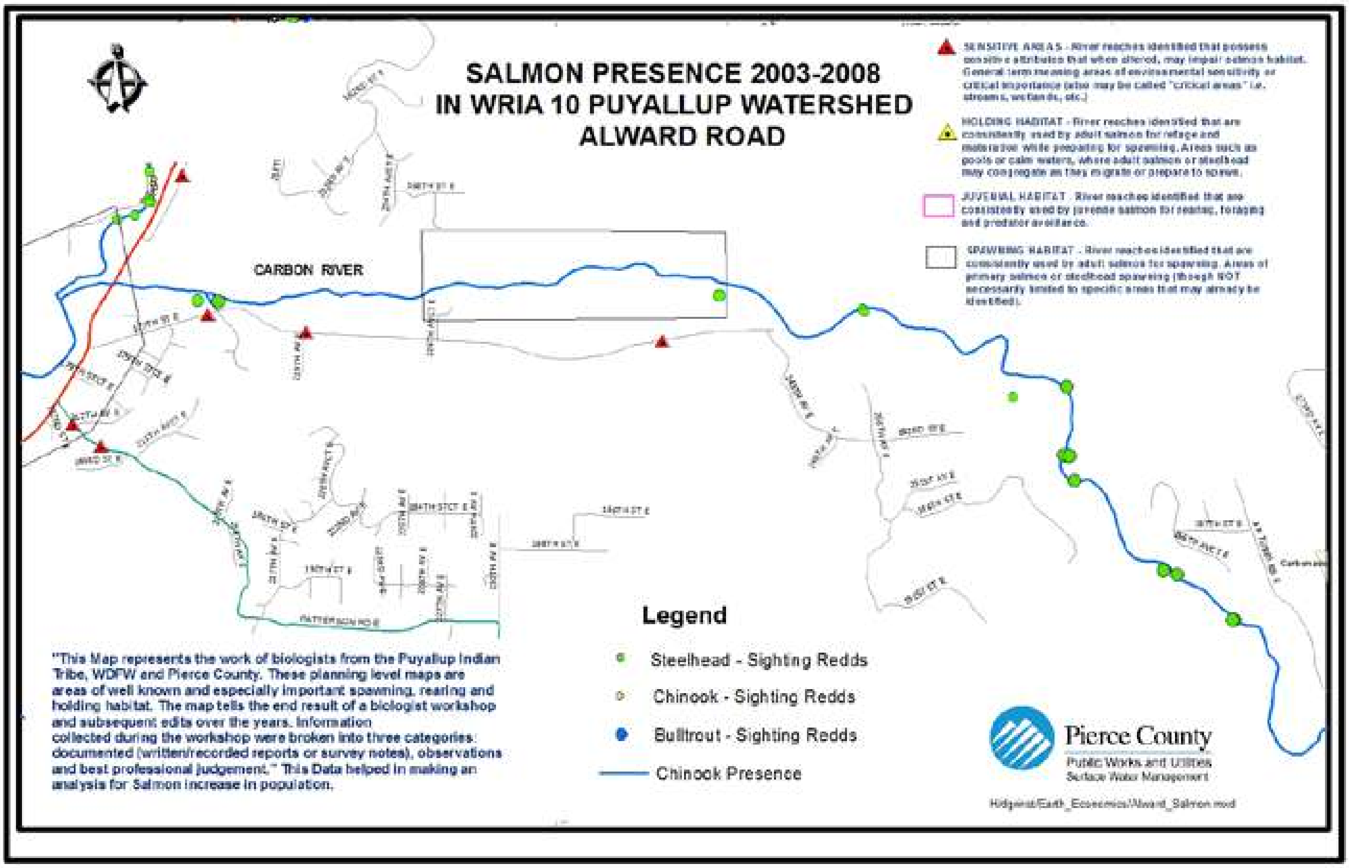


Figure 7: Salmon Habitat at Alward Road
Source: Pierce County

Figure 8, a 1931 photo, shows that the Carbon has historically been a complex, extensively braided and meandering river. Since the 1960s, however, the river in this reach has been transformed into a single, relatively straight stream. The consequences have been costly to both the built and natural resources. After the levees were constructed, property between the levee and the road was divided and homes were constructed. Once the homes were there the county was expected to maintain a level of protection to those homeowners and keep the road open for access. This began a cycle of damage and reactive investment that drags on the county and the residents. For Pierce County, addressing damage to the levees and structures in the Alward reach has been like rolling a boulder uphill. Major flooding has swept the Carbon six times since 1990. River infrastructure like bridges and storm sewer outfalls have been repeatedly destroyed or damaged, resulting in damage costs estimated at $15 million.[41] Damage from 2006 to 2009 totaled $3.5 million. This reach is one of the most expensive stretches of river that the county has to maintain.

The county has built no new levees in the highly active river reach since 1991, instead focusing on levee repairs and buying out property owners. The county has acquired 19 parcels, 16 of which contained structures, at total cost of $4.1 million, not including demolition costs. Much of that funding was provided by the FEMA Hazard Mitigation Grant Program, which provided a 75 percent match.[42]

Flooding on the Carbon also poses risks to public safety. A helicopter crew was required to rescue a family during the 2006 flood event. In addition to the unknown cost of the rescue, the county has also incurred road damage along 177th Street East. Incomplete records make it difficult to determine the full costs of these floods in terms of emergency reaction, rescue, road repair and other reconstruction costs.

Figure 8: Alward Road Reach on the Carbon River, 1931
Source: Pierce County

Property owners in the Alward reach also pay a substantial price. At least $2 million in home damage occurred from November 2006 to January 2009. Homeowners who hold federally backed mortgages and pay monthly premiums are required to purchase flood insurance. The risks of living in a major flood hazard zone, the lack of "peace of mind" and loss of treasured personal possessions are real but difficult-to-quantify social costs for these residents. Many residents in flood zones want to move out, but they feel trapped with mortgages and unable to sell these properties in frequently flooded areas. When they are able to sell their property to a new owner, it only transfers the problem to a new owner who later feels she wasn't given enough notice about the potential for flooding. County staff also spends time educating current and new owners as well as dealing with calls to improve the level of flood protection. The four largest floods on record on the Carbon River have all occurred during the past 20 years. As expensive as the Alward reach has been to maintain, climate change projections indicate that the flooding risks will only increase in coming years.

The Alward reach flooding problems are painfully ironic. Both man and nature have exacerbated the problem. Levees built from 1930 to the 1960s dramatically narrowed the channel and facilitated the private home construction behind the levees. This increased flood velocities, water flood elevations, and downstream flows, give the river more destructive power, and caused overtopping of the levees in this reach. High river velocities damaged the older levee system more severely and increased maintenance costs in areas that will be hit again. The Carbon River falls steeply from Mount Rainier and transports large amounts of sediment and woody debris downstream. The raging waters in the Carbon River can move boulders that scour the riverbed and increase sediment loads. The Carbon River will never be a slow meandering river, easily controlled with structures. During normal flows, the excess sediment material being carried by the river flow is deposited in the channel as the incline and the velocity is reduced. During high and fast flows, the material may again be suspended and swept downstream. But the buildup of excess gravel material also reduces the channel's carrying capacity, causing the river to shift within the floodplain and overtop the levees more frequently.

Figure 9: Levee Breach at Alward Road, 2006
Source: Pierce County

Figure 10: Repairing a Levee at Alward Road
Source: Pierce County

Table 4: Recent Levee Maintenance Costs Alward Road

Levee	Approx. Location (River Mile)	Length (Linear Feet)	Damage	Estimated Cost (2010 USD)	Flood Event
Alward Road	7.5	118	Face scour with core exposure	$60,000	Jan. 2009
Alward Road	6.4	110	Lower face scoured. Large face rock lost and causing unravelling of upper face.	$56,000	Jan. 2009
Water Ski	6.75	200	Lower face scour with core exposure	$102,000	Jan. 2009
Water Ski	6.4	310	Face scour with loss of most face rock and core exposure	$158,000	Jan. 2009
Water Ski	6.25	144	Lower face scour causing upper face sloughing	$73,000	Jan. 2009
Water Ski	6.2	255	Face scour with loss of most face rock and core exposure	$130,000	Jan. 2009
Alward Road	8.0	100	Toe scour and loss of face rock. Lower face slumping	$20,000	Nov. 2008
Alward Road	7.2 - 7.3	796	Toe scour and loss of face rock. Lower face slumping	$403,000	Nov. 2008
Alward Road	7.0	100	Face scour and loss of face rock	$20,000	Nov. 2008
Alward Road	6.4	171	Toe scour and loss of face rock	$87,000	Nov. 2008
Alward Road	6.35	136	Toe scour and loss of face rock	$69,000	Nov. 2008
Alward Road	6.25	302	Toe scour and loss of face rock	$107,000	Nov. 2008
Alward Road	6.0	824	Face rock scour and some core exposure	$292,000	Nov. 2008
Water Ski	7	139	Wash out	$70,000	Nov. 2008
Water Ski	6.45 - 6.6	900	Face scour, loss of face rock	$273,000	Nov. 2008
Water Ski	6.25	140	Toe scour, loss of face rock, exposed core	$50,000	Nov. 2008
Water Ski	6	336	Face Erosion	$170,000	Nov. 2008
Alward Road	6.0 - 6.1	600	Wash out	$184,000	Nov. 2006
Alward Road	6.3	600	Wash out	$519,000	Nov. 2006
Alward Road	7.5	1,200	Wash out	$1,038,000	Nov. 2006
Alward Road	7.6	700	Wash out	$606,000	Nov. 2006
Water Ski	6.0	500	Wash out	$433,000	Nov. 2006
Water Ski	6.0	300	Face erosion	$87,000	Nov. 2006
Water Ski	6.3	100	Wash out	$433,000	Nov. 2006
Water Ski	6.4	500	Wash out	$476,000	Nov. 2006
Water Ski	6.8	550	Wash out	$476,00	Nov. 2006

Table 4: Recent Levee Maintenance Costs Alward Road Continued

Levee	Approx. Location (River Mile)	Length (Linear Feet)	Damage	Estimated Cost (2010 USD)	Flood Event
Alward Road	6.05	250	Toe/Slope failure	$108,000	Feb. 1996
Alward Road	6.25	250	Toe/Slope failure	$108,000	Feb. 1996
Alward Road	6.3	100	Toe/Slope failure	$43,000	Feb. 1996
Alward Road	6.4	50	Toe/Slope failure	$22,000	Feb. 1996
Alward Road	6.6	500	Toe failure	$217,000	Feb. 1996
Alward Road	6.9	250	Toe/Slope failure	$208,000	Feb. 1996
Alward Road	7.2	850	Total levee failure	$675,000	Feb. 1996
Water Ski	6.18	40	Toe/Slope failure	$17,000	Feb. 1996
Water Ski	6.9	400	Total levee failure	$173,000	Feb. 1996
Water Ski	7.1	800	Total levee failure	$635,000	Feb. 1996
Alward Road	7.3	100	Partial wash out, toe and face rock	$47,000	Nov. 1995
Alward Road	7.1	700	Full wash out	$452,000	Nov. 1995

County Proposal

The county's new flood management plan identifies property acquisition and a new setback levee along a 2.4-mile stretch of Alward Road as one of its highest-rated capital projects. The levee would be 9,800 linear feet, or 1.85 miles.[44] The proposal includes 25 engineered logjams to slow the current and protect both the new setback levee and downstream levees currently hammered by the swift current churned out by this stretch of river. The work is estimated to cost around $29.6 million.[45] The costs are high, but so are the benefits. The project would reconnect over 175 acres of riparian floodplain to the river, improve salmon habitat, substantially increase floodplain storage, reduce public safety risks and end a perpetual cycle of reactive investment in outdated levees and temporary fixes.

The historical management of flood risk in the Alward Road reach is a classic example of costly 20th century approaches to flooding. County officials recognize the costs of repairing the existing levees will only get larger, while providing less flood protection. But as long as the homes remain there is little choice. Unfortunately, removing the levee and incorporating green infrastructure for the solution requires substantial capital investment.

Figure 11: Proposed Levee Setback at Alward Road

Source: Pierce County Flood Plan

Neadham Road

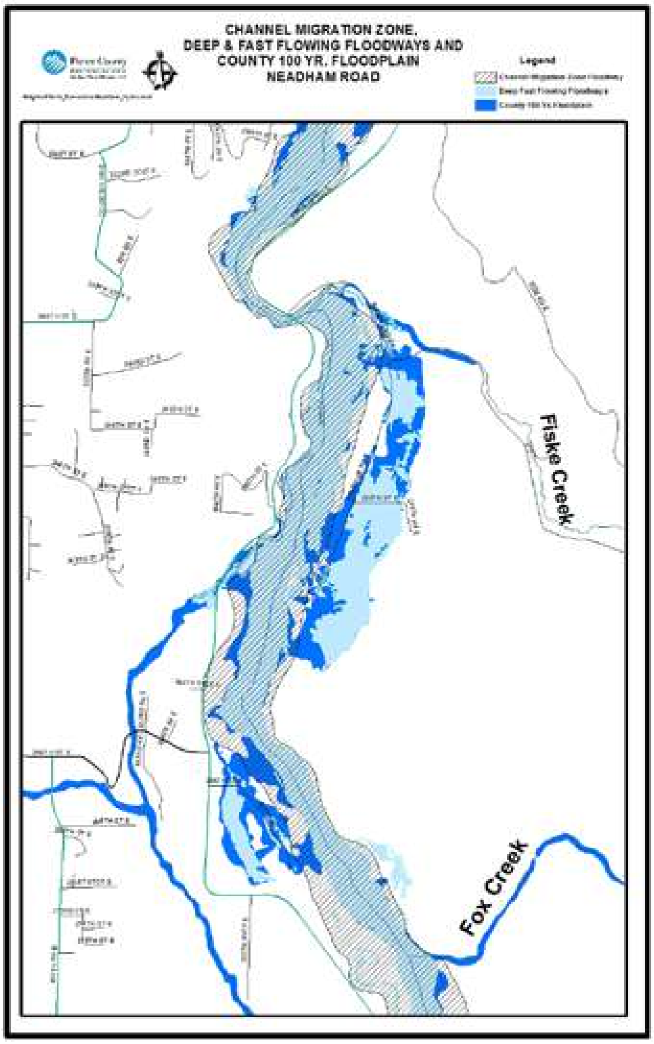
History and Context

Neadham Road is a dead-end road located in the Upper Puyallup River floodplain about four miles south of Orting. For Pierce County Public Works, it is a constant and costly challenge. Like the Alward Road reach, Neadham Road clearly demonstrates the problems of allowing development within a flood hazard area and trying to constrain a powerful river from causing more flood damage.

The Puyallup in this vicinity is highly dynamic; the flood management plan characterizes the river as "actively migrating towards the right bank" – toward Neadham Road. The road serves a development of about 40 properties. When the development along Neadham Road began, there were no regulations designating this area as part of the floodway. Both the location of the river and the presence of the levees made the area appear to be attractive development opportunity with low flood risk. However, the Puyallup River is highly dynamic in this reach, and the geomorphology shows clearly that the river migration zone will be a hazard development in the future. Every flood event has moved the river towards the existing development so that the existing homes are now squarely within the DFF, CMZ, and mapped 100-year floodplain, Figure 12.

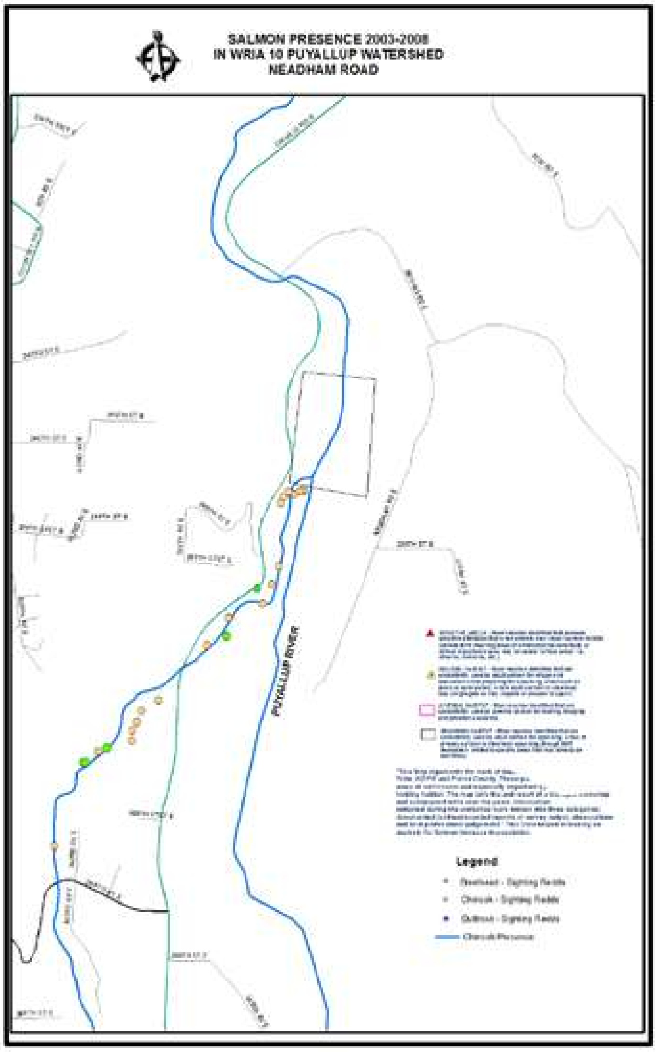
The Upper Puyallup also supports several salmonid species. Kapowsin Creek, a tributary that flows near the reach, is the largest and most productive Chinook and steelhead spawning tributary on the Upper Puyallup River. Such habitat is extremely valuable in the Puget Sound region, where Chinook have been listed as a threatened species since 1999.

Figure 12: Flood Hazard Areas at Neadham Road



Source: Pierce County Flood Plan

Figure 13: Salmon Habitat Near Neadham Road



Source: Pierce County

With a "control the river" approach, construction of levees and revetments were begun in 1968 and concluded in 1975. The work greatly constrained the channel to less than 15 percent of its historical active channel width. In 1931, the active river corridor ranged from 2,000 to 3,000 feet wide. Levees have reduced the active corridor to 200 to 300 feet.

Figure 14: Neadham Road Reach of the Puyallup River, 1931

Source: Pierce County

Levees seemed like a good, cost effective flood management strategy at the time. However, in the long run they have proven to be costly. Along much of the powerful Upper Puyallup River, the 20th century levee strategy was destined for erosion and washout. A 2011 geomorphic report prepared for the county lists the following undesirable consequences.[46] The Upper Puyallup levees:

- Caused "pronounced" disruption of natural processes in the channel and floodplain
- Encouraged building and development in a highly vulnerable area.
- Increased the vulnerability of roads during high flows.
- Disconnected floodplain wetlands and riparian forests.
- Allowed conversion of floodplain forest to agriculture or residential use, reducing soil cohesion and the hydraulic roughness that slows current and limits channel migration.
- Reduced accumulation of large woody material (LWM) – e.g., stumps, logs and large limbs – a process that limits channel migration and forms valuable salmon habitat by creating pools and side channels.
- Constricted and thus deepened and increased flood flow in the channel, moving sediment and LMW downstream where it can create more flood and erosion problems.
- Boosted the river's erosive energy to a level far exceeding the resistance of the levees. "Once a levee fails, the river can easily erode it from the land side," the report notes.

Figure 15: Neadham Road Levees and Revetments

Source: Pierce County

In the Neadham Road reach, levee construction has produced particularly costly and disastrous results. While the development was not in a designated, regulated floodway when it broke ground, the dynamic nature of the river through this reach has brought the floodwaters to the doors of the current homeowners. The weight, momentum and erosive power of a river in flood, rushing from high to low elevations is something only recently appreciated. The river has eroded well beyond its 1990 channel, leaving only fragments of the costly levees in its wake. The river is reoccupying many of the areas in its historic channel migration zone and in some cases eroding areas it has not occupied in 500 years. Bank erosion has accelerated since 1978. The original unconfined channel migration rate is estimated at 13.5 feet per year; since 1978, the average rate of lateral bank erosion has increased to 87 feet per year.

Figure 16: A Compromised Levee at Neadham Road, 2008

Source: Pierce County

Table 5: Recent Levee Maintenance Costs Neadham Road

Levee	Approx. Location (River Mile)	Length (Linear Feet)	Damage	Estimated Cost (2010 USD)	Flood Event
Neadham Road	26.3	738	Full washout	$374,000	Nov. 2008
Neadham Road	26.8	1,000	Washout	$865,000	Nov. 2006
Neadham Road	26.2	2,000	Total failure	$1,587,000	Feb. 1996
Neadham Road	26.4	600	Total failure	$476,000	Feb. 1996
Neadham Road	26.6	1,000	Total failure	$794,000	Feb. 1996
Orville Road	25.2	250	Toe/Slope failure	$108,000	Feb. 1996
Orville Road	26.6	900	Toe/Slope failure	$714,000	Feb. 1996
Orville Road	26.7	1,200	Toe/Slope failure	$952,000	Feb. 1996
Neadham Road	25.1	200	Partial washout, toe and face rock	$101,000	Nov. 1995
Neadham Road	25.6	200	Partial washout, toe and face rock	$101,000	Nov. 1995
Neadham Road	26.8	500	Partial washout, toe and face rock	$225,000	Nov. 1995
Orville Road	26.2	1,500	Full washout	$1,110,000	Nov. 1995
Orville Road	26.5	225	Partial washout, toe and face rock	$111,000	Nov. 1995
Orville Road	26.6	200	Partial washout, toe and face rock	$101,000	Nov. 1995
Orville Road	27	600	Full washout	$455,000	Nov. 1995
Neadham Road	26	900		$1,3570,000*	Nov. 1990
Neadham Road	26.2	800			
Neadham Road	26.4	700			
Orville Road	26.6	900			
Orville Road	26.8	250			
Orville Road	27	800			
Orville Road	27.6	1,000			
Total				**$9,431,000**	

Source: Randy Brake, Pierce County

* Total for all November 1990 damages

Figure 17: Flooding at Neadham Road, 2006

Source: Pierce County

County Response

Not surprisingly, some time ago the county decided rebuilding levees in the Neadham reach is a lost cause. The county has been acquiring properties with an eye toward removing the levees and abandoning the road. Since 1991, 180 acres of land, including some parcels with homes, have been acquired in this area. [47] Nineteen homes, which are regularly cut off when Neadham Road is flooded, remain to be purchased. [48] These homes sit at an average of two feet below flood level.[49]

The county's proposed capital project, rated as a high priority, has an estimated cost of $8.1 million.[50] The county would purchase the remaining properties, remove the homes and abandon Neadham Road. To protect Brooks Road, which now provides access to Neadham Road and to other areas beyond the floodplain, the county would build a short setback levee and engineered log jams within the channel. Even so, some risk of flooding will remain. The plan would allow the river to migrate much more freely and reconnect 200 acres of historic floodplain to the Upper Puyallup River. This would provide more flood storage and add more critical habitat for Chinook salmon and bull trout.

Calculating the full historic costs of fighting the river along Neadham Road is difficult due to incomplete records. Some individual repair operations have exceeded $1 million.[51] Costly evacuations of residents were required in the 1996 flooding. The costs of repairing flood damage to Neadham Road, while not recorded, have not been negligible. In addition, there are difficult-to-quantify social costs borne by residents who have suffered damaged homes, higher costs for flood insurance and worries about rain events and future flooding calamities.

Climate change means the Neadham Road area can anticipate more frequent and worse flooding in coming years. The largest floods in the area have all occurred since 1990.[52] As in the Alward Road example, Neadham Road's history demonstrates the need to adopt regulations that prevent construction in channel migration zones and to recognize and accommodate the power and value of natural processes. Preserving the meander zone also provides increased salmon habitat, recreational opportunities and other ecosystem service benefits.

Clover Creek Open Space

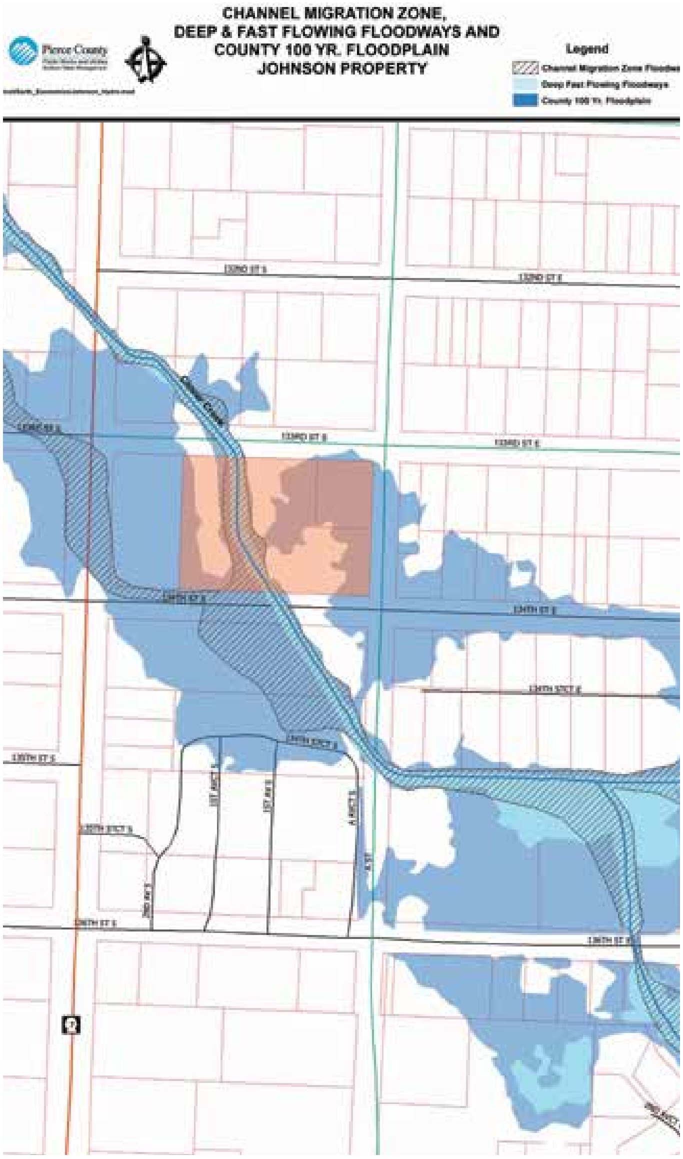
This case study raises the following questions: Does it make sense to allow new homes to be built in an ecologically sensitive flood-prone location in spite of the existing regulatory structure that would prohibit construction of structures and homes at this location? Does building the homes on mounds satisfactorily mitigate flood risk for future homeowners?

The focus in this study is a 2.98-acre undeveloped property in the Parkland area of southeast Pierce County. It lies in a highly developed residential and commercial area a short distance east of State Route 7, a heavily traveled commuter corridor characterized by strip-type development with big-box stores, fast-food restaurants, gas stations, branch banks and other commercial activity. SR 7 is also a principal route to Mount Rainier National Park.

Although not abutting commercial development, the property lies in an area zoned for intensive commercial, multifamily, civic or residential development. Clover Creek, a flood-prone stream that enters Steilacoom Lake, runs north to south through the property before turning southwest toward Lakewood and Puget Sound. Although Clover Creek is not navigable, it falls under the jurisdiction of the state Shorelines Management Act as well as the county's critical areas regulations. Regulations designate an enforceable buffer of 150 feet on each side of the creek where structures do not already exist.

The property lies almost entirely within the 100-year floodplain for Clover Creek, almost completely in the DFF zone, and in a designated open space and fish and wildlife corridor. The area has flooded three times in the past 20 years. Clover Creek was channelized in the mid-20th century. The creek has been straightened and lined with rocks. There are no levees in this reach, although there are some berms further downstream.

Figure 18: Flood Hazard Areas for Clover Creek Open Space



In 2007, the county's Department of Planning and Land-Use Services granted a Declaration of Non-Significance (DNS) for a proposal to build seven homes on lots roughly 50' x 150' each, all on the east bank of Clover Creek.[53] DNS approval meant no environmental impact statement was required. In 2008, the applicant sought and received through the county hearing examiner process a variance to meet requirements stemming from the site's location in shoreline, floodplain and critical areas environments.

Prior to the development application, unauthorized filling and grading occurred on the site. The applicant proposes to bring the site back into compliance as part of the development work. As of February 2013, no application for building permits or other necessary permits have been submitted.

Source: Pierce County

Figure 19: Flooding Near Clover Creek Open Space, 2009

Source: Pierce County

Under terms of the variance, the west bank of Clover Creek will remain undeveloped with the normally required 150-foot buffer area. The required buffer area on the east bank is reduced to 35 feet, with the buffer to be fenced off by a split-rail fence. [54] For purposes of the variance, an additional 15 feet in the back yards of the proposed homes is to be considered buffer as well, and no structures will be allowed in this section of the property. No restoration is required on the west bank. The developer will be required to re-grade the east bank, and replace non-native vegetation with native trees and shrubs. In the process, soil from the regrading would be used to "mound" the foundations for the houses and to create compensatory flood storage between them. However, the developer will not be required to modify the surrounding roads in any way. Those roads have been known to flood with up to three feet of water (Figure 19). In the event of 100-year flooding, the houses would become islands, according to testimony at the variance hearing.[55]

The examiner's rationale for granting the variance was that the vicinity is already heavily developed, that residential use would have less impact than other allowable development and that restoration of the east bank would improve habitat along the creek.[56]

In terms of progressive floodplain management and smart economic development, the rationale falls short. Storage for floodwaters in this area regularly subject to flooding will simply be maintained, not improved. However, the public costs will likely rise if buildings are constructed on the site. The proposal would result in a loss of 43,500 square feet of buffer (one acre) and the enhancement of only 10,500 square feet. [57] When flooding inevitably occurs, the new residential properties and the utilities and infrastructure that serve them will be adversely impacted. Restoration rather than development would actually increase flood storage capacity and benefit the community. Recognizing this, Surface Water Management has approached the developer about possible property swaps that would allow the Clover Creek site to remain as open space; to date, nothing has come of those discussions. [58] A community group long involved in Clover Creek restoration efforts upstream from the site has advocated purchasing the site with county Conservation Futures funds, which are used for open space acquisitions.[59]

Effects on Ecosystem Services

If built, the proposed development would adversely impact the potential for enhancing existing ecosystem services at the development site and within Clover Creek. Although the variance requires low-impact development techniques (such as pervious driveway surfaces) to be used, the volume of stormwater runoff will increase. There is also the real possibility that when flooding surrounds the property there will be dissatisfaction among the new homeowners. They will want the county to either build flood facilities upstream to prevent flooding or buy them out (which at that time will be a much higher expense to the county than buying vacant land now). If they aren't successful at first they can try again when new elected officials are in place or they can sell their property to new unsuspecting buyers and the cycle starts all over again.

Water quality will decline due to increased erosion and polluted stormwater runoff. The variance prohibits the use of fertilizers, pesticides and sheds in the new homes' back yards, but future homeowners may not be advised of that restriction; experience shows that it is unlikely to be enforced in any meaningful way.[60] Homeowners will naturally have expectations that they should be able to use their property as other homeowners do. Natural habitat will be adversely affected by increased human activity (noise, light, pet traffic and waste, yard waste disposal, etc.), and there will be no positive effect on the west bank. During the variance hearing, several agencies had urged that restoration of the west bank be required as well.[61]

Development at this location would represent a lost opportunity for effective natural restoration and the economic benefits that restoration provides. Just upstream of this site a major restoration project was begun in 2007. A little more than 14.2 acres of habitat was restored at a cost of $6.5 million.[62] An additional 4.8 acres were acquired for future restoration. Substantial restoration work also been conducted by the county and citizen volunteers downstream from the development site. Restoring the site would contribute to a connected corridor of restored habitat along much of Clover Creek. Restoring it would also increase aquifer recharge.[63] Clover Creek is a groundwater-fed system. Most of the problems affecting the system stem from lowered groundwater levels, so aquifer recharge is critical to the overall sustainability and health of natural capital at Clover Creek. Currently, fourteen percent of the water budget is lost due to water drawn by wells. Restoration of the development site would attenuate flooding only slightly, but it would help reconnect wetlands, improve fish and wildfowl habitat and offer opportunities for passive recreation.[64]

If current regulations are enforced, there will not be an increase in flood risk, loss of a potential restoration site, and some of the costs associated with flooding could be avoided. Restoration could provide great benefits to the surrounding neighborhood and downstream development.

The Value of Regulation

Pierce County's high CRS rating and its regulatory designation of Deep and/or Fast Flowing zones, Channel Migration Zones and Compensatory Storage Requirements demonstrate the county's leadership in terms of flood risk mitigation standards. However, if exemptions are granted, the beneficial effects are seriously undermined. It is politically difficult to invest proactively; the political controversy that surrounded the county's creation of a countywide Flood Control Zone District attests to that. As it was, political sensitivity to raising taxes prompted the council, as the district's governing body, to authorize a property tax of only 10 cents per $1,000 of assessed value; the council could have authorized as much as 50 cents per $1,000, which would have raised much more revenue and allowed much more progress in reducing flood risk.[65] A higher tax rate, however, might have generated more public opposition and objections from officials of cities that are not directly subject to flood threats. Unfortunately, unpopular proactive investments with high up front costs both in terms of dollars and political capital are frequently the investments with the highest return. In the end, it is the role of government to preventatively protect its citizens, not merely to rescue them in time of disaster.

This report is an attempt to demonstrate the economic value of the key regulations involved in flood risk reduction. The economically valuable ecosystem benefits that can be derived from natural processes greatly increase protection of the county's residents. The higher flood peaks associated with climate change could cause more property damage and erosion if development is not avoided in highly vulnerable flood zones. The changes in weather patterns and stream flows anticipated with climate change, such as more summer drought, will increasingly jeopardize endangered species. The retreat of Mount Rainier glaciers adds more channel-filling sediment to the watershed's stream systems, reducing their carrying capacity and increasing flood frequency.

Avoided Cost

A key concept in assessing the economic value of regulations used for flood risk reduction is avoided cost. The Alward Road and Neadham Road case studies are retrospective: They involve the costs that could have been avoided and the benefits that could have been accrued if development had not been allowed in those reaches. The Clover Creek case is prospective: It involves the costs that could be avoided and the benefits that could be gained if the property is not developed. In our economic analysis, avoided cost is the value of costs avoided or mitigated by ecosystem services that would have been incurred in the absence of those services. For example, wetlands have demonstrable economic value when they effectively buffer against floodwater in a riverine system or the storm surge in a hurricane and reduce coastal damage.

Benefit Transfer Methodology is used to calculate these economic benefits. It is worth taking some time to explain how this works. Benefit transfer methodology is a widely accepted economic method in which the estimated economic value of an ecological good or service is determined by examining previous valuation studies of similar goods or services in other comparable locations. This method is used when the cost of conducting original valuation studies on specific sites for every ecological good or service is prohibitive.

Transfer refers to the application of derived values and other information from the original study site to another but sufficiently similar site, much as "comps" are used in business or real estate appraisals. Considered a "bedrock of practical policy analysis," benefit transfer methodology has gained respect in recent decades as decision-makers have sought timely and cost-effective ways to value ecosystem services and natural capital. The method is tailor-made for addressing the value of the natural flood-protection systems in the Puyallup River watershed.

To show the benefits lost due to development in the Alward and Neadham Road floodplains, for example, we calculated the ecosystem benefits as they are and as they would be without development, and then multiplied those benefits over 50 years to simulate the lifespan of development. The difference between the benefits would be the value lost to development. As we shall see, factoring in the long-term financial costs of developing in a highly sensitive natural area shows that it has cost Pierce County a great deal.

The Economics of Flood Protection and Time

The economic technique of discounting is decidedly unsexy, but it, too, merits some explanation. Discounting calculates a present value for a future economic benefit. In a moment, we'll briefly discuss discounting more fully, but here let us note that we discount out to 50 years for all three case studies. For Neadham and Alward, this shows what value could have accrued over the past 50 years had those reaches not been developed. For Clover Creek, discounting is applied as a projection of two possible future scenarios: development or restoration. While built infrastructure provides value over dozens of years, the value of green infrastructure can last much longer and in many cases increase in value over time.

An ecosystem produces a flow of valuable services across time. In this sense it can be thought of as a capital asset. This analogy can be extended by calculating the net present value of the future flows of ecosystem services, just as the asset value of a traditional capital asset can be approximately calculated as the net present value of its future benefits. This calculation is an exercise, however, because ecosystems are not bought and sold in this manner.

Calculating the net present value of an asset in traditional economics requires the use of a discount rate. Applying a positive discount rate inherently says "this thing is less valuable to me in the future than it is to me now." For large water projects, the Army Corps of Engineers uses a 4 percent discount rate, which lowers the value of the benefits by 4 percent every year into the future. Seattle Public Utilities and some other institutions use as 5 percent discount rate for capital construction projects. The net present value of the ecosystem assets valued in our Pierce County case studies was calculated using two discount rates, zero and 4 percent. Using a zero percent discount rate recognizes the renewable nature of natural assets and that people a century from now can enjoy same level of benefits that we enjoy today – provided the ecosystems are not degraded or destroyed.

A discount rate is designed to control for the following:

1. Pure time preference of money. This is the rate at which people value what they can have now, compared with putting off consumption or income until later.

2. Opportunity cost of investment. A dollar in one year's time has a present value of less than a dollar today, because a dollar today can be invested for future return.

3. Depreciation. Built assets such as cars and levees tend to deteriorate and lose value due to wear and tear, while natural assets tend to appreciate in value. Discounting can be adjusted for different types of assets.

Discounting has limitations. Using a discount rate assumes the benefits that people reap in the present are more valuable than the benefits provided to future generations. Renewable resources should be assessed with lower discount rates than built capital assets because they provide a rate of return over a much longer period of time. Most of the benefits that a natural asset such as a functional floodplain provides reside in the distant future, whereas most of the benefits of built capital, like a car, reside in the near term. Both types of assets are important to maintain a high quality of life, but they operate on different time scales. It would be unwise to treat our time preference for a forest as if it were a building, or a building as if it were a disposable coffee cup. Similarly, built capital is priced with the concept of scarcity in mind. As a product becomes scarcer, its value increases. This is important when thinking of natural capital because it appears that fully functioning natural capital will only become scarcer with time. Therefore a low discount rate better reflects the true asset value of the flood areas examined in this study.

Valuation

To identify the ecosystem services present at Alward and Neadham Roads, Geographical Information Systems (GIS) data was used to determine the types and extent of land cover. GIS data is gathered through aerial and/or satellite photography. The Western Washington Land Cover (2006) was used as the foundational GIS layer. Land covers were identified through recorded observations at the Clover Creek site.

For the assessment of what the Alward and Neadham Road reaches would have looked like without development, other sites within the county where levees have been removed were analyzed using aerial photography. It is apparent that without the constraints of a levee, the rivers reclaim much of what used to be forest, grassland, or shrubland with the first big storm. Relic channels are often reoccupied, and what was once an artificially straightened river becomes a complex, braided system once more. As such it was assumed that without the levees and development, the area of the river would increase and the rest of the land would become riparian buffer and reconnected wetlands.

In each analysis, figures are provided to show the geographic distribution of land cover within the reach. Also provided is a table that lists the Western Washington land cover types occurring in the reach, and a table that presents the final land cover classes and acreage totals. Because all three sites are in the same county, the same ecosystem service values are applied to each case. Table 6 shows the ecosystem services valued at the case study sites. The Alward and Neadham reaches currently represent all of those land covers, but as it is a smaller site in an urban area, Clover Creek only represents Riparian Buffer, Scrub/Shrub, and River.

Table 6: Ecosystem Services Valued at the Case Study Sites

	Forest	Grassland	Rivers	Riparian Buffer	Shrub / Scrub	Wetland
Gas Regulation	x	x			x	x
Climate Regulation						
Disturbance Regulation				x		x
Biological Control	x	x		x		
Water Regulation	x	x	x			x
Water Supply	x		x			x
Waste Treatment	x	x	x			x
Soil Retention		x		x		x
Soil Formation	x	x				
Nutrient Regulation						
Pollination	x	x			x	
Food Production	x	x		x		x
Raw Materials						
Genetic Resources		x				
Medicinal Resources						
Ornamental Resources						
Habitat and Biodiversity	x		x	x	x	x
Nursery						
Aesthetic Information			x	x		x
Recreation	x	x	x	x	x	x
Cultural and Artistic Information	x		x			x
Science and Education	x					
Spiritual and Historic Information						

Key

(shaded)	**Ecosystem service produced by land cover class but not valued in this report**
x	**Ecosystem service produced by land cover class and valued in this report**

Most of the studies used here for calculating transfer values were conducted in the United States. All estimates are based on studies conducted in temperate zone ecosystems. In the very few cases where no local or national figures were available, international values were used where appropriate; they were derived from countries both temperate and high income. Thus estimates from ecosystem types with poorly comparable ecological processes were excluded. For information on the limitations of the benefit-transfer approach, please refer to Appendix D.

Recreation and habitat values received particular attention in this study. Often in benefit-transfer, values for a particular service are considered to be substitutive. However, many recreation and habitat studies value a particular form of recreation or habitat for one species and should be considered additive when the specificities vary. For example, the wetland habitat values used in this report were derived by adding together fish and waterfowl habitat values.

The resulting high value for riparian buffer might seem extraordinary at first glance. The high value for soil erosion control provided by riparian buffers is due to the inclusion of a study that valued the avoided cost of dredging. It is easy for people to think back to 30 years ago when dredging was common and imagine that dredging could solve the flooding problems of today. However with the increased sediment outflow from Mount Rainier and the higher flood rates of the last 20 years, dredging is not an affordable option for Pierce County. Dredging could easily cost $2 million per year with no end in sight.* Nonstructural solutions to flood risk mitigation, on the other hand, have an end game.

All values were standardized to 2010 dollars using the Bureau of Labor Statistics Consumer Price Index Inflation Calculator. Appendix A lists the studies used for the value transfer estimates. Tables 6 through 8 below summarize the combined high and low ecosystem service values for each land cover assessed at the three case study sites

* Based on sediment aggradation found by Washington USGS on the lower Puyallup multiplied by estimated cost of dredging 1 cubic meter of sediment. http://pubs.usgs.gov/sir/2010/5240/

Table 7: High and Low Dollar per-acre Estimates for Forest and Grassland

Ecosystem Service	FOREST Low Value ($/acre/year)	FOREST High Value ($/acre/year)	GRASSLAND Low Value ($/acre/year)	GRASSLAND High Value ($/acre/year)
Aesthetic				
Biological Control	2	11	13	13
Climate Regulation				
Cultural and Artistic	11	11		
Disturbance Regulation				
Food Production	30	30	34	34
Gas Regulation	12	331	0.03	158
Genetic Resources			0.01	0.01
Habitat and Biodiversity	539	1,065		
Medicinal Resources				
Nursery				
Nutrient Regulation				
Ornamental Resources				
Pollination	68	399	15	399
Raw Materials				
Recreation	120	809	0.29	0.29
Science and Education	438	438		
Soil Formation	6	6	1	1
Soil Retention			17	17
Spiritual and Historic				
Waste Treatment	195	195	52	52
Water Regulation	637	637	2	2
Water Supply	10	1,770		
Total	**$2,070**	**$5,703**	**$134**	**$675**

Table 8: High and Low Dollar per-acre Estimates for Wetland and Riparian Buffer

	WETLAND		RIPARIAN BUFFER	
Ecosystem Service	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/acre/year)	High Value ($/acre/year)
Aesthetic	1348	4985	77	1169
Biological Control			23	294
Climate Regulation				
Cultural and Artistic	1045	1045		
Disturbance Regulation	148	7364	58	3884
Food Production	63	9373	17	49
Gas Regulation	5	490		
Genetic Resources				
Habitat and Biodiversity	288	51914	11	51
Medicinal Resources				
Nursery				
Nutrient Regulation				
Ornamental Resources				
Pollination				
Raw Materials				
Recreation	2243	12307		
Science and Education				
Soil Formation				
Soil Retention	18	8579	37	26117
Spiritual and Historic				
Waste Treatment	210	5328	88	512
Water Regulation	148	17351		
Water Supply	534	21748	336	1085
Total	**$6,052**	**$140,483**	**$646**	**$33,162**

Table 9: High and Low Dollar per-acre Estimates for Shrub/Scrub and River

Ecosystem Service	SHRUB/SCRUB Low Value ($/acre/year)	SHRUB/SCRUB High Value ($/acre/year)	RIVER Low Value ($/acre/year)	RIVER High Value ($/acre/year)
Aesthetic			88	88
Biological Control				
Climate Regulation				
Cultural and Artistic			5	5
Disturbance Regulation				
Food Production				
Gas Regulation	6	8		
Genetic Resources				
Habitat and Biodiversity	1	314	368	368
Medicinal Resources				
Nursery				
Nutrient Regulation				
Ornamental Resources				
Pollination	1	7		
Raw Materials				
Recreation	2	183	21	21223
Science and Education				
Soil Formation				
Soil Retention				
Spiritual and Historic				
Waste Treatment			1	8
Water Regulation			691	2668
Water Supply			41	1664
Total	**$10**	**$511**	**$1,213**	**$26,024**

One of the assumptions made in the valuations of Alward and Neadham Roads is that in the absence of development, the case study areas in question would have remained natural areas. There exists the possibility that they would have been put to other uses, such as logging or agriculture. However, as a part of the purpose of this study is to examine the value of functional floodplains, floodplain preservation was used as the alternate scenario to development.

Alward Road Valuation

Here we discuss the savings – or rather, the costs that would have been avoided – had homes never been constructed there. If the river had been given the space it naturally needed, much of the damage that has occurred would have been avoided and many benefits would have accrued over that time.

When the Alward Road area was developed, the current regulations weren't on the books, and levees were believed to be sufficient protection against minor or moderate flooding and to maintain the channel from migration. If current DFF and CMZ regulations had been in place:

- No homes would have been built because of the risk to life and property.
- Hundreds of thousands, if not millions, of dollars spent to build levees and allow floodplain development would have been saved.
- The money spent for levee maintenance and repair and the money spent on road repair and reconstruction would have been saved.
- Local, state and federal funds spent for property acquisitions in flood-prone areas could have been saved.
- The county would have accrued the benefits of a host of ecosystem services provided by the natural floodplain.

Unfortunately, incomplete recordkeeping prevents a clear picture of the full costs the development has imposed on Pierce County. The cost estimate provided here represents:

- An estimate of the cost of the original levee in present-day dollars based on a calculation of $1,000 per linear foot.
- Damage estimates for the Alward Road levee and the Water Ski levee on the opposite bank dating back to the 1990s.
- The costs of property acquisitions made to date.
- The county's estimate of the cost of acquiring the remaining 41 properties, demolishing existing structures, removing the existing levees, restoring habitat and building a new, 9,800-linear-foot setback levee.

The actual total costs over time are much higher than the estimate provided here. This calculation leaves out earlier levee operation and maintenance costs, emergency management costs and roads division costs. It also leaves out the staff time of inspecting levees, routine maintenance, record keeping, efforts to request federal funding for repairs, acquiring and maintaining access roads for levees, annual warning and preparedness for residents. It also doesn't include the staff time needed to respond to the questions and concerns local residents have about flood-protection issues. Private costs cannot be determined because homeowners are not required to report costs attributable to flooding. But a very conservative estimate for public costs incurred by levee construction and floodplain development at Alward Road, based on our calculations, is about $50 million in 2010 dollars.

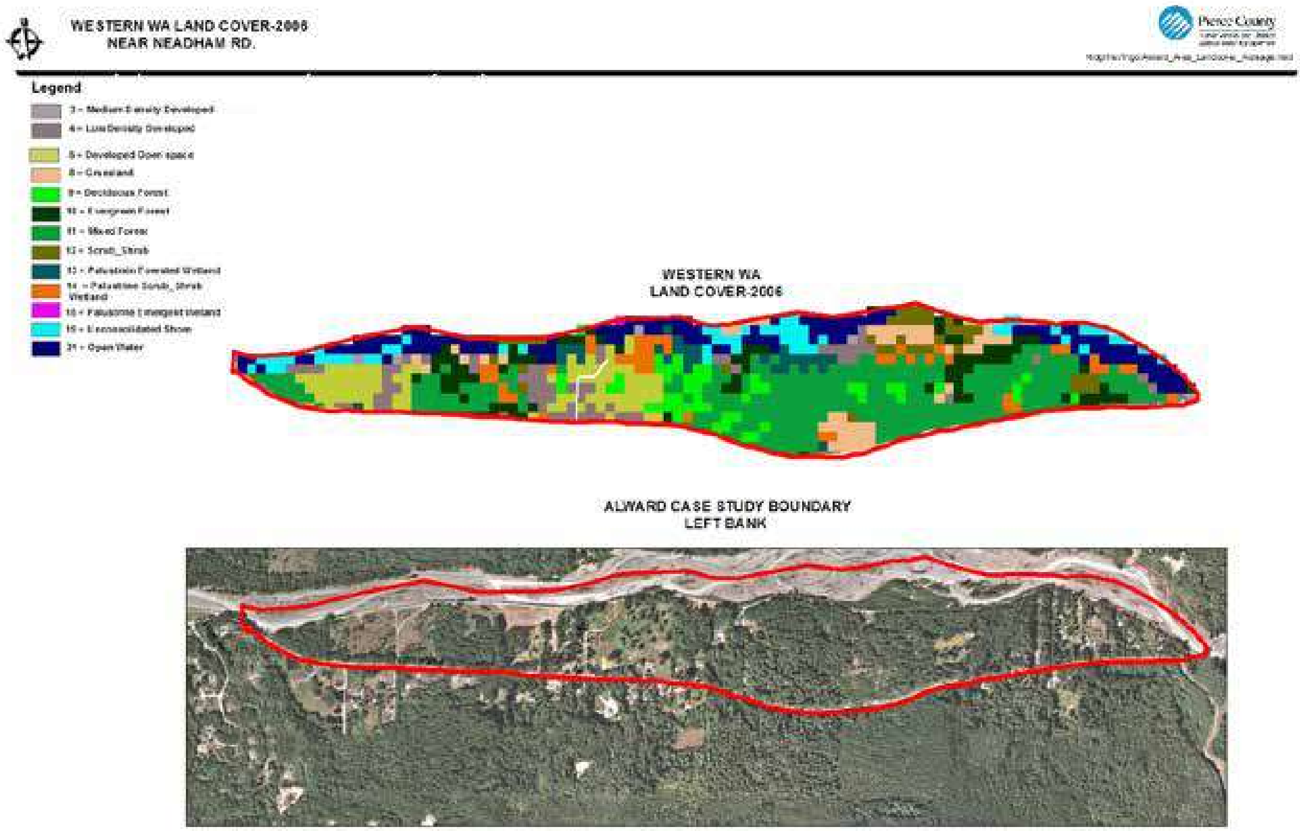
Table 10: Estimated Costs of Development at Alward Road

Investment Required	Est. Cost	Year
Levee Construction of 91,150 l.f.	$9,150,000	1960s
Water Ski Levee Damage	$3,859,570	1990-2009
Alward Road Levee Damage	$6,041,430	1990-2009
Property Acquisition	$1,317,919	1989-2003
Capital Improvement Project	$29,600,000	unknown
Total	**$49,968,919**	

Ecosystem Services

Here the value of ecosystem services that could be provided if the Alward reach were in a fully natural state is discussed. The ecosystem services already provided have been severely impacted by levees and development. To identify the present ecosystem services, GIS data was used and calculations were made using Benefit Transfer Methodology. Figure 20 shows geographic distribution of land cover within the reach. Table 11 shows the existing land cover types. Table 12 presents the final land cover classes and acreages that comprise the reach, with references to Table 11. Recall that the amount of landcover change was estimated with aerial photography from other levee setbacks. No forest, grassland, or scrubland would be there without levees protecting them from the river.

Figure 20: Land Cover at Alward Road



Source: Pierce County

Table 11: Western Washington Classes Used in This Study

Western WA Code	Land Cover Description
21	Open Water
19	Unconsolidated Shore
5	Developed Open Space
4	Developed, Low Intensity
3	Developed Medium Intensity
2	Developed High Intensity
9	Deciduous Forest
10	Evergreen Forest
11	Mixed Forest
12	Shrub / Scrub
8	Grassland
13	Palustrine Forested Wetland
14	Palustrine Scrub/Shrub Wetland
15	Palustrine Emergent Wetland

Table 12: Total Acreages by Land Cover Class in Alward Road Reach

Land Cover Class	Area (Acres)	Data Sources / Layers Used
Forest	111	Western WA 9,10,11
Riparian Buffer	13	Western WA 19
Grassland	12	Western WA 8
Shrub/Scrub	9	Western WA 12
River	30	Western WA 21
Wetlands	17	Western WA 13,14,15
Developed Land	26	Western WA 3,4,5
Total	**217**	

Table 13: Annual Value of Ecosystem Services Produced at Alward Road

Land Cover Class	Area (Acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Forest	111	2,070	5,703	229,029	631,101
Riparian Buffer	13	646	33,162	8,304	426,461
Grassland	12	134	675	1,629	8,231
Shrub/Scrub	9	10	511	88	4,691
River	30	1,213	26,024	36210	776,550
Wetlands	17	6,052	140,483	103791	2,409,423
Developed Land	26	Not Valued	Not Valued	Not Valued	Not Valued
Total	**250**			**$379,050**	**$4,256,456**

Table 14: Annual Value at Alward Road Without Development

Land Cover Class	Area (Acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Forest	0	2,070	5,703	-	-
Riparian Buffer	109	646	33,162	70212	3605950
Grassland	0	134	675	-	-
Shrub/Scrub	0	10	511	-	-
River	65	1,213	26,024	79169	1697865
Wetlands	43	6,052	140,483	263215	6110333
Developed Land	0	Not Valued	Not Valued	Not Valued	Not Valued
Total	**217**			**$412,597**	**$11,414,148**

Table 15: Estimates of the Cost of Development at Alward Road

Discount Rate	Low Estimate	High Estimate
With Development		
0% (50 years)	$18,952,000	$212,823,000
4% (50 years	$8,143,000	$91,438,000
Without Development		
0% (50 years)	$20,630,000	$570,707,000
4% (50 years	$8,863,000	$245,201,000
Benefits Lost		
0% (50 years)	$1,678,000	$357,884,000
4% (50 years	$720,000	$153,763,000
Benefits Lost Plus Cost Incurred		
0% (50 years)	$51,646,000	$407,854,000
4% (50 years	$50,690,000	$203,732,000

The only reason that the levee was built so far away from the road was to encourage development, and now it is clear what some of the costs of that decision have been. It has been roughly 50 years since the development went in at Alward Road, by applying two different discount rates – zero and 4 percent – the net present value of benefits lost and costs incurred by those decisions can be calculated. A conservative estimate for the ecosystem benefits lost and the public costs incurred, using a zero percent discount rate, ranges from $51.6 million to $407.9 million. Using a 4 percent discount rate yields a conservative estimate that ranges from $50.7 million to $203.7 million. If the current regulations had been on the books 50 years ago the residents of Pierce County could have saved at least this much.

Neadham Road

Our calculations for the Neadham Road reach follow the same path as those outlined in the Alward Road valuations. As with Alward Road, understanding the risk of damage to life and property from floods 50 years ago would have forestalled building in the Neadham reach. The costs of building, maintaining and repairing levees would have been avoided. The costs of acquiring properties in flood-prone areas would have been avoided. And a host of ecosystem services would have been provided over decades, had development not occurred. Ecosystem services in the Neadham reach were calculated in the same manner as those of the Alward reach in the previous section.

Table 16: Estimated Public Costs of Developing Neadham Road

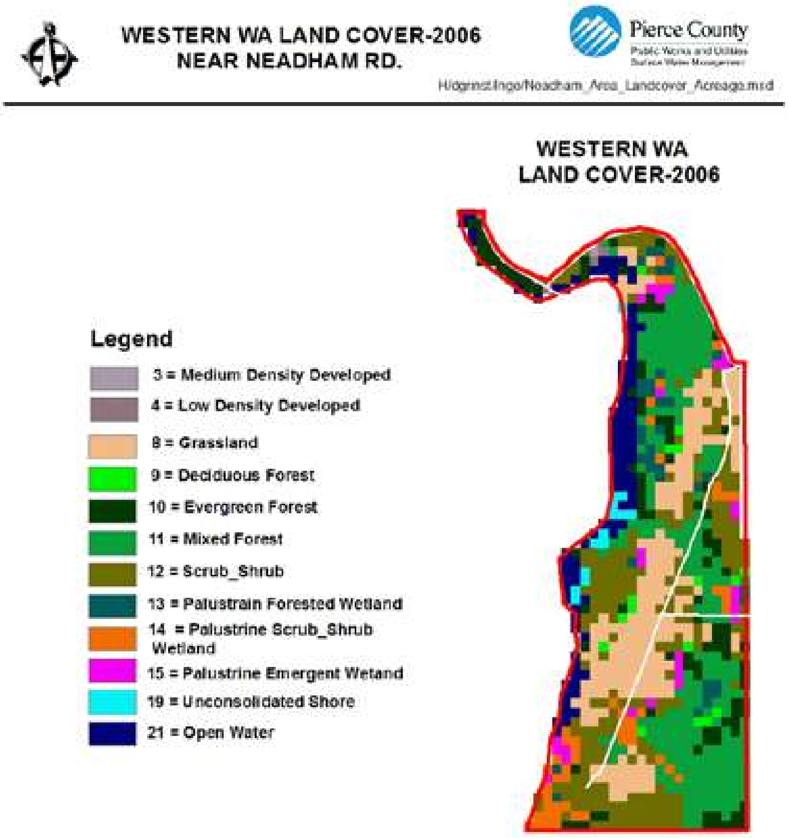
Investment Required	Est. Cost	Year
Levee Construction of 8,900 l.f.	$8,900,000	1960s
Orville Road Levee Damage	$4,299,252	1990-2009
Neadham Road Levee Damage	$5,131,748	1990-2009
Property Acquisition	$15,31,636	1994-2000
Capital Improvement Project	$8,100,000	Unknown
Total	**$27,962,636**	

Sources: Personal Com. Ingo Kuchta; Flood Plan

Ecosystem Services

Figure 21 shows the geographical distribution of land cover within the reach. Table 18 presents the final land cover classes and acreage totals that comprise the Neadham reach, with references to Table 17. Table 21 shows the calculations, based on 0 and 4 percent discount rates, for the public costs incurred by development in the reach and the lost benefits of ecosystem services

Figure 21: Land Cover in Neadham Road



Source: Pierce County

Table 17: Western Washington Classes Used in this Study

Western WA Code	Land Cover Description
21	Open Water
19	Unconsolidated Shore
5	Developed Open Space
4	Developed, Low Intensity
3	Developed Medium Intensity
2	Developed High Intensity
9	Deciduous Forest
10	Evergreen Forest
11	Mixed Forest
12	Shrub / Scrub
8	Grassland
13	Palustrine Forested Wetland
14	Palustrine Scrub/Shrub Wetland
15	Palustrine Emergent Wetland

Table 18: Total Acreages by Land Cover Class in Neadham Road Reach

Land Cover Class	Area (Acres)	Data Sources / Layers Used
Forest	94	Western WA 9,10,11
Riparian Buffer	3	Western WA 19
Grassland	48	Western WA 8
Shrub/Scrub	55	Western WA 12
River	23	Western WA 21
Wetlands	27	Western WA 13,14,15
Other	1	Western WA 3,4,5
Total	**250**	

Table 19: Annual Value of Ecosystem Services Produced at Alward Road

Land Cover Class	Area (Acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Forest	94	2,070	5,703	194,246	53,525
Riparian Buffer	3	646	33,162	2,073	106,449
Grassland	48	134	675	6,423	32,462
Shrub/Scrub	55	10	511	531	28,171
River	23	1,213	26,024	27,303	585,535
Wetlands	27	6,052	140,483	161,157	3,741,136
Developed Land	1	Not Valued	Not Valued	Not Valued	Not Valued
Total	**250**			**$391,733**	**$5,029,008**

Table 20: Annual Value at Neadham Road After Levee Removal

Land Cover Class	Area (Acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Forest	0	2,070	5,703	-	-
Riparian Buffer	125	646	33,162	80,820	4,150,741
Grassland	0	134	675	-	-
Shrub/Scrub	0	10	511	-	-
River	75	1,213	26,024	91,130	1,954,380
Wetlands	50	6,052	140,483	302,982	7,033,489
Developed Land	0	Not Valued	Not Valued	Not Valued	Not Valued
Total	**250**			**$474,933**	**$13,138,611**

Table 20: Estimates of the Cost of Development at Alward Road

Discount Rate	Low Estimate	High Estimate
With Development		
0% (50 years)	$19,587,000	$251,450,000
4% (50 years	$8,415,000	$108,034,000
Without Development		
0% (50 years)	$23,747,000	$656,931,000
4% (50 years	$10,203,000	$282,246,000
Benefits Lost		
0% (50 years)	$4,160,000	$405,481,000
4% (50 years	$1,788,000	$174,212,000
Benefits Lost Plus Cost Incurred		
0% (50 years)	$32,123,000	$433,443,000
4% (50 years	$29,750,000	$202,175,000

Again, it is important to note that these are conservative estimates, in part because not all of the actual costs incurred during flood events were recorded and thus were not included in the calculations. Based on these calculations, the estimates of benefits lost plus the costs incurred over the last 50 years, with a zero percent discount rate, ranges from $32.1 million to $433.4 million. With a 4 percent discount rate, the estimates ranges from $29.8 million to $202.2 million.

Clover Creek Case Study

Although a variance has been permitted along Clover Creek, the development has yet to break ground in a significant way, and it is still possible to opt for enhancing the riparian buffer. For this valuation, we looked at the benefits provided by the property that encompasses the proposed development as it is now, as it will be if the development goes in, and as it could be if restoration work is done on the property instead. GIS layers were not appropriate at this scale, so the acreage estimates are made from observations on the land.

Currently the plot is mostly filled with invasive species and Shrub/Scrub type vegetation. The bank down to the creek is very steep due to illegal filling and grading done in the last 40 years. Despite the fact that roughly 80 percent of the property has the legal designation "riparian buffer," the land is not functioning as such due to poor ecosystem conditions. As such, 70 percent of the property was considered Shrub/Scrub, and only 30 percent was considered to be Riparian Buffer. The development area was calculated as seven 50 by 100-foot plots, or 1.205 acres. This was considered to largely impact the Shrub/Scrub area. While it will have some impact on the area of Riparian Buffer, the developers plan to enhance 10,500 square feet of buffer, so no change was produced there. In the case of restoration, for a conservative estimate, it was considered that only the 80 percent of the land that could be legally designated Riparian Buffer would be restored. The rest would remain Shrub/Scrub. Table 22 represents an estimate of annual value of ecosystem services currently provided by the property; Table 23 represents an estimate of the annual value of ecosystem services provided by the property in the event of development; and Table 24 represents an estimate of the annual value of ecosystem services provided by the property in the event of meaningful restoration work.

Table 22: Annual Value of Ecosystem Services produced at Clover Creek

Land Cover Class	Area (Acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Riparian Buffer	0.704	646	33,162	455	23,343
Shrub / Scrub	1.9924	10	511	19	1,018
River	0.234	1,213	26,024	284	6,081
Total	**2.93**			**$757**	**$30,442**

Table 23: Annual Value of Ecosystem Services Produced at Clover Creek with Development

Land Cover Class	Area (Acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Riparian Buffer	0.704	646	33,162	455	23,346
Shrub / Scrub	0.787	10	511	8	402
River	0.234	1,213	26,024	284	6,081
Developed Land	1.205	Not Valued	Not Valued	Not Valued	Not Valued
Total	**2.93**			**$746**	**$29,829**

Table 24: Annual Value of Ecosystem Services Produced at Clover Creek with Restoration

Land Cover Class	Area (Acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Shrub/Scrub	0.350	10	511	3	179
River	0.234	1,213	26,024	284	6,081
Restored Riparian Buffer	2.344	646	33,162	1,514	77,731
Total	**2.93**			**$1,800**	**$83,991**

Table 25: Net Present Value of Ecosystem Services at Clover Creek, Three Scenarios

Discount Rate	Low Estimate	High Estimate
With Development		
0% (50 years)	$38,000	$1,522,000
4% (50 years	$16,000	$654,000
Without Development		
0% (50 years)	$37,000	$1,491,000
4% (50 years	$16,000	$641,000
Benefits Lost		
0% (50 years)	$90,000	$4,200,000
4% (50 years	$39,000	$1,804,000
Benefits Lost Plus Cost Incurred		
0% (50 years)	$52,000	$2,678,000
4% (50 years	$23,000	$1,150,000

The annual values are not radically different between the property as is and with development. This is partly because it is difficult to show the inherent risk that the county may have to spend quite a bit of money in the future if development is allowed. The homeowners may well demand buyouts or flood infrastructure to right the wrong inflicted by allowing structures to be built in a flood-prone location. An assessment of current prices of single-family homes on comparable plot sizes within a one-mile radius of the property shows an average price of $149,000. When the county is conducting buyouts, officials are authorized to add 5 percent to the property value to compensate for sentimental value for the homeowners. So the risk is that if development moves forward, the county will have to divert money to buy out these homes in the next 20-50 years at a cost of at least $1 million. This doesn't include the cost of deconstruction, which can cost around $25,000 per structure. With that included, the potential cost rises to at least $1.2 million. This is not a sure thing, but it is a risk that has materialized repeatedly in Pierce County flood hazard areas.

Regardless, there is a huge gain to be had by doing restoration. Based on these calculations, development is not the best-use scenario for this plot of land. Development will only detract from the current ecosystem service benefits provided by the land. With an added value of $52,000 to $2.7 million at a zero percent discount rate, or $23,000 to $1.2 million at a 4 percent discount rate, restoration is clearly the best use for this property.

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Conclusions

The three case studies clearly demonstrate that development regulations taking into account both the risks associated with flooding and the valuable ecological services that natural areas provide are cost-effective. The county's present flood-related regulations and other steps it has taken have earned a high FEMA Community Rating System classification that entitles homeowners to lower flood insurance premiums. In addition, the studies show that leaving floodplains intact or minimally impacted by development improves the quality of life, preserves public safety, improves salmon habitat and improves economic efficiency – by reducing disruptions of transportation such as the need to repair roads, for example. Rather than being regarded as unwarranted intrusions on personal freedom, these regulations should be seen as conferring great public and private benefit to the taxpayers of Pierce County and the local economy. Allowing construction where it will pose hazards to public safety and risk flood damage is a foolish path that threatens economic sustainability.

The bottom-line numbers and comparisons in our three case studies demonstrate that the proactive investments envisioned in part of Pierce County's latest flood management plan are clearly worth the investment, even though the financial resources for accomplishing the significant list of projects are limited.

Reflecting on the original objectives of this report, this investigation set out to determine whether or not well-formulated land use regulations decrease public and private costs and if possible, demonstrate measurable benefits to those regulations through case studies. It is clear that the three regulations investigated here do decrease costs. The total public costs of just two sites, Alward and Neadham Roads, that did not have CMZs and DFF Floodways mapped and on the books come to between $2.5 million and $328 million over 50 years. It is likely that the costs were even higher, especially factoring in private costs that were not estimated. Compensatory Storage Requirements do decrease public costs by mitigating downstream flooding. They also place at least some of the costs of filling in the floodplain on the responsible parties rather than imposing damage costs downstream.

The final objective of this report was to inform future mitigation project implementation to achieve the best possible value at the lowest cost for Pierce County residents. The county has already done some of the most important planning and prioritization necessary to accomplish this in the Rivers Flood Hazard Management Plan, but the valuations done here show just how important it is to enforce the recommendations set forward in the plan. No matter how sound the county's floodplain development regulations, their effectiveness depends on reliable and consistent enforcement. The Clover Creek case study demonstrates how outdated standards can prevent the application of newer and smarter development regulations. This is a problem for Pierce County's growth management and land use planning in general and in flood risk reduction specifically.

The case studies demonstrate that for most environmentally sensitive areas, where the costs of "fighting the river" continually exceed the costs of mopping up and rebuilding after floods, it is cheaper to let nature and the rivers take their natural course.

Moving forward, how do we get state and local regulations changed to prevent the expenditure of public funds or giving tax breaks that incentivize building in flood hazard areas or designated regulatory floodplains? Should taxpayers disallow any public services to any new development in those designated flood hazard areas?

Engineered solutions such as levees will necessarily be part of the region's answer to the increased risk of flooding in the decades ahead. To the greatest extent possible, however, built solutions should be complemented with naturally provided ecological services, such as water storage in wetlands, floodplains and forests. Social infrastructure, such as effective land-use planning and regulation and early warning systems, must also be part of the equation. The result of a well-balanced approach will be improved flood protection, improved water quality, better agricultural soil quality, recovering fish and wildlife populations and higher recreational and aesthetic values.

A flood protection management regime that combines the lessons learned in the last century with nonstructural approaches will be the most effective. A 21st century management regime, then, should introduce river naturalization and adopt green infrastructure. This will allow more floodplain for the Puyallup and other rivers, reduce flood velocities and damage to levees, and lower maintenance costs for flood protection systems. Land acquisition to restore floodplain can be expensive up front, but one study has shown that such acquisitions can significantly reduce total costs over a 30-year-period.[lxvi]

In short, an effective, comprehensive approach to flood risk reduction in Pierce County would mean improved quality of life. It would mean economic savings as well.

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Appendix A: References

[1] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[2] Maynard, S., 2012. Pierce County's new flood-control district Oks countywide tax. The News Tribune. Tacoma, WA. <http://www.thenewstribune.com/2012/11/07/2359363/pierce-countys-new-flood-control.html>

[3] U.S. Army Corps of Engineers (USACE), 2009. National Levee Database. <http://nld.usace.army.mil/egis/f?p=471:1:>.

[4] Personal Communication with Hans Hunger 3-26-2013

[5] Pierce County, 2011. Frequently asked questions about the proposed Flood Control Zone District (FCZD). <http://www.co.pierce.wa.us/DocumentCenter/View/3337>

[6] Maynard, S., 2012. Pierce County's new flood-control district Oks countywide tax. The News Tribune. Tacoma, WA. <http://www.thenewstribune.com/2012/11/07/2359363/pierce-countys- new-flood-control.html>

[7] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[8] Maynard, S., 2012. Pierce County's new flood-control district Oks countywide tax. The News Tribune. Tacoma, WA. <http://www.thenewstribune.com/2012/11/07/2359363/pierce-countys- new-flood-control.html>

[9] USGS Surface-Water Data for the Nation. http://nwis.waterdata.usgs.gov/nwis/sw

[10] Associated Press, 2006. Flood damage will keep Mount Rainier's popular Paradise area closed all winter. The Seattle Times. Seattle, WA. <http://seattletimes.com/html/traveloutdoors/2003466303_webrainier07.html>

[11] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[12] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[13] Redman, S., 2013. Aggradation. Mount Rainier National Park; National Parks Service. <http://www.nps.gov/mora/naturescience/aggradation.htm>

[14] Andrews, J., 2011. Vital Signs Monitoring Overviews; Glaciers. National Parks Service (NPS). 25-41.

[15] Pierce County. Pierce County Flooding. Pierce County Public Works and Utilities. < http://www.piercecountywa.org/archives/103/2012%20flood%20bulletin%20for%20web.pdf>

[16] Visit Rainier, 2007. Mud Mountain Damn Recreation Area. Ashford, WA. <http://www.visitrainier.com/pg/hike/60/Mud%20Mt.%20Dam%20Recreational%20Area>

[17] McDonald, J. (Council member), 2011. Ordinance No. 2011-95s. Pierce County Council.

[18] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[19] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[20] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[21] Cowlitz Wahkiakum Council of Governments 2009. Lewis County 2007 Flood Disaster Recovery Strategy

[22] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[23] Batker, D., Schmidt, R., Harrison-Cox, J., Christin, Z., 2011. The Puyallup River Watershed: An Ecological Economic Characterization. Earth Economics, Tacoma, WA.

[24] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[25] Batker, D., de la Torre, I., Costanza, R., Swedeen, P., Day, J., Boumans, R., Bagstad, K. 2010. Gaining Ground: Wetlands, Hurricanes, and the Economy: The Value of Restoring the Mississippi River Delta. Earth Economics, Tacoma, WA.

[26] Sledge, M., 2012. After Hurricane Sandy, The Costs Of Doing Nothing To Protect New York Come Into Focus. Huffington Post. New York, NY. <http://www.huffingtonpost.com/2012/11/21/hurricane-sandy-newyork_n_2171199.html>

[27] Maynard, S., 2013. Flood report says upgrades in county to cost $350 million. The News Tribune. Tacoma, WA. <http://www.thenewstribune.com/2013/02/22/2484762/flood-report-says-upgrades-to.html>

[28] Rose, A., Porter, K., Dash, N., Bouabid, J., Huyck, C., Whitehead, J., Shaw, D., Eguchi, R., Taylor, C., McLane, T., Tobin, L., Ganderton, P., Godschalk, D., Kiremidjian, A., Tierney, K., and West, C, 2007. Benefit-Cost Analysis of FEMA Hazard Mitigation Grants. Natural Hazards Review. 97-111. <http://research.create.usc.edu/cgi/viewcontent.cgi?article=1014&context=published_papers>

[29] Archbold, M., 2007. Strict laws handcuff flood-zone residents. The News Tribune. Tacoma, WA. <http://www.thenewstribune.com/2007/05/14/61701/strict-laws-handcuff-flood-zone.html>

[30] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[31] Cardno Entrix, 2011. Upper Puyallup RM 25.3 to RM 28.6; Site Assessment and Conceptual Design Recommendations. Prepared for Pierce County Public Works and Utilities. Seattle, WA.

[32] Pierce County. Title 18E Development Regulations; Chapter 18E.70 Flood Hazard Areas. Critical Areas. <http://www.co.pierce.wa.us/DocumentCenter/View/1160>.

[33] Pierce County. An Ordinance of the Pierce County Council Repealing Chapters 12.05, "Offsite Road Improvement Regulations"; 12.06, "Development Using Local Access Roads"; 12.16, "Road Approach Control"; 15.42, "Pierce County Storm Drainage Ordinance"; 15.46, "Grading, Filling and Clearing Ordinance"; 17.10, "Flood Damage Prevention"; and Section 81.02.040(H), "Platting Fees" of the Pierce County Code and Enacting a New Chapter 15.42 Entitled "Site Development Regulations." < http://online.co.pierce.wa.us/cfapps/EDocs/ViewDocument.cfm?did=12095&dnum=>.

[34] Brake, R., e-mail message to David Carlton, February 26, 2013.

[35] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[36] Dillon, P., and Gould, S., 2007. Pierce County DFF Floodway Mapping. Northwest Hydraulic Consultants. Seattle, WA. <http://www.co.pierce.wa.us/archives/150/DFF-FloodwayReport.pdf>

[37] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[38] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[39] Brake, R., e-mail message to Nora Wahlund, February, 11, 2013.

[40] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[41] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[42] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[43] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[44] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[45] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[46] Cardno Entrix, 2011. Upper Puyallup RM 25.3 to RM 28.6; Site Assessment and Conceptual Design Recommendations. Prepared for Pierce County Public Works and Utilities. Seattle, WA.

[47] Kuchta, I., e-mail message to Nora Wahlund, February 11, 2013.

[48] Kuchta, I., e-mail message to Nora Wahlund, February 11, 2013.

[49] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[50] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[51] Reinelt, L. et al., 2012. Draft Pierce County Rivers Flood Hazard Management Plan: Public Review Draft. Pierce County Public Works and Utilities.

[52] USGS Surface-Water Data for the Nation. http://nwis.waterdata.usgs.gov/nwis/sw

[53] McCarthy, T. (Hearing Examiner), 2008. Determination of Nonsignificance. Environmental Application No. 568238. Pierce County. Tacoma, WA.

[54] McCarthy, T. (Hearing Examiner), 2008. RE: Shoreline Substantial Development Permit: SD49-07. Office of the Hearing Examiner. Pierce County. Tacoma, WA.

[55] McCarthy, T. (Hearing Examiner), 2008. RE: Shoreline Substantial Development Permit: SD49-07. Office of the Hearing Examiner. Pierce County. Tacoma, WA.

[56] McCarthy, T. (Hearing Examiner), 2008. RE: Shoreline Substantial Development Permit: SD49-07. Office of the Hearing Examiner. Pierce County. Tacoma, WA.

[57] McCarthy, T. (Hearing Examiner), 2008. RE: Shoreline Substantial Development Permit: SD49-07. Office of the Hearing Examiner. Pierce County. Tacoma, WA.

[58] Kuchta, I., e-mail message to Nora Wahlund, September 20, 2012.

[59] McCarthy, T. (Hearing Examiner), 2008. RE: Shoreline Substantial Development Permit: SD49-07. Office of the Hearing Examiner. Pierce County. Tacoma, WA.

[60] McCarthy, T. (Hearing Examiner), 2008. RE: Shoreline Substantial Development Permit: SD49-07. Office of the Hearing Examiner. Pierce County. Tacoma, WA.

[61] McCarthy, T. (Hearing Examiner), 2008. RE: Shoreline Substantial Development Permit: SD49-07. Office of the Hearing Examiner. Pierce County. Tacoma, WA.

[62] Kuchta, I., e-mail message to Nora Wahlund, December 20, 2012.

[63] Kuchta, I., e-mail message to Nora Wahlund, January 9, 2013

[64] Kuchta, I., e-mail message to Nora Wahlund, January 9, 2013

[65] Maynard, S., 2012. Pierce County's new flood-control district Oks countywide tax. The News Tribune. Tacoma, WA. <http://www.thenewstribune.com/2012/11/07/2359363/pierce-countys-new-flood-control.html>

[lxvi] White, E., 2011. Establishing Long-Term Cost Effectiveness of FEMA Buyouts: A Loss Avoidance Study of the Acquisition/Demolition of 22 Properties in Shepherdsville, Kentucky. Capstone for Graduate Degree, University of Kentucky Martin School of Public Policy and Administration.

Appendix B: Value Transfer Studies Used

Allen, J., Cunningham, M., Greenwood, A., Rosenthal, L., 1992. The value of California wetlands: an analysis of their economic benefits. Campaign to Save California Wetlands, Oakland, California.

Barrow, C. J. 1991. Land degradation. Cambridge University Press, Cambridge.

Bennett, R., Tranter, R., Beard, N., Jones, P., 1995. The value of footpath provision in the countryside: a case-study of public access to urbanfringe woodland. Journal of Environmental Planning and Management 38, 409-417.

Bouwes, N. W., Scheider, R., 1979. Procedures in estimating benefits of water quality change. American Journal of Agricultural Economics 61, 635-639.

Bowker, J.M., English, D.B., Donovan, J.A., 1996. Toward a value for guided rafting on southern rivers. Journal of Agricultural and Resource Economics 28, 423-432.

Boxall, P. C., McFarlane, B.L., Gartrell, M., 1996. An aggregate travel cost approach to valuing forest recreation at managed sites. Forestry Chronicle 72, 615-621.

Brookshire, D., M.A. Thayer, W.D. Schulze, and R.C. D'Arge.1982. Valuing public goods: a comparison of survey and hedonic approach. American Economic Review 72 (1): 165 -177.

Brouwer, R., Langford, I. H., Bateman, I.J., and Turner, R.K., 1999. A meta-analysis of wetland contingent valuation studies. Regional Environmental Change 1 1, 47-57.

Burt, O.R., Brewer. D., 1971. Estimation of net social benefits from outdoor recreation. Econometrica 39, 813-827.

Cooper, J., and Loomis, J. B. 1991. Economic value of wildlife resources in the San Joaquin Valley: Hunting and viewing values. In Economic and Management of Water and Drainage in Agriculture eds. Diner and Zilberman., Vol. 23. Kluwer Academic Publishers.

Copeland, J. H., R. A. Pielke, and T. G. F. Kittel. 1996. Potential climatic impacts of vegetation change: a regional modeling study. Journal of Geophysical Research (submitted).

Cordell, H. K., Bergstrom, J.C., 1993. Comparison of recreation use values among alternative reservoir water level management scenarios. Water Resources Research 29, 247-258.

Costanza, R, d'Arge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, RV., Paruelo, J., Raskin, RG., Sutton, P., van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253-2

Costanza, R., Farber, S.C., Maxwell, J., 1989. Valuation and management of wetlands ecosystems. Ecological Economics 1, 335-361.

Costanza, R., Pérez-Maqueo, O., Martinez, M. L., Sutton, P., Anderson, S. J., and Mulder, K. 2008. The value of coastal wetlands for hurricane protection. AMBIO: A Journal of the Human Environment, 374, 241–248.

Costanza, R., Wilson M., Troy A., Voinov A., Liu S., D'Agostino, J., 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Institute for Sustainable Solutions, Portland State University, Portland, Oregon.

Creel, M., Loomis, J., 1992. Recreation value of water to wetlands in the San-Joaquin Valley - linked multinomial logit and count data trip frequency models. Water Resources Research 28, 2597-2606.

Croke, K., Fabian, R., Brenniman, G., 1986. Estimating the value of improved water-quality in an urban river system. Journal of Environmental Systems 16, 13-24.

Doss, C. R., Taff, S.J., 1996. The Influence of Wetland Type and Wetland Proximity on Residential Property Values. Journal of Agricultural and Resource Economics 21, 120-129.

Duffield, J. W., Neher, C.J., Brown, T.C., 1992. Recreation benefits of instream flow - application to Montana Big Hole and Bitterroot Rivers. Water Resources Research 2, 2169-2181.

Gibbons, D. C. 1986. The economic value of water. Resources for the Future, Washington D.C.

Gramlich, F.W., 1977. The demand for clean water: the case of the Charles River. National Tax Journal 77, 183-194.

Greenley, D., Walsh, R.G., Young, R.A., 1981. Option value: empirical evidence from a case study of recreation and water quality. The Quarterly Journal of Economics 96, 657-673.

Gren, I.-M. and T. Soderqvist 1994. Economic valuation of wetlands: a survey. Beijer International Institute of Ecological Economics. Beijer Discussion Paper series No. 54, Stockholm, Sweden.

Gupta, T. R. and J. H. Foster 1975. Economic criteria for freshwater wetland policy in Massachussettss. American Journal of Agricultural Economics 57: 40-45.

Haener, M.K., Adamowicz, W.L., 2000. Regional forest resource accounting: A northern Alberta case study. Canadian Journal of Forest Research 30, 264-273.

Hayes, K.M., Tyrrell, T.J., Anderson, G., 1992. Estimating the benefits of water quality improvements in the Upper Narragansett Bay. Marine Resource Economics 7, 75-85.

Henry, R., Ley, R., Welle, P., 1988. The economic value of water resources: the Lake Bemidji survey. Journal of the Minnesota Academy of Science 53, 37-44.

Hicks, R., Haab, T., and Lipton, D. 2002. Estimating the Economic Benefits of Oyster Reef Restoration and Marine Preserve Establishment in the Lower Chesapeake Bay, 1-19.

Hougner, C., 2006. Economic valuation of a seed dispersal service in the Stockholm National Urban Park, Sweden. Ecological Economics 59, 364-374.

Howe, C. W. and K. W. Easter. 1971. Interbasin transfer of water: Economic issues and impacts. The Johns Hopkins Press, Baltimore.

Jenkins, W. A., Murray, B. C., Kramer, R. A., and Faulkner, S. P. 2010. Valuing ecosystem services from wetlands restoration in the Mississippi Alluvial Valley. Ecological Economics, 695, 1051-1061.

Jones, O. R., H. V. Eck, S. J. Smith, G. A. Coleman, and V. L. Hauser. 1985. Runoff, soil, and nutrient losses from rangeland and dry-farmed cropland in the southern high plains. Journal of Soil and Water Conservation 1:161-164.

Kenyon, W., Nevin, C., 2001. The use of economic and participatory approaches to assess forest development: a case study in the Ettrick Valley. Forest Policy and Economics 3, 69-80.

Knowler, D.J., MacGregor, B.W., Bradford, M.J., Peterman, R.M., 2003. Valuing freshwater salmon habitat on the west coast of Canada. Journal of Environmental Management 69, 261–273.

Kozak, J., Lant, C., Shaikh, S., and Wang, G. (2011). The geography of ecosystem service value: The case of the Des Plaines and Cache River wetlands, Illinois. Applied Geography 31, 303-311.

Kreutzwiser, R., 1981. The economic significance of the long point marsh, Lake Erie, as a recreational resource. Journal of Great Lakes Resources 7, 105-110.

Krieger, D.J., 2001. Economic value of forest ecosystem services: A review. The Wilderness Society, Washington, D.C. http://www.wilderness.org/Library/Documents/upload/Economic-Value-of-Forest-Ecosystem-Services-A-Review.pdf

Kulshreshtha, S. N., Gillies, J.A., 1993. Economic-evaluation of aesthetic amenities - a case-study of river view. Water Resources Bulletin 29, 257-266.

Lampietti, J.A. and J.A. Dixon. 1995. To see the forest for the trees: a guide to non-timber forest benefits. The World Bank,. Environmental Economics Series 013, Washington, D.C.

Lant, C. L. and R. S. Roberts 1990. Greenbelts in the cornbelt: riparian wetlands, instrinsic values and market failure. Environment and Planning A 22: 1375-1388.

Lant, C. L., Tobin, G., 1989. The economic value of riparian corridors in cornbelt floodplains: a research framework. Professional Geographer 41, 337-349.

Leschine, T. M., K.F. Wellman and T. H. Green. 1997. Wetlands’ Role in Flood Protection. October 1997. Report prepared for: Washington State Department of Ecology Publication No. 97-100. http://www.ecy.wa.gov/pubs/97100.pdf

Loomis, J.B., 2002. Quantifying Recreation Use Values from Removing Dams and Restoring Free-Flowing Rivers: A Contingent Behavior Travel Cost Demand Model for the Lower Snake River. Water Resources Research 38.

Mates. W., Reyes, J., 2004. The economic value of New Jersey state parks and forests. New Jersey Department of Environmental Protection, New Jersey.

Mathews, L. G., Homans, F.R., Easter, K.W., 2002. Estimating the benefits of phosphorus pollution reductions: an application in the Minnesota River. Journal of the American Water Resources Association 38, 1217-1223.

Mullen, J. K., Menz, F.C., 1985. The effect of acidification damages on the economic value of the Adirondack Fishery to New-York anglers. American Journal of Agricultural Economics 67, 112-119.

Olewiler, N., 2004. The value of natural capital in settled areas of Canada. Ducks Unlimited Canada and the Nature Conservancy of Canada. http://www.ducks.ca/aboutduc/news/archives/pdf/ncapital.pdf.

Pate, J., Loomis, J., 1997. The effect of distance on willingness to pay values: a case study of wetlands and salmon in California. Ecological Economics 20, 199-207.

Perrings, C. 1995. Economic values of biodiversity. in Global Biodiversity Assessment. United Nations Environment Programme (UNEP), Press Syndicate of the University of Cambridge 1995. pp 823-915.

Pimentel, D., 1998. Benefits of biological diversity in the state of Maryland. Cornell University, College of Agricultural and Life Sciences. Ithica, New York.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, P. Sphpritz, L. Fitton, R. Saffouri, R. Blair. 1995. Environmental and economic costs of soil erosion and conservation benefits. Science 267:1117-1123.

Pimentel, D., Wilson, C., McCullum, C., Huang, R., Owen, P., Flack, J., Trand, Q., Saltman, T., Cliff. B., 1997. Economic and Environmental Benefits of Biodiversity. BioScience 47, 747-757.

Piper, S., 1997. Rigonal impacts and benefits of water-based activities: an application in the Black Hills region of South Dakota and Wyoming. Impact Assessment 15, 335-359.

Pope, C.A. & J.W. Jones. 1990. Value of wilderness designation in Utah. Journal of Environmental Management 30: 157-174.

Prince, R., Ahmed, E., 1989. Estimating individual recreation benefits under congestion and uncertainty. Journal of Leisure Research 21, 61-76.

Qiu, Z., Prato, T., Boehm, G. 2006. Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed. Journal of the American Resources Association. 42. 6. 1583–1596.

Rein, F. A., 1999. An economic analysis of vegetative buffer strip implementation - Case study: Elkhorn Slough, Monterey Bay, California. Coastal Management 27, 377-390.

Ribaudo, M., Epp, D.J., 1984. The importance of sample descrimination in using the travel cost method to estimate the benefits of improved water quality. Land Economics 60, 397-403.

Sala, O. E., and J. M. Paruelo. 1996. Ecosystem services in grasslands. in G. Daily, editor. Ecosystem services. Island Press, Washington, DC.

Sanders, L. D., Walsh, R.G., Loomis, J.B., 1990. Toward empirical estimation of the total value of protecting rivers. Water Resources Research 26, 1345-1357.

Shafer, E. L., Carline, R., Guldin, R.W., Cordell, H.K., 1993. Economic amenity values of wildlife - 6 case-studies in Pennsylvania. Environmental Management 17, 669-682.

Streiner, C., Loomis, J., 1996. Estimating the Benefits of Urban Stream Restoration Using the Hedonic Price Methods Rivers 5(4) 267-78

Thibodeau, F.R., and Ostro, B.D., 1981. An economic analysis of wetland protection. Journal of Environmental Management 12, 19-30.

US Department of Commerce. 1995. Census of Agriculture 1992. Washington DC, Bureau of Census.

van Kooten, G.C., Schmitz, A., 1992. Preserving Waterfowl Habitat on the Canadian Prairies: Economic Incentives Versus Moral Suasion. American Journal of Agricultural Economics 74, 79-89.

van Vuuren, W., and Roy, P. 1993. Private and social returns from wetland preservation versus those from wetland conversion to agriculture. Ecological Economics, 8 3; 289-305.

Walsh, R. G., D. A. Greenley, and R.A. Young. 1978. Option values, preservation values, and recreational benefits of improved water quality: a case study of the SouthPlatte River Basin, Colorado. EPA., report no. 600/5-78-001. USA.

Ward, F.A., Roach, B.A., Henderson, J.E., 1996. The economic value of water in recreation: Evidence from the California drought. Water Resources Research 32, 1075-1081.

Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada. Http://www.davidsuzuki.org/Publications/Ontarios_Wealth_Canadas_Future.asp.

Wilson, S.J., 2010. Natural Capital in BC's Lower Mainland: Valuing the Benefits from Nature.

Woodward, R., and Wui, Y., 2001. The economic value of wetland services: a meta-analysis. Ecological Economics 37, 257-270.

Young, C.E., Shortle, J.S., 1989. Benefits and costs of agricultural nonpoint-source pollution controls: the case of St. Albans Bay. Journal of Soil and Water Conservation 44, 64-67.

Appendix C: Value Transfer Studies Used by Land Cover Class

Land Cover	Ecosystem Service General	Author(s)	Minimum ($/ac/yr)	Maximum ($/ac/yr)
Forest	Biological Control	Krieger, D.J.	$10	$10
		Pimentel et al.	$2	$2
		Wilson, S.J.	$11	$11
	Pollination	Costanza, R., et al.	$68	$306
		Houghner, C.	$68	$305
		Wilson, S.J.	$221	$399
	Soil Formation	Pimentel et al.	$6	$6
	Waste Treatment	Pimentel et al.	$52	$52
		Wilson, S.J.	$195	$195
	Water Regulation	Olewiler, N.	$32	$32
		Wilson, S.J.	$637	$637
	Water Supply	Constanza, R., et al.	$10	$444
		Ribaudo, M. and Epp, D.J.	$1,396	$1,770
	Food Production	Lampietti and Dixon	$30	$30
	Science and Education	Shafer, E.L., et al.	$438	$438
	Cultural	Pope and Jones	$11	$11
	Recreation			
	Hiking	Bennett, R., et al.	$182	$182
	Camping	Boxall, P.C., et al.	$0	$0
	General Recreation	Constanza, R., et al.	$0	$2,491
	Fishing, Hunting, Camping	Haener, M.K., and Adamowicz, W.L.	$0.48	$0.48
	Waterfowl Viewing	Shafer, E.L., et al.	$92	$92
	Watching Birds of Prey	Shafer, E.L., et al.	$532	$532
	Elk Viewing	Shafer, E.L., et al.	$3	$3
	General Recreation	Walsh et al.	$39	$39
		Wilson, S.J.	$120	$120
	Habitat Refugium and Nursery	Costanza, R., et al.	$1065	$1065
		Kenyon, W., and Nevin, C.	$539	$539
	Gas Regulation	Costanza, R., et al.	$12	$15
		Mates, W., Reyes, J.	$58	$254
		Pimentel et al.	$15	$15
		Pimentel et al.	$17	$17
		Wilson, S.J.	$14	$331

Land Cover	Ecosystem Service General	Author(s)	Minimum	Maximum
Wetland	Disturbance Regulation	Constanza et al.	$1,990	$1,990
		Constanza et al.	$1,990	$1,990
		Constanza et al.	$281	$281
			$3,723	$3,723
		Leschine et al.	$1,613	$7,364
		Thibodeau, F.R. and Ostro, B.D.	$7,197	$7,197
	Erosion Control	Woodward, R., and Wui, Y.	$18	$8,579
	Waste Treatment	Gren and Soderqvist	$252	$252
		Jenkins et al.	$545	$545
		Lant and Roberts	$193	$193
		Thibodeau, F.R. and Ostro, B.D.	$5,328	$5,328
		Wilson, S.J.	$195	$1,244
		Woodward, R., and Wui, Y.	$210	$2,299
		Olewiler, N.	$304	$854
	Water Regulation	Allen, J. et al.	$5,606	$17,351
		Wilson, S.J.	$1,665	$1,665
		Woodward, R. and Wui, Y.	$148	$2,915
	Water Supply	Brouwer, R. et al.	$22	$53
		Creel, M. and Loomis, J.	$534	$534
		Hayes, K.M. et al.	$1,266	$1,969
		Lant, C.L. and Tobin, G.	$336	$336
		Thibodeau, F.R. and Ostro, B.D.	$21,748	$21,748
		Woodward, R. and Wui, Y.	$10	$4,289
	Food Production	Allen, J. et al.	$63	$1,463
		Woodward, R. and Wui, Y.	$180	$9,373
	Cultural	Gupta and Foster	$1,045	$1,045
	Recreation			
	Recreation	Allen, J. et al.	$112	$579
	Waterflow | Hunting	Cooper, J. and Loomis, J.	$13	$316
	Recreation	Constanza, R. et al.	$101	$396
	Swamps	Gupta and Foster	$267	$267
	Swimming and Fishing	Hayes, K.M. et al.	$1,804	$3,448
	Fishing	Hicks et al.	$139	$139
	Recreation	Kozak et al.	$509	$509
	Fishing, Bird Watching, Waterflow, Hunting	Kreutwiser, R.	$195	$195
	Recreation	Lant and Roberts	$193	$193
	Recreation and Tourism	Thibodeau, F.R and Ostro, B.D.	$676	$12,112
	Recreation	Wilson, S.J.	$121	$121
	Fishing	Woodward, R. and Wui, Y.	$158	$2,239
	Birdwatching	Woodward, R. and Wui, Y.	$881	$4,641
	Bird Hunting	Woodward, R. and Wui, Y.	$42	$329

Land Cover	Ecosystem Service General	Author(s)	Minimum	Maximum
Wetland	Habitat Refugium and Nursery			
	Salmon Habitat	Pate, J. and Loomis, J.	$51,908	$51,908
	Habitat Refugium and Nursery	Allen, J. et al.	$5,567	$13,561
	Fish Habitat	Streiner, C., Loomis, J.	$282	$282
	Waterfowl Habitat	van Kooten, G.C. and Schmitz, A.	$6	$6
	Habitat Refugium and Nursery	Wilson, S.J.	$2,405	$2,405
	Aquatic, Terrestrial, and Avian Habitat	Woodward, R. and Wui, Y.	$158	$1,637
	Aesthetic	Doss, C.R and Taff, S.J.	$4,512	$4,985
		van Vuuren, W., and Roy, P.	$1,348	$1,348
	Gas Regulation	Jenkins et al.	$75	$97
		Wilson, S.J.	$5	$490
		Wilson, S.J.	$294	$294

Land Cover	Ecosystem Service General	Author(s)	Minimum	Maximum
River	Waste Treatment	Gibbons	$1	$8
	Water Regulation	Gibbons	$691	$2,668
	Water Supply	Bouwes, N.W., and Schneider, R.	$607	$607
		Croke, K. et al.	$557	$557
		Gibbons	$51	$1,664
		Henry, R., Ley, R., and Welle, P.	$422	$422
		Howe and Easter	$41	$411
		Piper, S.	$48	$48
		Ribaudo, M. and Epp, D.J.	$909	$909
	Cultural	Greenley, D., Walsh, R.G., and Young, R.A.	$5	$5
	Recreation	Bowker, J.M. et al.	$4,763	$11,446
		Burt, O.R. and Brewer, D.	$454	$454
		Cordell, H.K., and Bergstrom, J.C.	$195	$2,040
		Duffield, J.W. et al.	$1,696	$17,485
		Greenley, D. et al.	$21	$21
		Kreutzwiser, R.	$178	$178
		Loomis, D.B.	$11,992	$21,223
		Mullen, J.K. and Menz, F.C.	$287	$411
		Piper, S.	$236	$236
		Sanders, L.D. et al.	$2,475	$2,475
		Shafer, E.L. et al.	$96	$543
		Shafer, E.L. et al.	$1,083	$1,083
		Ward, F.A. et al.	$22	$2,067
	Habitat Refugium and Nursery	Streiner, C., Loomis, J.	$368	$368
	Aesthetic and Recreational	Young, C.E. and Shortle, J.S.	$88	$88

Land Cover	Ecosystem Service General	Author(s)	Minimum	Maximum
Shrub / Scrub	Pollination	Constanza, R., et al.	$1	$7
	Recreation			
	Hiking	Bennett, R., et al.	$182	$182
	Camping	Boxall, P.C., et al.	$0.19	$0.19
	Fishing, Hunting and Camping	Haener, M.K. and Adamowicz, W.L.	$0.29	$0.29
	Recreation	Prince, R., Ahmed, E.	$2	$2
	Habitat Refugium and Nursery	Constanza, R., et al.	$1	$314
	Gas Regulation	Costanza, R., et al.	$6	$8

Land Cover	Ecosystem Service General	Author(s)	Minimum	Maximum
Riparian Buffer	Biological Control	Rein, F.A.	$23	$294
	Disturbance Regulation	Rein, F.A.	$58	$3,884
	Waste Treatment	Rein, F.A.	$20,524	$20,254
	Water Suppy	Gramlich, F.W.	$1,085	$1,085
		Lant, C.L. and Tobin, G.	$336	$336
		Mathews, L.G., et al.	$14,022	$14,022
	Food Production	Knowler, D.J. et al.	$17	$49
	Recreation	Rein, F.A.	$14,714	$14,714
	Habitat Refugium and Nursery	Knowler, D.J. et al.	$11	$51
	Aesthetic	Kulshreshtha, S.N., and Gillies, J.A.	$77	$77
		Qiu et al.	$239	$1,169
	Soil Retention	Rein, F.A.	$37	$37
		Rein, F.A.	$212	$26,117

Land Cover	Ecosystem Service General	Author(s)	Minimum	Maximum
Grasslands	Biological Control	Pimentel et al.	$13	$13
	Genetic Resources	Perrings	$0	$0
	Pollination	Pimentel et al.	$15	$15
		Wilson, S.J.	$399	$399
	Soil Formation	Sala and Paruelo	$1	$1
	Waste Treatment	Pimentel et al.	$52	$52
	Water Regulation	Jones et al.	$2	$2
	Food Production	US Department of Commerce	$34	$34
	Recreation	Brookshire, D.	$0	$0
	Gas Regulation	Copeland et al.	$0	$0
		Sala and Paruelo	$0	$4
		Wilson, S.J.	$10	$158
	Soil Retention	Barrow, C.J.	$17	$17

Appendix D: Study Limitations

This study provides a best-possible first estimate of the economic value of the ecological goods and services generated within Pierce County floodplains. The study, based primarily on value transfer and not on original research of each ecosystem service within the case study locations, should be regarded as the best first estimate but also have the potential for improved accuracy from further research.

While a number of study limitations should be kept in mind when considering the results, these limitations do not detract from the fact that ecosystem services provide high value. Floodplain management is better informed with fact-based estimates rather than an implicit assumption of zero value for the following reasons:

1. **Limited ecosystem service studies.** Not all ecosystems have been well studied or valued. This results in a serious underestimate of the value of ecosystem services. This was the case with riparian buffer habitat and biodiversity values. Only one study was found to be applicable, and this has kept the values for this service artificially low. Also, the approach does not fully include the "existence" value of ecosystems.

2. **Uncertainty and service identification.** Some ecological services may not yet be identified. The dollar estimates of the value produced by natural systems are inherently underestimates. For example, while we may be able to place a dollar value on the water filtration services provided by a forest, we cannot fully capture the aesthetic pleasure that people gain from looking at the forest, nor every aspect of the forest's role in supporting the intricate web of life. Thus, most ecological service valuations serve as base markers somewhere below the minimum value of the true social, ecological, and economic value of an ecological service.

3. **Lack of appropriate valuation studies.** Medicinal, historic and spiritual values were identified but eliminated from the study because existing studies were inappropriate for this area. However, assuming that the case study locations produce no value in these categories is incorrect and reduces its true value. Historical values are site specific and resources were insufficient for a specific study of Pierce County floodplains. Similarly, there is no accepted method for monetizing spiritual value.

4. **Static analysis.** The values of goods and services, natural capital or otherwise, are dynamic. The current analysis provides a "snapshot" of value in Pierce County and for the project site. The values of many ecological services rapidly increase as they become increasingly scarce (Boumans et al. 2002). This could give rise to a general tendency for value transfer based on studies performed over the past ten years to underestimate the value of ecological services produced by ecosystems today. Dynamic models are being developed but are outside the scope of this study.

5. **GIS information.** The GIS vegetation cover data used is fairly coarse. For instance, it does not differentiate the quality of different wetlands. An assumption was made that ecosystems identified in the GIS analysis are fully functioning. As fewer and fewer ecosystems are fully intact due to human impact, this may result in an over-estimate of current value. This method assumes spatial homogeneity of services within ecosystems. That every acre of forest produces the same ecosystem services. This is clearly not the case. Whether this would increase or decrease valuations depends on the spatial patterns and services involved. Solving this difficulty requires spatial dynamic analysis, which is outside the scope of a basic ESV study.

6. **Process.** Since this methodology is based on ecosystem services provided per acre of vegetation type, it does not pick up the full value of process changes. The valuation assumes smooth responses to changes. If ecosystems approach thresholds of collapse higher values for affected services would be produced.

7. **Irreversibility.** If a threshold is passed, valuation is out of the "normal" sphere of marginal change

8. **Endangered species status.** This report does not incorporate adequate analysis appropriate for consideration of endangered species as an element of critical natural capital. In particular, it overlooks any non-incremental impacts such as the potential for land management to contribute to a radical decline or even extinction in populations of endangered species.

9. **Bias.** Bias can be introduced in choosing the valuation studies, as in any appraisal methodology. The use of a range partially mitigates this problem.

10. **Sustainability.** The value estimates are not necessarily based on sustainable use levels. Limiting use to sustainable levels would imply higher values.

If these problems and limitations were addressed, the result would most likely be significantly higher values. At this point, however, it is impossible to know how much higher the low and high values would be.

Appendix E: The Clover Creek Appraisal

At the request of Pierce County, an appraisal was done on the Clover Creek Open Space property. This appraisal references the habitat regulations and floodway and floodplain considerations that exist on this property, but fails to account for the full costs of compliance with these regulations in its final property valuation. The appraisal also assumes "full compliance with all applicable federal, state, and local environmental regulations and laws unless otherwise stated in this report", which includes the assumption that no hazardous materials exist on the property (Shedd, 2011). This assumption fails to account for the actual costs of compliance with the regulations and skews the land valuation of the property. Because several important constraints are not seriously considered in the appraisal, it recommends an incorrect best-use recommendation for this plot of land and fails to consider a non-development option.

First, the Clover Creek Property contains valuable riparian habitat and open space surrounding Clover Creek. The entire property is located in an open space corridor, and, except for a small portion in the northeast corner, within a Fish and Wildlife habitat zone. For Fish and Wildlife habitat, usually regulations require a 150 foot buffer from the steam high-water line, however a variance of a 35 foot buffer was granted to the property owners (expiring in 2011) if the property owners completed agreed upon habitat restoration projects. The appraisal assumes that this variance will expire before the necessary project could be completed. Instead of using the 150 foot buffer as a precautionary measure, the report uses the stated assumption that a buffer reduction to 100 feet would be a likely scenario for the subject property. Therefore, most of the report relies on a probable but not fully assured future regulatory variance.

Second, because most of the property lies in the 100-year floodplain, the floodway and floodplain restrictions on the property make construction of any homes or buildings significantly more difficult and risky. In order to construct buildings on the site, the "remaining area outside the 100-foot buffer (the northeast portion) would need to be filled to two feet above base flood elevation and on-site compensatory storage would be necessary" (Shedd, 2011). This would increase grading costs during construction and limit the amount of land available for development since any lost flood storage would have to be compensated for on another part of the property, thanks to Compensatory Storage Requirements. Finally, since no new wells or septic systems are allowed within the floodplain, an improved septic system would need to be installed which would greatly increase costs.

Third, the appraisal's methodology for accounting for the ecosystems present on the property does not demonstrate an understanding of what the true costs of construction of any kind are. The sales comparison approach used in the appraisal values the Clover Creek property by looking at similar properties with riparian buffers or wetlands. However, a close analysis shows that the environmental costs of construction and maintenance on the Clover Creek Property greatly outweigh environmental costs for the comparison properties; the appraisal's assumptions about the similarities of the environmental costs for the surrounding land sales invalidate this appraisal's final valuation. The appraisal evaluates "comparable" properties with and without environmental land use regulations. For those properties without environmental land use regulations, the appraisal downwardly adjusts the sales costs to account for the Clover Creek property's additional environmental engineering and permitting work. For properties with existing environmental land use regulations, the appraisal makes no cost adjustments. Of those properties with regulations in force, the one with the most weight in the analysis maintains a 65-foot buffer around the stream running through it, while the Clover Creek property appraisal accounts for a 100 foot buffer. This same property also has access to a force main sewer in Canyon Road in front of the property, whereas the Clover Creek Property requires a high standard and high cost septic system.

The discussion on the other properties with regulations hardly mentions environmental costs. In comparison to all of the other properties, the Clover Creek Property will have higher building development costs because of the requirements and restrictions of building within the 100-year floodplain and higher property management costs due to the required construction and maintenance costs of the riparian buffer zone. The assumption of comparable costs between these properties with such a lack of information leaves a huge margin of error that excludes many of the costs that will arise in developing the Clover Creek Property.

The most significant hole in the appraisal, though, is that the evaluation only considers options for development, pitting residential against commercial as the primary consideration. Because the appraisal fails to include these additional environmental costs when adjusting the sales costs of comparable properties, it overvalues the property for development use. It skirts discussion of the regulations that are in place to protect wildlife, water quality, and public safety in order to argue that development is still possible, and in fact recommendable, on a 3-acre plot of land almost entirely within the 100-year floodplain and the Deep and/or Fast Flowing Floodway, therefore being subject to Compensatory Storage Requirements. By not seriously considering the benefits that could be provided by restoring the property to provide flood storage and improved habitat, the appraisal does not, in the end, recommend the “best-use” for the property.

Shedd, D., Stokesberry, J., 2011. Summary Appraisal Report of Johnson Property. Allen Brackett Shedd Real Estate Appraisers and Consultants.

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