2010 Stormwater Needs Assessment Program

Cedar Creek (Middle)/Cedar Creek (Lower)/Pup Creek Subwatershed Needs Assessment Report

Clark County Department of Environmental Services

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Acronyms and Abbreviations

B-IBI	Benthic Macroinvertebrate Index of Biological Integrity
BOCC	Board of County Commissioners
BMP	Best Management Practices
CCD	Clark Conservation District
CIP	Capital Improvement Program
CPU	Clark Public Utilities
CRFPO	Columbia River Fisheries Program Office
CWA	Clean Water Act
CWC	Clean Water Commission
CWP	Clean Water Program
DNR	Department of Natural Resources
EDT	Ecosystem Diagnostic and Treatment model
EIA	Effective Impervious Area
EIM	Environmental Information Management
EMAP	Environmental Mapping and Assessment
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FPIA	Focused Public Investment Area
FWS	Fall, Winter, Spring
GCEC	Gee Creek Watershed Enhancement Committee
GIS	Geographic Information System
GMA	Growth Management Act
GPS	Geographic Positioning System
HPA	Hydraulic Project Approval
IDDE	Illicit Discharge Detection and Elimination
LCFEG	Lower Columbia Fish Enhancement Group
LCFRB	Lower Columbia Fish Recovery Board
LID	Low-Impact Development
LiDAR	Light Detection and Ranging
LISP	Long-term Index Site Project
LWD	Large Woody Debris
MS4	Municipal Separate Storm Sewer System
MOP	Mitigation Opportunities Project
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit
NWIFC	Northwest Indian Fisheries Commission
ODEQ	Oregon Department of Environmental Quality

OWQI	Oregon Water Quality Index
PFC	Properly Functioning Condition
RM	River Mile
SCIP	Stormwater Capital Improvement Program
SCIPIT	Stormwater Capital Improvement Program Involvement Team
SCMP	Salmon Creek Monitoring Project
SCWC	Salmon Creek Watershed Council
SNAP	Stormwater Needs Assessment Program
SWMP	Stormwater Management Program
SWMMWW	Stormwater Management Manual for Western Washington
TIA	Total Impervious Area
TIP	Transportation Improvement Program
TIR	Technical Information Report
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
UGA	Urban Growth Area
UIC	Underground Injection Control
USFS	U.S. Forest Service
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VBLM	Vacant Buildable Lands Model
VLWP	Vancouver Lake Watershed Partnership
WAC	Washington Administrative Code
WCC	Washington Conservation Commission
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WSDOT	Washington Department of Transportation
WSU	Washington State University

Executive Summary

Study Area

This Stormwater Needs Assessment report includes the Cedar Creek (Middle), Cedar Creek (Lower), and Pup Creek subwatersheds in the Cedar Creek watershed.

Intent

Stormwater Needs Assessment reports compile and provide summary information relevant to stormwater management, propose stormwater-related projects and activities to improve stream health, and assist with adaptive management of the county's Stormwater Management Program. Assessments are conducted at a subwatershed scale, providing a greater level of detail related to stormwater management than regional Water Resource Inventory Area (WRIA) or Endangered Species Act (ESA) plans. Stormwater Needs Assessments are not comprehensive watershed plans or stormwater basin plans.

Findings

Watershed Conditions

The table on the following page summarizes conditions in the study area including water quality, biological health, habitat, hydrology and the stormwater system.

Ongoing Projects and Involvement

The DES coordinates with the Washington Department of Ecology, Lower Columbia Fish Recovery Board and Vancouver-Clark Parks and Recreation in efforts to improve stream health. Fish First is active in fish recovery efforts in the Cedar Creek watershed.

There are no planned road improvement projects included in the 2010-2015 Clark County Transportation Improvement Program and no planned projects in the 2011-2012 stormwater capital program.

Category	Status
Water Quality	
Overall	• No recent data on overall water quality
Fecal coliform bacteria	• TMDL required (Category 5 303(d) listing); not scheduled
Temperature	• Mainstem Cedar Creek does not meet temperature standard
Biological	
Benthic macroinvertebrates	• Moderate biological integrity within Cedar Creek mainstem • High biological integrity in Pup and John creeks
Anadramous fish	• Chum, Coho, spring Chinook, and winter steelhead; moderate regional recovery priority
Habitat	
NOAA Fisheries criteria	• Forest cover and impervious are fall between the Not Properly Functioning and Functioning thresholds • Stream crossing density is in Properly Functioning category; road density is Not Properly Functioning
Riparian	• Overall rated 'moderately impaired' • Large woody debris recruitment potential is variable, ranging from poor to good • Shade levels are below state targets
Wetland	• Wetlands only 2 percent of overall area • Primarily associated with main stream channel; few large complexes • No significant mapped wetlands in Pup Creek • Opportunities for improvement are limited; protection of existing wetlands recommended
Hydrology and Geomorphology	
Overall hydrology	• At or near natural forested conditions; Ecology gage at Grist Mill 2001-2009
Future condition	• Projected impervious area should remain at levels that do not alter hydrology if forest cover is retained or expanded
Stormwater (unincorporated areas)	
System description	• Primarily road-side ditches; 10 stormwater facilities (2 public and 8 private)
Inventory status	• Complete; 2995 stormwater infrastructure features mapped
System adequacy	• Largely unknown
Retrofit opportunity	• None
Maintenance evaluation	• one maintenance evaluation conducted; facility in compliance
Offsite assessment	• Six offsite assessments conducted; two outfalls referred for cleanup of trash accumulation

Opportunities

No specific project opportunities were discovered in this assessment area.

Riparian restoration:

There are numerous locations where riparian areas are narrow or absent. Reforestation of these areas would provide improved LWD recruitment and channel shading, and should be encouraged. No specific projects were identified because Clark County owns little land in this area. In most cases, working with private landowners would be required.

Non-project recommendations address activities that may promote more effective mitigation of stormwater problems or overall stream improvement. Management recommendations relevant to the assessment area include:

- Conserve existing agricultural and forest lands and promote healthy practices
- Restore stream channels
- Protect and/or enhance existing wetlands
- Encourage and support riparian planting efforts by private landowners

Introduction

This Stormwater Needs Assessment includes the Cedar Creek (Middle), Cedar Creek (Lower), and Pup Creek subwatersheds within the Lewis River watershed. The Clean Water Program (CWP) is gathering and assembling information to support capital improvement project (CIP) planning and other management actions related to protecting water bodies from stormwater runoff.

Purpose

The Stormwater Needs Assessment Program (SNAP), initiated in 2007, creates a system for the CWP to focus activities, coordinate efforts, pool resources and ensure the use of consistent methodologies. SNAP activities assess watershed resources, identify problems and opportunities, and recommend specific actions to help meet the CWP mission of protecting water quality through stormwater management.

The overall goals of SNAP are to:

- Analyze and recommend the best, most cost effective mix of actions to protect, restore or improve beneficial uses consistent with NPDES permit objectives and the goals identified by the state Growth Management Act (GMA), ESA recovery plan implementation, Total Maximum Daily Load (TMDLs), WRIA planning, floodplain management, and other local or regional planning efforts
- Inform county efforts to address the following issues related to hydrology, hydraulics, habitat and water quality:
    - Impacts from current or past development projects subject to lesser or non-existent stormwater treatment and flow control standards
    - Subwatershed-specific needs due to inherent sensitivities or the present condition of water quality or habitat
    - Potential impacts from future development

The CWP recognizes the need to translate assessment information into on-the-ground actions to improve water quality and habitat. Facilitating this process is a key requirement for the program's long-term success.

Results and products of needs assessments promote more effective implementation of various programs and mandates. These include identifying mitigation opportunities and providing a better understanding of stream and watershed conditions for use in planning county road projects. Similar information also is needed by county programs implementing critical areas protection and salmon recovery planning under the state GMA and federal ESA.

Scope

This report summarizes and incorporates new information collected for SNAP, as well as pre-existing information. In many cases, it includes basic summary information or incorporates by reference longer reports which may be consulted for more detailed information.

SNAP reports produce information related to three general categories:

- Potential stormwater capital projects for county implementation or referral to other organizations
- Management and policy recommendations
- Natural resource information

Descriptions of potential projects and recommended program management actions are provided to county programs, including: Public Works CWP, Stormwater Capital Improvement Program (SCIP) and Development Engineering; Community Planning; Public Health; Legacy Lands; ESA. Potential project or leveraging opportunities also are referred to local agencies, groups and municipalities as appropriate.

Assessment Approach

Priorities for Needs Assessment in Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek

Clark County subwatersheds were placed into a five year schedule for assessment using the procedures described in Prioritizing Areas for Stormwater Basin Planning (Swanson, July 2006).

For SNAP purposes, Cedar Creek (Middle) and Cedar Creek (Lower) subwatersheds are categorized as "Rural Residential with No UGA." Subwatersheds in this category generally are not heavily forested but have limited stormwater management needs due to the lack of urbanization. Assessment efforts for these subwatersheds focus primarily on summarizing existing information to identify potential restoration projects.

Pup Creek subwatershed is categorized as "Largely Forested Land." Subwatersheds in this category contain significant amounts of private land zoned for industrial forestry and DNR forest lands. These areas have few county roads and stormwater management is limited to mapping and evaluating the area draining to county outfalls and possible habitat protection or restoration to mitigate for stormwater impacts to other parts of a watershed.

Assessment Tools Applied in this study area

SNAP uses a standardized set of tools for subwatershed assessment, including desktop mapping analyses, modeling, outreach activities and a variety of field data collection procedures. Tools follow standard protocols to provide a range of information for stormwater management. Though not every tool is applied in every subwatershed, the use of a standard toolbox ensures the consistent application of assessment activities county-wide.

Table 1 lists the set of tools available for use in the SNAP. Tools with an asterisk (*) are those for which new data was gathered or new analyses were conducted during this needs assessment. The remaining tools or chapters were completed based on pre-existing information where available.

Table 1: Stormwater Needs Assessment Tools

Outreach And Involvement *	Riparian Assessment *
Coordination with Other Programs *	Floodplain Assessment
Drainage System Inventory and Condition *	Wetland Assessment *
Review Of Existing Data	Macroinvertebrate Assessment *
Illicit Discharge Screening	Fish Use And Distribution *
Broad Scale GIS Characterization *	Water Quality Assessment *
Rapid Stream Reconnaissance	Hydrologic and Hydraulic Modeling
Physical Habitat Assessment *	Source Control *
Geomorphology Assessment	

Assessment Actions

Outreach Activities

Outreach activities were limited and focused primarily on raising awareness about the SNAP effort. The following activities were completed:

- Press release to local media
- April 2010 – article in Clean Water Program E-Newsletter
- August 2010 – information on SNAP distributed at 10-day Clark County Fair
- Clean Water Program web pages updated as needed; 135 visitors to SNAP Web page since June 2010. (Note: these figures are under-reported as tracking software only records top 20 pages and documents monthly)
- A description of SNAP is included in Clark County's annual stormwater management program plan submitted to Ecology

Clark County Clean Water Commission members were updated periodically on SNAP progress.

Actions available to educate in response to identified problem areas include:

- Site visits by CWP technical assistance staff
- Letters detailing specific problems and solutions to individual landowners
- General educational mailings to selected groups of property owners
- Workshops on best management practices, including septic maintenance, mud, manure and streamside property management
- Referral to other agencies, such as Clark Conservation District or WSU Extension, for educational follow-up

Review of Existing Data

Data and information review are incorporated throughout this report in pertinent sections. A standardized list of typical data sources created for the overall SNAP effort is supplemented by subwatershed-specific sources as they are discovered. Data sources consulted for this report include, but are not limited to:

- LCFRB Habitat Characterization (2004)
- LCFRB 6-Year Habitat Workplan
- Ecology 303(d) list
- WRIA 27/28 Plan
- Ecology EIM data
- Clark County 2004 Subwatershed summary

- Clark County 2010 Stream Health Report
- Clark County 6-Year TIP

Broad-Scale GIS Characterization and Metrics

The broad-scale characterization is a GIS-based exercise providing an overview of the biophysical setting for each subwatershed, background information for use in implementing other SNAP tools, and identification of potential acquisition or project sites. GIS data describe subwatershed characteristics such as topography, geology, soils, hydrology, land cover, land use and GMA critical areas. A standard GIS workspace, including shape files for more than 65 characteristics, forms the basis for the characterization.

GIS data are generally used as a tool to complete the report and not presented in the report itself. Summary metrics are taken from existing reports and data. For example, Wierenga (2005) summarized many GIS characteristics for Clark County subwatersheds. Some of these characteristics are described in greater detail in later sections.

The characterization includes three components:

- A set of four standard map products, as paper maps for SNAP use
- A summary table of selected subwatershed-scale metrics
- A brief narrative including comparison of metrics to literature values, and conclusions about general subwatershed condition and potential future changes

Map Products

The four standard SNAP map products are: 1) Stormwater Infrastructure and Hydrologic Soil Groups; 2) Critical Areas information; 3) Vacant Buildable Lands within UGAs; 4) Orthophoto. These maps are printed out for tabletop evaluations.

General Conditions and Subwatershed Metrics

General Geography

The study area comprises three Cedar Creek subwatersheds in the North Fork Lewis River watershed. Land use in the study area is primarily forest and agriculture, with few developed areas (Figure 1). Much of the northeastern part of Cedar Creek (Middle) is dominated by forestry operations. Areas of open space tend to be agriculture or wetlands.

Topography

Historically, mountain glaciers covered most of the study area. Receding glaciers left behind alluvial and terraced valleys and bedrock hills locally mantled by glacial till. Cedar Creek follows a large, roughly east-west trending valley. Cedar Creek valley descends from about 400 feet elevation in the upper part of the study area to a series of cascading falls at the Grist Mill site. Bald Mountain south of Cedar Creek is about 1,500 feet high, while ridges bounding the Cedar Creek valley are 900 to 1,000 feet high.

Geology and Soils
Volcanic and shallow intrusive rocks underlie the study area. Alluvial processes have been strongly influenced by regional uplift of the Cascade Range. Glaciation and structural deformation in the Cascade Range shaped the terrain, forming valleys containing glacial and alluvial deposits. Glacial till deposits cover much of the area.

The study area soils are primarily well-drained Cinebar Silt Loam. Slopes in the study area are varying but are primarily 8-20 percent, with significant portions up to 70 percent.

Hydrology
Geology and topography play the main role in determining study area hydrologic framework. Steep slopes in the Cedar Creek tributaries carrying sediment and available gravel in glacial and alluvial deposits create a pool-riffle morphology.

All tributary streams drain primarily forest and some agriculture lands. The stream hydrology is at or close to natural forested conditions. Clark County does not have stream gauges on any creeks in the study area. The Washington Department of Ecology operated a gauge at the Grist Mill from 2001-2009.

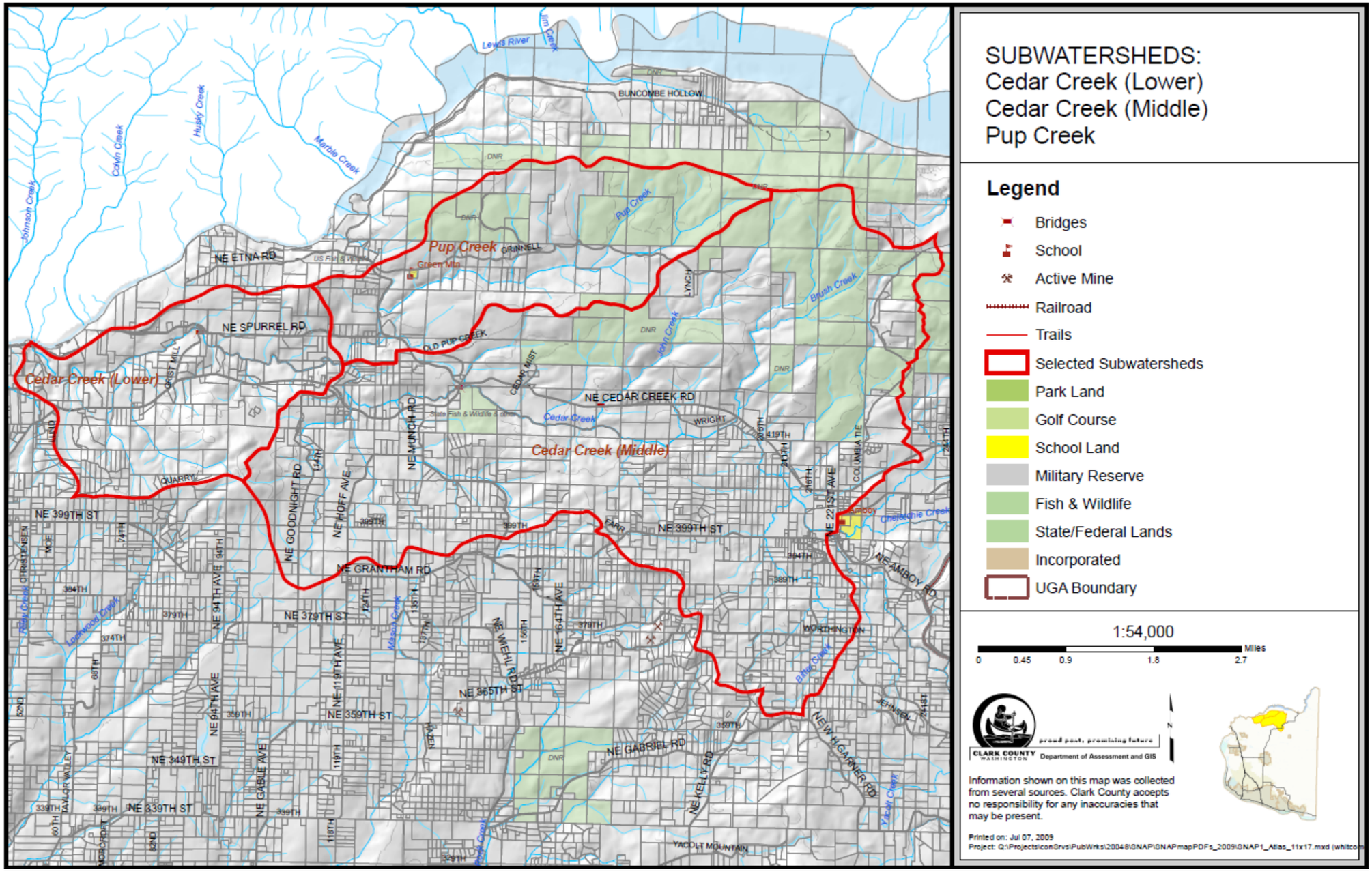

Figure 1: Subwatershed Map: Cedar Creek Middle, Cedar Creek Lower, and Pup Creek

Subwatershed Metrics
Subwatershed scale metrics provide a simple way to summarize overall conditions. Metrics are calculated from Landsat land cover analysis and current GIS data. Benchmarks for properly functioning and not properly functioning are based on NOAA fisheries standards for salmon protection and restoration (1996 and 2003).

Overall, these metrics suggest that the study area has partially functioning stream habitat (Table 2) with road density and percent forested being of concern.

Table 2: Watershed Scale Metrics

Metric	Cedar Creek (Lower)	Cedar Creek (Middle)	Pup Creek	Functioning	Non-functioning
Percent Forested (2000 Landsat)	55.1	57.4	69.4	> 65 %	< 50 %
Percent TIA (2000 Landsat)	7.6	6.9	6.0	< 5 %	> 15 %
Road Density 2007 data (miles/mile2)	4.88	5.28	4.46	< 2	> 3
Stream Crossing Density (crossings per stream mile)	1.72	2.16	1.79	< 3.2/mile	> 6.4/mile
Percent EIA estimated from the Comprehensive Plan	2.36	1.91	0.19	< 10 %	> 10 %

Forest Cover
The proportion of a watershed in forest cover is known to have a profound influence on watershed processes. Forest cover estimates are taken from a report summarizing land cover for Clark County (Hill and Bidwell, January 2003). Research in the Pacific Northwest has shown that when forest cover declines below approximately 65 percent, watershed forming processes become degraded (Booth and Jackson, 1997). These include reducing riparian shade, less wood debris delivery to streams, increased stormwater runoff and increased fine sediment delivery due to mass wasting.

The study area encompasses one of the least developed areas of Clark County, primarily rural residential and commercial logging. Forest cover is below the functioning threshold (Table 2).

TIA (Total Impervious Area)
Total impervious area is one of the most widely used indicators of urbanization and coincident watershed degradation (Center for Watershed Protection, March 2003). Total impervious areas are estimated from land cover data in Hill and Bidwell (January 2003). While various organizations and publications categorize stream condition based on TIA, the NOAA fisheries

standard is less than five percent as fully functional and greater than 15 percent as non-functioning. Values for the subwatersheds are just beyond the threshold for functioning habitat.

Road Density
Road density, including all public and private roads, is an easily calculated development measure. Based on criteria set by NOAA Fisheries to protect salmon habitat, road densities are just beyond the threshold for non-functioning (>3 road miles/mi^2).

Stream Crossing Density
Stream crossing densities are easily measured using available road and stream channel data. The salmon protection standard considers larger fills more than 60 feet wide, which would be approximately five- to 10-foot high road fill. The study area subwatersheds have stream crossing densities within the functioning category (<3.2 crossings/stream mile NOAA Fisheries criteria).

Future Effective Impervious Area
Effective impervious area is the amount of impervious area that actually drains to a water body. Depending on factors such as soil types and level of development, effective impervious area is about half (lower intensity development) to almost equal (high intensity development) the TIA value.

The Comprehensive Plan guides development for the next few years, and when used to estimate effective impervious area, it can provide a metric for potential hydrologic impacts due to expected development. Expected EIA places the study area in the functioning category.

Estimated Channel Stability Based on Forest and EIA
In a recent publication by Booth, Hartley and Jackson (June 2002), a relationship between forest and percent EIA was presented as a graphic (**Error! Reference source not found.**). According to this figure, streams in the subwatersheds would be expected to have stable channels.

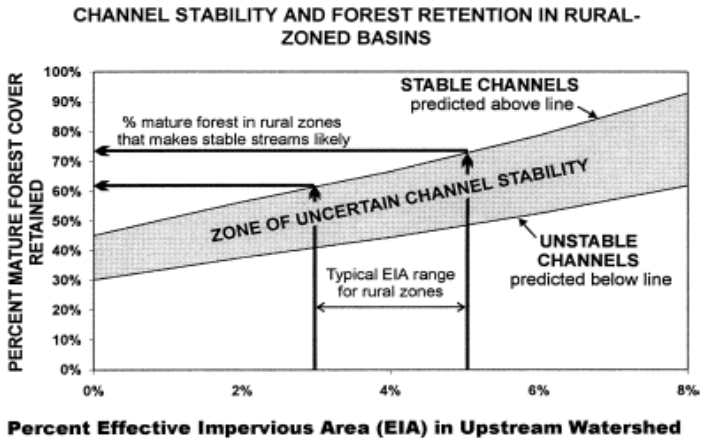

Figure 2: Channel stability in rural areas (Booth, Hartley and Jackson)

Water Quality Assessment

This section briefly summarizes and references available water quality data from the Cedar Creek (Middle), Cedar Creek (Lower), and Pup Creek subwatersheds. A description of applicable water quality criteria is included, along with discussions of beneficial use impacts, likely pollution sources, and possible implications for stormwater management planning.

Water Quality Criteria

For a full explanation of current water quality standards see the Ecology website at: http://www.ecy.wa.gov/programs/wq/swqs/index.html

Under Washington state water quality standards, the Lewis River from Houghton Creek (including tributaries) to Lake Merwin is to be protected for the designated uses of: "Core Summer Salmonid Habitat; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values" (WAC 173-201A-600, Table 602).

Table 3 summarizes currently applicable water quality criteria for the assessment area.

Table 3: Applicable Water Quality Criteria for Cedar Creek (Middle), Cedar Creek (Lower), and p Creek Subwatersheds

Characteristic	Ecology criteria
Temperature	≤ 16 °C (60.8 °F)
Dissolved Oxygen	≥ 9.5 mg/L
Turbidity	shall not exceed 5 NTU over background when background is 50 NTU or less
pH	6.5 – 8.5 units
Fecal coliform bacteria	Geometric mean fecal coliform concentration not to exceed 100 colonies/100mL, and not more than 10% of samples exceeding 200 colonies/100mL.
Aesthetics	Aesthetic values must not be impaired by the presence of materials or their effects… which offend the senses of sight, smell, touch, or taste
Toxics	Toxic substances shall not be introduced… which have the potential…to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health

Source: Washington Department of Ecology (http://www.ecy.wa.gov/programs/wq/swqs/index.html)

303(d) Listed Impairments

The 2008 303(d) list of impaired waters is on the Ecology website at: http://www.ecy.wa.gov/programs/wq/303d/index.html

Cedar Creek in the study area is Category 5 listed (polluted waters that require a TMDL) for fecal coliform bacteria and Category 2 listed (Waters of Concern) for pH and temperature. There are no listings for Pup Creek.

Clark County Stream Health Report

In 2010, the CWP compiled available data and produced a countywide assessment of general stream health.

Based on the available dataset, including water quality, biological health and stream flow patterns, overall stream health in the Cedar Creek (middle) subwatershed scored in the fair range. Sufficient data were not available to score the Cedar Creek (lower) subwatershed.

The 2010 Stream Health Report may be viewed on the county website at: http://www.clark.wa.gov/water-resources/stream.html.

Available Data

Recent water quality data from this study area are limited to summertime temperature readings from two stations in the Cedar Creek (Middle) subwatershed and collected during 2004 in support of the LCFRB Clark County Watershed Characterization.

Data and information sources reviewed or summarized as part of this water quality characterization are listed in Table 4.

Table 4: Data Sources

Source	Data and/or Report
Clark County Clean Water Program	2010 Stream Health Report Benthic Macroinvertebrate and Water Temperature Monitoring for Clark County Watershed Assessments in 2004

Water Quality Summary

Stream temperature was recorded continuously during summer 2004 at the following stations:

- CED050 (Cedar Cr upstream of Cedar Cr Road)
- CED055 (Cedar Cr upstream of John Cr)

Stream Temperature

One summer of continuous temperature monitoring (2004) at Station CED050 and Station CED055 indicated that Cedar Creek water temperature in this segment greatly exceeded target levels. The maximum of the 7-day moving average of daily maximum temperatures (7-DAD Max) at the time of the study was not to exceed 64º F. At both stations, the 7-DAD Max reached 74º F. As of 2006, the temperature criterion changed to 60.8º F for this segment of Cedar Creek.

Due to the negative effects of chronic high temperatures on salmonids and other cold-water biota, the amount of time spent with elevated temperatures also is of interest. Sixty-four degrees was the Class A criterion prior to November 2006 and is a threshold above which salmonids are known to suffer deleterious effects. At both stations, daily temperatures exceeded 64º F on nearly 60 days during July and August.

Habitat reports indicated this segment of Cedar Creek is largely open to the sky, with minimal shading and riparian disturbance extending 50-60 m from the creek center on average.

Impacts to Beneficial Uses and Potential Sources

Overall water quality in this assessment area is largely unknown due to lack of data. Observed water temperatures likely have negative impacts on the listed beneficial use of core summer salmonid habitat. Table 5 at the conclusion of this section summarizes temperature impacts to beneficial uses in Cedar Creek and probable sources of the observed impact.

Implications for Stormwater Management

Solutions listed in bold (Table 5) indicate areas where CWP activities can have a positive impact. It should be noted that CWP activities, though important, are not likely to achieve water quality improvement goals on their own. Other county departments, local agencies, and not least of all, the public must all contribute to water quality improvement.

Table 5: Known Water Quality Concerns, Sources, and Solutions for lower and middle Cedar Creek

Characteristic	Beneficial Use Affected	Potential Sources	Mechanism	Solutions (bold indicates direct Clean Water Program involvement)
Water temperature	Core summer salmonid habitat	vegetation removal	direct solar radiation	**Streamside planting/vegetation enhancement/riparian preservation through acquisition** **Education programs** Pond removal or limitation
		low summer flows	decreased resistance to thermal inputs	

Drainage System Inventory and Condition

Inventory

Clark County's drainage system inventory resides in the StormwaterClk GIS database and is available to users through the county's Department of Assessment and GIS.

Drainage system inventory is an ongoing CWP work effort focused on updating the StormwaterClk database to include all existing stormwater drainage infrastructure. In 2008-2009, the inventory was a significant priority for the CWP, with a major work effort focused on identifying and mapping previously unmapped infrastructure and reviewing existing records for completeness and accuracy.

Table 6 indicates the number of features currently inventoried in StormwaterClk. Of the 10 stormwater facilities, two are publicly owned and operated.

Table 6: Drainage System Inventory Results, Cedar Creek (Middle and Lower)/Pup Creek

Database Feature Category	Inventoried prior to 2007	Added during 2007-2009	Total Features
Inlet	7	22	29
Discharge Point (outfall)	1	537	538
Flow Control	4	3	7
Storage/Treatment	41	22	63
Manhole	0	0	0
Filter System	1	0	1
Channel	53	1549	1602
Gravity Main	215	530	745
Facilities	5	5	10

Condition

Stormwater system condition is assessed based on three components:

- An evaluation of retrofit opportunities at public stormwater facilities
- An inspection and maintenance evaluation at public stormwater facilities
- An off-site assessment to check for outfall-related problems in downstream receiving waters

Component 1: Retrofit Evaluation

Purpose

The purpose of this component is to identify existing public stormwater facilities that may be retrofitted to provide additional storage or treatment, beyond the level intended during original construction.

Methods
The evaluation is conducted at all public stormwater facilities that contain detention ponds, treatment wetlands, wet ponds, pre-settling cells, open filters or bioswales and discharge to surface waters or stormwater drainage infrastructure that eventually discharges to surface waters.

The retrofit evaluation includes a review of the drainage area, stormwater infrastructure condition, facility lot size, ownership of adjacent parcels, and the functionality of the facility objects listed above. Facilities or parcels with the potential to provide additional storage and/or treatment of stormwater are referred as "potential retrofit" opportunities for further evaluation as Capital Improvement Projects.

Results
Based on the county's StormwaterClk database, as of August 2010, there were two mapped public stormwater facilities in the Cedar Creek (Middle) subwatershed and no mapped public stormwater facilities in the Cedar Creek (Lower) and Pup Creek subwatersheds.

Fifty percent (1) of the mapped public stormwater facilities in the Cedar Creek (Middle) subwatershed was evaluated for retrofit opportunities.

No public stormwater facilities were referred for further evaluation as Capital Improvement Projects.

No major defects or hazardous conditions were discovered in the Cedar Creek (Middle) subwatershed.

Component 2: Inspection and Maintenance Evaluation

Purpose
The inspection and maintenance evaluation verifies that maintenance activities are implemented and facilities are properly functioning.

Methods
The inspection and maintenance evaluation is conducted at public stormwater facilities in conjunction with retrofit evaluations. Public stormwater facilities were evaluated if they contained detention ponds, treatment wetlands, wet ponds, pre-settling cells, open filters or bioswales and discharge to surface waters or stormwater drainage infrastructure that eventually discharges to surface waters.

Public stormwater facilities that contain filter systems, buried detention or retention vaults and facilities that infiltrate stormwater typically are not included in this evaluation. They may be inspected on a case-by-case basis as resources allow.

The evaluation is conducted using county and state standards equivalent to maintenance standards specified in Chapter 4, Volume V, of the 2005 Stormwater Management Manual for Western Washington. The standards list the part or component of the facility, condition when repair or

maintenance is needed, and expected results. Individual components of a facility are referred to as "facility objects."

The inspection and maintenance evaluation process involves inspecting all facility objects to determine if maintenance complies with the standards. If any facility object fails to meet the maintenance standards, the entire facility is not in compliance. Noncompliant stormwater facilities are referred to the appropriate department for repairs or maintenance.

Results

One inspection and maintenance evaluations was conducted in the Cedar Creek (Middle) subwatershed. This facility was found in compliance with maintenance standards and to include 14 facility objects.

The inspection process in the Cedar Creek (Middle) subwatershed generated no referrals to Public Works Maintenance and Operations for needed maintenance activities.

No major defects or hazardous conditions were discovered in the Cedar Creek (Middle) subwatershed.

Component 3: Offsite Assessment

Purpose

Discharges from stormwater outfalls can cause moderate to severe erosion as stormwater moves through the riparian zone and to the receiving water. Erosion creates a source of sediment to the stream due to incision and slope failures. It also can increase slope instability problems.

The Offsite Assessment looks for offsite or downstream problems associated with the county's storm sewer system, particularly from facility outfalls that discharge to critical areas.

Methods

County-owned and operated stormwater outfalls meeting one or more of the following criteria are included in the offsite assessment:

- Within 200 feet of a critical area (e.g. riparian, wellhead protection, landslide hazard, etc)
- Within 300 feet of a headwater stream
- Located on public land
- Originates from a public-dedicated facility currently under the two-year maintenance warranty bond

Stormwater outfalls are prioritized into three categories:

- Priority 1 outfalls are stormwater outfalls that discharge to landslide hazard areas outside of county road rights-of-way
- Priority 2 outfalls are stormwater outfalls that discharge to all other critical areas outside of county road rights-of-way
- Priority 3 outfalls are stormwater outfalls that discharge to critical areas within county road rights-of-way

At a minimum, all Priority 1 outfalls are inspected. As resources allow, Priority 2 and Priority 3 outfalls may be inspected. If an outfall fails to meet the general outfall design criteria or is contributing to a downstream erosion problem, the outfall is not in compliance. Non-compliant outfalls are referred to the appropriate Public Works program for maintenance or repair or, in some cases, referred as potential Capital Projects.

Results

Based on the county's StormwaterClk database, as of August 2010 there were 40 mapped outfalls in the Pup Creek subwatershed discharging to critical areas: one Priority 1 outfall; no Priority 2 outfalls; 39 Priority 3 outfalls.

In the Cedar Creek (Lower) subwatershed, there were 72 mapped outfalls discharging to critical areas: no Priority 1 or Priority 2 outfalls and 72 Priority 3 outfalls.

In the Cedar Creek (Middle) subwatershed, there were 288 mapped outfalls discharging to critical areas: three Priority 1 outfalls; one Priority 2 outfall; 284 Priority 3 outfalls.

Table 7 summarizes results for the Pup Creek subwatershed. One Priority 1 outfall was assessed and found to be in compliance. There were no mapped Priority 2 outfalls. Five Priority 3 outfalls were assessed of which four were found to be in compliance. Trash accumulation was noted at one Priority 3 outfall. Thirty-four Priority 3 outfalls were not assessed.

Table 7: 2010 Off-site Assessment Project Activity Summary for Pup Creek subwatershed

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	1	0	39
# of outfalls assessed	1	n/a	5
# of outfalls compliant	1	n/a	4
# of noncompliant outfalls	n/a	n/a	1
# of referrals initiated	n/a	n/a	1
# of referrals ongoing	n/a	n/a	1
# of outfalls fixed	n/a	n/a	0

Table 8 summarizes results the Cedar Creek (Lower) subwatershed. There were 72 mapped outfalls discharging to critical areas. Seventy-two Priority 3 outfalls were not assessed.

Table 8: 2010 Off-site Assessment Project Activity Summary for Cedar Creek (Lower) subwatershed

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	0	0	72
# of outfalls assessed	n/a	n/a	0
# of outfalls compliant	n/a	n/a	n/a
# of noncompliant outfalls	n/a	n/a	n/a
# of referrals initiated	n/a	n/a	n/a
# of referrals ongoing	n/a	n/a	n/a
# of outfalls fixed	n/a	n/a	n/a

Table 9 summarizes results from the Cedar Creek (Middle) subwatershed. There which were 288 mapped outfalls discharging to critical areas. Three Priority 1 outfalls were assessed, two of which were found to be in compliance. Trash accumulation was noted at one Priority 1 outfall. One Priority 2 outfall and 284 Priority 3 outfalls were not assessed.

Table 9: 2010 Off-site Assessment Project Activity Summary for Cedar Creek (Middle) subwatershed

Metric	Number of Outfalls

	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	3	1	284
# of outfalls assessed	3	0	0
# of outfalls compliant	2	n/a	n/a
# of noncompliant outfalls	1	n/a	n/a
# of referrals initiated	1	n/a	n/a
# of referrals ongoing	1	n/a	n/a
# of outfalls fixed	0	n/a	n/a

Potential Projects

The offsite assessment project yielded no potential project opportunities. Two referrals were generated to Maintenance and Operations for litter removal. Two fish barriers were recorded.

Management Recommendations

Drainage system inventory is an ongoing CWP work effort focused on updating the StormwaterClk database to include all existing stormwater drainage infrastructure. Prior to 2007, stormwater drainage infrastructure in the Cedar Creek (Middle and Lower) and Pup Creek subwatersheds included 327 objects. In 2007-2009, an additional 2,668 previously unmapped objects were added to the StormwaterClk database.

Retrofit and inspection and maintenance evaluations were conducted at one public stormwater facility in the Cedar Creek (Lower) subwatershed. No referrals were generated for further evaluation as capital improvement projects. All facility objects (14) were found to be in compliance with county maintenance standards.

Outfall assessments generated no potential project opportunities. Two referrals were generated to Maintenance and Operations for littler removal and two fish barriers were recorded. Future efforts should be made to assess Priority 3 outfalls, which make up nearly all of the outfalls discharging to critical areas in these subwatersheds. Maintaining the frequency of offsite assessment activities may reduce downstream erosion problems by discovering potential issues before they become a more serious erosion problem.

Illicit Discharge Detection and Elimination Screening

Illicit discharge screening was not conducted.

Source Control

Purpose

Source control visits to Clark County businesses provide both an educational and technical assistance purpose. An initial site visit allows staff to educate owners and employees by providing basic information about nearby water resources and Clark County's Water Quality Ordinance (13.26A). The initial site visit also provides information on how Clark County's storm sewer system works, how the site is connected to this storm system, and how the activities performed by the business may impact their subwatershed.

Most importantly, the source control visit can find, then eliminate or change, business activities that negatively impact stormwater runoff.

Methods

Under the County's 2007 NPDES municipal stormwater permit, each year staff is required to visit 20 percent of businesses that perform one of many potential pollution-generating activities listed in the permit. Additionally, the permit requires visits to any business with a paved parking area. To simplify project planning and tracking, the CWP plans to visit 20 percent of all county businesses each year.

To determine which specific businesses will be inspected each year, SNAP prioritizes a list of subwatersheds where source control visits will be performed. Once those subwatersheds are determined, GIS maps are developed to highlight all parcels paying the Type 4 (commercial and industrial property) and Type 3 (Multi-Family property) Clean Water Fee. Each highlighted parcel is labeled with the parcel number (Property Account Number).

At each site, staff asks the business manager or owner to lead a tour of the business, inside and out. By closely observing business activities and asking questions, staff gains information about site-specific conditions and current stormwater best management practices (BMPs).

If any business related activities allow contaminants to enter stormwater runoff, specific BMPs are suggested to the business manager or owner. Following the tour, BMP sheets explaining the issue and required fixes are left with the manager or owner. If the BMP will take some time to implement, a follow up visit date is agreed upon. Letters are sent to businesses when multiple activities require BMPs and/or when a specific BMP may take some time to implement. Letters usually give a deadline for completion of BMP implementation.

Following the deadline date, a follow up visit is made to the business to confirm BMP implementation. As long as some corrective effort has been made, the source control staff will continue working with the business until it is in compliance. However, if the business fails to take any corrective action despite repeated visits, a referral to Clark County Code Enforcement and possibly the Washington Department of Ecology is made to assist with compliance through enforcement.

During or immediately after each site visit, a Business Site Visit Report Form is completed for entry into the Tidemark database.

Results

In 2010, staff visited all businesses required under the NPDES permit in the Cedar Creek (Middle)/ Cedar Creek (Lower)/ Pub Creek subwatershed. Table 10 summarizes source control activities.

Table 10: Source Control Project Summary, Cedar Creek (Middle)/ Cedar Creek (Lower)/ Pup Creek subwatershed

Metric	Number
Number of sites visited	20
Number of sites with source control issues	0
Number of repeat visits	0
Number of sites with issues successfully resolved	0
Number of sites referred to other agencies	0

Overview

The Cedar Creek (Middle)/ Cedar Creek (Lower)/ Pup Creek subwatershed lies in north central Clark County. This subwatershed is dominated by farms and large rural residences.

The Type 4 parcels in this subwatershed included a school, several churches, a fire district building and other small isolated businesses. This subwatershed should be a medium priority for future Type 4 (business) source control site visits.

Stream Reconnaissance and Feature Inventory

A stream reconnaissance and feature inventory assessment was not conducted.

Physical Habitat Assessment

Purpose

Physical habitat assessments provide direct measurements of stream channel morphology, habitat conditions, and riparian conditions for specific stream reaches. This information can be used for planning projects and interpreting hydrologic, macroinvertebrate, and geomorphologic information at reach and subwatershed scales.

Methods

R2 Resource Consultants, Inc. (December 2004) collected physical habitat measurements at three reaches in the Cedar Creek (Middle) subwatershed, including Cedar Creek 2 (RM 4.3 to RM 7.7), Cedar Creek 3 (RM 7.7 to RM 9.3), and John Creek (RM 0.0 to RM 1.1) for the Lower Columbia

Fish Recovery Board. The project followed modified USFS Level II Stream Reach Inventory protocols.

Results

The R2 Resource Consultants, Inc. (R2) report includes a good narrative summary of the habitat survey results, including figures and tables, some of which are presented here. The full report may be found on the CWP website at:
http://www.clark.wa.gov/water-resources/documents-monitoring.html#strmac

The Cedar Creek 2 survey reach is a narrow, low gradient floodplain channel. The reach has a map gradient of 0.5 percent. The channel is characterized by pool-riffle bedforms, with moderate channel confinement. Habitat consists primarily of small riffles, which represent 68 percent of the survey reach habitat by length. Pools comprise 27 percent, with a small amount of glide habitat making up the remainder. The maximum depth of pools averages 0.9 meters.

R2 noted that the dominate and subdominant substrate classes of streambed riffles are comprised of cobble (38 percent) and gravel (34 percent). Embeddedness is rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75%, and 75-100%). The overall mean embeddedness level is 28 percent. Table 11 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

The Cedar Creek 3 survey reach is a narrow, low gradient floodplain channel. The reach has a map gradient of 0.5 percent. The channel is characterized by pool-riffle bedforms, with moderate channel confinement. Habitat consists primarily of small riffles, which represent 61 percent of the survey reach habitat by length. Pools comprise 30 percent, with a small amount of glide habitat making up the remainder. The maximum depth of pools averages 1.0 meter.

R2 noted that the dominate and subdominant substrate classes of streambed riffles are comprised of gravel (39 percent) and cobble (34 percent). The overall mean embeddedness level is 29 percent. Table 12 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

The John Creek survey reach is classified as a moderate gradient contained channel. The reach has a map gradient of 4 percent. The channel is steep enough that bedforms consist of step-pool sequences, and channel confinement is moderate to high. Habitat consists primarily of cascade, which represents 45 percent of the survey reach habitat by length. Large riffles comprise 28 percent, with pools (17 percent) and small riffles (11 percent) making up the remainder. The maximum depth of pools averages 0.6 meter.

R2 noted that the dominate and subdominant substrate classes of streambed riffles are comprised of sand (48 percent) and cobble (20 percent). The overall mean embeddedness level is 56 percent. Table 13 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

Table 11 Summary of Habitat Evaluations of Cedar Creek (Cedar Creek 2 Survey Reach) Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards

Parameter	WCC[1]	PFC[2]
% Pool by Surface Area	Poor	
Pool Frequency		Not properly functioning
Pool Quality	Fair	At risk
LWD	Poor	Not properly functioning
Substrate	Good	At risk
Streambank Stability	Good	Properly functioning
Water temperature	Poor	Not properly functioning
[1] Available Ratings: Good; Fair; Poor		
[2] Available Ratings: Properly Functioning; At Risk; Not Properly Functioning		

Table 12: Summary of Habitat Evaluations of Cedar Creek (Cedar Creek 3 Survey Reach) Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards

Parameter	WCC[1]	PFC[2]
% Pool by Surface Area	Poor	
Pool Frequency		Not properly functioning
Pool Quality	Fair	At risk
LWD	Poor	Not properly functioning
Substrate	Fair	At risk
Streambank Stability	Good	Properly functioning
Water temperature	Poor	Not properly functioning
[1] Available Ratings: Good; Fair; Poor		
[2] Available Ratings: Properly Functioning; At Risk; Not Properly Functioning		

Table 13: Summary of Habitat Evaluations of John Creek Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards

Parameter	WCC[1]	PFC[2]
% Pool by Surface Area	Poor	
Pool Frequency		Not properly functioning
Pool Quality	Fair	At risk
LWD	Poor	Not properly functioning
Substrate	Poor	Not properly functioning
Streambank Stability	Good	Properly functioning

Water temperature		
[1] Available Ratings: Good; Fair; Poor		
[2] Available Ratings: Properly Functioning; At Risk; Not Properly Functioning		

Geomorphology Assessment

A geomorphology assessment was not conducted.

Riparian Assessment

Purpose

The riparian assessment characterizes existing conditions, based on available data, to identify general riparian needs and potential areas for rehabilitation projects. Riparian enhancement projects, such as installation or protection of native plantings within riparian areas, can provide for increased future shading and woody debris recruitment, which can further provide an opportunity for stormwater-related watershed improvement.

The need for riparian rehabilitation tends to be widespread and exceeds the scope and resources of the CWP mission of stormwater management. Therefore, potential riparian projects are usually referred to agencies such as the LCFRB, Lower Columbia Fish Enhancement Group (LCFEG), Clark Public Utilities, Fish First, Washington State University (WSU) Watershed Stewards Program and Clark Conservation District for possible implementation.

This section focuses on opportunities likely located on publicly owned lands in high priority salmon-bearing stream reaches, as defined by LCFRB salmon recovery priorities.

Method

Where possible, the assessment is based on GIS data from existing reports, primarily the Habitat Assessment reports prepared for the Lower Columbia Fish Recovery Board (R2 Resource Consultants, Inc., 2004). Summary information from the Draft Shoreline Inventory and Characterization also is reviewed (ESA Adolfson, June 2010). These reports apply primarily to salmon-bearing stream reaches and therefore do not provide information for many smaller streams. Results are based on aerial photo interpretation using Washington Forest Practices Board methods for LWD delivery and channel shade estimates.

In streams where no data exists from the LCFRB characterization, an examination of current orthophotographs is used to make a general assessment of riparian condition and identify areas where restoration or preservation projects may be appropriate.

Many riparian project opportunities are discovered through other SNAP activities, including Rapid Stream Reconnaissance feature inventories and geomorphological assessments. Potential projects discovered through these activities are discussed in their respective sections, and most are included on a final list for referral to outside agencies.

The 2004 LCFRB Habitat Assessment report, 2010 Draft Shoreline Inventory and Characterization Report and current orthophotographs also were reviewed for specific project opportunities in each subwatershed. Potential project sites have been reviewed and verified through field reconnaissance and are detailed in the results.

Results

Results are based primarily on the 2004 LCFRB Habitat Assessment contained within the Kalama, Washougal and Lewis River Habitat Assessments Chapter 3: The North Fork Lewis River Basin. The full characterization report is available on the Clark County website at: http://www.clark.wa.gov/water-resources/documents.html#mon

For areas in the subwatersheds not included in the habitat assessment (unnamed tributaries to Cedar Creek, Pup Creek, John Creek, Brush Creek and Bitter Creek), LWD recruitment potential and shade rating analyses were based on a qualitative review of 2010 orthophotographs available through Google Earth.

At the subwatershed scale, the LCFRB rated the riparian conditions in the study area as "Moderately Impaired."

Riparian (Large Woody Debris (LWD) Delivery)

Figure 3 shows the Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek subwatersheds LWD delivery potential. In the Cedar Creek (Middle) subwatershed, the survey includes the mainstem of Cedar Creek and portions of the mainstems of John Creek, Brush Creek and Bitter Creek. The mainstem of Cedar Creek is shown as having primarily Low LWD recruitement potential. The survey data show primarily "Poor" (63% of length) LWD recruitment, with some areas of "Fair" (14% of length) and "Good" (23% of length) along the approximate 6.8 mile distance surveyed (EDT reaches "Cedar Creek 2," "Cedar Creek 3," "Cedar Creek 4" and "Cedar Creek 5").

The mainstem of John Creek is shown as having Low LWD recruitment for the entire length surveyed (appx 1.1 mi). The mainstem of Brush Creek is shown as a mix of Low, Moderate and High LWD recruitment potential. The survey data for Brush Creek shows primarily "Fair" (65% of length) LWD recruitment, with some areas of "Good" (35%) LWD recruitment along the appx 1.1 mile distance surveyed. The mainstem of Bitter Creek is shown as having Primarily poor LWD recruitment, with some areas of fair. The survey data for Bitter Creek show "Poor" LWD recruitment potential along 87 percent of the length surveyed and "Fair" along 13 percent.

Within the Cedar Creek (Lower) subwatershed, the survey includes the mainstem of Cedar Creek. The mainstem is shown as having primarily High LWD recruitment potential, with some areas of Moderate. The survey data show "Good" (76% of length) LWD recruitment potential and "Fair" (24% of length) LWD recruitment along the appx 4.3 mile distance surveyed (EDT reaches "Cedar Creek 1a" and "Cedar Creek 1b").

Within the Pup Creek subwatershed, the survey includes the mainstem of Pup Creek. The mainstem of Pup Creek is shown as having a mix of High, Moderate and Low LWD recruitment potential. The survey data show “Good” (37% of length), “Fair” (45% of length) and “Poor” (18 % of length) LWD recruitment along the appx 2 miles surveyed.

The Cedar Creek (Lower and Middle) and Pup Creek watersheds contain many miles of unsurveyed tributaries. Land use patterns suggest a mix of High, Moderate and Low LWD recruitment potential throughout. Unsurveyed portions of John and Brush Creeks (upstream of surveyed portions) are forested and likely have moderate to high LWD recruitment. Unsurveyed portions of Bitter Creek (upstream of surveyed portions) likely have low to moderate LWD recruitment. Unsurveyed portions of Pup Creek (upstream of surveyed portions) likely have mix of High, Moderate and Low LWD recruitment potential.

Some of the areas where Pup Creek currently has relatively low LWD recruitment potential (such as between appx (45.948748, -122.510819) (45.949027, -122.506807) and (45.959653, -122.47056)) exist where the creek passes near fields that appear to have been recently planted and are likely to exhibit higher LWD recruitment over time.

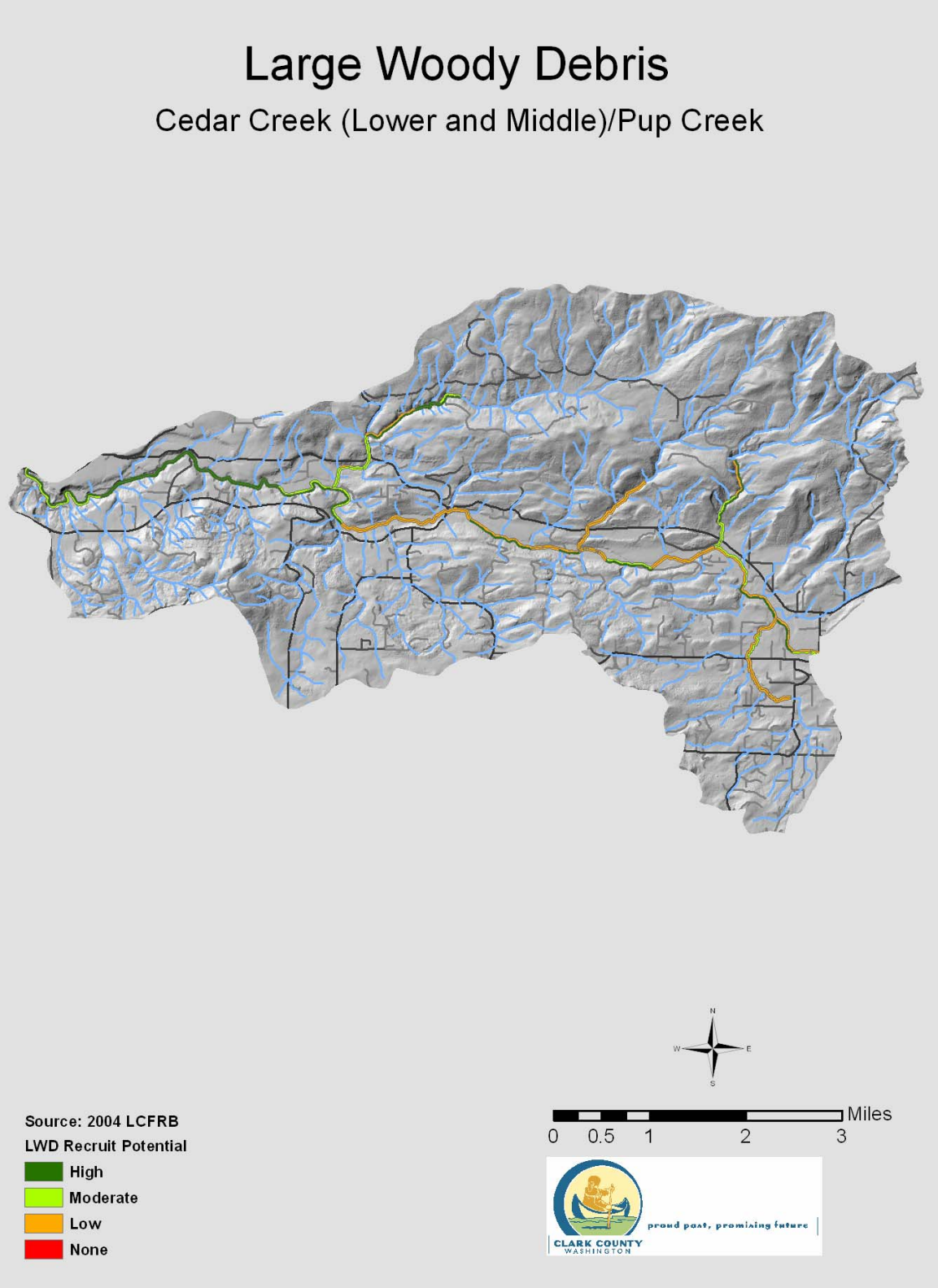

Figure 3: Cedar Creek (Middle), Cedar Creek (Lower), and Pup Creek LWD Recruitment Potential (adapted from R2 Resource Consultants, Inc., 2004)

Shade

Shade ratings from the 2004 LCFRB Habitat Assessment are illustrated on Figure 4. In the Cedar Creek (Middle) subwatershed, the survey includes the mainstem of Cedar Creek and portions of the mainstems of John Creek, Brush Creek and Bitter Creek. The mainstem of Cedar Creek in the Cedar Creek (Middle) subwatershed has shade levels ranging from 10 percent to 30 percent. Percent shade levels were distributed as follows:

% Shade	% of Reach Length
10	59
30	41

The mainstem of John Creek has 30 percent shade for the entire length surveyed.

The mainstem of Brush Creek has shade levels ranging from 10 percent to 30 percent, distributed as follows:

% Shade	% of Reach Length
10	30
30	70

The mainstem of Bitter Creek has shade levels ranging from 10 percent to 55 percent, distributed as follows:

% Shade	% of Reach Length
10	47
30	28
55	25

In the Cedar Creek (Lower) subwatershed, the survey includes the mainstem of Cedar Creek. The mainstem has shade levels ranging from 30 percent to 55 percent, distributed as follows:

% Shade	% of Reach Length
30	73
55	27

In the Pup Creek subwatershed, the survey includes the mainstem of Pup Creek. The mainstem has shade levels ranging from 30 percent to 80 percent, distributed as follows:

% Shade	% of Reach Length
30	38
55	50
80	11

The LCFRB habitat assessment indicated that all reaches surveyed are currently off-target with respect to the State Forest Practices shade/elevation screen standards.

Management Recommendations

Overall recommended management activities for the study area include riparian plantings on John Creek and enhancement of spawning habitats and riparian restoration of Cedar Creek. Working with private landowners would be required.

Potential Projects

Potential riparian restoration projects for the Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek subwatersheds were identified from review of the 2004 LCFRB Habitat Assessment report, along with orthophotography analysis in areas not formally surveyed. Recommended restoration projects in both watersheds include riparian plantings in areas where the forested riparian zone is relatively narrow (see discussions under LWD and Shade, above). Reforestation of such areas would provide both improved riparian LWD recruitment and stream channel shading. However, these subwatersheds contain little county-owned land and so specific potential projects are difficult to identify.

The locations listed in Table 14 may provide limited potential for small-scale restoration on adjacent banks. It may be necessary to work with private landowners to accomplish significant riparian enhancements.

Washington State owns and operates a significant amount of land in these subwatersheds for forestry purposes. It is assumed that these lands would be managed with riparian conservation best management practices in place and as such would be unavailable for, and lack ecological opportunity for, county-driven enhancement projects.

Table 14: Tax Exempt Parcels Overlapping Potential Riparian Restoration Areas

ASSR_SN	ASSR_AC	OWNER	PT1DESC	Description
Road R.O.W. at appx 45.92892, -122.49761	N/A			Site of existing PW Mitigation Project #10: Clark County Fish Passage Replacement Culverts (on John Creek)
261743-000 261746-000	100.8 acres 26 acres	Washington State	Forestry Operations	Cedar Creek State Wildlife Recreation Area. North end contains appx 5.3 acres with reforestation potential adjacent to Cedar Creek.

Figure 4: Cedar Creek (Middle), Cedar Creek (Lower), and Pup Creek Shade Values (adapted from R2 Resource Consultants, Inc, 2004)

Floodplain Assessment

A floodplain assessment was not conducted.

Wetland Assessment

Purpose

Wetlands perform important hydrologic, water quality and habitat functions. The primary reasons for the wetlands assessments are to:

- Describe wetland conditions related to how they influence hydrology, water quality and habitat
- Identify priority potential wetland projects to mitigate for stormwater impacts
- Make management recommendations for wetlands related to stormwater management

A primary objective of the wetland assessment is to identify sites containing modestly sized, degraded or ditched wetlands where minor construction projects can be used to improve wetland hydrology. Improved wetland function can reduce peak storm discharges, increase groundwater recharge and improve habitat through increasing biodiversity, species population health and organic input.

Methods

The assessment includes review of existing GIS data for wetlands. Primary information sources are the county wetlands atlas, Watershed Characterization and Analysis of Clark County (Ecology Publication # 09-06-019, 2009) and personal communication with other county programs.

Potential project sites have been reviewed and verified through field reconnaissance and are detailed in the results section below.

Tax-exempt parcels often indicate the presence of publicly owned land, schools or churches where large parcel sizes and opportunities for leveraging may exist. Potential wetlands were overlaid with tax-exempt parcels and county vacant buildable lands model (VBLM) information to identify possible wetland enhancement opportunities.

Results

Figure 5 shows potential wetland areas in the study area based on data from the county wetlands atlas, including the Clark County wetland model and National Wetlands Inventory.

The Cedar Creek (Lower) and Cedar Creek (Middle) subwatersheds have wetlands associated with the main channels of Cedar Creek and it tributaries, including natural depressions and man-made impoundments, flood influenced riverine wetlands, and sloped seep wetlands dominated by groundwater discharge. There are few large complexes of wetlands in headwater areas or on the valley floors.

Table 15: Distribution of Wetlands by Hydrogeomorphic Class

HGM Class	Area (ac.)	% of Sub-basin*	% of total wetland
Slope Wetlands	129	0.7	33.5
Depressional Wetlands	127	0.7	33
Riverine Wetlands	130	0.7	33.5
All Wetlands	386	2.1	

*Subwatershed area 18,823 ac.

There are no significant mapped wetlands in the Pup Creek subwatershed.

The majority of wetlands are located in landscape positions (along stream channels) where there are limited opportunities to improve water quality or hydrologic functions in these subwatersheds. Review of the wetland inventories and studies did not identify any significant project opportunities within publicly held or tax-exempt land.

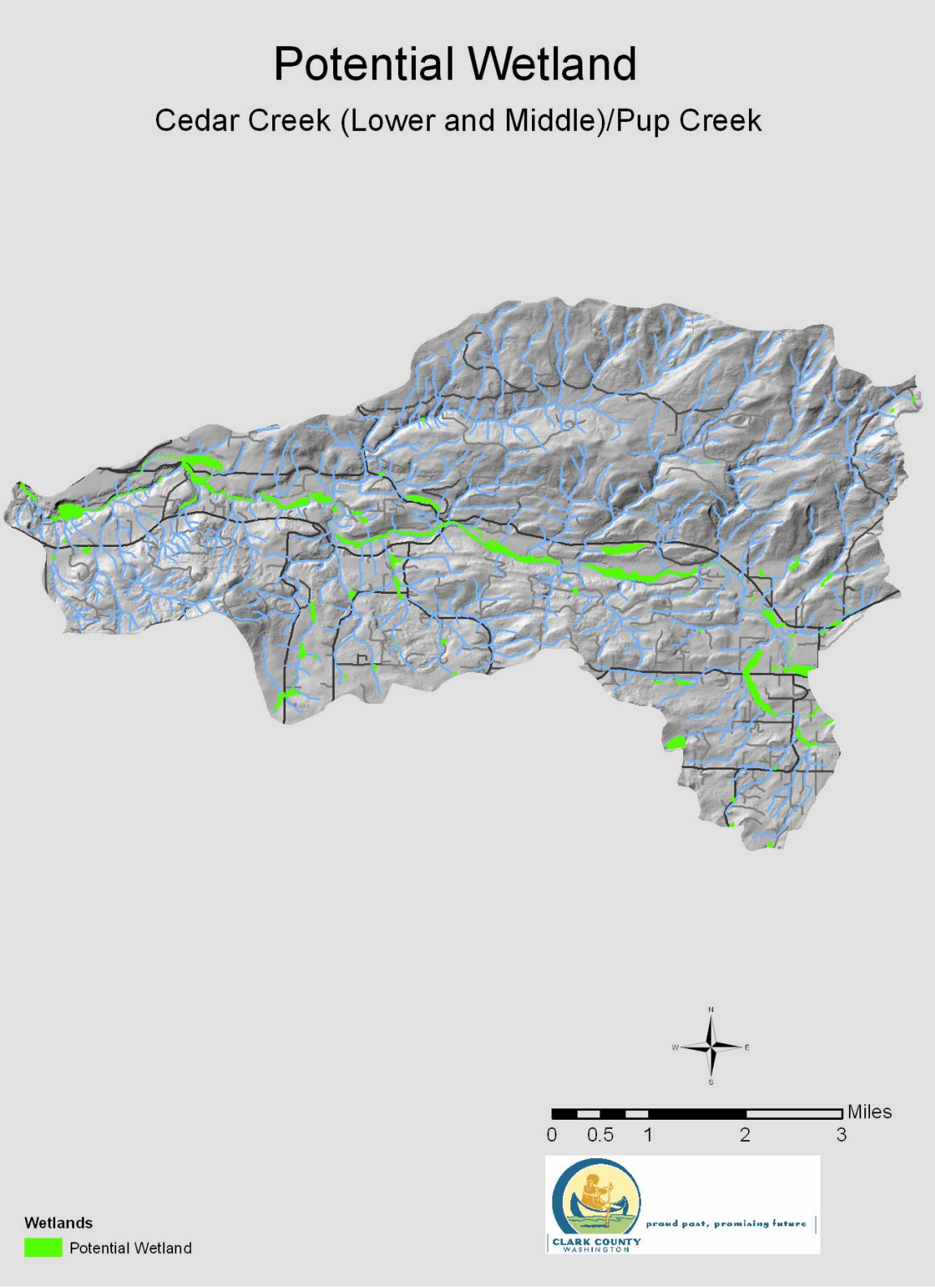

Figure 5: Cedar Creek (Middle)/Cedar Creek (Lower)/Pup Creek Potential Wetlands

Watershed Characterization

The Washington Department of Ecology completed the Watershed Characterization and Analysis of Clark County (2009) to assist in planning wetland and riparian habitat restoration and preservation projects.

Results pertaining to the Cedar Creek (Middle)/Cedar Creek (Lower)/Pup Creek subwatersheds are summarized below.

The study area is part of the "Lewis" Rain Dominated Mountainous hydrogeologic unit. It is characterized by rain dominated precipitation, shallow and deep patterns of groundwater flow, and glacial till over consolidated formations, as well as more permeable sedimentary formations (e.g. river alluvium and Troutdale formation) and moderate to steep topography (Ecology, 2009).

Figure 6 depicts priority areas for protection and restoration of hydrologic and denitrification processes county-wide based on an analysis of the relative importance and level of alteration in each subwatershed.

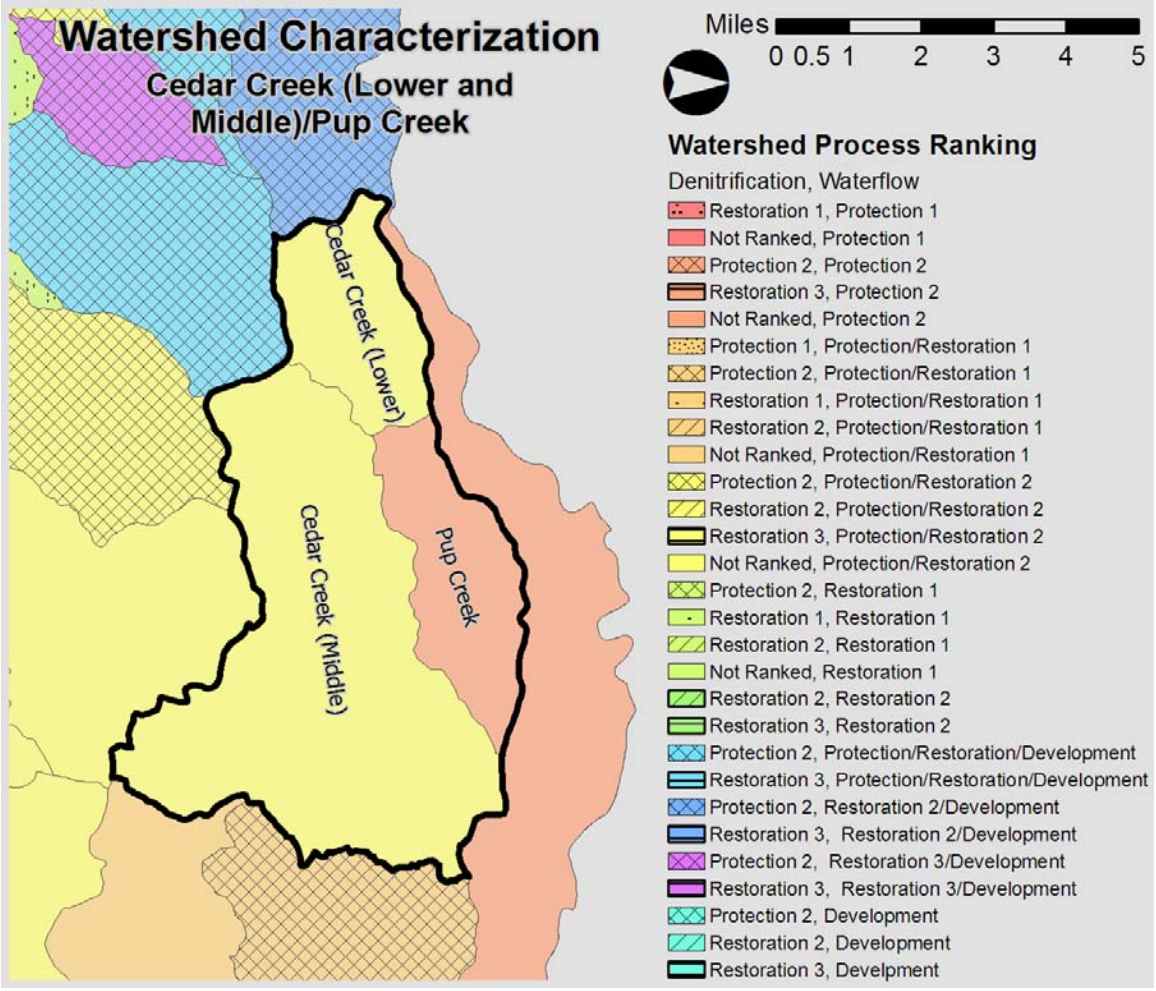

Figure 6: Priorities for suitability of areas for protection and restoration for the hydrogeologic process (from Watershed Characterization and Analysis of Clark County (Ecology, 2009))

In general, red areas have higher levels of importance for watershed hydrologic processes and limited alteration, and should be considered for protection. Yellow areas have a higher level of importance for watershed processes and a higher level of alteration, and should be considered for restoration unless watershed processes are permanently altered by urban development. Green to blue areas have lower levels of importance for watershed processes and higher levels of alteration, and should be considered as more suitable for development. Because and blue green, purple areas represent a transition from restoration areas, planning measures employing both restoration and appropriately sited development should be considered (Ecology, 2009). Hatch patterns represent the importance of denitrification processes.

Protection of hydrologic (waterflow) processes is recommended for the Pup Creek subwatershed (dark orange). The Cedar Creek (Middle) and Cedar Creek (Lower) subwatersheds are ranked for protection and restoration of hydrologic processes (yellow). None of these subwatersheds is ranked for denitrification processes due to the small percentage of wetland area.

Macroinvertebrate Assessment

Purpose

The Benthic Macroinvertebrate Index of Biological Integrity or B-IBI (Karr, 1998) is a widely used measurement of stream biological integrity or health based on macroinvertebrate populations. Macroinvertebrates spend most of their lives in the stream substrate before emerging as adults. While in the stream, they are subject to impacts from continuous and intermittent pollutant sources, hydrology and habitat changes, and high summer water temperatures.

The B-IBI score is an index of 10 metrics describing characteristics of stream biology, including: tolerance and intolerance to pollution; taxonomic richness; feeding ecology; reproductive strategy; population structure. Each metric was selected because it has a predictable response to stream degradation. For example, stonefly species often are the most sensitive and first to disappear as human-caused disturbances increase, resulting in lower values for the metric "Number of Stonefly taxa."

In addition to the overall B-IBI scores, examining individual metric scores gives insight into stream conditions and better explains differences in the overall score.

Methods

All field and laboratory work followed CWP protocols for macroinvertebrate sampling and analyses (June 2003). Samples are collected during late summer, preserved and delivered to a contracted lab for organism identification, enumeration and calculation of B-IBI metrics.

Raw data values for each metric are converted to a score of one, three or five, and the 10 individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores 10 to 24 indicate low biological integrity, 25 to 39 indicate moderate integrity, and greater than 39 indicate high biological integrity.

Results are influenced by both cumulative impacts of upstream land use and reach-specific conditions at or upstream of sampling sites. Thus, samples from a reach integrate local and upstream influences. Many of the B-IBI metrics also are influenced by naturally occurring factors in a watershed. For example, the absence of gravel substrate can lower scores.

Data are available for the following locations in this study area:

- CED050 (Cedar Creek upstream of Cedar Creek Road bridge)
- CED055 (Cedar Creek upstream of John Creek)
- PUP020 (Pup Creek downstream of Pup Creek Road)
- JON010 (John Creek near confluence with Cedar Creek)

Cedar Creek samples were collected by county staff at Station CED050 in 2002 and at both mainstem stations in 2004. A John Creek sample (JON010) also was collected in 2004. Pup Creek was sampled by county staff in 2009.

Results

The average of two samples at CED050 and a single sample at CED055 place both stations in the category of moderate biological integrity. Individual annual scores ranged only from 32 to 34 at these stations. John Creek in 2004 and Pup Creek in 2009 both were in the category of high biological integrity with scores of 44 and 42, respectively.

Table 16 and Table 17 show submetric results for the four stations.

In the Cedar Creek (Middle) subwatershed, there are three high, six moderate and one low score among the average results for individual metrics at Station CED050, compared with four high, four moderate and two low at Station CED055. The low scoring metrics for Number of Intolerant taxa and Percent Predator taxa suggest human disturbance. Intolerant taxa typically are the first to disappear as human disturbance increases, while predator taxa are a measure of food web complexity which decreases as human disturbance increases (Fore, 1999).

Pup Creek results include seven high and three moderate scores. John Creek scores are nearly identical, with the exception of one low score for Percent Predator taxa. This low score and the moderate score for Pup Creek for this metric may be cause for some concern in these otherwise high-scoring subwatersheds. As one of the first metrics to decline with increasing human disturbance, low scores for Predator Taxa could indicate that these areas have started to degrade.

Table 16: Station CED050 and Station CED055 Average Annual Macroinvertebrate Community Metrics and Total Scores from 2002 and 2004

B-IBI Metrics	CED050 2-Year Averages			CED055 2004		
	Value	Score	Category	Value	Score	Category
Total number of taxa	36.5	3	moderate	44.0	5	high
Number of Mayfly taxa	7.0	3	moderate	8.0	3	moderate

B-IBI Metrics	CED050 2-Year Averages			CED055 2004		
	Value	Score	Category	Value	Score	Category
Number of Stonefly taxa	5.5	3	moderate	7.0	3	moderate
Number of Caddisfly taxa	7.0	3	moderate	5.0	3	moderate
Number of long-lived taxa	6.5	5	high	6.0	5	high
Number of intolerant taxa	1.0	1	low	1.0	1	low
Percent tolerant taxa	28.6	3	moderate	26.9	3	moderate
Percent predator taxa	10.7	3	moderate	7.0	1	low
Number of clinger taxa	24.5	5	high	30.0	5	high
Percent dominance (3 taxa)	45.0	5	high	41.2	5	high
Average annual B-IBI Score		33	moderate		34	moderate

Table 17: Station JON010 and Station PUP020 Average Annual Macroinvertebrate Community Metrics and Total Score from 2004 and 2009

B-IBI Metrics	JON010 2004			PUP020 2009		
	Value	Score	Category	Value	Score	Category
Total number of taxa	43	5	high	53	5	high
Number of Mayfly taxa	8	3	moderate	8	3	moderate
Number of Stonefly taxa	9	5	high	10	5	high
Number of Caddisfly taxa	12	5	high	8	3	moderate
Number of long-lived taxa	8	5	high	6	5	high
Number of intolerant taxa	4	5	high	6	5	high
Percent tolerant taxa	19.5	3	moderate	11.6	5	high
Percent predator taxa	16.1	3	moderate	5.0	1	low

B-IBI Metrics	JON010 2004			PUP020 2009		
	Value	Score	Category	Value	Score	Category
Number of clinger taxa	26	5	high	38	5	high
Percent dominance (3 taxa)	39.8	5	high	46.1	5	high
Average annual B-IBI Score		44	high		42	high

Booth et al. (2004) found a wide but well defined range of B-IBI scores for most levels of development, but observed overall that B-IBI scores decline consistently with increasing watershed total impervious area (TIA).

By comparing B-IBI scores in the study area with the likely range of conditions for watersheds with similar amounts of development, measured as total impervious area, it is possible to make some general statements about the potential benefits from improving stream habitat.

Figure 7 indicates that scores for both Cedar Creek stations are in the middle of the range of expected scores for subwatersheds with relatively low amounts of impervious area (estimated 2000 Total Impervious Area from Wierenga, 2005). This suggests that factors other than impervious area are contributing to poor biological integrity. This implies an opportunity to increase the level of biological health by improving habitat and stream conditions. Management strategies that limit further degradation and promote stewardship are important to realizing that opportunity.

Figure 8 indicates that scores for Pup Creek and John Creek are near the upper end of the range of expected scores. It is unlikely that scores could be improved significantly in these areas. However, management strategies that limit degradation are critical to preventing eventual deterioration of biological health at these sites. Sub-metric scores suggest these streams may be starting to show impacts.

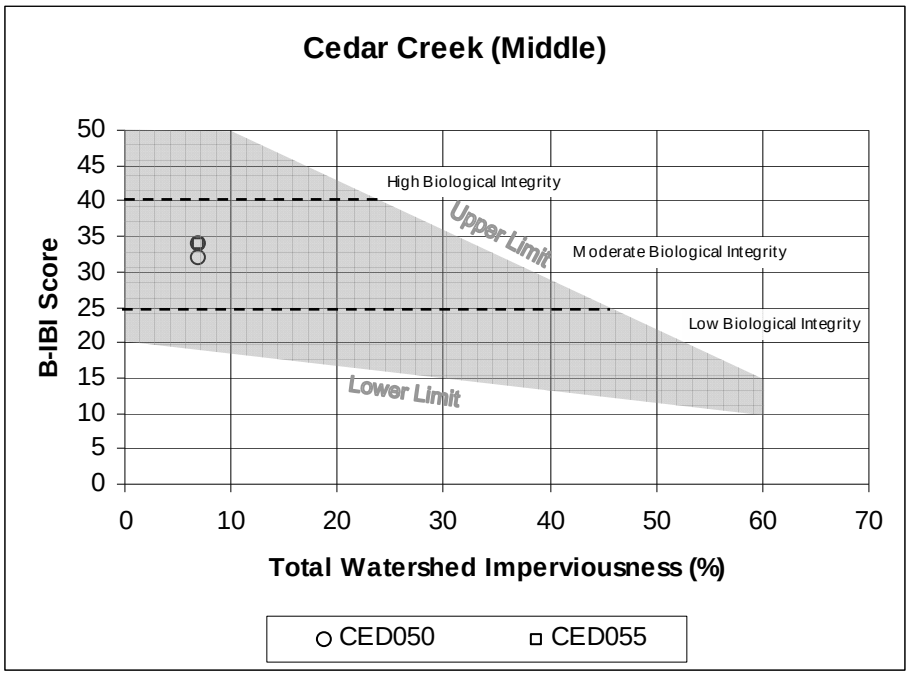

Figure 7: Approximate range of B-IBI in Puget Lowland watersheds, showing progressive decline with increasing imperviousness in the upstream watershed. Adapted from Booth et. al, 2004. Markers indicate B-IBI scores at Station CED050 and Station CED055 for particular years, versus estimated 2000 subwatersheds TIA.

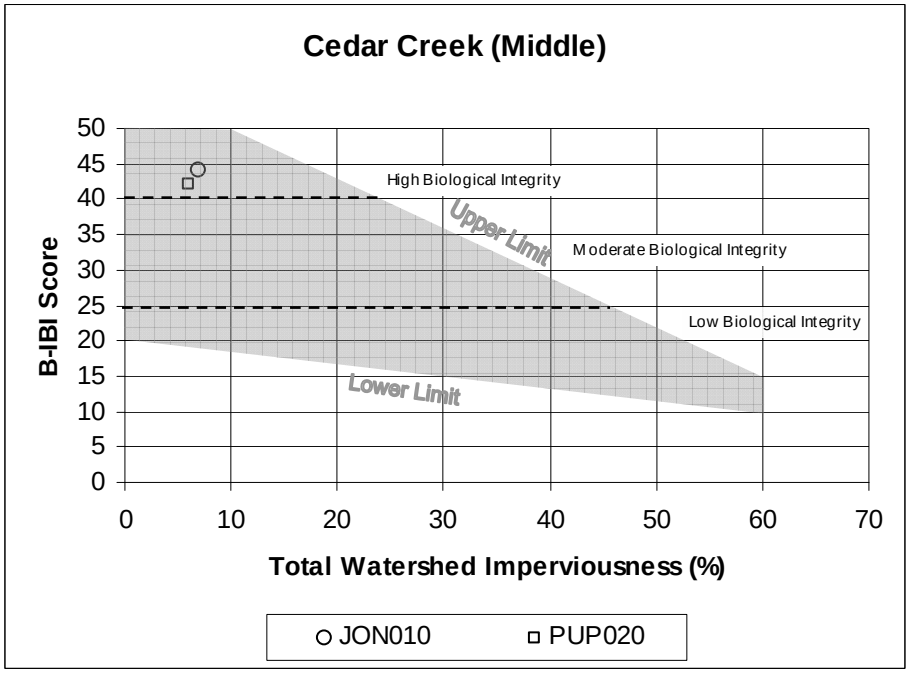

Figure 8: Approximate range of B-IBI in Puget Lowland watersheds, showing progressive decline with increasing imperviousness in the upstream watershed. Adapted from Booth et. al., 2004.

Markers indicate B-IBI scores at Station JON010 and Station PUP020 for particular years, versus estimated 2000 subwatershed TIA.

Fish Use and Distribution

Purpose

Fish distribution refers to salmon and steelhead use. This information helps to identify stream segments where land-use changes may impact fish populations, informs management decisions, and aids in identifying and prioritizing potential habitat improvement and protection projects.

Methods

Fish distribution for the study area is mapped from existing Clark County GIS information, which reflects data collected and analyzed by the Northwest Indian Fisheries Commission (NWIFC). Fish distribution data for Clark County is available on the County's website.

Several sources of barrier assessment data are available and are briefly summarized here, including:

- WDFW passage barrier database.
- SalmonScape (http://wdfw.wa.gov/mapping/salmonscape/)
- Clark County 1997 passage barrier data.
- Clark Conservation District/LCFRB passage barrier dataset.

Many stream crossings have not been assessed for passage barrier potential, and the extent of public and private road crossings is a good indicator of the potential for additional barriers. Road crossings were mapped by overlaying the county road layer with LiDAR-derived stream data.

The barrier assessment data was also reviewed for specific project opportunities within each subwatershed. Potential project sites have been reviewed and verified through field reconnaissance and are detailed in the results section below.

Results/Summary

Distribution

The available evidence suggests that anadromous fish use of the mainstem of Cedar Creek within the Cedar Creek (Middle) and Cedar Creek (Lower) subwatersheds includes chum (up to the Grist Mill, Figure 9), coho (Figure 10), spring Chinook (Figure 11) and winter steelhead (Figure 12). Upstream of the Grist Mill, Cedar Creek is shown as potential chum habitat.

In the Pup Creek subwatershed, evidence suggests potential presence of chum (Figure 9) and known presence of coho and winter steelhead (Figure 10 and Figure 12). Presence of spring Chinook is presumed in Pup Creek up to NE Spurrel Rd (Figure 11). Chinook presence in Pup Creek may be constrained by the species biological preference to spawn in larger, lower gradient waters.

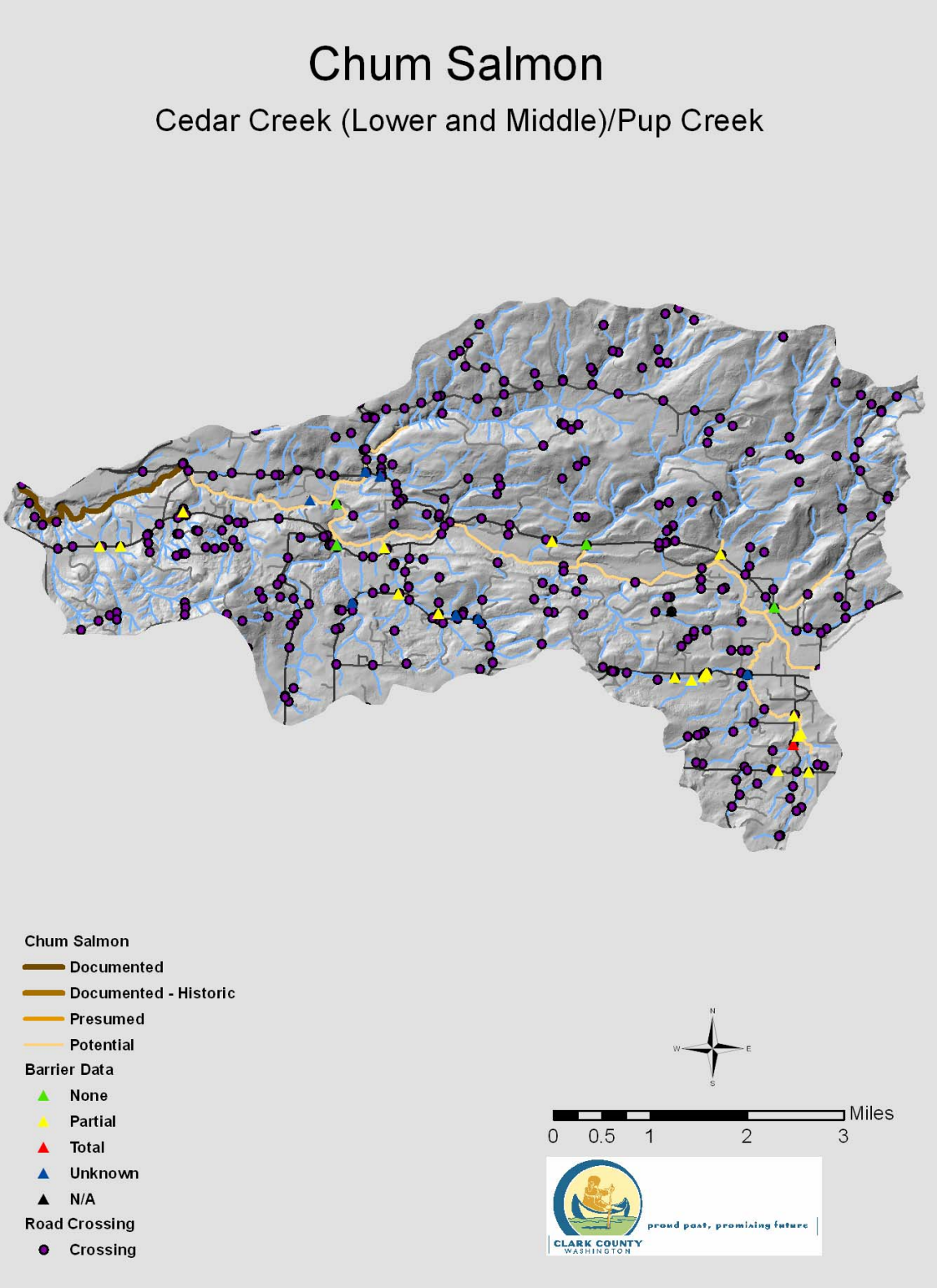

Figure 9: Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek Chum Salmon Distribution and Barriers

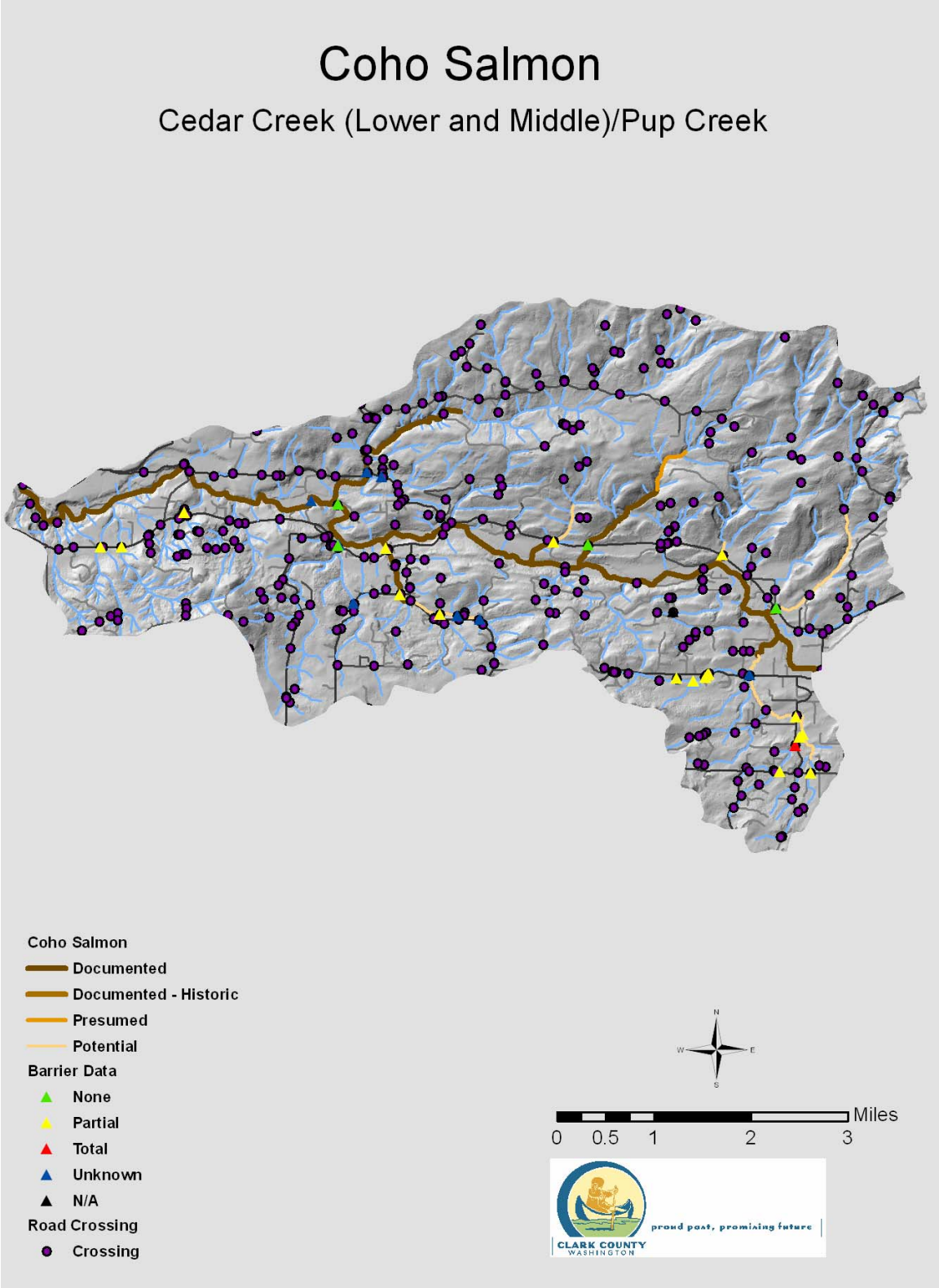

Figure 10: Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek Coho Salmon Distribution and Barriers

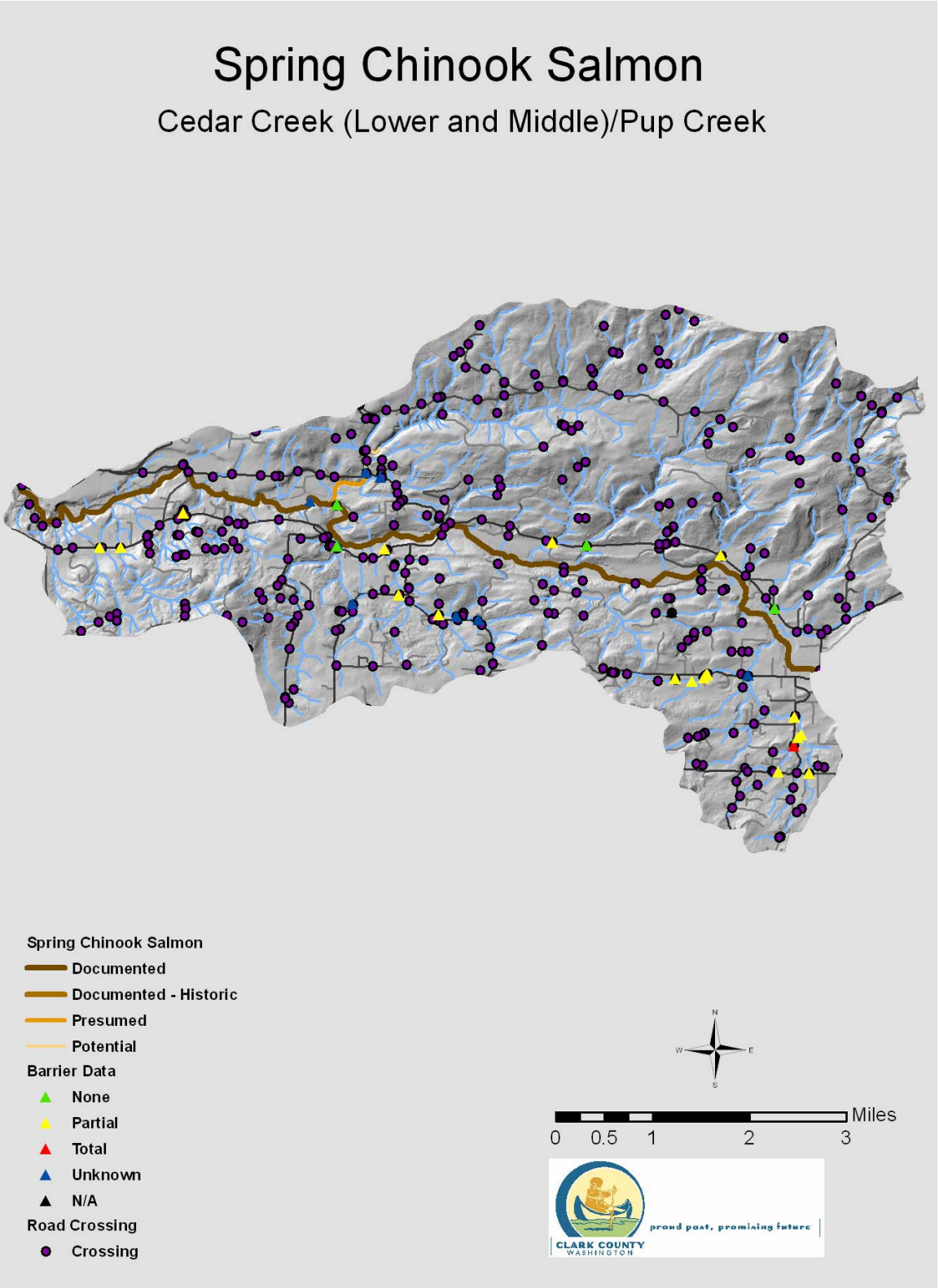

Figure 11: Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek Spring Chinook Distribution and Barriers

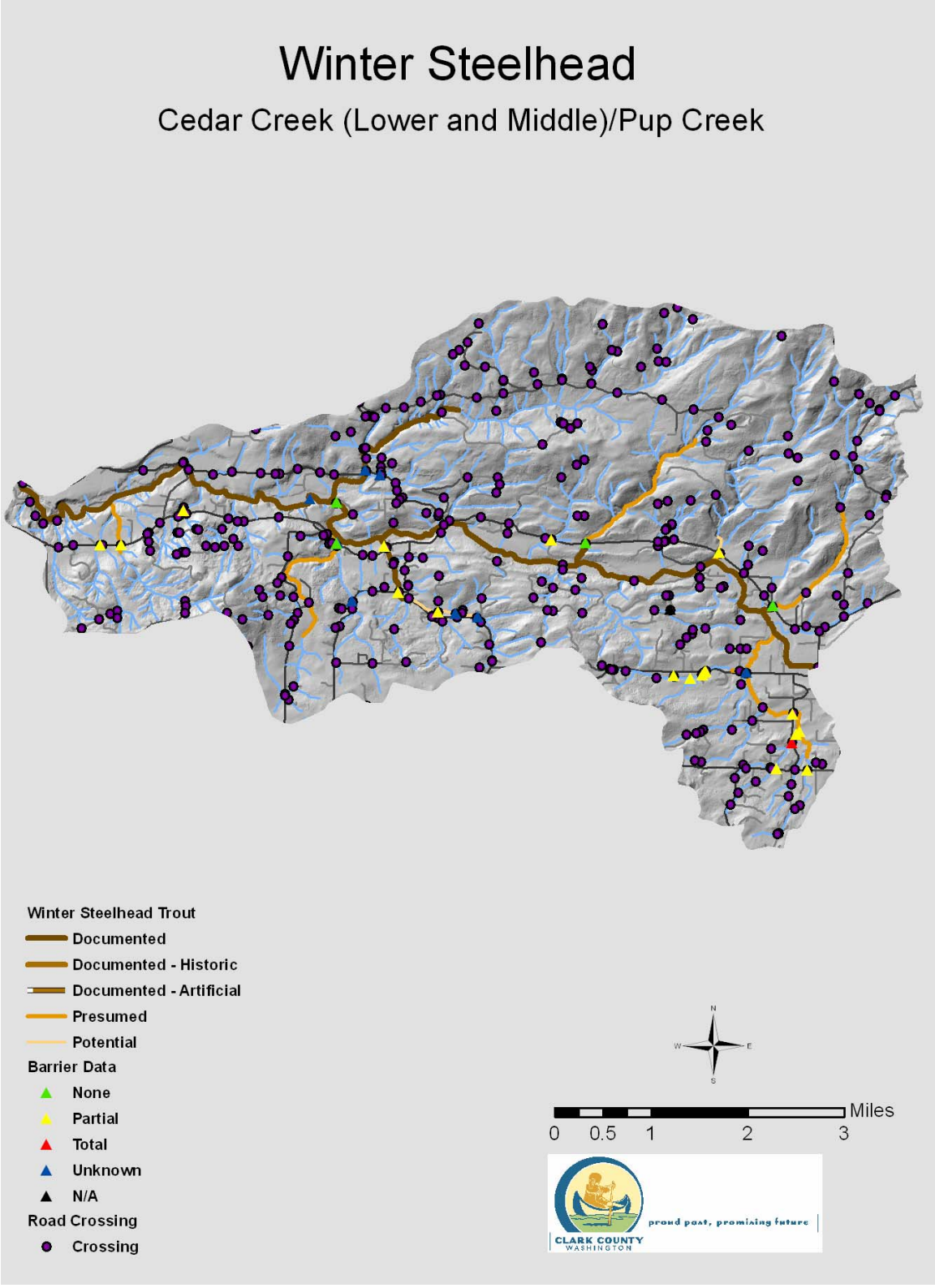

Figure 12: Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek Winter Steelhead Distribution and Barriers

Barriers

The WDFW barrier database provides the most complete assessment of barriers in the Cedar Creek (Middle), Cedar Creek (Lower) and Pup Creek subwatersheds (Figure 9, Figure 10, Figure 11, Figure 12). There are no total fish barriers mapped on the mainstem of Cedar Creek or Pup Creek in these subwatersheds. "Unknown" barriers are shown on Cedar Creek at (45.934523, -122.556996), on Pup Creek at Spurrel Rd (45.939046, -122.545258), and on Bitter Creek at (45.910146, -122.462238). One total barrier is mapped in these subwatersheds on a tributary to Bitter Creek at its crossing of SR 503 (45.899677, -122.451968). Multiple partial barriers are mapped on tributaries throughout these subwatersheds, including one on John Creek that was the site of a Clark County Public Works fish passage replacement culvert project (45.928918, -122.497598).

Recommendations

Removal of the barrier at SR 503 (45.899677, -122.545258) would not open any habitat currently mapped as "Potential" and therefore should probably be considered a low priority. The LCFRB report suggests that reconnecting some in-channel and off-channel habitats could have significant positive benefits for all species using the system. However, "The blocked habitat is believed to be marginal in the majority of cases and no individual barriers in themselves account for a significant portion of blocked miles." Therefore, projects should be carefully selected to optimize the cost-benefit ratio (LCFRB 2009).

Hydrologic and Hydraulic Models

Hydrologic and Hydraulic modeling was not conducted.

Analysis of Potential Projects

The analysis of potential projects:

- Briefly summarizes stormwater conditions, problems and opportunities
- Notes recently completed or current projects in the study area that may be relevant to SNAP project selection
- Describes the analytical approach
- Lists recommended projects and activities for further evaluation

Projects or activities are placed in one of several categories.

Project descriptions summarize more detailed descriptions found in report sections. Project planners are encouraged to reference the longer descriptions and use information found for each potential project in the SNAP GIS database available from the Clean Water Program. Reference IDs for the database are included in the tables for each project.

Summary of Conditions, Problems, and Opportunities

Conditions and Problems

This section briefly summarizes important results from the assessment chapters and identifies overall stormwater-related problems.

Coordination with Other Programs

The DES coordinates on an ongoing basis with the Washington Department of Ecology, Lower Columbia Fish Recovery Board and Vancouver-Clark Parks and Recreation in efforts to improve stream health. Fish First is active in fish recovery efforts in the Cedar Creek watershed.

There are no planned road improvement projects included in the 2010-2015 Clark County Transportation Improvement Program and no planned projects in the 2011-2012 stormwater capital program.

Broad-Scale Characterization

The study area is primarily forest and agriculture, with little development. Areas of open space tend to be in agriculture or wetlands. The topography is alluvial and terraced valleys bordered by bedrock hills, with slopes primarily 8-20 percent and some portions sloping up to 70 percent. Geology consists of volcanic and intrusive rock underlying glacial alluvial deposits. Glacial till covers much of the area. Soils are primarily well-drained Cinebar silt loam. Stream hydrology is at or close to natural forested conditions. Ecology operated a gage at the Grist Mill in lower Cedar Creek from 2001-2009.

Standard subwatershed scale metrics such as percent forest, percent total impervious area, road density and effective impervious area, when compared to NOAA fisheries standards, suggest stream habitat is partially functioning. The percent forest cover and impervious area are between

the thresholds for functioning and non-functioning systems, and road density is in the non-functioning category.

Water Quality Assessment
Cedar Creek in this study area is 303(d) listed for fecal coliform (Category 5) and temperature (Category 2). There are no listings in Pup Creek, and no active TMDLs in the study area.

Recent data are limited to summertime water temperature readings from two locations in 2004. Both stations exceeded the temperature standard by 13º F, and daily temperatures were elevated for much of the summer period.

Drainage System Inventory and Condition
Stormwater infrastructure is limited in this area, consisting primarily of roadside ditches. Overall drainage mapping is complete. There are 10 stormwater facilities, two of which are publicly owned and operated. No facilities were identified as potential retrofit projects.

Off-site evaluations were conducted at six outfalls discharging to critical areas. Two referrals were made for trash accumulation at outfalls.

Source Control
There were 20 businesses qualifying for source control visits in this study area. All sites were inspected and no source control issues were discovered.

Illicit Discharge Screening
Illicit discharge screening was not conducted.

Stream Reconnaissance Feature Inventory
A feature inventory was not conducted.

Physical Habitat
Physical habitat measurements in this assessment area were made in 2004 (R2 Resource Consultants, Inc., 2004) for three reaches in the Cedar Creek (Middle) subwatershed, including two on the main stem and one in John Creek.

The main stem survey reaches are classified as narrow, low gradient floodplain channels, with a map gradient of 0.5 percent. Habitat in these reaches consists mainly of small riffles. In both of these reaches, parameters including pool frequency, pool quality, LWD, substrate and water temperature were classified as at-risk or not properly functioning. Streambanks were classified as stable and properly functioning.

The John Creek survey reach is a moderate gradient contained channel with a map gradient of 4 percent. Habitat is primarily cascade and large riffles. Habitat parameters were impaired and classified the same as the main stem reaches.

Embededdness in the mainstem reaches was estimated at 28-29 percent, compared with 56 percent in John Creek.

Geomorphology Assessment
A geomorphology assessment was not conducted.

Riparian Assessment
The 2004 LCFRB Habitat Assessment rated overall riparian conditions as 'moderately impaired' in this study area. Large woody debris recruitment potential was primarily poor in John Creek, fair in Brush Creek, poor in Cedar Creek (Middle) mainstem, good in Cedar Creek (Lower) mainstem, and mixed in Pup Creek. Shade levels were below state targets in all reaches.

Wetland Assessment
Wetlands comprise only 2 percent of the watershed in this study area. The Cedar Creek (Middle) and Cedar Creek (Lower) subwatersheds have wetlands primarily associated with the main channels of the creek and tributaries. There are few large wetland complexes. Pup Creek has no significant mapped wetlands.

Existing wetlands are located in landscape positions where opportunities to improve water quality or hydrologic functions are limited. Protection of hydrologic processes is recommended for the Pup Creek subwatershed, while Cedar Creek (Middle) and Cedar Creek (Lower) are ranked for both protection and restoration.

Macroinvertebrate Assessment
Data are available from four locations in this study area, collected at various times between 2002-2009. Based on these samples, Pup Creek and John Creek have high biological integrity, while Cedar Creek (Middle) and Cedar Creek (Lower) mainstem stations have moderate biological integrity. Submetric scores indicate limited human disturbance in Pup and John creeks, with a higher level of disturbance evident in the Cedar Creek mainstem.

Overall B-IBI scores in Pup and John creeks are near the upper limit of the predicted range for areas with similar levels of total impervious area. In these areas, management should focus on retaining high biological integrity. A relatively small loss of integrity could degrade both of these streams into the Moderate category. Scores in Cedar Creek mainstem are at the middle of the expected range, implying that factors other than impervious area are contributing to less than optimal biological health. There is an opportunity in the mainstem to increase biological integrity by improving habitat and stream conditions.

Fish Use and Distribution
The available information suggests that anadramous fish use in the Cedar Creek mainstem within this study area includes Chum, Coho and spring Chinook salmon, as well as winter steelhead. Pup Creek contains Coho, winter steelhead and potentially Chum.

There are no total fish barriers mapped on mainstem creeks in this assessment area, but a few potential barriers are mapped "unknown." One total barrier exists on the Bitter Creek tributary at SR503, and multiple partial barriers also are mapped on tributaries. Clark County removed a

significant barrier culvert in John Creek several years ago. There are no high priority removal projects at this time.

Recently Completed or Current Projects

There are no recently completed or current County projects in this assessment area.

Analysis Approach

Purpose

The Analysis of Potential Projects narrows the initial list of possible opportunities to a subset of higher priority items. Listed opportunities in sections of the SNAP report include sites requiring immediate follow-up, possible stormwater capital improvement projects, internal followup by DES staff and, in some cases, information to be forwarded to other county departments or outside agencies.

Stormwater capital improvement project opportunities are recommended for further evaluation by engineering staff and potential development into projects for consideration through the capital planning process. Sites flagged for internal action by ongoing programs, such as illicit discharge screening, operations and maintenance and source control outreach, receive follow-up within the context and schedules of the individual programs. Information forwarded to other county departments, such as Public Health, or to outside agencies, such as Clark Conservation District and Clark Public Utilities, may lead to additional activities outside the scope of DES work.

Methods

An initial review is conducted for all potential projects identified during the stormwater needs assessment. Field notes, descriptions, field photos and other associated information are reviewed. In some cases, additional field reconnaissance is performed.

In general, capital project opportunities are initially evaluated by considering problem severity, land availability, access, proximity and potential for grouping with other projects, and potential for leveraging resources. Staff considers supporting data and information from the SNAP report to assist in the initial project review.

Based on this review, lower priority opportunities are removed and higher priority opportunities are recommended for further consideration below.

There were no specific project opportunities identified in this study area.

Riparian restoration:

There are numerous locations in this study area where riparian areas are narrow or absent. Reforestation of these areas would provide improved LWD recruitment and channel shading and

should be encouraged. No specific projects were identified because Clark County owns little land in this area. In most cases working with private landowners would be required.

Washington State owns a significant amount of land for forestry purposes. It is assumed these lands are managed with riparian conservation practices in place and thus do not present an opportunity for county-driven enhancement projects. The Cedar Creek State Wildlife Recreation Area is one possible exception.

Non-Project Management Recommendations

Non-project stormwater management recommendations address areas where county programs or activities could be modified to better address NPDES permit components or promote more effective mitigation of stormwater problems. Information of this type contributes to adaptive management strategies and more effective stormwater management during the permit term.

There were no NPDES permit-related management recommendations identified for this study area.

Overall management actions that may lead to improved watershed health include:

- Conserve existing agricultural and forest lands and promote healthy practices
- Restore stream channels
- Protect and/or enhance existing wetlands
- Encourage and support riparian planting efforts by private landowners

References

Booth, D.B. and C.R. Jackson. (1997). Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detention, and the Limits of Mitigation: Journal of the American Water Resources Association, vol. 33, no. 5, p. 1077-1090.

Booth, D.B., Hartley, D., and Jackson, R. (June 2002). Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts: Journal of the American Water Resources Association vol. 38, no. 3. p. 835-845.

Booth, D. B., et al. (October 2004). Reviving Urban Streams: Land Use, Hydrology, Biology, and Human Behavior: Journal of the American Water Resources Association, pp. 1351-1364.

Center for Watershed Protection (March 2003). Impacts of Impervious Cover on Aquatic Systems: Watershed Protection Monograph No. 1.

City of Vancouver – Surface Water Management (May 2007). Burnt Bridge Creek Watershed Program. Vancouver, WA

Clark County Public Works Water Resources (June 2003). Standard Procedures for Monitoring Activities, pp. 46-48.

Clark County Public Works Water Resources (December 2003). Long-Term Index Site Monitoring Project: 2002 Physical Habitat Characterization, pp. 35.

Clark County Public Works Water Resources (2004). Clark County Stream Health, A comprehensive overview of the condition of Clark County's streams, rivers, and lakes, pp 46.

Clark County (2004). Regional wetland inventory and strategy: 51 pages.

Cornelius, L. (July 2006). Gee Creek Watershed Restoration Background Report: WSU Clark County Extension.

Cornelius, L. and J. Finley (January, 2008). Gee Creek Watershed Restoration Project 2007 Annual Report: WSU Clark County Extension.

Cramer, S.P. & Associates, Inc. (January 2005). Chapter 4: East Fork Lewis River Basin – Habitat Assessment, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

Cude, C. (2001). Oregon Water Quality Index: A Tool for Evaluating Water Quality Management Effectiveness. Journal of the American Water Resources Association. Vol. 37, No.1.

Everts, Russel C. (2004). Geologic map of the Ridgefield 7.5' quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map 2834, scale 1:24,000. (http://pubs.usgs.gov/sim/2004/2844).

Fore, L.S., City of Bellevue (March 1999). Measuring the Effects of Urbanization on Bellevue Streams, pp. 24.

Hill, K., and M.C. Bidwell (January 2003). A Rapid Land Cover Classification for Clark County: Washington: Department of Landscape Architecture and Urban

Ecology Lab, College of Architecture and planning, University of Washington, Seattle, Washington.

Hutton, R., and C. Hoxeng (April 2007). Clark County Long-term Index Site and Salmon Creek Monitoring Projects' Status and Trends Based on Oregon Water Quality Indices and Turbidity: Clark County Water Resources Program, Vancouver, Washington.

Karr, J.R. (1998). Rivers as Sentinels: Using the Biology of Rivers to Guide Landscape Management, River Ecology and Management: Lessons from the Pacific Coastal Ecosystems. Springer, NY, pp. 502-528.

Law, A.W. (1994). The effects of watershed urbanization on stream ecosystem integrity. Masters Thesis. University of Washington, Seattle Washington.

Lower Columbia Fish Recovery Board. (Dec. 2004). Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Volume II, Subbasin Plan Chapter G, North Fork and East Fork Lewis.

Lower Columbia Fish Recovery Board. (Dec. 2004). Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Volume II, Subbasin Plan Chapter H, Lower Columbia Tributaries Bonneville and Salmon.

Lower Columbia Fish Recovery Board. (Dec. 2004). Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Volume II, Subbasin Plan Chapter I, Washougal.

Lower Columbia Fish Recovery Board. (2007). Regional Culvert Inventory, Project #02-1658N, Final Report.

Lower Columbia Fish Recovery Board. (2008). East Fork Lewis River Community Habitat Restoration Plan and Project Design – Draft Technical Memorandum 1 and 2.

Lower Columbia Fish Recovery Board. (2009). Lower Columbia Salmon Recovery 6-Year Habitat Work Schedule and Lead Entity Habitat Strategy.

Montgomery, David R. and John M Buffington (1997). Channel-reach morphology in mountain drainage basins: GSA Bulletin; May 1997; v. 109; no. 5; p. 596–611.

National Marines Fisheries Service (August 1996). Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale: Environmental and Technical Services Division, Habitat Conservation Branch.

National Marines Fisheries Service (March 2003). ESA Guidance for Analyzing Stormwater Effects: NOAA Fisheries Service, Northwest Region.

Parametrix, Inc. (2002). Burnt Bridge Creek Riparian Habitat Assessment. Prepared for the City of Vancouver, 37 pp.

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 1: Introduction and Methods, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 3: The North Fork Lewis River Basin, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 5: The Salmon Creek Basin, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 6: The Washougal River Basin, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

Schnabel, J. (December 2003). Long-Term Index Site Monitoring Project: 2002 Physical Habitat Data Summary: Clark County Public Works Department, Water Resources Program, Vancouver, Washington.

Schnabel, J. (September 2004). Salmon Creek Watershed: Summer 2003 Stream Temperature. Clark County Public Works Department, Water Resources Program, Vancouver, Washington.

Schueler, T. (1999). Microbes and Urban Watersheds: Ways to Kill ‘em. Watershed Protection Techniques. 3(1): 566-574.

S.P. Cramer & Associates, Inc. (January 2005). Chapter 4: East Fork Lewis River Basin – Habitat Assessment, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

State of Oregon Department of Environmental Quality (July 2004). Draft Lower Willamette Subbasin TMDL.

Swanson, R.D. (July 2006). Prioritizing Areas for Stormwater Basin Planning: Clark County Public Works, Water Resources Program.

Vancouver Lake Watershed Partnership Technical Group. Technical Foundation for Future Management of Vancouver Lake (November 2008).

Turney, G.L. (1990). Quality of Groundwater in Clark County, Washington: US Geological Survey Water Resource Investigation Report 90-4149, 97 p.

United States Environmental Protection Agency (1986). Quality Criteria for Water 1986: EPA 440/5-86-011, Office of Water Regulations and standards, Washington, DC.

US Army Corps of Engineers (November 2007). Review of Biological Research on Juvenile and Adult Salmonid use of Vancouver Lake. Portland District.

U.S.G.S. (2002). Hydrologic Trends Associated with Urban Development for Selected Streams in the Puget Sound Basin: Western Washington (Water-Resources Investigations Report 02-4040), Tacoma, WA, pp. 40.

Washington Department of Ecology (November 2006). Water Quality Standards for Surface Waters of the State of Washington: Chapter 173-201A WAC. Publication # 06-10-091.

Washington Department of Ecology (April 2005). O'Brien, Ed. 2005 Stormwater Management Manual for Western Washington: Volume I -- Minimum Technical Requirements and Site Planning, Report 05-10-029, Olympia, WA.

Washington State Department of Ecology. Stormwater Management Manual for Western Washington (February 2005). Publication Numbers 05-10-029 through 05-10-033.

Washington Department of Ecology (April 2007). Draft Watershed Characterization of Clark County, Version 3: Shorelines and Environmental Assistance Program.

Washington Forest Practices Board Manual (March 2000).

Washington State University Vancouver (2009). Bollens, Stephen and Gretchen Rollwagen-Bollens. Year One Annual Report: Biological Assessment of the Plankton in Vancouver Lake, WA.

Wierenga, R., Clark County Water Resources, (January 2005). Technical Report: Subwatershed Characterization and Classification: Clark County Washington, pp. 17.

Wierenga, R. (2005.) Benthic Macroinvertebrate and Water Temperature Monitoring for Clark County Watershed Assessments in 2004. Clark County Public Works Department – Water Resources Program. Washington Department of Ecology Grant number G0300020 and Clark County Clean Water Program.