2010 Stormwater Needs Assessment Program

Lower Lacamas Creek/Lacamas Lake
Subwatershed Needs Assessment Report

Clark County Department of Environmental Services

March 2011

2010 Stormwater Needs Assessment Program
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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 Lower Lacamas Creek and Lacamas Lake subwatersheds in the Lacamas 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 two study area subwatersheds, 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, Clark County Legacy Lands and Vancouver-Clark Parks and Recreation in efforts to improve stream health.

Ecology is collecting field data for a multi-parameter TMDL in 2010-2011. Clark County participates in the TMDL process. Clark County Legacy Lands recently purchased seven acres of riparian and wetland habitat along the shoreline of Lacamas Lake near the intersection of SR 500 and Leadbetter Road, and is currently working to protect another 65 acres.

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. There is one project in this assessment area currently in the stormwater capital projects database. Project CP-120 is a reforestation project at Harmony Ridge Neighborhood Park. This project has not been funded or scheduled.

Category	Status
Water Quality	
Overall	• Fair • TMDL in development for dissolved oxygen, fecal coliform bacteria, temperature, and pH upstream of Lacamas Lake • Lacamas Lake categorized as eutrophic
Phosphorus	• Significant reductions since early 1980s • 2 of 12 samples in 2006 exceeded EPA criteria
Toxics	• 2006-2007 pesticide sampling found almost no detections • Lacamas Lake 303(d) listed for PCBs (Category 5)
Biological	
Benthic macroinvertebrates	• Low biological integrity
Anadramous fish	• Limited to reach below Lacamas Lake • Documented Coho and chum; presumed steelhead, fall Chinook
Habitat	
NOAA Fisheries criteria	• Forest cover, impervious area, and road density fall into the category of Non-Functioning habitat; stream crossing density in Properly Functioning category
Riparian	• Forest cover is 20-30 percent • Large woody debris and shade potential are highly variable
Wetland	• 10 percent of study area is wetlands • Riverine wetlands associated with the main creek channel; large areas of slope and depressional wetlands • Highly altered from agricultural use • Protection and restoration recommended in Lacamas Lake area; restoration recommended in upstream areas
Hydrology and Geomorphology	
Overall hydrology	• Low gradient and wide floodplain • Relatively stable stream flows; not flashy • Dam on Round Lake regulates flow in lowest reaches
Future condition	• Projected impervious area is expected to significantly alter natural hydrology; unstable stream channels are likely
Stormwater (unincorporated areas)	
System description	• Primarily road-side ditches, but piped infrastructure inside UGA; 111 stormwater facilities (65 public and 46 private)
Inventory status	• Complete; 8281 stormwater infrastructure features mapped
System adequacy	• Largely unknown
Retrofit opportunity	• Four facilities referred for possible retrofit
Maintenance evaluation	• 8 maintenance evaluations conducted; 83 percent of facility objects in compliance with maintenance standards

Category	Status
Offsite assessment	• Six priority outfalls assessed; all in compliance

Opportunities

Opportunities for stormwater-related projects are relatively limited in this assessment area. Field work and review of existing information identified the following projects and actions that can improve stream conditions:

- Evaluation of four potential stormwater facility retrofit projects for increased detention and/or treatment
- Evaluation of one potential reforestation project on public property
- Contact four private landowners with opportunities to improve degraded riparian conditions
- Cleanup of one location with large amounts of yard debris entering stream
- Removal of one large infestation of Canada thistle
- Streambank stabilization to protect public roadway at one location

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:

- Implement development regulations to minimize impacts, particularly enhanced nutrient control regulations to protect Lacamas Lake
- Focus on protecting reaches that are currently unstable or sensitive to future disturbance
- Increase infiltration and retention of stormwater runoff from older developments
- Focus additional effort on maintenance of bioswales, particularly excessive sediment conditions
- Educate private landowners on importance of native riparian vegetation and intact riparian forests for shading streams and preserving hydrology
- Continue collaboration on Lacamas Creek TMDL development
- Educate landowners to discourage disposal of trash and yard debris in streams or other receiving waters
- Assess Priority 3 outfalls, which make up nearly all of the outfalls discharging to critical areas in these subwatersheds; offsite assessment activities may reduce downstream erosion problems by discovering potential issues before they become more serious
- Encourage appropriate agricultural practices that emphasize soil and water conservation and reduction in nutrient load to streams.
- Protect streams from future stormwater impacts by creating stream buffers, establishing conservation easements, and eliminating agricultural runoff inputs.

- Encourage reforestation

Introduction

This Stormwater Needs Assessment includes the Lower Lacamas Creek and Lacamas Lake subwatersheds in the Lacamas 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 Lower Lacamas Creek and Lacamas Lake

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, the Lower Lacamas Creek and Lacamas Lake subwatersheds are categorized as "Rural Residential Including City-Serviced Fringes of Urban Growth Area." Subwatersheds in this category typically include rural areas bordering cities. These subwatersheds often score a high priority for stormwater management in general, but are a lower priority for Clark County due to the rural nature of unincorporated portions. Stormwater management needs tend to be limited in these areas.

Assessment Tools Applied in Lower Lacamas Creek and Lacamas Lake

The SNAP utilizes 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.

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 the following:

- Site visits by DES 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 and 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 is 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 LISP/SCMP/ Project data
- 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 two subwatersheds in the lower Lacamas Creek watershed: Lower Lacamas Creek and Lacamas Lake. There are several named tributaries and agricultural drainage ditches in the Lower Lacamas Creek subwatershed. Several small tributaries drain directly to Lacamas Lake or Lacamas Creek downstream of the lake (Figure 1). The study area is urban or urbanizing inside the Urban Growth Area along the western and southern borders, with relatively dense rural residential land use throughout much of the remainder. Areas of open space remain chiefly as golf courses, parklands and large agricultural operations. Much of the Lacamas Lake subwatershed is in the City of Camas UGA. The City of Vancouver UGA includes a small piece in the northwest corner of the Lower Lacamas Creek subwatershed.

Topography

The study area has low rolling hills between about 200 and 500 feet elevation and a high point around 800 feet at Green Mountain, a volcanic cone near Lacamas Lake. A relatively wide

floodplain occupies the low elevations along the mainstem of Lacamas Creek, which drains to Lacamas Lake at an elevation of 180 feet.

Geology and Soils

The study area is part of the Willamette Valley, separating the Cascade range from the Oregon Coast range. Volcanic basalt flows underlie much of the area, overlain by ancestral Columbia River sediments. The Late Ice Age glacial-outburst floods deposited poorly sorted gravels in the southwestern portion and finer sandy sediment farther north. The outburst floods also are thought to have scoured the valley holding Lacamas Lake. There are several Northwest-striking faults in the vicinity of Lacamas Lake.

Upland areas tend to have soils in soil group B and C, including Hesson Clay loams (C), Olympic Stoney Clay Loam (B), and Hillsboro Silt loams (B). In the floodplain areas, soils are typically from soil group D and include Hockinson Loam and Cove Silty Clay Loam.

Hydrology

Geology and topography play the main role in determining study area hydrologic framework. Lacamas Creek in these subwatersheds has a low gradient and flows in a wide floodplain. Lacamas Lake elevation and downstream flow are regulated by dams on Round Lake and a channel west of Round Lake under long-held water rights owned by the paper mill in Camas. Clark County has a stream gauge on lower Lacamas Creek at Goodwin Road. Data are available on the county website at http://www.clark.wa.gov/water-resources/monitoring/flow.html.

Based on analysis in 2010, stream flows at Goodwin Road are relatively stable and not as prone to rapid runoff. Most uplands were cleared long ago and stream channels have adjusted to some extent. Lacamas Creek has a broad flood plain that is largely zoned for agriculture upstream of Goodwin Road.

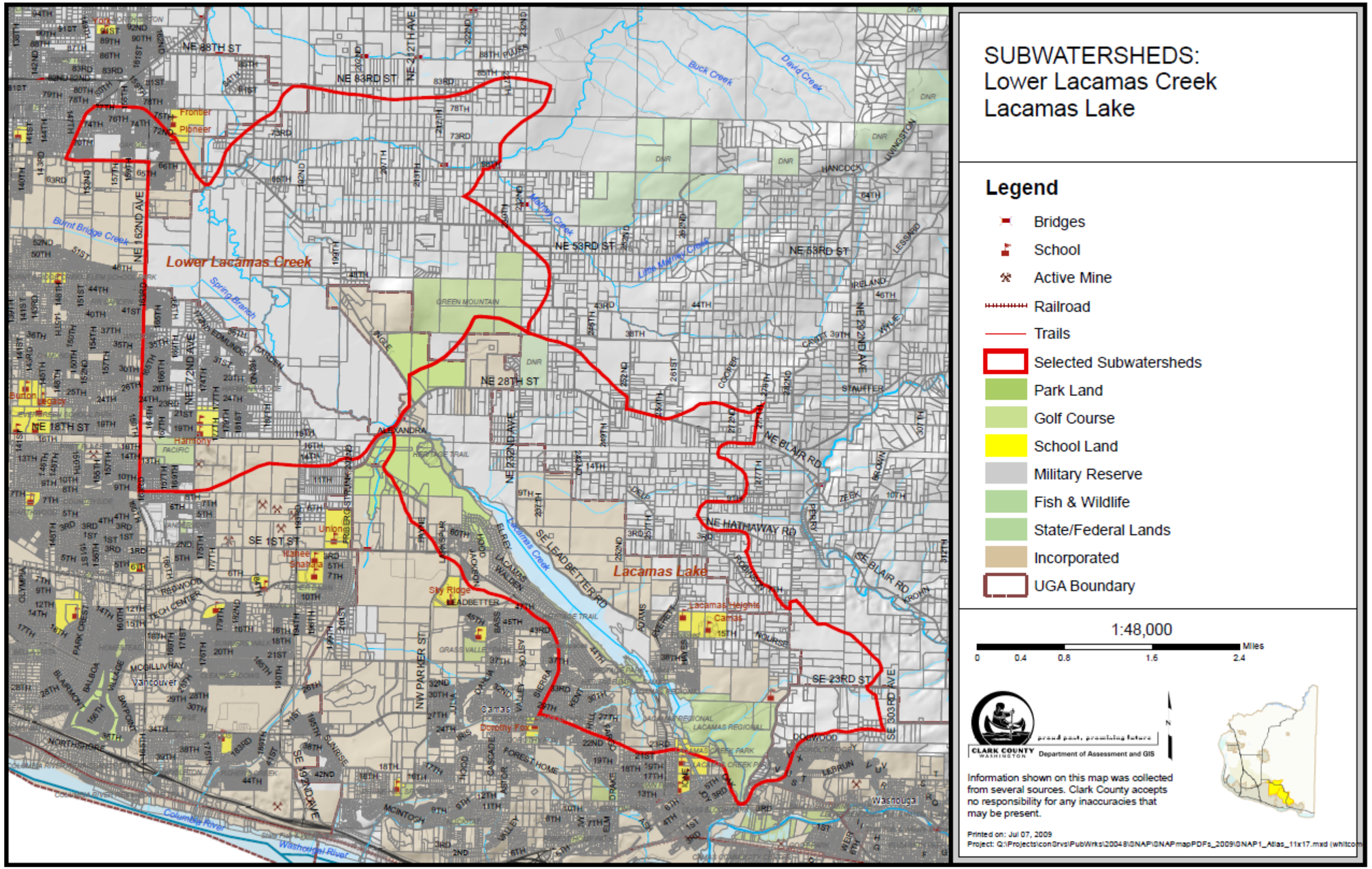


Figure 1: Subwatershed Map: Lower Lacamas Creek and Lacamas Lake

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 stream habitat that is not properly functioning (Table 2).

Table 2: Watershed Scale Metrics

Metric	Lower Lacamas Creek	Lacamas Lake	Functioning	Non-functioning
Percent Forested (2000 Landsat)	23	32	> 65 %	< 50 %
Percent TIA (2000 Landsat)	26	19	< 5 %	> 15 %
Road Density 2007 data (miles/mile2)	7.4	6.3	< 2	> 3
Stream Crossing Density (crossings per stream mile)	0.6	1.3	< 3.2/mile	> 6.4/mile
Percent EIA estimated from the Comprehensive Plan	14	24	< 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.

Much of the study area was historically cleared for agriculture. Additional clearing has occurred more recently as agriculture has given way to residential development in the western and southern portions. Remaining forest cover is well below the threshold necessary for properly functioning habitat.

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 5 percent as fully functional and greater than 15 percent as non-functioning. Values for both subwatersheds are well beyond the threshold indicating habitat is not properly functioning.

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 approximately twice as dense as the threshold for not properly 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 both have stream crossing densities within the properly 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 not properly functioning category, although the Lower Lacamas Creek subwatershed will likely have much lower EIA than the Lacamas Lake subwatershed.

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 (Figure 2). According to this figure, streams in both subwatersheds would be expected to have very unstable channels.

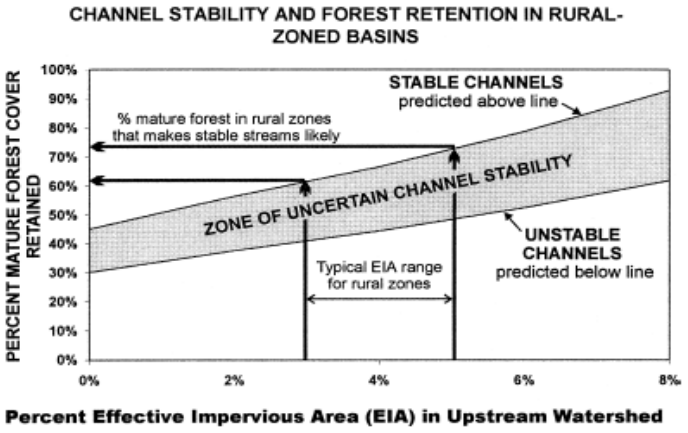


Figure 2: Channel stability in rural areas (Booth, Hartley, and Jackson, June 2002)

Water Quality Assessment

This section briefly summarizes and references available water quality data from the Lower Lacamas Creek and Lacamas Lake 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, all lakes and all feeder streams to lakes are to be protected for the designated uses of: "Core Summer Salmonid Habitat; extraordinary 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 Lower Lacamas Creek and Lacamas Lake 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 50 colonies/100mL, and not more than 10% of samples exceeding 100 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

Lower Lacamas Creek includes segments that are Category 5 listed (polluted waters that require a TMDL) for temperature, dissolved oxygen and fecal coliform and Category 2 listed (waters of concern) for pH and fecal coliform.

Additionally, both lakes in the Lacamas Lake subwatershed have 303(d) listings. Lacamas Lake is Category 5 listed for Poly-Chlorinated Bi-phenyls (PCBs) and phosphorus and Category 4c listed (waters impaired by a non-pollutant) for invasive exotic species. Adjacent Round Lake is Category 5 listed for pH and dissolved oxygen and Category 2 listed for temperature.

Both subwatersheds are included in ongoing TMDL development for fecal coliform, temperature, dissolved oxygen and pH in Lacamas Creek above Lacamas Lake.

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 Lower Lacamas Creek subwatershed scored in the fair range. Sufficient data were not available to score the streams in the Lacamas Lake 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

A considerable historical dataset is available for this study area. However, only limited data have been collected in the past decade. Ecology's Statewide River and Stream Ambient Monitoring program collected monthly data from Lacamas Creek at Goodwin Road from October 2006-September 2007. In 2003, Ecology's Washington State Toxics Monitoring Program conducted exploratory monitoring at the same location. A review and summary of other historical data and studies are beyond the scope of this document.

Ecology began collecting data for TMDL development in late 2010. Available results and reports may be found on the Ecology website at:
http://www.ecy.wa.gov/programs/wq/tmdl/LacamasTMDL.html
As of January 2011, the current Ecology dataset is too limited for inclusion in this report.

An extensive water quality dataset is available for Lacamas Lake spanning the early 1980s through early 2000s. Data and reports are available from Clark County. Lake water quality conditions are briefly summarized in this document.

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 Lacamas Lake reports

Ecology EIM database	Statewide River and Stream Ambient Monitoring: WY 2000 through 2009 (Station 28I120) Washington State Toxics Monitoring Program: Exploratory Monitoring 2003 (Station LACAMAS CR)

Water Quality Summary

Nutrients

Nutrient criteria are not established for Washington streams. EPA suggests a total phosphorus criterion of 0.100 mg/L for most streams and 0.050 mg/L for streams which enter lakes (EPA, 1986). EPA nitrate criteria are focused on drinking water standards and are not generally applicable to aquatic life issues.

Phosphorus and/or nitrogen in excess may contribute to elevated levels of algal or plant growth, especially in slower moving, low gradient streams or downstream water bodies.

Total phosphorus samples from Station 28I120 (Goodwin Road) between October 2006 and September 2007 ranged from 0.026 mg/L to 0.095 mg/L, with a median of 0.036 mg/L. Only 17 percent of samples (2 of 12) exceeded the EPA criterion of 0.050 mg/L.

Turbidity

It is difficult to establish an exact background turbidity level for Lacamas Creek because no data exist from a time when the creek was not impacted by human activities. However, based on data from the least-impacted streams monitored by the county, we estimate that natural background turbidity in most Clark County streams would have been in the range of 0.5 to 2 NTU. Based on this estimate, the turbidity criterion for Lacamas Creek is likely between 5.5 and 7 NTU.

From October 2006 to September 2007, the median of 12 turbidity samples at Station 28I120 was 6 NTU, with individual samples ranging from 4.1 NTU to 12 NTU.

Fecal coliform bacteria

Based on 11 monthly samples from October 2006 to September 2007, fecal coliform levels failed to meet both parts of the state criteria. Geometric mean concentration at Station 28I120 was 78 cfu/100mL and the 90th percentile value was 480 cfu/100mL. Eight of eleven samples (73 percent) exceeded 100 cfu/100mL.

Dissolved oxygen and pH

Based on 12 monthly samples from October 2006 to September 2007, there were two excursions below the dissolved oxygen criterion (9.5 mg/L). There were no excursions beyond the pH criterion.

Toxics

In 2003, Ecology's Washington State Toxics Monitoring Program collected three samples from Station LACAMAS CR at Goodwin Road. Samples were analyzed for 115 chlorinated, organophosphorus and nitrogen pesticides. One detection was recorded (Bromacil) and the level

was below standard reporting levels. The full report may be viewed at: http://www.ecy.wa.gov/pubs/0603019.pdf

Lacamas Lake

Based on a series of investigations dating back to the early 1980s, Lacamas and Round Lakes are categorized as "eutrophic" (see Table 5 for summary water quality values). The terms oligotrophic, mesotrophic and eutrophic are often used to characterize lakesaccording to a low, medium or high level of algal production, respectively. Over time, lakes naturally move slowly along this continuum toward eutrophic conditions (high algal production). In some cases, however, this movement can be dramatically accelerated due to human activities in a lake or watershed.

In the case of Lacamas Lake, accelerated eutrophication has dramatically altered the lake from its natural historical condition and resulted in conditions that may impair current desired uses such as fishing, swimming, and aesthetic enjoyment. Most recently, water quality monitoring in 2007 supports previous conclusions regarding the eutrophic condition of the lake.

Overall conditions in Lacamas Lake were similar in 2007 to those observed over the past several years. Phosphorus levels were slightly higher than EPA's aquatic life criteria to avoid nuisance algal blooms, and nitrogen levels were relatively high. Elevated surface water temperatures combined with low dissolved oxygen conditions in the deeper areas limited summer cold-water fish habitat. Light penetration was consistently low due to abundant algal growth. Trophic state indices for Secchi disk, total phosphorus and chlorophyll-a all indicated Lacamas Lake was eutrophic.

Data Source	Date Range	Maximum Surface water temperature *(deg-C)*	Minimum water column oxygen concentration *(mg/L)*	Surface water pH *(units)*	Secchi Depth *(meters)*	Turbidity *(NTU)*	Total phosphorus *(mg/L-P)*	Total nitrogen *(mg/L-N)*	Chlorophyll-a *(ug/L)*
Beak and SRI, 1984	Dec 1983 to Nov 1984	23.2	<0.1	7.7 (6.6 - 9.4)	1.3 (0.6 – 2.0)	7.3	0.070	1.16	19 (0.4 – 65)
Clark County, 1994 (Lafer)	July 1991 to Nov. 1992	23.0	<0.1	8.5 (7.5 – 9.6)	1.7	--	0.030 (0.015 – 0.063)	0.8 (0.4 – 1.6)	25 (est) 64 (max)
E&S, 1996	April to Nov. 1995	25.0	<0.1	7.9 (6.4 – 9.9)	1.4 (0.9 – 2.8)	4.3 (2.0 – 8.5)	0.041 (0.030 – 0.066)	1.13 (0.8– 1.4)	--
E&S, 1997	February to May, 1996	15.2	<0.1	6.4 (6.2 – 6.7)	1.1 (0.9 – 1.3)	6.8 (4.0 – 9.3)	0.102 (0.026 – 0.310)	1.5 (1.1 -1.9)	--
Clark County, 2000 (Schnabel)	Oct. 1998 to Sept. 1999	22.1	<0.1	7.5 (6.7 – 8.9)	1.6 (0.9 -2.1)	--	0.033 (0.018 – 0.050)	--	--
Clark County, 2002 (Schnabel)	Oct. 1999 to Sept. 2001	23.2	<0.1	--	1.4 (0.6 – 3.0)	--	0.030 (0.010 – 0.053)	1.2 (0.6 – 2.3)	--
Clark County, 2004 (Schnabel)	Oct. 2001 to Sept. 2003	25	<0.1	7.9 (6.8 – 9.3)	1.7 (0.5 – 3.0)	--	0.036 (0.010 – 0.079)	1.3 (0.4 – 2.4)	(May-Oct 2003 data unreliable)
Clark County (unpublished)	Oct. 2003 to Oct. 2004	24	<0.1	8.1 (6.9 – 9.0)	1.7 (1.2 – 2.5)	3.5	0.041 (0.023 – 0.144)	1.2 (0.5 – 2.2)	29 (18 – 35)
Clark County, 2006 (Schnabel)	May to Oct. 2005	23.6	<0.1	8.6 (8.0 – 9.0)	1.5 (1.1 – 2.0)	6.0	0.036 (0.021 – 0.58)	1.09 (0.7 – 1.3)	37 (15 – 82)
Clark County, 2007 (Schnabel)	May to Oct. 2006	22.9	<0.1	8.2 (6.6 – 9.2)	1.7 (1.3 – 2.6)	3.6 (1.4 – 6.9)	0.037 (0.023 – 0.060)	1.13 (0.8 – 1.6)	(July-Oct only) 13 (10-13)
Clark County, 2008 (Hutton & Schnabel)	May thru Oct. 2007	24.8	0.13	7.9 (6.5-9.1)	1.8 (0.9-3.0)	5.6 (1.5-10.4)	0.042 (0.030-0.050)	1.02 (0.8-1.29)	11 (1-23)

Table 5: Average values for Lacamas Lake monitoring projects; values in parentheses are ranges for the period. From Clark County 2007 annual lake data summary

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 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 111 stormwater facilities, 65 are publicly owned and operated.

Table 6: Drainage System Inventory Results, Lower Lacamas Creek/Lacamas Lake

Database Feature Category	Inventoried prior to 2007	Added during 2007-2009	Total Features
Inlet	1213	185	1398
Discharge Point (outfall)	16	204	220
Flow Control	32	9	41
Storage/Treatment	395	254	649
Manhole	605	32	637
Filter System	14	1	15
Channel	335	1415	1750
Gravity Main	2243	1217	3460
Facilities	76	35	111

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 65 mapped public stormwater facilities in the Lower Lacamas Creek subwatershed and no mapped public stormwater facilities in the Lacamas Lake subwatershed.

Eight, or 12 percent of the mapped public stormwater facilities in the Lower Lacamas Creek subwatershed were evaluated for retrofit opportunities.

Figure 3 summarizes notable retrofit evaluation activities in the Lower Lacamas Creek subwatershed, including general facility location, evaluated facilities and referrals for retrofit opportunities.

As listed in Table 7, four public stormwater facilities in the Lower Lacamas Creek subwatershed were referred for further evaluation as Capital Improvement Projects. All included an increase in potential storage as part of the project description. The average age of the facility referred was 14.8 years. The majority of the referred facilities had large lots where storage and stormwater treatment could potentially be enhanced.

No major defects or hazardous conditions were discovered in the Lower Lacamas Creek subwatershed.

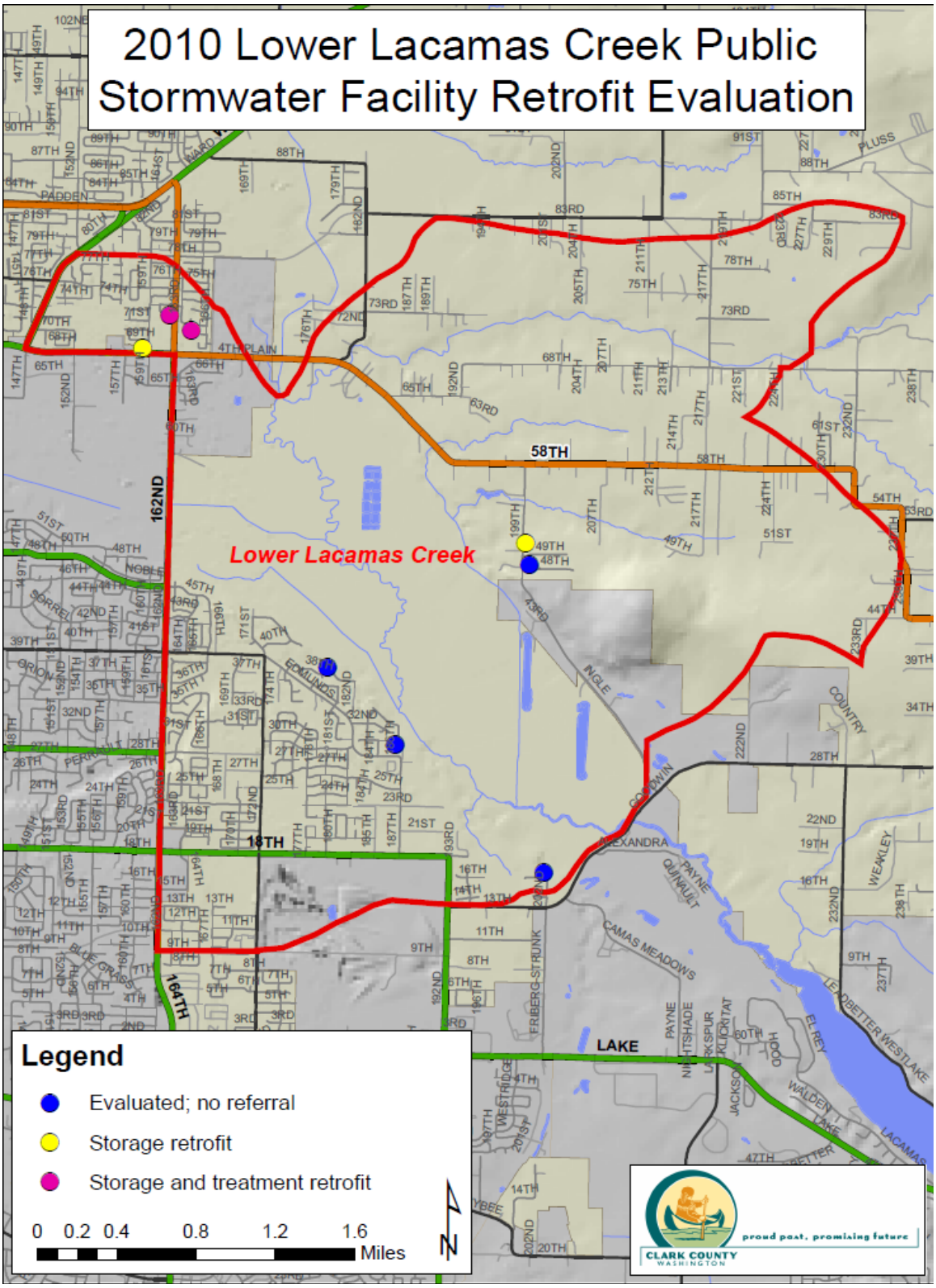


Figure 3: Summary of 2010 Retrofit Evaluation Activities in the Lower Lacamas Creek subwatershed

Table 7: Description of Potential Retrofit Opportunities in Lower Lacamas Creek subwatershed

Identifier	Facility Name	ID	Install Date	Basis for Project	Project Description
OS-221	Cambridge Estates	401	16-Sep-90	Potential storage retrofit	Large lot with little infrastructure
OS-222	East Lake Village	820	01-Mar-97	Potential storage retrofit	Potential expansion into adjacent lot
OS-223	Parkside Place	113	17-Aug-00	Potential storage and treatment retrofit	Potential LID opportunity
OS-224	Snyder's Country Place Ph 2	1242	01-Nov-94	Potential storage and treatment retrofit	Potential LID opportunity

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 of 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

Figure 4 summarizes notable inspection and maintenance evaluation activities in the Lower Lacamas Creek subwatershed, including general facility location, compliant facilities, and referrals of noncompliant facilities.

As listed in Table 8, eight public stormwater facilities were inspected in the Lower Lacamas Creek subwatershed. These facilities included 54 facility objects of which 45 (83 percent) were in compliance.

The inspection process in the Lower Lacamas Creek subwatershed generated five referrals to Public Works Maintenance and Operations for needed maintenance activities.

No major defects or hazardous conditions were discovered. Non-compliant issues included excess sediment depth and vegetative management issues.

Based on the county's StormwaterClk database, as of August 2010, there were no mapped public stormwater facilities in the Lacamas Lake subwatershed.

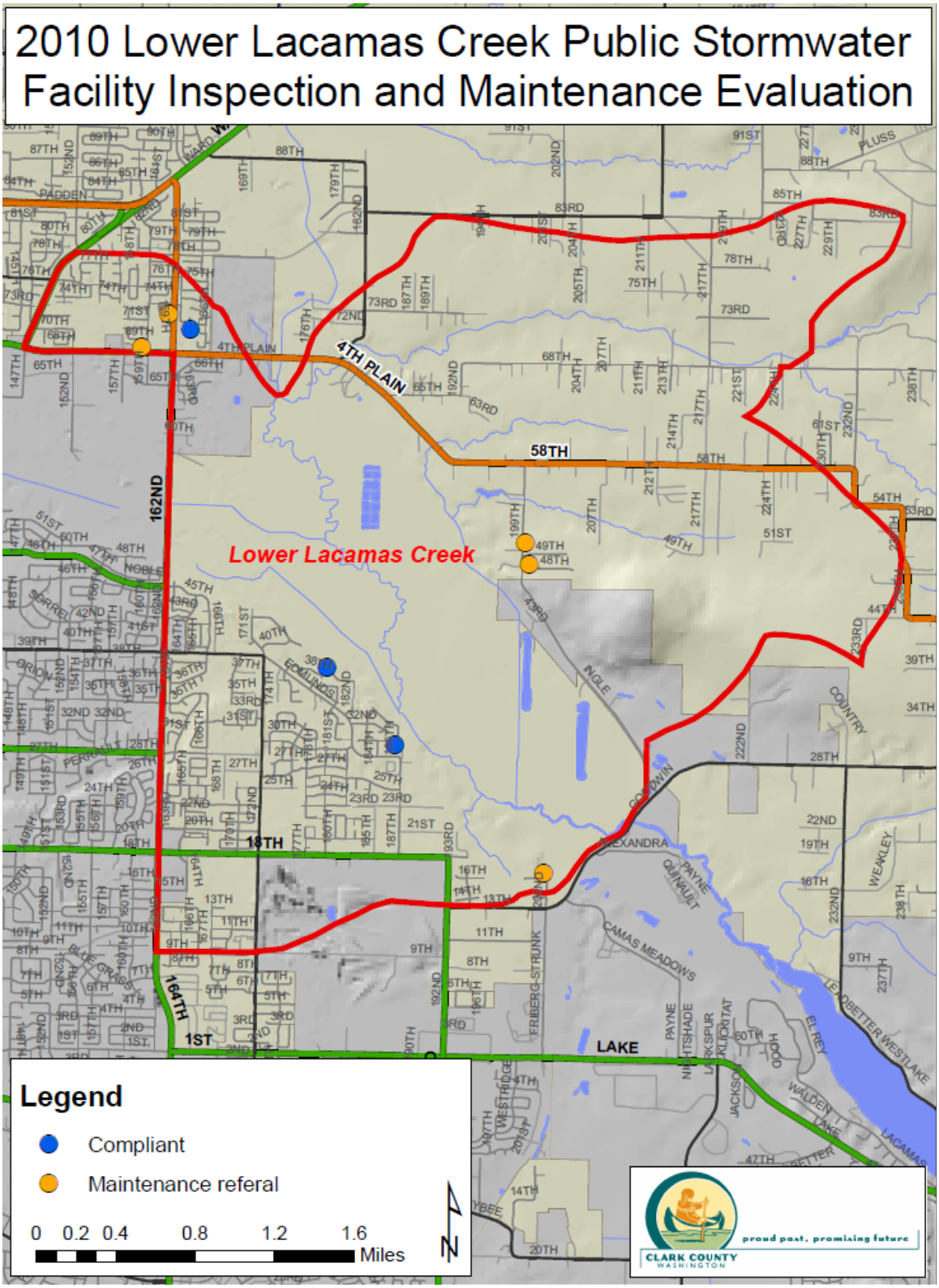
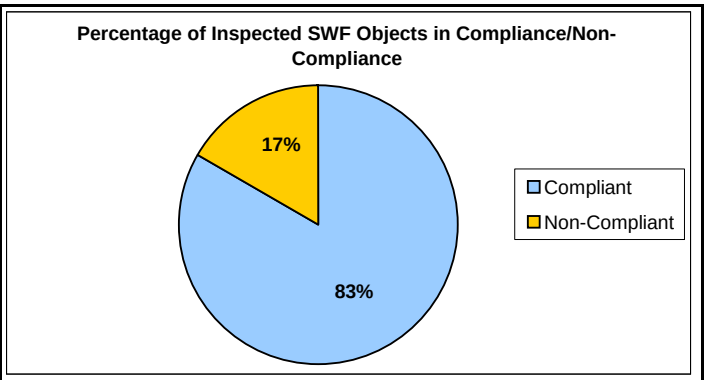


Figure 4: Summary of 2010 Public Stormwater Facility Inspection and Maintenance Evaluation Activities in the Lower Lacamas Creek subwatershed

Table 8: 2010 Public Stormwater Facility Inspection and Maintenance Evaluation Activity in the Lower Lacamas Creek subwatershed

SNAP Public Stormwater Facility Maintenance and Inspection Evaluation	
Subwatershed: Lower Lacamas Creek	
Public SWF Inspected	**8**
Stormwater Facility Objects Inspected	**54**
% Compliant SWF Objects	**83**
% Non-Compliant SWF Objects	**17**



Facility Objects Inspected	Initial Inspections: Compliant	Initial Inspections: Non-Compliant	Most Common Defect	Maintenance Trigger
Access Road or Easement	7	1	access restricted	poor accsess to facility
Catch Basin	4	0	n/a	n/a
Control Structure / Flow Restrictor	4	1	cover is missing	cover is missing or only partially in place
Conveyance Stormwater Pipe	7	1	sediment & debris	sediment depth is greater than 20% of pipe diameter
Detention Pond	2	2	sediment & debris	sediment exceeds 10% of the designed pond depth
Energy Dissipater	7	1	sediment & debris	sediment covers rock pad
Fence, Gate or Water Quality Sign	3	1	sign unreadable	water quality sign is missing or 20% of the surface is unreadable
Field Inlet	1	0	n/a	n/a
Sediment Trap	1	0	n/a	n/a
Typical Biofiltration Swale	3	1	n/a	n/a
Wetpond	6	1	sediment	sediment exceeds 10% of the designed pond depth
Total	**45**	**9**		

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, 61 mapped outfalls in the Lower Lacamas Creek subwatershed were discharging to critical areas: one Priority 1 outfall; nine Priority 2 outfalls; 51 Priority 3 outfalls.

In the Lacamas Lake subwatershed, 84 mapped outfalls were discharging to critical areas: no Priority 1 outfalls; two Priority 2 outfalls; 82 Priority 3 outfalls.

Table 9 summarizes results the Lower Lacamas Creek subwatershed. There were 61 mapped outfalls discharging to critical areas. One Priority 1 outfall was assessed and found to be in compliance. Two Priority 2 outfalls were assessed and found to be in compliance, and seven Priority 2 outfalls were not assessed. Three Priority 3 outfalls were assessed and found to be in compliance, and 48 Priority 3 outfalls were not assessed.

Table 9: 2010 Off-site Assessment Project Activity Summary for Lower Lacamas Creek subwatershed

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	1	9	51
# of outfalls assessed	1	2	3
# of outfalls compliant	1	2	3
# 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 10 summarizes results the Lacamas Lake subwatershed. There were 84 mapped outfalls discharging to critical areas. Two Priority 2 outfalls and 82 Priority 3 outfalls were not assessed.

Table 10: 2010 Off-site Assessment Project Activity Summary for Lacamas Lake subwatershed

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	0	2	82
# of outfalls assessed	n/a	0	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

Potential Projects

The offsite assessment project yielded no potential project opportunities.

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 Lower Lacamas Creek and Lacamas Lake subwatersheds included 4,929 objects. In 2007-2009, an additional 3,352 previously unmapped objects were added to the StormwaterClk database.

Retrofit evaluations conducted at eight public stormwater facilities generated four referrals for further evaluation as capital improvement projects. The most common treatment BMP across referred facilities was either a typical bioswale or detention pond. Referred facilities that had a typical bioswale had large lots containing minimal stormwater infrastructure. Referred facilities with a detention pond had sedimentation maintenance defects. All referred facilities included an increase in potential storage as part of the project description. The average age of the facilities was 14.8 years. Further evaluations of other stormwater facilities with similar age and stormwater infrastructure may identify additional referrals for evaluation as capital improvement projects.

The inspection and maintenance evaluation is conducted at public stormwater facilities in conjunction with retrofit evaluations. The most common facility objects found out of compliance were bioswales and detention ponds. Excessive sedimentation was the most common noncompliant defect across facility objects. Vegetative management issues were the most common noncompliant defects regarding bioswales. These defects included landscaped and overgrown bioswales where grasses exceeded 10 inches in height and nuisance weeds and other vegetation were starting to take over. Correcting facility sedimentation issues and maintenance of bioswales will bring most facilities into compliance.

Outfall assessments generated no potential project opportunities. 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 Lacamas Creek (Lower)/Lacamas Lake subwatershed. Table 11 summarizes source control activities.

Table 11: Source Control Project Summary, Lacamas Creek (Lower)/Lacamas Lake subwatershed

Metric	Number
Number of sites visited	29
Number of sites with source control issues	5
Number of repeat visits	1
Number of sites with issues successfully resolved	5
Number of sites referred to other agencies	1

Overview

The study subwatersheds lie in southeastern Clark County in an area with many large rural farm properties and some new rural residential subdivisions.

Besides the farms and residences, this subwatershed contains two golf courses and some small isolated businesses, including an auto wrecking yard. Because of the number of businesses in this subwatershed, we should continue with regular Type 4 source control inspections.

Success story:

The following case highlights a parcel in Lacamas Creek (Lower)/Lacamas Lake subwatershed where an interesting situation was addressed.

Case:

- Following an initial inspection by county staff of an automotive wrecking yard, the property was referred to the Washington Department of Ecology for a joint re-inspection.
- Though the business owners were doing a commendable job organizing and keeping under cover what they could, considerable oily runoff was leaving the site and flowing into a neighboring field, then potentially into a down slope pond.
- Ecology determined this auto wrecking yard should have a NPDES Industrial Stormwater Permit. This permit requires the business to keep contaminants on site and test the runoff to be sure it is in compliance. During the application process, the auto wrecking yard will need to take additional source control measures to prevent the oil from contaminating the runoff.

The wrecking yard is now in the process of obtaining their NPDES Industrial Stormwater Permit.

Stream Reconnaissance and Feature Inventory

Purpose

The Feature Inventory records the type and location of significant stream impairments, potential environmental and safety hazards and project opportunities in selected stream reaches.

Feature Inventory results are used primarily to document conditions and identify potential improvement projects or management actions for implementation by the CWP or other agencies. They also provide an extensive GIS database of sites that can be evaluated for project mitigation needs and as a countywide planning tool for riparian and habitat enhancement projects.

Methods/Limitations

Geographic scope of the Feature Inventory was established by the CWP taking into consideration projected TIA, DNR water types, stream gradient, zoning, Clark County development permitting authority, and land ownership.

The Feature Inventory recorded significant conditions in the stream corridor relevant to SNAP components. Feature types are listed in Table 12.

The in-stream assessment approach allowed investigators to observe stream corridor features that are not always identifiable through desk methods, such as analysis of existing aerial photographs and GIS data.

A GPS position, one or more digital photos, and relevant attribute information were collected for each logged feature. All data and linked photos are stored in the Stormwater SQL Geodatabase located on the Clark County server. Feature data include field observations, estimated measurements and notes describing important feature characteristics or potential projects.

The Feature Inventory project is not intended to be an exhaustive inventory of all human alterations to the stream corridor. Rather, the project seeks to identify the most significant features pertaining to stormwater management and potential stormwater mitigation projects.

Feature dimensions and other attribute data are estimates, and should not be used for quantitative calculations.

Study Area

The extent of the completed Feature Inventory in Lower Lacamas Creek subwatershed is shown in Figure 5. Approximately 2.2 miles of the stream corridor was assessed in the subwatershed. Of the proposed survey extents, two short reaches were not accessible due to private property concerns.

Results/Findings

A total of 21 features were identified in the Lower Lacamas Creek subwatershed. A breakdown of recorded features by type is presented in Table 12. Stream crossings (bridge) and impacted stream buffers were the most prevalent feature type identified.

In addition to stream features, three geomorphology data points (shown as GG points on Figure 6 and Figure 7) were collected.

Table 12: Summary of Features Recorded in Lower Lacamas Creek Subwatershed

Feature Type	Number Recorded
AGR - Aggradation	0
AP – Access point	0
CM – Channel modification	0
ER – Severe bank erosion	1
IB – Impacted stream buffer	6
IW – Impacted wetland	0
MB – Miscellaneous barrier	0
MI – Miscellaneous point	4
OT – Stormwater outfall	3
RR – Road Reconnaissance feature	0
SCB – Stream crossing, bridge	6
SCC – Stream crossing, culvert	0
SCF – Stream crossing, ford	0
TR – Trash and debris	1
UT – Utility impact	0
WQ – Water quality impact	0
Total	21

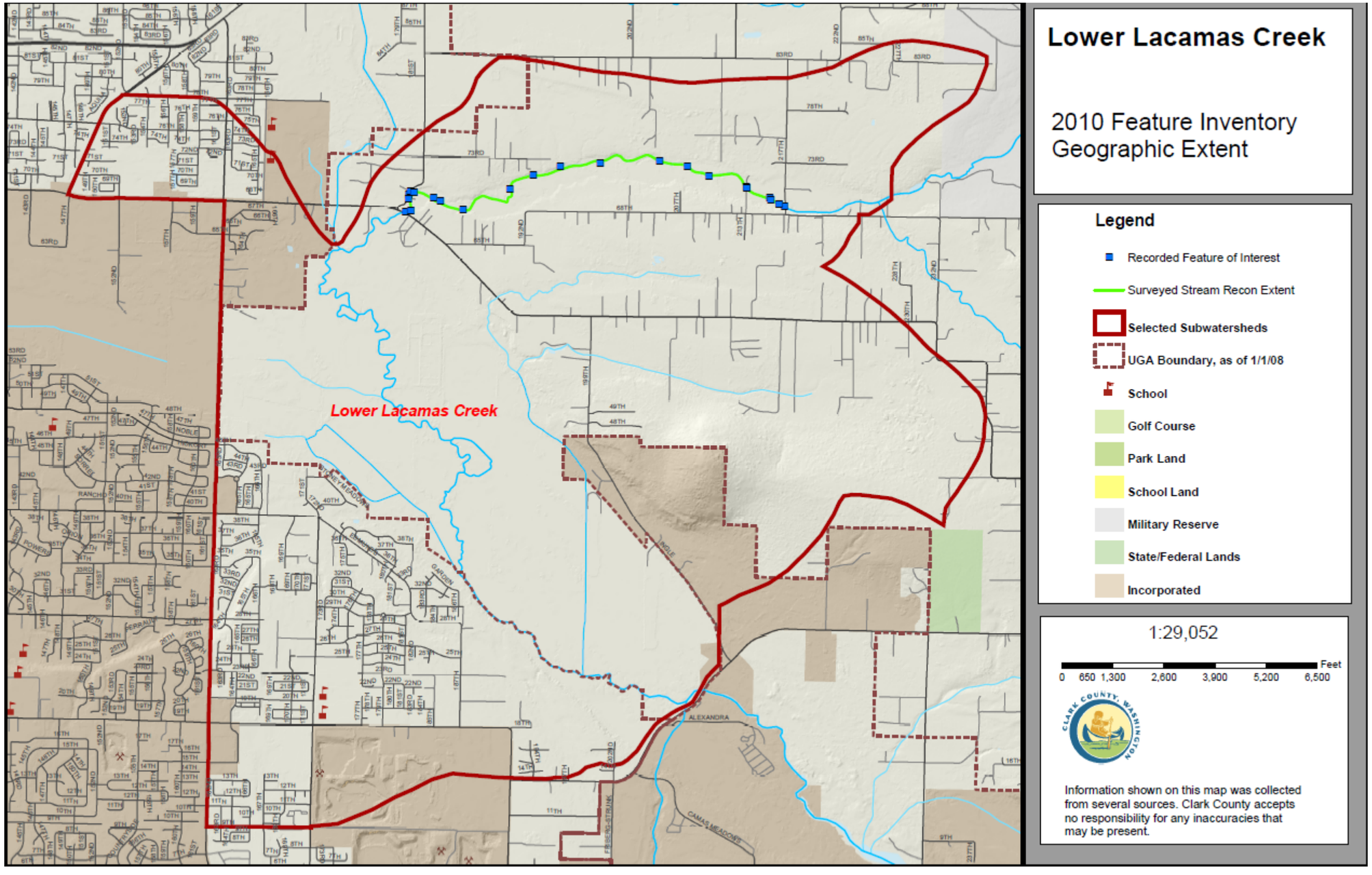


Figure 5: Lower Lacamas Creek Geographic Extent of 2010 Feature Inventory

The following subsections contain general descriptions of the Lower Lacamas Creek subwatershed conditions. The descriptions include observations, trends, and issues that were identified either during the field work or during subsequent review of collected information.

Stormwater Infrastructure
The stormwater conveyance to Lower Lacamas Creek is primarily via roadside ditches and drainage from agricultural fields. Flow is predominately east to west in the upper portion and north to south in the lower reaches. Several large agricultural drainage ditches act as tributaries in the lower reaches, primarily entering from the west. The predominant sources of stormwater in the subwatershed are agricultural land, public and private roadways and rural residential developments draining to streams via small open channels such as field drain ditches, grassy swales and roadside ditches. Few facilities that treat consolidated stormwater flow are present in this subwatershed.

Riparian Vegetation
Impacted stream buffers are prevalent in the assessed reaches. A significant portion of surveyed stream reaches have narrow, established riparian forest canopy with vegetation communities composed of small- to medium-sized canopy trees such as alder and various conifers with woody and herbaceous undergrowth. Undergrowth is typically a mix of native species, invasive reed canary grass and blackberry. Lack of riparian vegetation due to mowing and landscaping is common in areas where residential development abuts the channel. Agricultural areas in the subwatershed typically have little or no woody riparian vegetation.

Potential Project Opportunities
Listed opportunities represent potential projects or project areas. They are not fully developed projects, and therefore require additional evaluation and development by Clark County or consultant staff. Identifying them as potential projects in this document is the first step in the process of developing SCIP projects.

Potential project opportunities were identified based on the results of the Feature Inventory conducted in the Lower Lacamas Creek subwatershed. The CWP will evaluate potential projects for further development or referral to the appropriate organization. Each potential project is listed in tables, including the basis for the project and description of the potential project. The location of each potential project is shown in the figure(s) below. Potential project opportunities were categorized into six groups based on the nature of the potential work. A total of nine potential projects were identified. A summary of identified project opportunities by potential project category is shown in Table 13.

Table 13: Breakdown of Potential Project Opportunities by Category

Potential Project Category	Potential Projects Identified
Emergency/Immediate Actions	0
Stormwater Capital Projects	0
Referrals for Followup by DES (or County programs supporting DES)	9

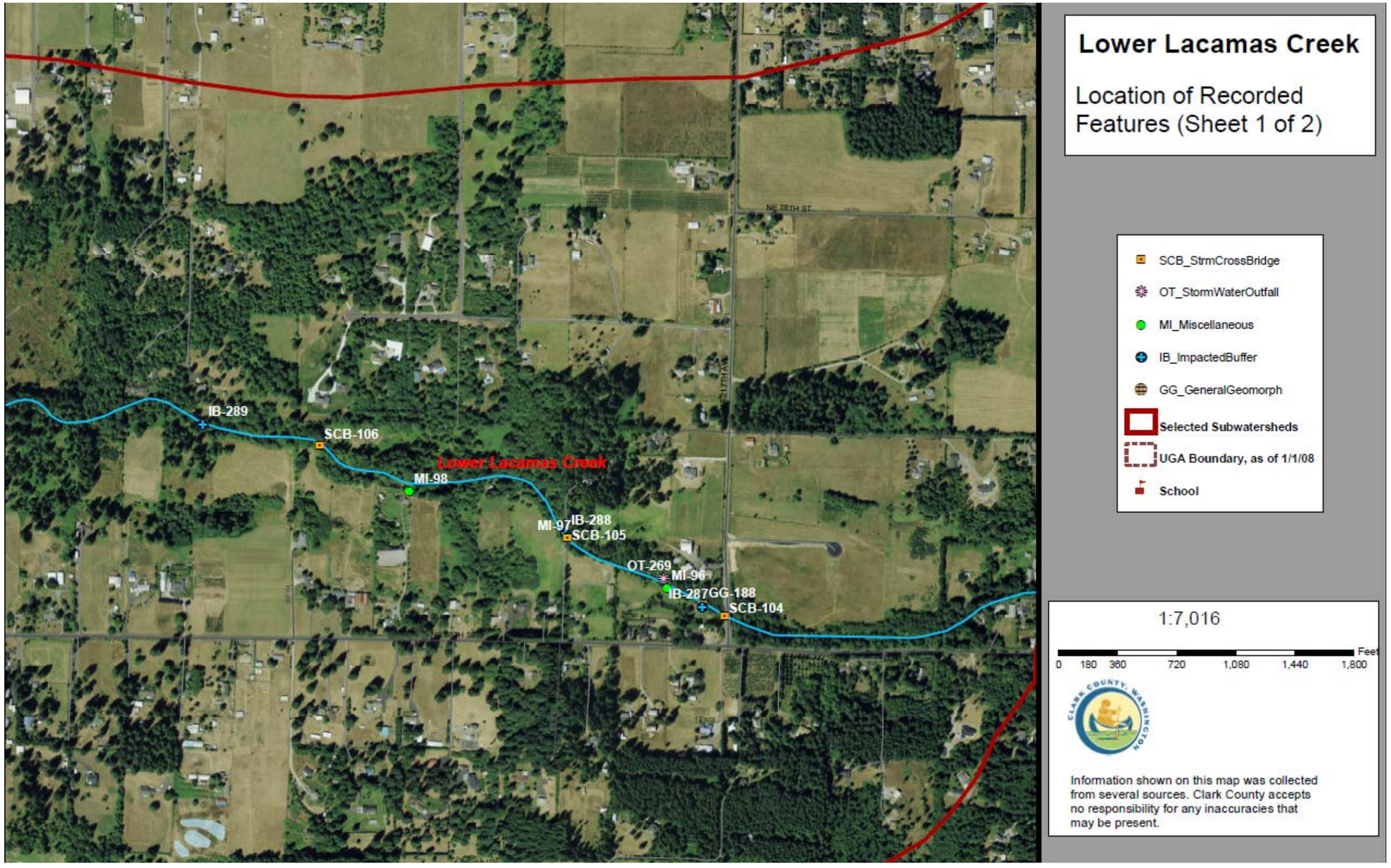


Figure 6: Lower Lacamas Creek location of recorded features

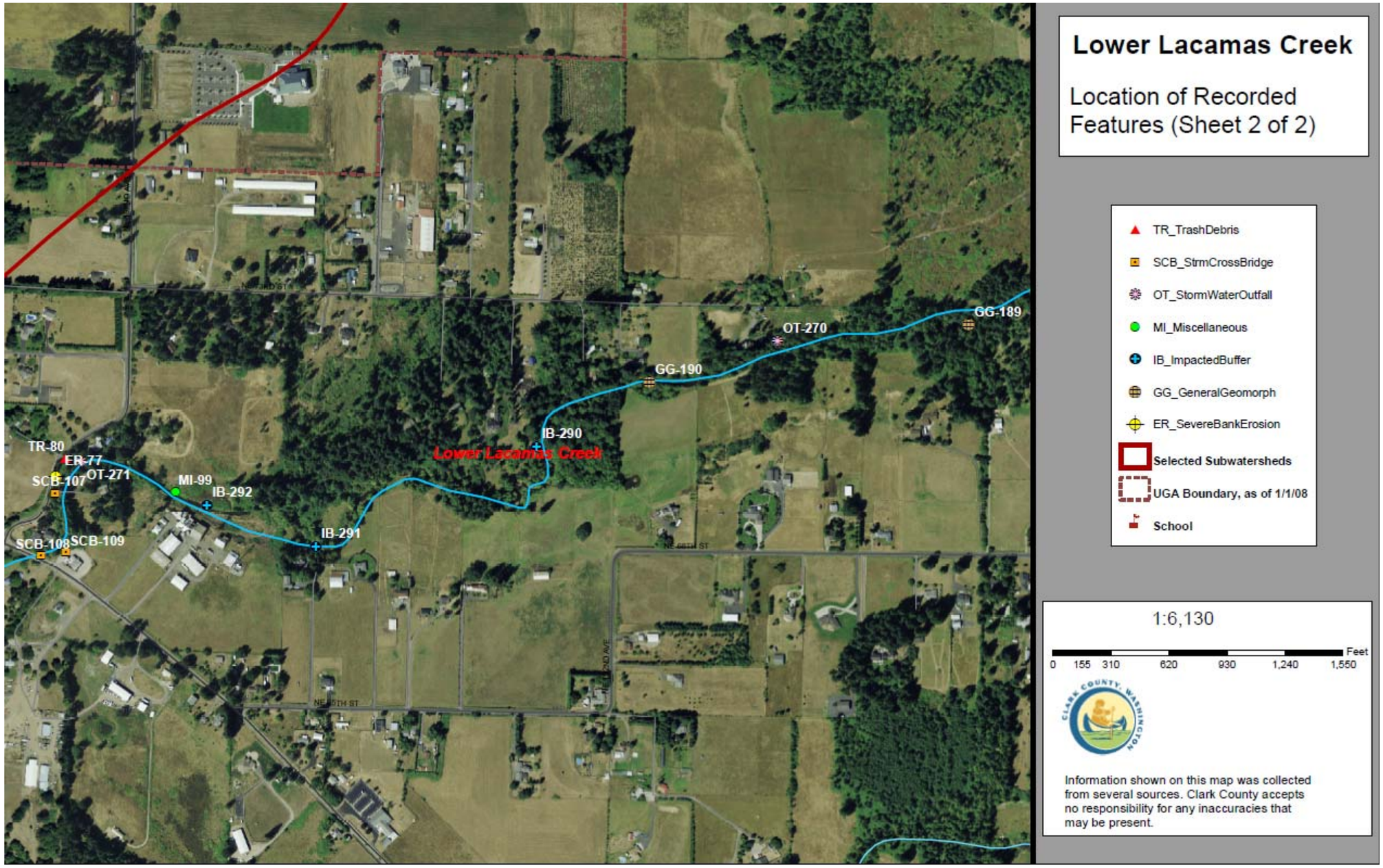


Figure 7: Lower Lacamas Creek location of recorded features

Emergency/Immediate Actions
Emergency/Immediate Actions require an immediate site response project to address a potential or imminent threat to public heath, safety, or the environment.

No opportunities were identified in this category.

Stormwater Capital Improvement Projects
Stormwater Capital Improvement Projects include projects that create new or retrofit existing stormwater flow control or treatment facilities, substantial infrastructure maintenance projects, habitat enhancement projects, or property acquisition to mitigate for stormwater impacts. Facility retrofits refer to projects that will increase an existing facility's ability to control or treat stormwater in excess of the original facility's design goals.

No opportunities were identified in this category.

Referrals for Followup by DES (or County programs under DES oversight)
This category includes opportunities other than capital projects that are dependent upon DES programs or oversight. Examples include referrals to: Public Works Operations for public stormwater infrastructure maintenance or private facility inspection; DES Sustainability and Outreach for landowner letters regarding trash pickup or agricultural BMPS; Illicit Discharge screening project; and general reach information forwarded to DES engineers for capital planning purposes. Possible fish barriers or culvert maintenance issues may also be included.

Table 14: Description of Referrals for followup by DES

ID	Basis for Project	Project Description	Action
ER-77	Stream makes sharp bend against road grade; active erosion within 5 feet of road, may eventually undermine	Stabilize bank	Refer to PW Operations
IB-288	Ivy on streambank along private road	Remove ivy and plant native vegetation	Refer to DES Outreach; contact landowner about BMPs, CCD assistance
IB-289; IB-290; IB-291	Little to no riparian vegetation; lawn to creek and channel armored with rock	Riparian planting; bioengineering	Refer to DES Outreach; contact landowner
IB-292	Large stand of Canadian thistle	Remove thistle and plant native vegetation	Refer to DES Vegetation Management
TR-80	Large pile of grass clippings dumped in channel and bank; several cubic yards	Eliminate dumping; move to upland location or compost	Refer to DES Outreach; contact landowner
ER-77	Stream makes sharp bend	Stabilize bank	Refer to PW Operations

ID	Basis for Project	Project Description	Action
	against road grade; active erosion within 5 feet of road, may eventually undermine		
IB-292	Large stand of Canadian thistle	Remove thistle and plant native vegetation	Refer to DES Vegetation Management

Stormwater Management Recommendations

A number of general stormwater management measures should be implemented throughout the study subwatersheds:

- Educate private landowners concerning importance of invasive plant removal, and suggest removal techniques
- Educate private landowners on importance of native riparian vegetation for shading streams
- Encourage appropriate agricultural practices that emphasize soil and water conservation and reduction in nutrient load to streams
- In the case of some water impoundments or withdrawals, the State should verify that the owner has water rights
- Protect streams from future stormwater impacts by creating stream buffers, establishing conservation easements, and eliminating agricultural runoff inputs
- Encourage reforestation
- Implement development regulations to minimize impacts, particularly enhanced nutrient control regulations to protect Lacamas Lake

Physical Habitat Assessment

A physical habitat assessment was not conducted.

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 in 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 to be considered by the CWP SCIP, which are primarily on publicly owned lands within 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 prepared for the Lower Columbia Fish Recovery Board. These include the Habitat Assessment reports (R2 Resource Consultants, Inc., 2004) and the 2010 Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (LCFRB 2010). Both can be found at http://www.lcfrb.gen.wa.us/default1.htm

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 exist 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 and 2010 Subbasin Plan 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 for the Lacamas Lake subwatershed. The full characterization report is available on the Clark County website at: http://www.clark.wa.gov/water-resources/documents.html#mon

The 2004 LCFRB Habitat Assessment included one reach in the Lacamas Lake subwatershed and did not include any reaches in the Lower Lacamas Creek subwatershed. For areas in the subwatersheds not included in the habitat assessment, LWD recruitment potential and shade rating analyses were based on a qualitative review of 2010 aerial photographs available through Google Earth.

At the subwatershed scale, the LCFRB rated the riparian conditions in the Lacamas Lake subwatershed as "Moderately Impaired" and in the Lower Lacamas Creek subwatershed as "Impaired."

Riparian (Large Woody Debris (LWD) Delivery)
Figure 8 shows the Lacamas Lake subwatershed LWD delivery potential. In the Lacamas Lake subwatershed, the survey includes the mainstem of Lacamas Creek downstream of Round Lake. The mainstem of Lacamas Creek is shown as having high LWD recruitment along the approximate 0.7 mile distance surveyed.

In the Lacamas Lake subwatershed, an unnamed tributary discharges into Lacamas Lake from the east at appx (45.597555, -122.39745). The portion of this stream which passes through Lacamas Regional Park (appx 0.6 mi) has a relatively large forested riparian zone and would be expected to have high LWD recruitment. Upstream from Lacamas Park, the reaches would be expected to have low to moderate LWD recruitment, with lowest levels near the headwaters where vegetation is more sparse.

At the lower end of Lacamas Lake, the riparian zones around Round Lake, Dead Lake and an associated tributary are forested and would be expected to have moderate to high LWD recruitment potential.

The northeast shore of Lacamas Lake is likely to have a mixture of LWD recruitment potential levels. From appx (45.60802, -122.41020) to (45.61194, -122.41615), lake shore vegetation is forested and LWD recruitment is likely moderate to high. For appx 1.5 miles between (45.61410, -122.41499) and (45.62550, -122.43477), the lake is bordered by SE Leadbetter Rd, which would likely intercept woody debris otherwise entering the lake from the forest on the other side. West of SE Leadbetter Rd., along the edge of Camp Currie for appx 0.5 mi between (45.62550, -122.43477) and (45.62965, -122.44261), forested vegetation borders the lake and likely facilitates high LWD recruitment.

On the southwest shore of Lacamas Lake, most of the shore is bordered by forested vegetation and will likely have moderate to high LWD recruitment potential. The upper end of Lacamas Lake, at appx 0.5 mi between (45.62298, -122.43703) and (45.62844, -122.44243), is bordered by vegetation which is more sparse and so will have lower LWD recruitment potential.

Two tributaries converge in Camp Currie at appx (45.631333, -122.43887) and discharge to Lacamas Creek from the north at appx (45.628782, -122.44019). In Camp Currie, vegetation is forested and LWD recruitment potential is high. Outside Camp Currie, LWD recruitment potential is low to moderate, with the lower levels where tributaries pass through open fields.

Examples are from appx (45.634852, -122.43861) to (45.636382, -122.43592) and from appx (45.63082, -122.42885) to (45.62808, -122.41658).

Upstream of Lacamas Lake, from NE Goodwin Rd to Lacamas Lake (appx 1.2 mi), Lacamas Creek flows through a forested riparian zone which likely has moderate to high LWD recruitment potential on both banks.

The 2004 LCFRB Habitat Assessment did not include any reaches in the Lower Lacamas Creek subwatershed. The Lower Lacamas Creek subwatershed is characterized by agricultural fields (Anderson dairy cattle pasture), patchy forests, water ski lakes and historic wet prairie. Because portions of the Lower Lacamas Creek subwatershed were likely historic wet prairie, it is likely that the subwatershed naturally had low LWD recruitment potential for the majority of reaches.

In the lower (southeast) portion of the Lower Lacamas Creek subwatershed, for about 0.4 mi from appx (45.63865, -122.46340) to (45.63880, -122.45713), the mainstem of Lacamas Creek flows through a patch of forest. This section would be expected to have moderate to high LWD recruitment potential. Between this forested reach and NE Fourth Plain Rd (about 4.5 mi from appx (45.67178, -122.48818) to (45.63865, -122.46340)), Lacamas Creek flows through relatively narrow (~100) linear forest fragments intermixed with open pasture. These reaches would be expected to have low to moderate LWD recruitment potential. Upstream of NE Fourth Plain Rd, the forested riparian zone is more intact and moderate LWD recruitment potential is expected.

An unnamed tributary discharges to Lacamas Creek from the north at appx (45.63962, -122.46898). The majority of this tributary system flows through open pasture land with little to no LWD recruitment potential. Exceptions are upstream of NE 199th Ave from appx (45.66214, -122.46885) to (45.65995, -122.44696) and upstream of NE Fourth Plain Rd from appx (45.66700, -122.47245) to (45.66749, -122.45829), where the tributaries pass through forested vegetation on one or both banks and likely have moderate to high LWD recruitment potential.

Spring Branch Creek discharges into Lacamas Creek from the west at appx (45.64675, -122.48144). For most of its appx 1.5 mi length, Spring Branch Creek flows through herbaceous vegetation with no LWD recruitment potential. A possible exception is at its headwaters, where some woody vegetation may provide low LWD recruitment.

Ditch Creek discharges into Lacamas Creek from the west at appx (45.658980, -122.489651). The riparian zone of Ditch Creek contains a narrow band of trees which may provide low levels of LWD recruitment.

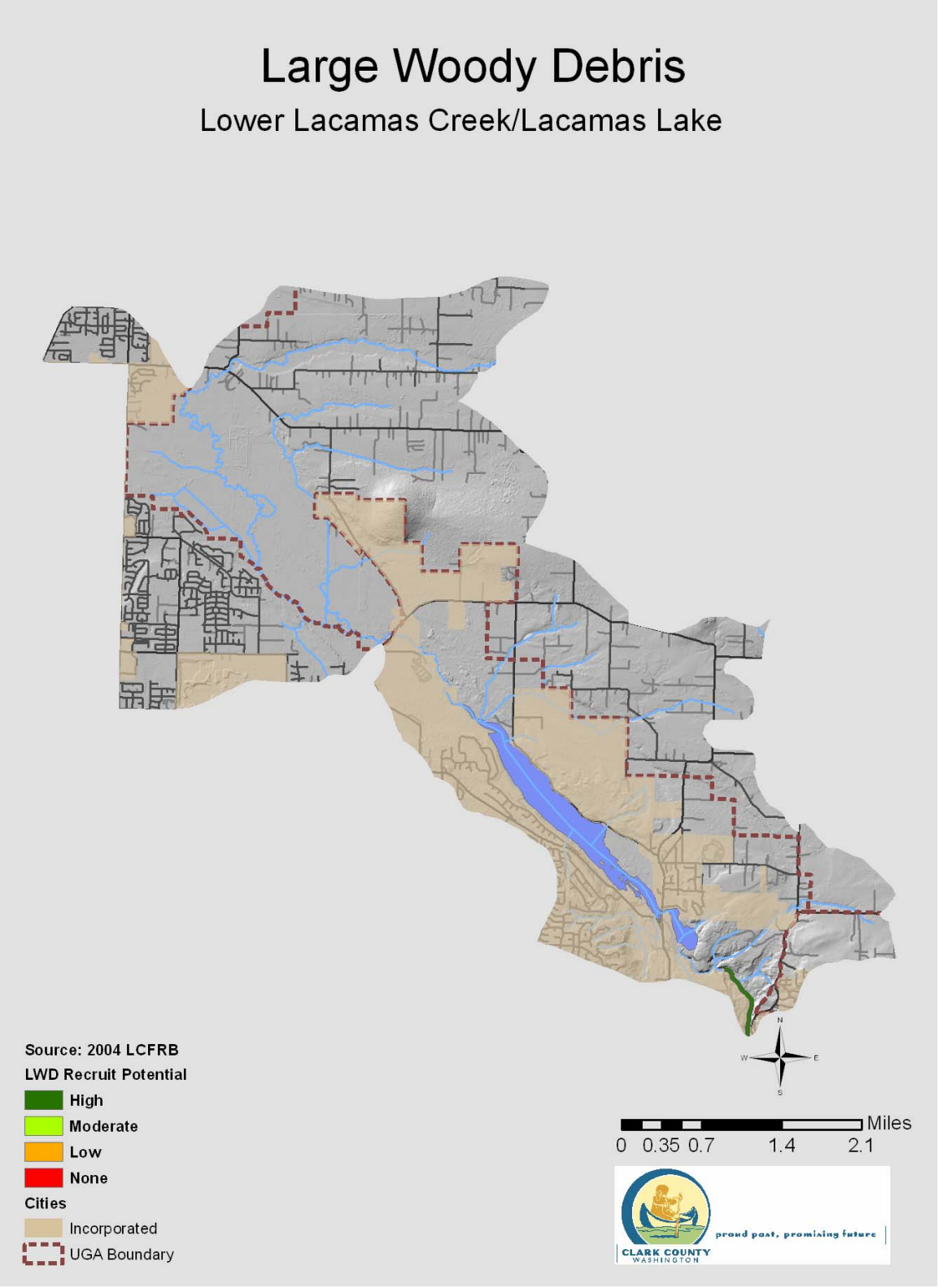


Figure 8: Lacamas Lake LWD Recruitment Potential (adapted from R2 Resource Consultants, Inc., 2004)

Shade

Figure 9 shows the Lacamas Lake subwatershed LWD delivery potential. In the Lacamas Lake subwatershed, the survey includes the mainstem of Lacamas Creek downstream of Round Lake. The mainstem of Lacamas Creek is shown as having shade levels ranging from 40 percent to 70 percent along the approximate 0.7 mile distance surveyed.

In the Lacamas Lake subwatershed, an unnamed tributary discharges to Lacamas Lake from the east at appx (45.597555, -122.39745). The portion of this stream which passes through Lacamas Regional Park (appx 0.6 mi) has a relatively large forested riparian zone and would be expected to have high levels of shade. Upstream from Lacamas Park, the reaches would be expected to have low to moderate levels of shade, with lowest levels near the headwaters where vegetation is more sparse. At the headwaters, appx (45.60362, -122.36847), a 3+ acre pond receives little or no shade.

While the shores of Lacamas Lake, Round Lake and Dead Lake have forested vegetation, the ratios of potential shade to the overall area of the lakes are low. Even if the shores were completely vegetated with mature trees, the majority of these lakes would still be exposed to sunlight.

A tributary associated with Dead Lake is forested and would be expected to have moderate to high levels of shade.

Two tributaries converge in Camp Currie at appx (45.631333, -122.43887) and discharge to Lacamas Creek from the north at appx (45.628782, -122.44019). In Camp Currie, vegetation is forested and shade levels are high. Outside Camp Currie, shade levels are low to moderate, with the lower levels where tributaries pass through open fields. Examples are from appx (45.634852, -122.43861) to (45.636382, -122.43592) and from appx (45.63082, -122.42885) to (45.62808, -122.41658). An in-stream pond in one of these tributaries (appx 1.2 acres at (45.62963, -122.40973) would likely be exposed to the sun regardless of riparian condition.

Upstream of Lacamas Lake, from NE Goodwin Rd to Lacamas Lake (appx 1.2 mi), Lacamas Creek flows through a forested riparian zone which likely has moderate to high shade levels.

The 2004 LCFRB Habitat Assessment did not include any reaches in the Lower Lacamas Creek subwatershed. The Lower Lacamas Creek subwatershed is characterized by agricultural fields (Anderson dairy cattle pasture), patchy forests, water ski lakes and historic wet prairie. Because portions of the Lower Lacamas Creek subwatershed were likely historic wet prairie, it is likely that the subwatershed naturally had low levels of shade for the majority of reaches.

Within the lower (southeast) portion of the Lower Lacamas Creek subwatershed, for about 0.4 mi from appx (45.63865, -122.46340) to (45.63880, -122.45713), the mainstem of Lacamas Creek flows through a patch of forest. This section would be expected to have moderate to high levels of shade. Between this forested reach and NE Fourth Plain Rd (about 4.5 mi from appx (45.67178, -122.48818) to (45.63865, -122.46340)), Lacamas Creek flows through relatively narrow (~100) linear forest fragments intermixed with open pasture. These reaches would be

expected to have low to moderate levels of shade. Upstream of NE Fourth Plain Road, the forested riparian zone is more intact and moderate shade levels are expected.

An unnamed tributary discharges into Lacamas Creek from the north at appx (45.63962, -122.46898). The majority of this tributary system flows through open pasture land with little to no shade. Exceptions are upstream of NE 199th Ave from appx (45.66214, -122.46885) to (45.65995, -122.44696) and upstream of NE Fourth Plain Rd from appx (45.66700, -122.47245) to (45.66749, -122.45829). There, tributaries pass through forested vegetation on one or both banks and likely have moderate to high levels of shade. An in-stream pond (appx 1.4 acres at (45.66247, -122.47269)) would likely have some sun exposure regardless of riparian condition.

Spring Branch Creek discharges into Lacamas Creek from the west at appx (45.64675, -122.48144). For most of its appx 1.5 mi length, Spring Branch Creek flows through herbaceous vegetation with no shade. A possible exception is at its headwaters, where some woody vegetation may provide low levels of shade.

Ditch Creek discharges into Lacamas Creek from the west at appx (45.658980, -122.489651). The riparian zone of Ditch Creek contains a narrow band of trees which may provide low levels of shade.

The LCFRB habitat assessment for the Lacamas Lake subwatershed indicated that the surveyed reach is currently off-target with respect to the State Forest Practices shade/elevation screen standards.

Management Recommendations

Overall recommended management activities for the Lacamas Lake and Lower Lacamas Creek subwatersheds include riparian forest restoration in areas degraded by residential and agricultural land use, preservation and acquisition of existing forest land for future protection of streams and watersheds, and invasive species removal. However, because portions of the Lower Lacamas Creek subwatershed were likely historic wet prairie, it is likely that the subwatershed naturally had low LWD recruitment potential and shade for the majority of reaches.

Potential Projects

The Lower Lacamas Creek subwatershed and portions of the upper end of the Lacamas lake subwatershed are known habitat for several sensitive/threatened/endangered plants. The protected plants are generally associated with remnant grassland/prairie communities. Any potential reforestation sites should be surveyed for protected plants during early planning stages. Any site containing such plants should not be reforested.

The riparian zones in the Lacamas Lake subwatershed contain a significant amount of public land, including Lacamas Regional Park, Heritage Park, Heritage Trail and Camp Currie (all owned by Clark County). These lands are all forested and therefore present little opportunity for reforestation projects intended to increase shade or LWD recruitment. Such lands should be preserved and managed to maintain the level of functions provided.

In the Lower Lacamas Creek subwatershed, the City of Vancouver owns one parcel on the south bank of Lacamas Creek which may have some opportunity for a small-scale reforestation project. The parcel is described in Table 15.

Table 15: Tax Exempt Parcels Overlapping Potential Riparian Restoration Areas

ASSR_SN	ASSR_AC	OWNER	PT1DESC	Description
169705-010	4.87	City of Vancouver	Unused or Vacant Land – No Improvements	1-2 acres of reforestation potential on south bank of Lacamas Creek.

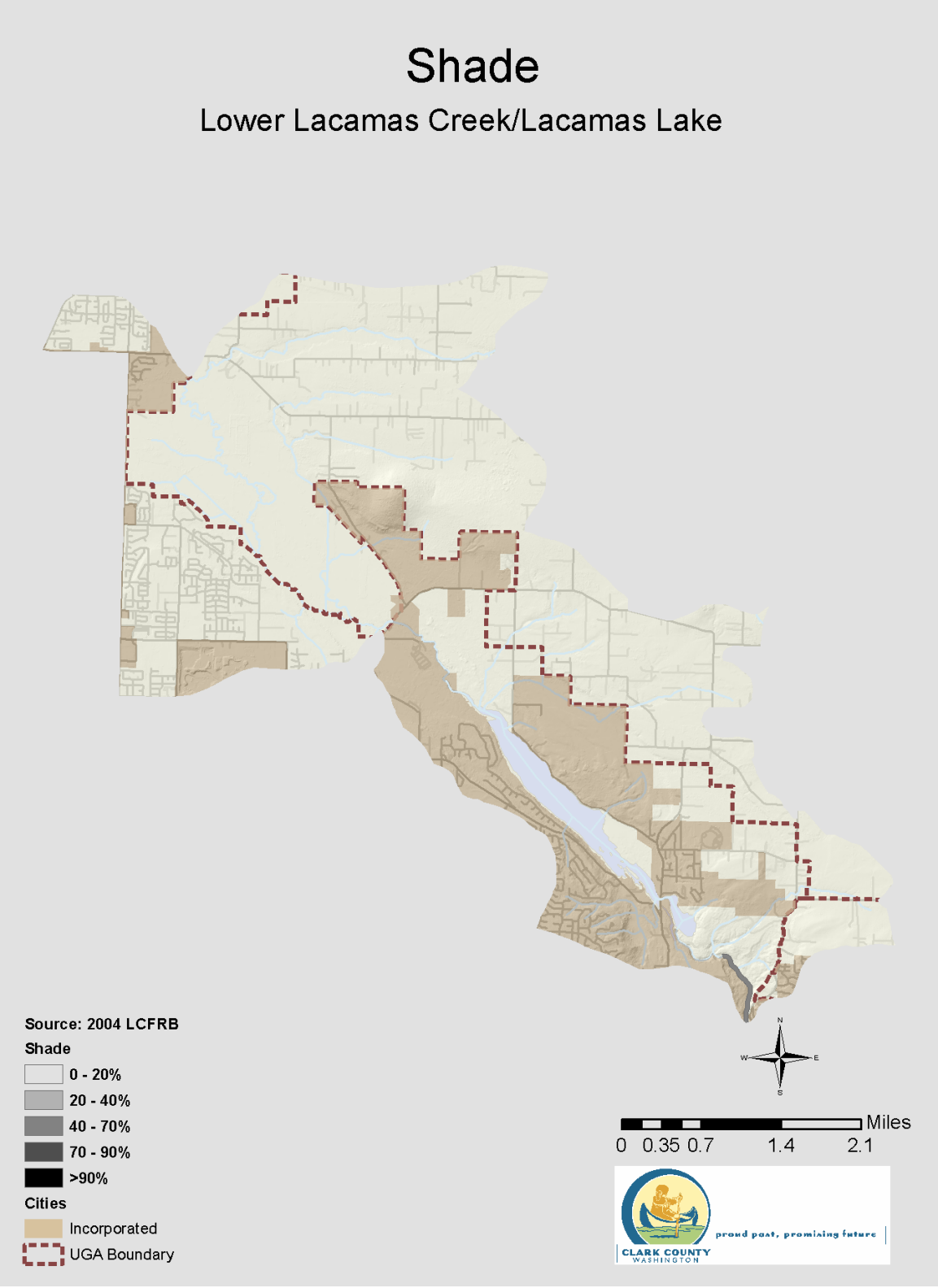


Figure 9: Lacamas Lake Shade Values (adapted from R2 Resource Consultants, Inc, 2004)

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 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, Draft Watershed Characterization of Clark County Version 3 (Ecology, 2007), 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 10 shows potential wetland areas within the Lower Lacamas Creek and Lacamas Lake based on data from the county wetlands atlas, including the Clark County wetland model and National Wetlands Inventory.

The Lower Lacamas Creek subwatershed has riverine wetlands associated with the main channel of the creek and its tributaries wetlands. It also has large areas of slope and depressional wetlands in both the flood plain of the creek and on terraces elevated above the creek. Hydrology in these wetlands generally is dominated by seasonal groundwater discharge, impoundment of surface run-off, and flooding in the lower reaches of the creek. Many of these wetlands have been highly altered for agricultural use.

Table 16: Distribution of Wetlands by Hydrogeomorphic Class

HGM Class	Area (ac.)	% of Sub-basin*	% of total wetland
Slope Wetlands	735	5.6	56
Lacustrine Wetlands	33	0.2	2.5
Depressional Wetlands	406	3.1	31
Riverine Wetlands	138	1.0	10.5
All Wetlands	1312	10	

*Subwatershed area 13,160 ac.

The Lacamas Lake subwatershed has wetlands associated with the lake fringe and other low laying areas adjacent to the lake. There also are wetlands associated with small tributary streams and terraces above the lake, including natural depressions and sloped seep wetlands dominated by groundwater discharge.

The wetlands in these subwatersheds generally are located in landscape positions where there could be significant opportunities to improve water quality or hydrologic functions. However, a review of the wetland inventories and studies reveals that the only publicly owned or tax-exempt land that is mapped potential wetland are rare wetland types (mature forested wetland or wet prairie remnants known to support endangered plant communities). Thus, these wetlands are not good candidates for potential project sites.

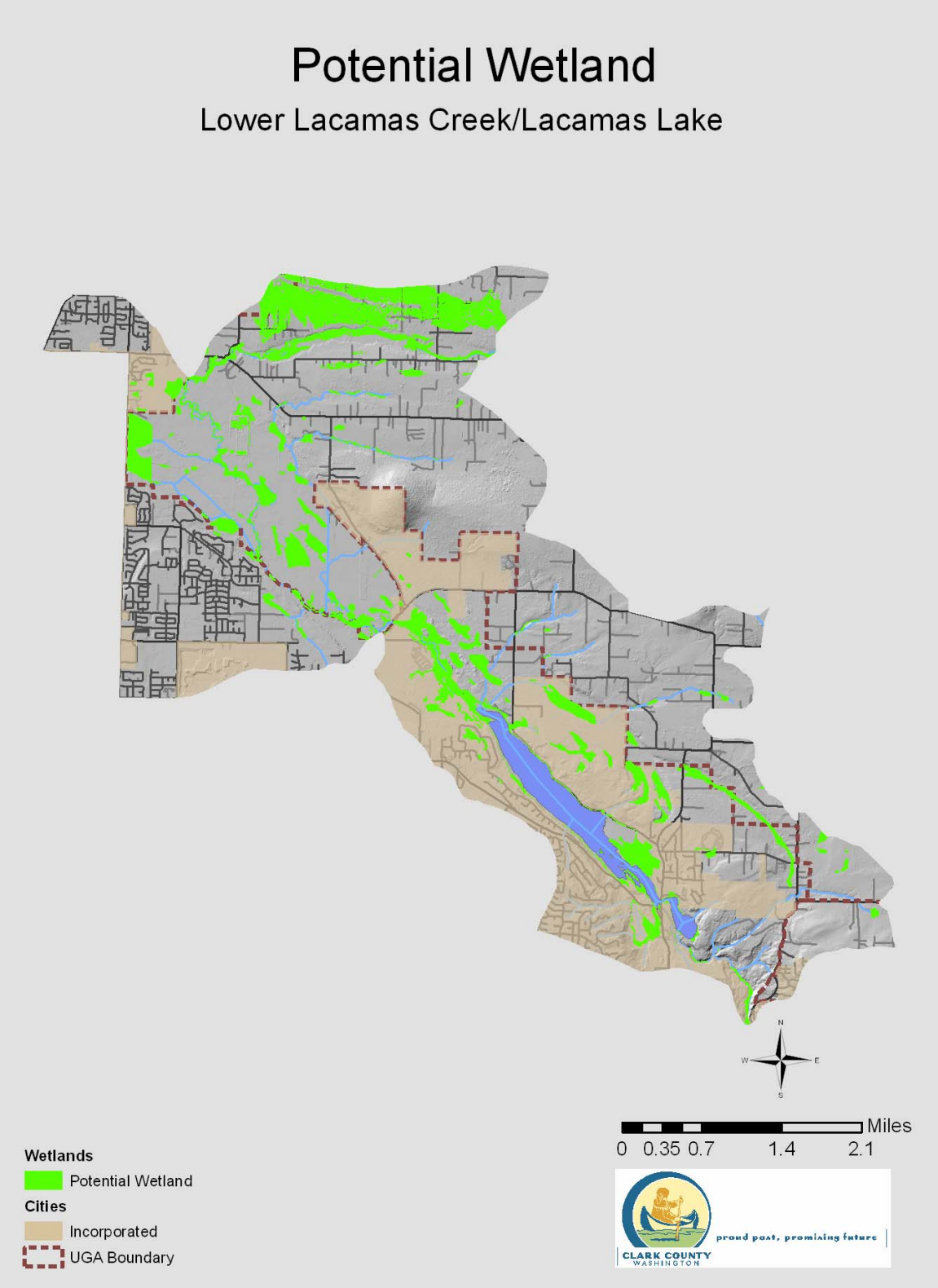


Figure 10: Lower Lacamas Creek and Lacamas Lake Potential Wetlands

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 Lower Lacamas Creek and Lacamas Lake are summarized below.

The Lower Lacamas Creek and Lacamas Lake subwatersheds are part of the Rain Dominated Terrace hydrogeologic unit. This unit is dominated by rain and has a: westward to southwestern trending groundwater flow pattern; large delta (now a terrace) formed by glacial floods consisting of gravels, sand, silts and clay; a relatively level to moderately steep topography in the foothills and slopes above the Columbia River (Ecology, 2009).

Figure 11 depicts priority areas for protection and restoration of hydrologic and denitrification processes countywide based on an analysis of the relative importance and level of alteration in each subwatershed.

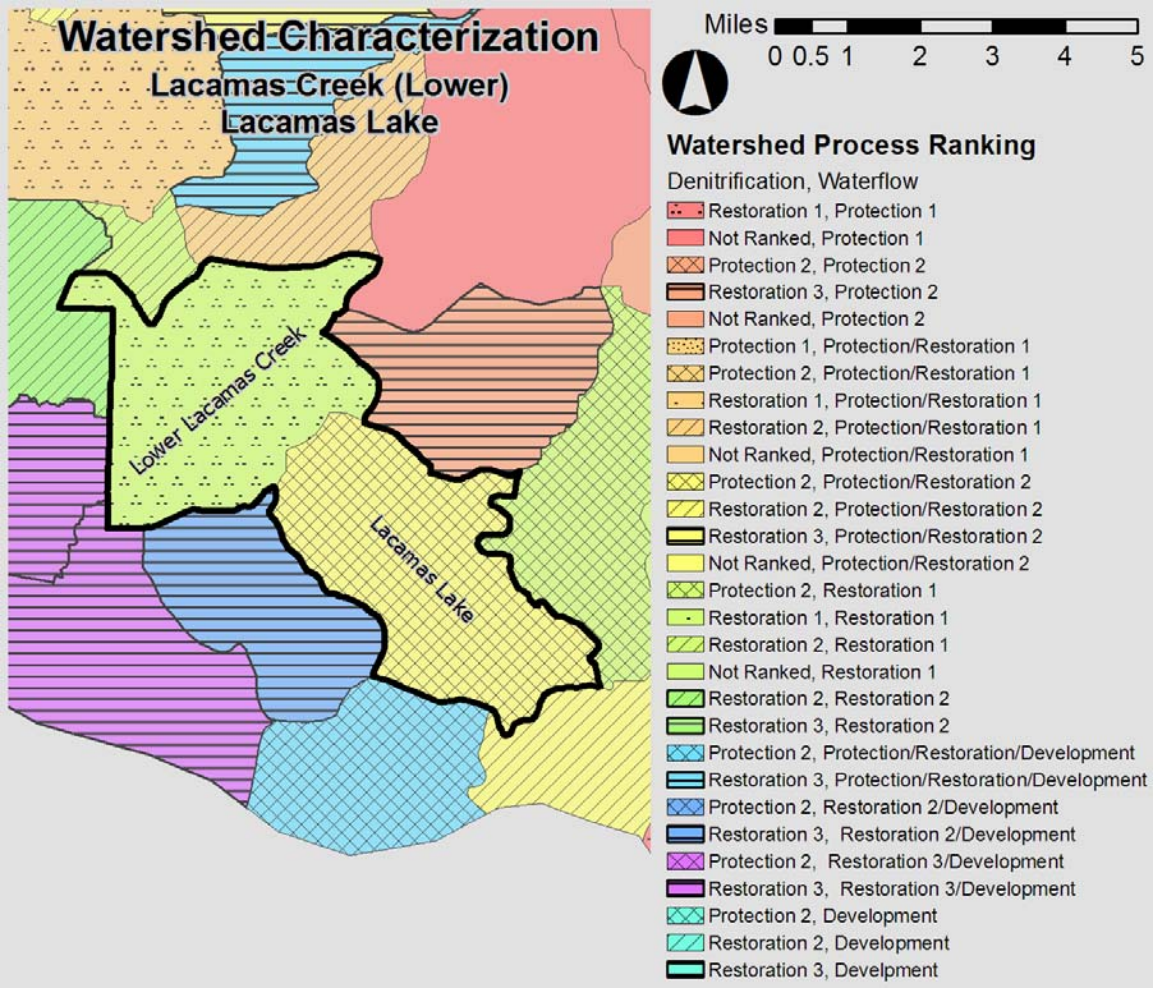


Figure 11: Priorities for suitability of areas for protection and restoration for the hydrogeologic process (from Watershed Characterization and Analysis of Clark County (Ecology, 2009))

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 green, purple and blue 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 and restoration of hydrologic (waterflow) processes are recommended for the Lacamas Lake subwatershed (yellow). This subwatershed also is ranked for protection of denitrification processes (cross-hatch pattern). The Lower Lacamas Creek subwatershed is recommended for restoration of both hydrologic (light green) and denitrification (triangular dot pattern) processes, indicating that watershed processes are degraded to the point that protection of existing function is not much of a priority.

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 and 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 are also influenced by naturally occurring factors in a watershed. For example, the absence of gravel substrate can lower scores.

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

- LAC050 (Lacamas Creek at Goodwin Road)

In the Lower Lacamas Creek subwatershed, a sample was collected by CWP staff in 2009.

Results

The 2009 score for LAC050 places this station in the category of low biological integrity.

Table 17 indicates there are five low, four moderate and one high score among the sub-metric results. Low scores for Number of Intolerant taxa, Number of Stonefly taxa, and Percent Predator taxa suggest human disturbance. Intolerant taxa and stonefly 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. Poor scores for Number of Mayfly taxa may indicate temperature or chemical contamination issues, while poor scores for Long-lived taxa (species with typical lifespans greater than one year) often indicate erratic streamflow and chronic exposure issues. (Fore, 1999).

Table 17: Station LAC050 Average Annual Macroinvertebrate Community Metrics and B-IBI Score from 2009.

B-IBI Metrics	LAC050 2009		
	Value	Score	Category
Total number of taxa	30	3	moderate
Number of Mayfly taxa	3	1	low
Number of Stonefly taxa	2	1	low
Number of Caddisfly taxa	5	3	moderate
Number of long-lived taxa	2	1	low
Number of intolerant taxa	0	1	low
Percent tolerant taxa	39.9	3	moderate
Percent predator taxa	0.5	1	low
Number of clinger taxa	21	5	high
Percent dominance (3 taxa)	55.7	3	moderate
Total B-IBI Score		22	low

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 to 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 12 indicates the score for LAC050 is near the bottom of the range of expected scores for subwatersheds with around 25 percent impervious area (estimated 2000 Total Impervious Area from Wierenga, 2005). This suggests factors other than impervious area are contributing to poor biological integrity and implies an opportunity to significantly 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 this opportunity.

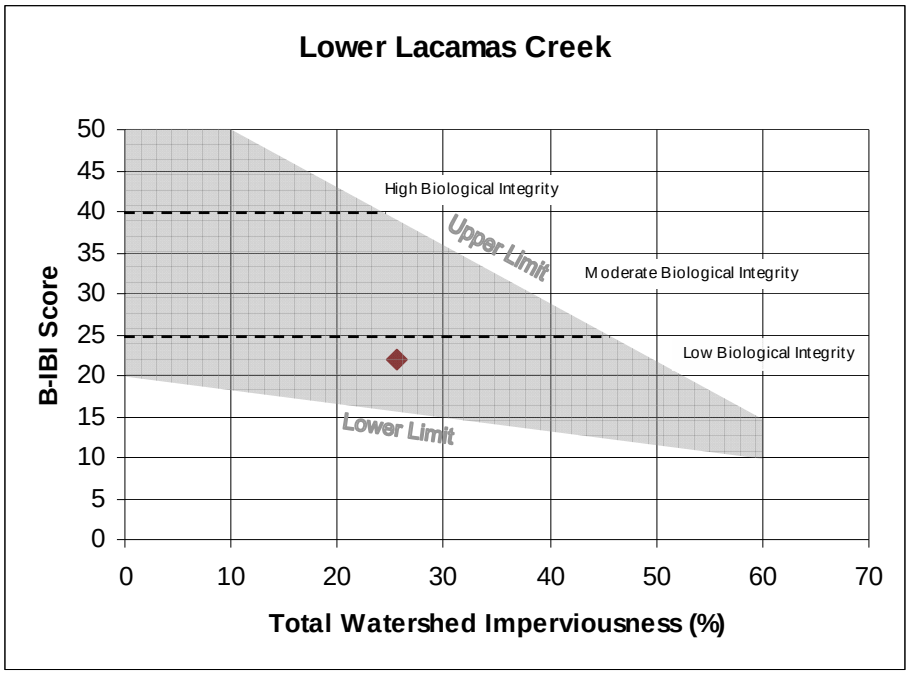


Figure 12: Approximate range of B-IBI in Puget Lowland watersheds, showing progressive decline with increasing imperviousness in the upstream watershed. Adapted from Booth et al, 2004. Markers indicate B-IBI scores at Station LAC050 for particular years, versus estimated 2000 subwatersheds TIA.

Fish Use and Distribution

Purpose

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

Methods

Fish distribution for the Lacamas Lake and Lower Lacamas Creek subwatersheds 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 briefly summarized here:

- 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 also were 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 in the Lacamas Lake subwatershed is limited to the lower reaches of Lacamas Creek, downstream of a waterfall located at appx (45.59720,-122.39439). Within that lower reach, Lacamas Creek is shown as having documented presence of coho and chum (Figure 13) and presumed presence of summer steelhead (Figure 14), winter steelhead and fall Chinook (Figure 15).

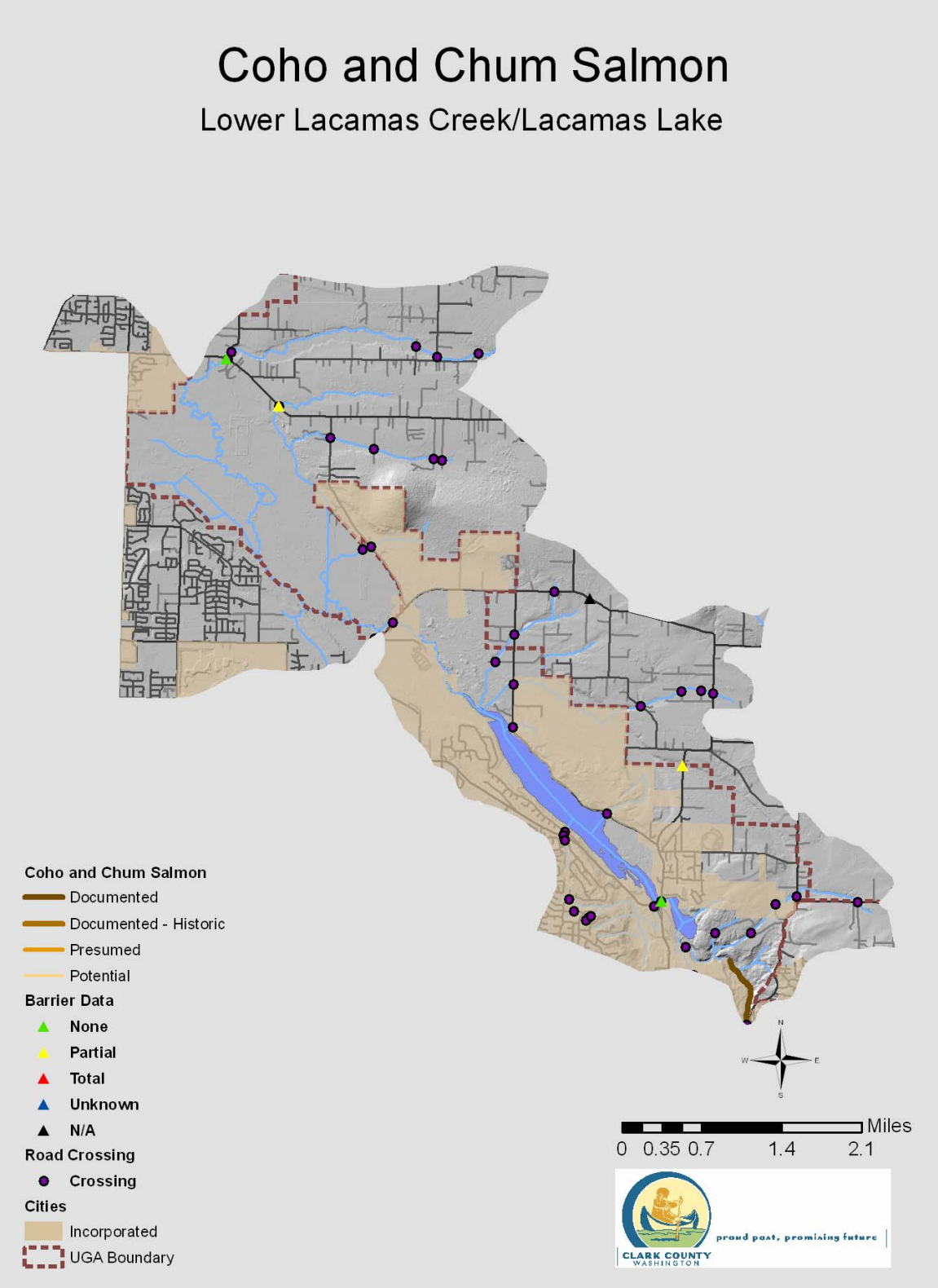


Figure 13: Lower Lacamas Creek and Lacamas Lake Coho and Chum Distribution and Barriers

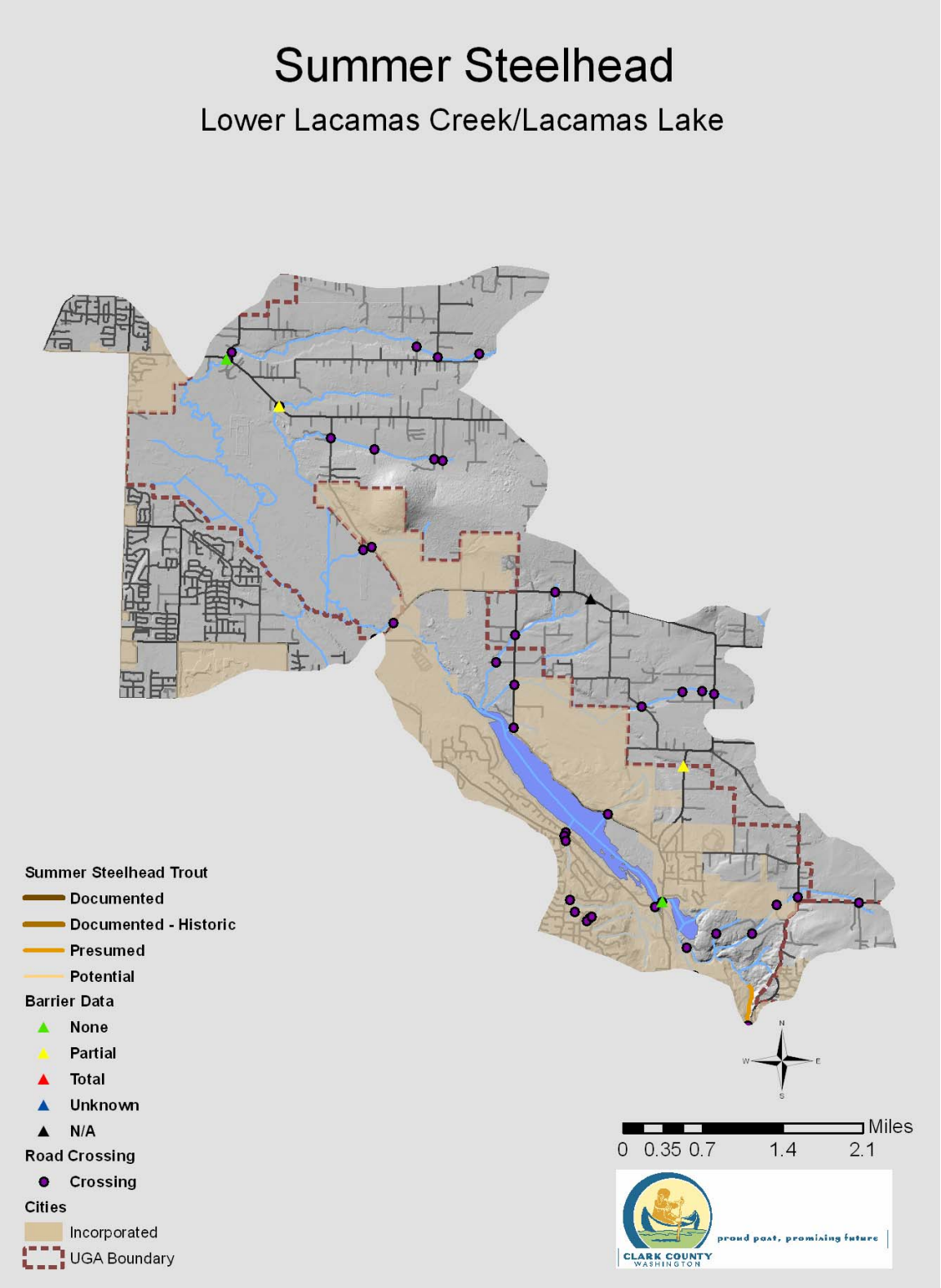


Figure 14: Lower Lacamas Creek and Lacamas Lake Summer Steelhead Distribution and Barriers

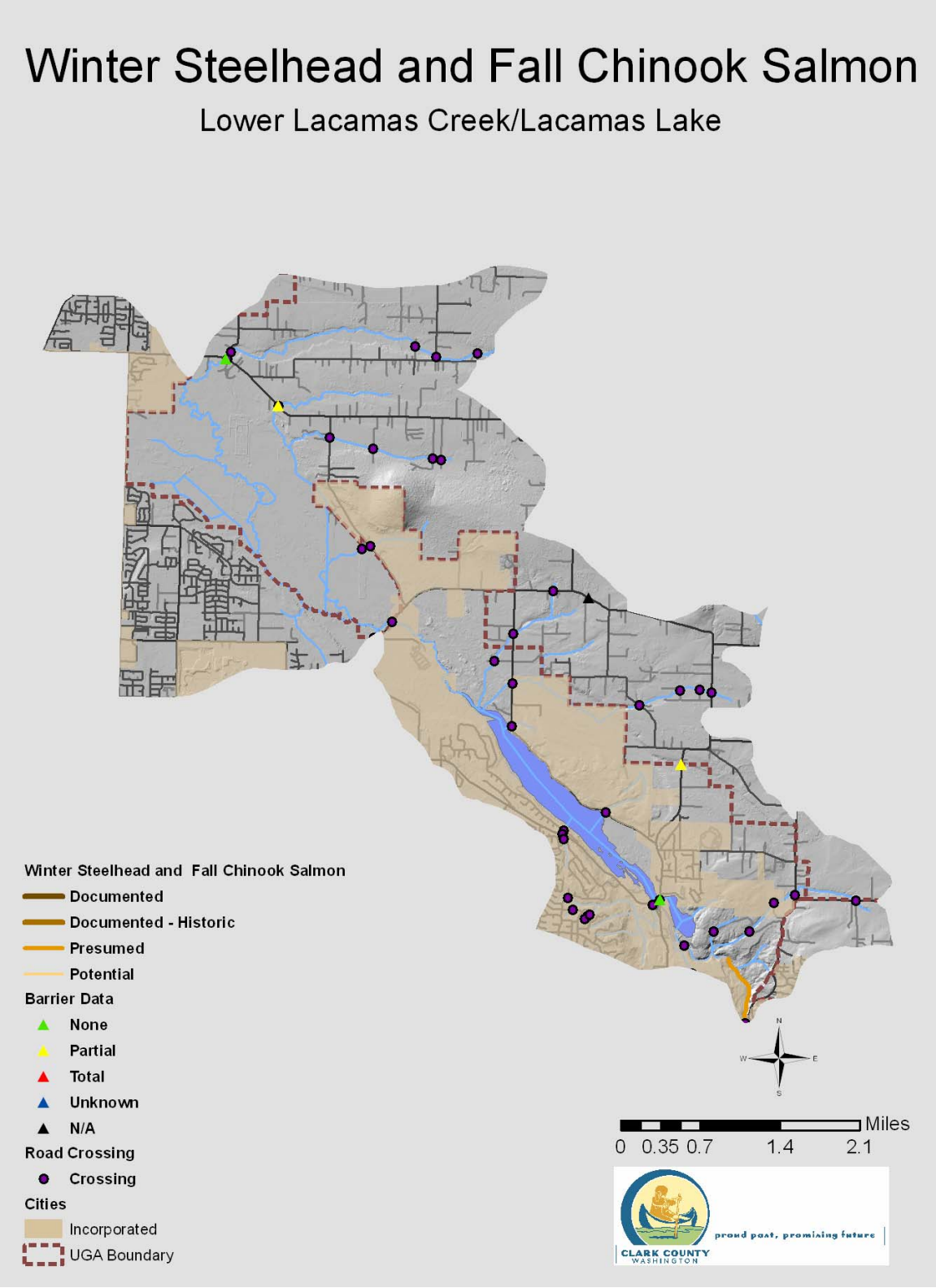


Figure 15: Lower Lacamas Creek and Lacamas Lake Winter Steelhead and Fall Chinook Distribution and Barriers

Barriers

The WDFW barrier database provides the most complete assessment of barriers in the Lacamas Lake and Lower Lacamas Creek subwatersheds (Figure 13, Figure 14, and Figure 15). No mapped barriers within the stream reaches are shown to have known, presumed or potential anadromous fish usage. The waterfalls located at appx (45.59720,-122.39439) are assumed to be a total natural barrier.

Two partial barriers are mapped on tributaries.

Recommendations

There are no project recommendations for fish passage at this time. Partial barriers should be removed over time as stream crossing infrastructure is replaced or upgraded.

Hydrologic and Hydraulic Models

Hydrologic and Hydraulic modeling were not conducted.

Analysis of Potential Projects

The analysis of potential projects:

- Briefly summarizes stormwater conditions, problems and opportunities
- Notes recently completed or current projects within 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 with the Washington Department of Ecology, Lower Columbia Fish Recovery Board, Clark County Legacy Lands and Vancouver-Clark Parks and Recreation in efforts to improve stream health.

Ecology is collecting field data for a multi-parameter TMDL in 2010-2011. Clark County participates in the TMDL process. Legacy Lands is involved with property purchases in the lower Lacamas Creek area. 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 urban or urbanizing inside the Urban Growth Area along the western and southern borders, with relatively dense rural residential land use throughout much of the remainder. Areas of open space remain chiefly as golf courses, parklands and large agricultural operations. Topography is low rolling hills between about 200 and 500 feet in elevation, with a high point around 800 feet at Green Mountain, a volcanic cone near Lacamas Lake. A relatively wide floodplain occupies the low elevations along the mainstem of Lacamas Creek.

Volcanic basalt flows underlie much of the area and are overlain by ancestral Columbia River sediments. The Late Ice Age glacial-outburst floods deposited poorly sorted gravels in the

southwestern portion and finer sandy sediment farther north. The outburst floods also are thought to have scoured the valley holding Lacamas Lake.

In these subwatersheds, Lacamas Creek has a low gradient and flows in a wide floodplain to Lacamas Lake. Lacamas Lake elevation and downstream flow are regulated by dams on Round Lake. Based on analysis in 2010, stream flows at Goodwin Road are relatively stable and not as prone to rapid runoff as more heavily developed basins.

Standard subwatershed scale metrics, such as percent forest, percent total impervious area, road density and effective impervious area, when compared with NOAA fisheries standards, suggest stream habitat is not properly functioning.

Water Quality Assessment
Multiple stream segments in this assessment area are included on the Ecology 2008 303(d) list of impaired water bodies. Both subwatersheds are included in ongoing TMDL development for fecal coliform, temperature, dissolved oxygen and pH in Lacamas Creek above Lacamas Lake.

A considerable historical dataset is available for this study area. However, only limited data have been collected in the past decade. Ecology began collecting data for TMDL development in late 2010. An extensive water quality dataset is available for Lacamas Lake spanning the early 1980s through early 2000s.

Overall data indicate that stream water quality is fair. Lacamas Lake is eutrophic and dramatically altered from its natural historical condition. Current conditions may impair desired uses such as fishing, swimming, and aesthetic enjoyment. Water quality monitoring during 2007 supports previous conclusions regarding the eutrophic condition of the lake.

Drainage System Inventory and Condition
Piped stormwater infrastructure is increasing in the urbanizing areas, while the rural areas are primarily served by roadside ditches. Drainage mapping is complete.

As of October 2010, there were 65 mapped public stormwater facilities in the study area. Eight were inspected and 83 percent of those facility components were in compliance with standards in the *2005 Stormwater Management Manual for Western Washington Volume 5*. Five referrals were generated for maintenance or engineering evaluation. Four of these eight facilities were referred for evaluation of potential retrofit projects.

No major defects or hazardous conditions were noted. Excessive sedimentation of bioswales and vegetation management were the most common reasons for non-compliance.

Off-site evaluations were conducted at six outfalls discharging to critical areas. No referrals were made for outfall repair.

Illicit Discharge Screening
Illicit discharge screening was not conducted in this study area.

Source Control
Source control inspections were conducted at 29 businesses in this assessment area. Five of the sites had source control problems, and all five were successfully resolved.

Stream Reconnaissance Feature Inventory
A feature inventory was conducted for 2.2 miles of stream corridor in the Lower. Twenty-one features were recorded, primarily stream crossings and impacted buffers. Seven potential opportunities for stream improvement were identified.

Physical Habitat
A physical habitat assessment was not conducted.

Geomorphology
A geomorphology assessment was not conducted.

Riparian Assessment
At the subwatershed scale, the LCFRB rated the riparian conditions in the Lacamas Lake subwatershed as "Moderately Impaired" and in the Lower Lacamas Creek subwatershed as "Impaired." Based on review of aerial photography, large woody debris recruitment potential and shade levels vary considerably throughout the study area.

Floodplain Assessment
A floodplain assessment was not conducted.

Wetland Assessment
The Lower Lacamas Creek subwatershed has riverine wetlands associated with the main channel of the creek and its tributaries wetlands, and large areas of slope and depressional wetlands in both the flood plain of the creek and on terraces above the creek. Many of these wetlands have been highly altered for agricultural use. The Lacamas Lake subwatershed has wetlands primarily associated with the lake fringe and other low laying areas adjacent to the lake. Overall, wetlands comprise 10 percent of the study area.

Wetlands in these subwatersheds generally are located in landscape positions where there could be significant opportunities to improve water quality or hydrologic functions. However, the only publicly owned or tax-exempt land that is mapped potential wetland are rare wetland types (mature forested wetland or wet prairie remnants known to support endangered plant communities). Thus, these wetlands are not good candidates for potential project sites.

Protection and restoration of hydrologic processes are recommended for the Lacamas Lake subwatershed. This subwatershed also is ranked for protection of denitrification processes. The Lower Lacamas Creek subwatershed is recommended for restoration of both hydrologic and denitrification processes, indicating that watershed processes are degraded to the point that protection of existing function is not much of a priority.

Macroinvertebrate Assessment
Based on a sample collected in 2009, biological integrity is low in the Lower Lacamas Creek subwatershed. No data are available in the Lacamas Lake subwatershed. This score is toward the lower end of the range of predicted scores areas with similar levels of total impervious area, suggesting that factors other than impervious area are contributing to poor biological integrity. This implies an opportunity to significantly increase the level of biological health by improving habitat and stream conditions.

Fish Use and Distribution
Anadramous fish use in the Lacamas watershed is limited to the lower reaches of Lacamas Creek, downstream of a natural waterfall below Lacamas Lake. Within the lower reach, Lacamas Creek is shown as having documented presence of Coho and Chum salmon, as well as presumed presence of summer steelhead, winter steelhead and fall Chinook. There are no known barriers to fish within the lower reaches.

Lacamas Lake is stocked annually with brown and rainbow trout. There also are naturally reproducing populations of warm water fish, including largemouth bass, bluegill sunfish, perch and suckers.

Recently Completed or Current Projects

One project in this assessment area currently is in the stormwater capital projects database; CP-120 is a reforestation project at Harmony Ridge Neighborhood Park. The project has not been funded or scheduled.

Clark County Legacy Lands recently purchased seven acres of riparian and wetland habitat along the shoreline of Lacamas Lake near the intersection of SR 500 and Leadbetter Road, and is currently working to protect 65 additional acres. The project site supports a variety of wildlife and adds to a significant amount of protected habitat in the Lacamas Lake subwatershed.

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 throughout 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.

Emergency/Immediate Actions

Emergency/Immediate actions may be pursued by Clark County staff or referred to other appropriate agencies. These cases represent a potential or immediate threat to public health, safety or the environment, and require timely follow-up.

No projects of this type were identified.

Potential Stormwater Capital Projects

Stormwater Capital Improvement Projects include projects that create new or retrofit existing stormwater flow control or treatment facilities, substantial infrastructure maintenance projects, habitat enhancement projects, or property acquisition to mitigate for stormwater impacts. Facility retrofits refer to projects that will increase an existing facility's ability to control or treat stormwater in excess of the original facility's design goals.

Stormwater Facility Capital Improvement Projects

ID	Basis for Project	Project Description	Action
OS-221	Potential storage retrofit	Large lot with little infrastructure Cambridge Estates ID#401	Refer to DES Capital Planning
OS-222	Potential storage retrofit	Potential expansion into adjacent lot East Lake Village ID#820	Refer to DES Capital Planning
OS-223	Potential storage and treatment retrofit	Potential LID opportunity Parkside Place ID#113	Refer to DES Capital Planning
OS-224	Potential storage and treatment retrofit	Potential LID opportunity Snyder's Country Place Ph 2 ID#1242	Refer to DES Capital Planning

Stormwater Infrastructure Maintenance CIPs

No projects of this type were identified

Stormwater Class V Underground Injection Control (UIC) Projects

No projects of this type were identified

Habitat Rehabilitation/Enhancement Projects

ID	Basis for Project	Project Description	Action
OS-225	Potential reforestation project on City of Vancouver property (parcel 169705-010)	5-acre lot with 1-2 acres of reforestation potential on south bank of Lacamas Creek	Refer to DES Capital Planning

Property Acquisition for Stormwater Mitigation

No projects of this type were identified.

Follow-up Activities for Referral within DES

This category includes opportunities other than capital projects that are dependent upon DES programs or oversight. Examples include referrals to: Public Works Operations for public stormwater infrastructure maintenance or private facility inspection; DES Sustainability and Outreach for landowner letters regarding trash pickup or agricultural BMPS; the Illicit Discharge screening project; general reach information forwarded to DES engineers for capital planning purposes. Other opportunities, such as possible fish barriers or culvert maintenance issues, also may be included.

Private Stormwater Facilities Maintenance

No projects of this type were identified.

Public Works Stormwater Infrastructure Maintenance

No projects of this type were identified.

CWP Outreach/Technical Assistance

ID	Basis for Project	Project Description	Action
IB-288	Ivy on streambank along private road	Remove ivy and plant native vegetation	Refer to DES Outreach; contact landowner about BMPs, CCD assistance
IB-289; IB-290; IB-291	Little to no riparian vegetation; lawn to creek and channel armored with rock	Riparian planting; bioengineering	Refer to DES Outreach; contact landowner
TR-80	Large pile of grass clippings dumped in channel and	Eliminate dumping; move to upland location or compost	Refer to DES Outreach; contact landowner

ID	Basis for Project	Project Description	Action
	bank; several cubic yards		

CWP Infrastructure Inventory
No projects of this type were identified.

CWP Capital Planning
No projects of this type were identified.

CWP Illicit Discharge Screening
No projects of this type were identified.

Other

ID	Basis for Project	Project Description	Action
ER-77	Stream makes sharp bend against road grade; active erosion within 5 feet of road, may eventually undermine	Stabilize bank	Refer to PW Operations
IB-292	Large stand of Canadian thistle	Remove thistle and plant native vegetation	Refer to DES Vegetation Management

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.

Management and programmatic recommendations in the study area subwatersheds, by NPDES permit component, include:

Storm Sewer Mapping and Inventory
None

Coordination of Stormwater Activities
None

Mechanisms for public involvement
None

Development Regulations for Stormwater and Erosion Control

- Implement development regulations to minimize impacts, particularly enhanced nutrient control regulations to protect Lacamas Lake

Stormwater Source Control Program for Existing Development

- Focus on protecting reaches that currently are unstable or sensitive to future disturbance
- Increase infiltration and retention of stormwater runoff from older developments

Operation and Maintenance Actions to Reduce Pollutants

- Focus additional effort on maintenance of bioswales, particularly excessive sediment conditions

Education and Outreach to Reduce Behaviors that Contribute Stormwater Pollution

- Educate private landowners on importance of native riparian vegetation and intact riparian forests for shading streams and preserving hydrology
- Educate landowners to discourage disposal of trash and yard debris in streams or other receiving waters

TMDL Compliance

- Continue collaboration on Lacamas Creek TMDL development. Clark County fulfills its TMDL compliance obligations through ongoing implementation of the Stormwater Management Program

Monitoring Stormwater Program Effectiveness
None

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

- Assess Priority 3 outfalls, which make up nearly all of the outfalls discharging to critical areas in these subwatersheds; offsite assessment activities may reduce downstream erosion problems by discovering potential issues before they become more serious
- Encourage appropriate agricultural practices that emphasize soil and water conservation and reduction in nutrient load to streams.
- Protect streams from future stormwater impacts by creating stream buffers, establishing conservation easements, and eliminating agricultural runoff inputs.
- Encourage reforestation

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