2007 Stormwater Needs Assessment Program

Curtin Creek
Subwatershed Needs Assessment Report

Clark County Public Works Water Resources

June 2008

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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
EIA	Effective Impervious Area
EDT	Ecosystem Diagnostic and Treatment model
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
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 Scores
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 Areas
UIC	Underground Injection Control
USFWS	U.S. Department Fish and Wildlife Services
VBLM	Vacant Buildable Lands Model
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WSDOT	Washington Department of Transportation

Executive Summary

Study Area

This Stormwater Needs Assessment report includes the Curtin Creek subwatershed, tributary to Salmon Creek in west central Clark County.

Intent

Stormwater Needs Assessment reports compile 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. The assessments are conducted at a subwatershed scale, providing a greater level of detail 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 Curtin Creek subwatershed, including water quality, biological health, habitat, hydrology, and the stormwater system.

Ongoing activities and involvement

Clark County CWP participates in the Total Maximum Daily Load (TMDL) process through implementation of the National Pollution Discharge Elimination System (NPDES) permit, provides water quality monitoring, and supports various local organizations working within the Curtin Creek area. The watershed continues to benefit from the efforts of these groups.

Clark County is currently constructing a large stormwater facility to meet a variety of stormwater management requirements. The stormwater facility referred to as Curtin Creek Enhancement Area Project is in the Curtin Creek subwatershed east of NE 72nd Avenue and south of NE 119th Street. The facility is constructed to meet the stormwater requirements of two major road projects, St. Johns Road (NE 50th Avenue to NE 72nd Avenue) and NE 72nd Avenue (NE 99th Street to St. Johns) with substantial residual capacity. Potential uses include providing stormwater capacity for additional county road projects or for private commercial/industrial development.

There are also several potentially significant Transportation Improvement Program (TIP) projects on the County's Capital Improvement Program (CIP) list within Curtin Creek subwatershed, including NE 99th Street (72nd Avenue to NE 94th Avenue), NE 99th Street (NE 94th Avenue to SR-503), NE 94th Avenue (Padden Parkway to NE 119th Street).

Category	Status
Water Quality	
Overall	• Poor
Fecal coliform bacteria	• Curtin Creek has Category 5 (requiring TMDL for DO and pH) and Category 4 segments (included in Salmon Creek fecal coliform TMDL). • Out of compliance with the state criterion (100 cfu/100mL).
Temperature	• Among the cooler streams monitored by Clark County
Sediment	• No data
Biological	
Benthic macroinvertebrates	• Moderate to poor biological integrity
Anadramous fish	• Presumed use by Coho. • Moderate regional recovery priority (LCFRB Tier 4).
Resident fish	• Unknown
Habitat	
NOAA Fisheries criteria	• Forest cover, road density, and impervious area percentage fall into the Non-Functioning category. • Stream crossing density falls into the Functioning category
Riparian	• Very limited large woody debris recruitment potential. • Very low overall shade
Wetland	• Excellent wetland restoration potential exists throughout the floodplain areas downstream (north) of NE 90th Street.
Hydrology and Geomorphology	
Overall hydrology	• Relatively good; typical of a mixed rural/urban or unforested rural watershed • Significant groundwater component especially downstream of NE 119th Street.
Future condition	• Projected impervious area should remain at levels that do not result in significant alteration of hydrologic conditions.
Stormwater (Unincorporated areas)	
System description	• The stormwater conveyance to Curtin Creek and its tributaries is mainly via piped outfalls that drain treated stormwater from engineered stormwater treatment facilities or untreated stormwater directly from the source.
Inventory status	• 85 publicly owned stormwater facilities • 80%+ of stormwater infrastructure mapping is completed
System adequacy	• Likely inadequate treatment.
System condition	• No outfall screening was performed. • 80% of facility objects in compliance with maintenance standards at the time of assessment

Opportunities

Projects listed in the SNAP report represent a small part of those required to protect and restore Curtin Creek. Potential project opportunities were identified based on the results of the Feature Inventory conducted in the Curtin Creek subwatershed. Immediate priorities based on current conditions and local program capabilities are listed. Numerous opportunities exist for stormwater-related watershed improvement, including the following:

- Focused outreach.
- Several stormwater facility capital improvement projects to provide flow control and water quality treatment.
- Repair and maintenance of existing stormwater infrastructure.
- Large-scale channel/watershed restoration project opportunity.
- Inspection of five (5) problem areas to address flooding hazard, erosion/sediment transport into stream.
- Potential capital improvement projects including ditch retrofits, swale retrofits, riparian enhancements, and flow control facilities.
- Updates to stormwater infrastructure database.
- Identification of several Referral Projects for other Groups/Agencies.

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. Management recommendations relevant to the Mill Creek subwatershed include:

- Seek coordination and leveraging opportunities with groups and agencies active in Curtin Creek improvement.
- Encourage the use of Low Impact Development techniques for new development.
- Confirm that county ditch maintenance practices minimize vegetation removal; provide education for private landowners on appropriate ditch maintenance.
- Encourage removal of invasive plants and riparian restoration through education, technical assistance and/or financial assistance.
- Promote protection of first-order tributary streams. Consider the use of habitat buffers, establishment of conservation easements, and increased control of existing stormwater and agricultural runoff.
- Pursue future collaborative stormwater activities between Clark County, Vancouver-Clark Parks and Recreation in the upper watershed.

Introduction

This report is a Stormwater Needs Assessment for the Curtin Creek subwatershed. The Clean Water Program (CWP) is gathering and assembling information to support 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 the SNAP are to:

- Analyze and recommend the best and most cost effective mix of improvement actions to protect existing beneficial uses, and to improve or allow for the improvement of lost or impaired beneficial uses consistent with NPDES objectives and improvement goals identified by the state GMA, ESA recovery plan implementation, TMDLs, WRIA planning, flood plain 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 natural watershed function, 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 is also needed by county programs implementing critical areas protection and salmon recovery planning under the state Growth Management Act (GMA) and the federal ESA.

Scope

This report summarizes and incorporates new information collected for the 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 the Public Works CWP and Stormwater Capital Improvement Program (SCIP), several programs within the Department of Community Development, and the county's ESA Program. Potential project or leveraging opportunities are also referred to local agencies, groups, and municipalities as appropriate.

Assessment Approach

Priorities for Needs Assessment in Curtin Creek

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

The Curtin Creek subwatershed is categorized as largely within the unincorporated Vancouver UGA. Priority for stormwater basin planning is often high in this category, leading to the field application of several SNAP tools.

Assessment Tools Applied in Curtin Creek

The SNAP utilizes a standardized set of tools for subwatershed assessment, including desktop mapping analysis, modeling, outreach activities, and a variety of field data collection. 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 marked with an asterisk (*) are those for which new data or analyses were conducted during the course of this needs assessment. The remainder of the tools were assessed based on pre-existing information.

Table 1: Stormwater Needs Assessment Tools	
Stakeholders *	Geomorphology And Hydrology Assessment *
Outreach And Involvement *	Riparian Assessment
Coordination with Other Programs *	Floodplain Assessment
Drainage System Inventory *	Wetland Assessment
Stormwater Facility Inspection *	Macroinvertebrate Assessment *
Review Of Existing Data *	Fish Use And Distribution
Illicit Discharge Screening *	Water Quality Assessment *
Broad Scale GIS Characterization *	Hydrologic Modeling
Rapid Stream Reconnaissance *	Hydraulic Modeling
Physical Habitat Assessment	

Assessment Actions

Outreach Activities

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

- July 2007 -- press release to local media
- August 2007 – article in “Planning Stormwater Projects” flyer distributed at Clark County fair and other public events.
- September 2007 – article in Clean Water Program E-Newsletter
- Clean Water Program web pages updated to include the SNAP and SCIP.
- March 31 of each year, a description of the SNAP is included in Clark County’s stormwater management program plan submitted to Ecology

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

Coordination with Other Programs

Purpose

Coordination with other county departments and with local agencies or organizations helps to explore potential cooperative projects and ensure that the best available information is used to complete the assessment.

Coordination is a two-way relationship; in addition to bringing information into the needs assessment process, coordinating agencies may use needs assessment results to improve their programs.

Methods

The CWP maintains a list of potential coordinating programs for each subwatershed area. The list was reviewed in early 2007 and general communications were planned. Coordination took the form of phone conversations, meetings, or electronic correspondence, and was intended to solicit potential project opportunities, encourage data and information sharing, and promote program leveraging.

Potential opportunities for coordination exceeded the scope of CWP and SNAP resources; therefore, not all potentially relevant coordination opportunities were pursued. Coordination was prioritized with departments and groups thought most likely to contribute materially to identifying potential projects and compiling information to complete the needs assessment.

Results

See Analysis of Potential Projects for an overall list and locations of potential projects gathered during the needs assessment process. Projects suggested or identified through coordination with other agencies are included.

The following list includes departments, agencies, and groups contacted for potential coordination during the course of the Curtin Creek needs assessment:

- Clark County Endangered Species Act program
- Lower Columbia Fish Recovery Board
- Clark County Transportation Improvement Program
- Clark County Legacy Lands Program
- Vancouver/Clark Parks and Recreation
- Washington Department of Ecology
- Clark County Weed Management

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 those listed below:

- LCFRB Habitat Assessments
- LCFRB Workplan
- Salmon Recovery Plan
- CC LISP/SCMP/Project Data
- Ecology 303(d) list
- WRIA Limiting Factors Analysis
- CC Consproj GIS Layer (conservation projects)
- CC 6-year and 20-year TIP
- Ecology EIM Data
- CC Mitigation Opportunities Project
- CC 2004 Subwatershed Summary
- CC 2004 Stream Health Report

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 describes many subwatershed characteristics such as topography, geology, soils, hydrology, land cover, land use, and GMA critical areas. A standard GIS workspace including shape files for over 65 characteristics forms the basis for the characterization.

GIS data is 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.

Many of these characteristics are described in greater detail in later sections. For example geology and soils form the cornerstone of the Geomorphology and Hydrology section.

The characterization includes three components:

- A set of three standard map products
- A summary table of selected subwatershed-scale metrics
- A brief narrative including comparison of metrics to literature values, conclusions about general subwatershed condition and potential future changes, and potential mitigation or improvement site identification.

Map Products

Three standard SNAP map products are: 1) Stormwater Infrastructure and Hydrologic Soil Group, 2) Critical Areas information, and 3) Vacant Buildable Lands within UGAs. These maps are printed out for tabletop evaluations.

General Conditions and Subwatershed Metrics

General Geography

Curtin Creek is a major tributary of Salmon Creek, contributing up to one quarter of the summer base flow. It originates in wetland areas near 78th Street and Andresen Road and flows north through relatively sparsely developed areas to Salmon Creek (Figure 1). Curtin Creek subwatershed covers approximately 10.8 square miles, receiving on average 44 inches of precipitation annually. The southern half of the basin, south of 107th Street, is largely urban except for larger wetland areas. The northern half of the Curtin Creek subwatershed is rural residential and small agricultural uses. Average parcel size is one acre. Population density is 1,550 people per square mile. The majority of the subwatershed is located within the Vancouver Urban Growth Area (UGA).

Topography

Curtin Creek subwatershed has subtle terrain, having an average subwatershed slope of 3.5 percent. The elevation at Curtin Creek's mouth is 170 feet and the highest points in the basin are 290 to 300 feet above sea level along the subwatershed's eastern margin. For the most part, Curtin Creek follows a broad, flat, south to north swale formed by the Ice Age catastrophic floods. These floods also left a south to north trending terrace-like deposit along the east side of the basin, where elevation rises from 40 to 50 feet.

The channel between NE 88th Street and NE 119th Street occupies a broad flat valley, which was a historical wetland that has been modified by past efforts to improve drainage in the area. The modifications included straightening the channel over a majority of the reach. Recently, the reach extending approximately 1,200 feet down-valley (north) of the Lewis & Clark Railroad, was converted to a meandering platform as mitigation for wetlands lost due to the construction of a Costco warehouse in the upper portion of the drainage basin (this reach is referred to as the Costco Mitigation Site). The channel gradient through this reach is approximately 0.09 percent and is much flatter than upstream or downstream reaches. The channel has an average gradient in the vicinity of the road of about 0.03 percent, with an adverse gradient over a portion of the reach that extends about 1,100 feet downstream of the road.

Geology and Soils

Geology and soils influence stream channel type, the size and amount of sediment in the channel, wetland formation, and overall hydrologic framework. Curtin Creek is underlain by sandy to silty catastrophic Ice Age flood deposits and peaty marsh deposits in some areas near the main channel. Geology is described in greater detail in the geomorphology and hydrology section.

The Ice Age catastrophic flood deposits mantle the entire study area, ranging in depth from a few feet in the upper most basins to perhaps over 100 feet thick at the east margins. These deposits are about 14,000 to 12,000 years old and were deposited by a succession of giant floods of the Columbia River caused by ice dam failures in the Missoula, Montana area. These deposits are coarse sand in the south eastern part of the basin and become finer textured sand and silt to the west and north. Localized peat deposits occur in low lying areas near Curtin Creek but are not mapped separately from the Ice Age flood deposits. The coarse sand underlying eastern Curtin Creek subwatershed is an important hydrologic feature because it facilitates stormwater infiltration.

The soils in Curtin Creek tend to reflect the coarser texture of the underlying Ice Age flood deposits, being largely Hydrologic Soil Group B. Finer-textured soils are generally limited to localized depressions or near natural drainageways.

Hydrology
Curtin Creek's hydrologic framework is determined by its unusual geology and topography. Much of the subwatershed is flat and underlain by permeable soils and geologic material. In the south and east parts of the basin, much of the stormwater runoff is routed to infiltration wells and produces little or no runoff to the creek. Curtin Creek is a manmade ditch for much of its length. A modified channel extends from about one mile above the mouth to the headwaters. The primary purpose for the channel modifications was to drain lengthy depressional wetlands for use as farmland. The geomorphology and hydrology report section describes hydrology in greater detail.

Groundwater is very shallow in much of the basin east of 87th Avenue and Curtin Creek tends to have a strong groundwater component with summer base flow of three to four cubic feet per second at the gauge station. It is also an important source of cold summer flows to Salmon Creek, which has typical summer flows of only four to ten cubic feet per second above Curtin Creek.

In the upper portion of the watershed, the creek is not well defined with possible areas of closed depressions that do not contribute surface runoff to the channel. The Curtin Creek watershed is composed of a mix of commercial, residential, and agriculture development. Areas in the southern, upstream portion of the watershed are generally more heavily developed with areas zoned for light industrial, commercial, and employment centers. Active development is taking place in the watershed along the east and west sides of the creek between NE 99th Street and NE 119th Street. A majority of the watershed is zoned for residential development and many subdivisions have already been platted and constructed. Some areas of agricultural and rural development have been set aside in the northern portion of the watershed, particularly north of NE 119th Street.

Clark County Public Works is in the planning process of widening NE 119th Street in response to active land development that is occurring in the area. The project will include replacing the existing culverts at the Curtin Creek crossing with a new culvert or bridge that meets fish passage requirements and reduces consistent upstream flooding problems caused by backwater from the currently undersized culverts. The study includes an evaluation of flood storage losses caused by the various design alternatives and attempts to mitigate for these losses. As part of this study, the Salmon Creek HSPF hydrology model was undated to include more detail in the Curtin Creek subwatershed, including a better accounting for the significant storage in the basin. The revised HSPF model resulted in a significant lowering of flood peaks along Curtin Creek compared to the original model.

Curtin Creek Enhancement Project, currently under construction in the reach between the Lewis & Clark Railroad and NE 99th Street, includes creation of multiple meandering low-flow channels and off-channel wetlands that lower water-surface elevations for low to moderate flows and significantly adds to the flood storage in the project reach (the increase in flood storage is 40 acre-feet over existing conditions).

This refinement to the Salmon Creek HSPF model did not include any calibration, as the majority of the input data was unchanged from the original model. The development of the original model included extensive calibration activities to refine the precipitation, evaporation, land use, and model parameter values. Model results were compared with the original Salmon Creek HSPF model of Curtin Creek, to evaluate changes resulting from the model refinements. Results of the comparison for existing land use conditions are provided in Table 2. The results show that computed peak flows in the updated HSPF model are significantly lower than the original HSPF model.

Table 2: Computed Peak Flows at Various Locations in the Curtin Creek Watershed Using the Updated HSPF Model

Location	Return Period	Existing Conditions	Future Conditions
Salmon Creek Confluence	2-yr	153	190
	10-yr	235	274
	100-yr	337	373
NE 139th Street	2-yr	148	186
	10-yr	225	264
	100-yr	319	354
NE 119th Street	2-yr	94	134
	10-yr	135	179
	100-yr	187	229
At the Railroad	2-yr	83	104
	10-yr	118	144
	100-yr	165	194
NE 88th Street	2-yr	73	89
	10-yr	112	136
	100-yr	164	198
Padden Creek Trib. at confluence with Curtin Creek	2-yr	57	59
	10-yr	86	89
	100-yr	125	130
I-205	2-yr	12	17
	10-yr	20	26
	100-yr	32	35
NE Andreson	2-yr	11	16
	10-yr	17	21
	100-yr	26	26

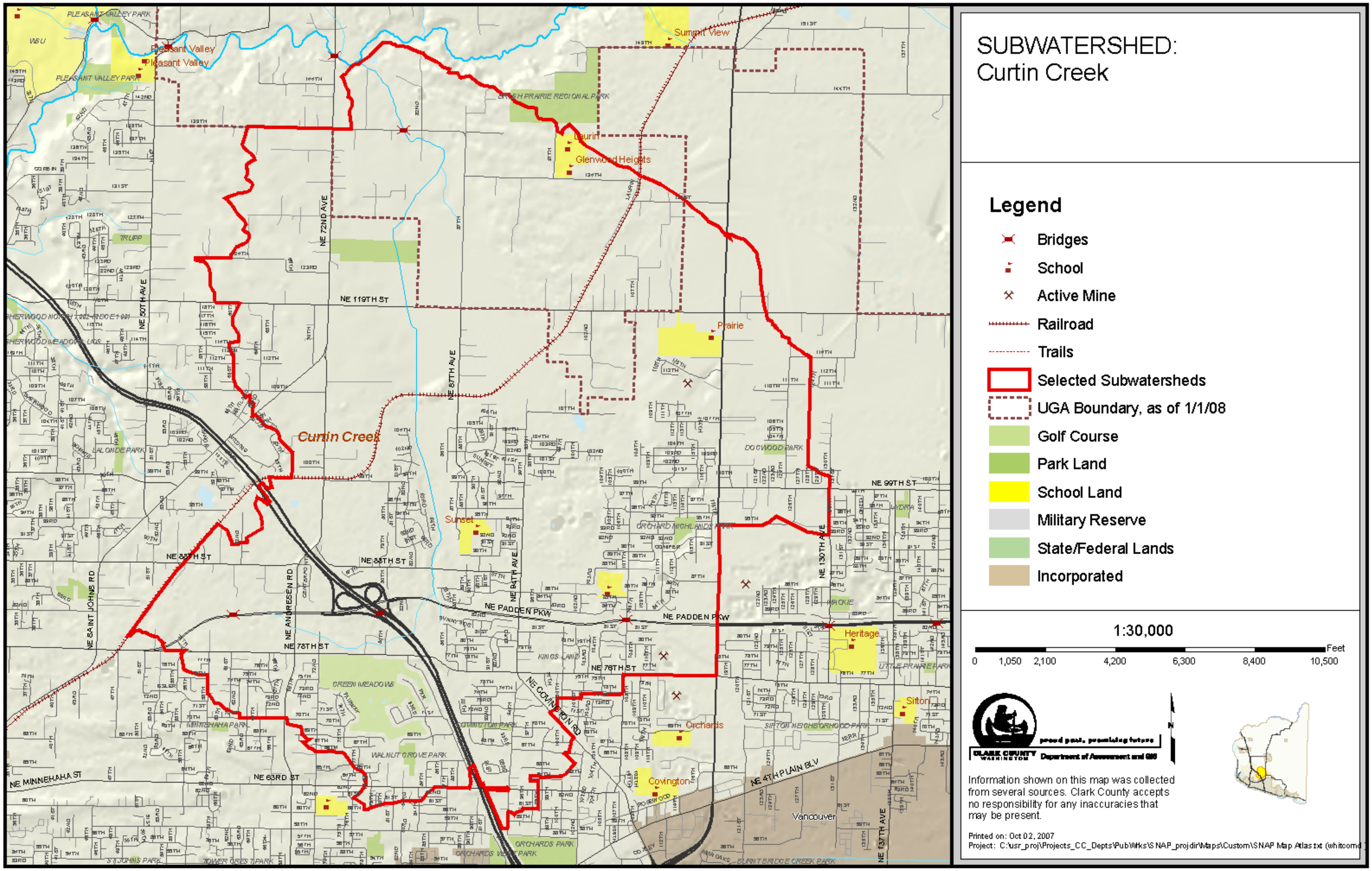


Figure 1: Subwatershed Map: Curtin Creek.

Clark County has operated a stream gauge near the mouth of Curtin Creek since 2003. Data from the stream gauge suggests that Curtin Creek is not a typical urban stream, having storm peak flows much lower than would be expected. The relatively muted peak discharges are due to much of the stormwater runoff east of 87th Avenue being routed to stormwater infiltration facilities and entering the stream as seeps and springs. Another likely reason for low peak discharges is the very low gradient of Curtin Creek channel between Padden Parkway and 139th Street. Examination of a simple hydrology metric, the TQmean, showed that 30 to 34 percent of the daily flows were greater than the mean daily flow. This is indicative of a mixed rural and urban or unforested rural watershed. Uncalibrated HSPF model flow estimates suggested that Curtin Creek hydrology is on the border between producing stable and unstable channels.

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).

Due to its unusual hydrology, typical habitat metrics don't apply well to Curtin Creek. Overall, metrics suggest that Curtin Creek has mixed stream habitat conditions. Future development in this area could have a significant impact because most of the metrics are in the range of non-functioning.

Table 3: Curtin Creek Metrics

Metric	Value	Functioning Criteria	Non-Functioning Criteria
Percent Forested (2000 Landsat)	7	> 65 %	< 50 %
Percent TIA (2000 Landsat)	39	< 5 %	> 15 %
Road Density 2007 data (miles/mile2)	12	< 2/mile	> 3/mile
Stream Crossing Density (crossings per stream mile)	2	< 3.2/mile	> 6.4/mile
Percent EIA estimated from the Comprehensive Plan	36	< 10 %	> 10 %

Forest Cover

The proportion of a watershed in forest 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 reduced riparian shade, less wood debris delivery to streams, increased stormwater runoff, and increased fine sediment delivery due to mass wasting. The same research indicates that when forest cover drops below 50 percent watershed forming processes are non-functioning.

The Curtin Creek subwatershed has almost no intact forest cover, and is categorized as “non-functioning”. Most of the forest is found as scattered woodlots outside the urban growth boundary. A review of 1955 aerial photos showed that most of the basin was small farm fields.

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 area is 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 of less than five percent as fully functional and greater than 15 percent as non-functional habitat is a reasonable indicator of habitat quality. Curtin Creek had a 39 percent TIA estimate. In some cases, the interpretation of the satellite images tends to overestimate the level of urbanization and the actual amount of TIA could be lower. Also, in Curtin Creek subwatershed, almost all of the impervious area east of 87th Avenue drains to stormwater infiltration facilities.

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, almost all of Clark County is non-functioning. Urban streams have road densities approaching 15 to 20 miles per square mile. Curtin Creek road density is 12 miles per square mile, typical of a mix of urban and rural land use.

Stream Crossing Density

Stream crossing density is easily measured using available road and stream channel data. The salmon protection standard considers larger fills over 60 feet wide, which would be approximately five to ten foot high road fill. According to NOAA Fisheries standards, Curtin Creek is functional for salmon habitat.

Effective Impervious Area

Impervious area that collects and drains the water directly to a stream or wetland system via pipes or sheet flow is considered “effective impervious area” because it effectively drains the landscape. Impervious area that drains to landscaping, swales, parks and other pervious areas is considered “ineffective” because the water is allowed to infiltrate through the soil and into ground water without a direct connection to the stream or wetland. 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 2008 Comprehensive Plan guides development for the next few years and when used to estimate effective impervious area it can provide a metric for expected hydrologic impacts due to development. Future effective impervious area estimated for Curtin Creek subwatershed under the 2008 Comprehensive Plan is estimated to be 36 percent. This EIA estimate, based on standard land use types, is probably too high because much of the storm runoff in the east half of the basin drains to infiltration facilities and is not conveyed to the stream.

Estimated Channel Stability Based on Forest and EIA

In a recent publication by Booth, Hartley, and Jackson (June 2003), a relationship between forest and percent EIA was presented as graphic (Figure 2). According to this figure, Curtin Creek is predicted to have predominantly unstable channels under current and future conditions if increased runoff is not managed properly.

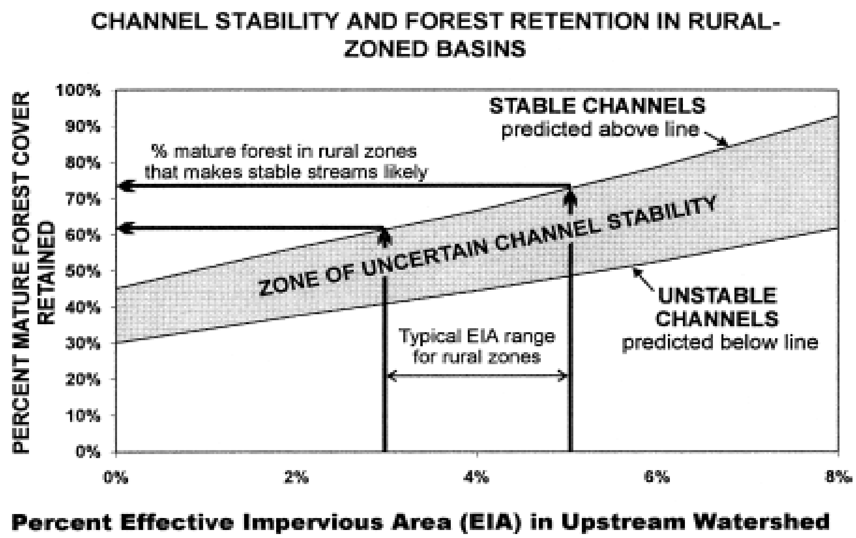


Figure 2: Channel Stability in Rural Areas (Booth, Hartley, and Jackson, June 2002)

Water Quality Assessment

This section briefly summarizes and references available water quality data from the Curtin Creek watershed. 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 current Washington State water quality standards, Curtin Creek is to be "protected for the designated uses of: core summer habitat; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values" (WAC 173-201A-600).

Table 4 summarizes currently applicable water quality criteria for Curtin Creek. With the exception of toxics, these characteristics are included in, or addressed by the Curtin Creek dataset.

Table 4: Applicable Water Quality Criteria for Curtin Creek

Characteristic	2006 Ecology Criteria
Temperature	≤ 16.0 °C (60.8 °F)
Dissolved Oxygen	≥ 9.5 mg/L
Turbidity	shall not exceed 5 NTU over background when background is 50 NTU or less
Ph	6.5 – 8.5 units
Fecal Coliform Bacteria	Geometric mean fecal coliform concentration not to exceed 100 colonies/100mL, and not more than 10% of samples exceeding 200 colonies/100mL.
Aesthetics	Aesthetic values must not be impaired by the presence of materials or their effects… which offend the senses of sight, smell, touch, or taste
Toxics	Toxic substances shall not be introduced… which have the potential…to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health

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

303(d) Listed Impairments
The 2002/2004 303(d) list of impacted waters may be found on the Ecology website at:

http://www.ecy.wa.gov/programs/wq/303d/index.html.

Curtin Creek contains segments that are Category 5 listed (polluted waters that require a TMDL) for dissolved oxygen and pH, and Category 4a listed (Polluted waters that have an approved TMDL) for fecal coliform.

A Category 5 listing requires Ecology to develop a Total Maximum Daily Load (TMDL) or Water Quality Improvement Project for the water body. A TMDL is the amount of pollutant loading that a given water body can receive and still meet water quality standards. For non-point pollution sources, TMDLs are implemented through Load Allocations and non-regulatory programs.

Implementation activities by several local agencies are ongoing in Curtin Creek under the approved Salmon Creek fecal coliform TMDL.

Clark County Stream Health Report
In 2004, the CWP compiled available data and produced the first county-wide assessment of general water quality.

Based on available data including fecal coliform bacteria, general water chemistry (temperature, pH, and dissolved oxygen), and benthic macroinvertebrate scores, overall stream health in the lower Curtin Creek subwatershed scored in the poor range. A simple land-use model predicted poor stream health in the remainder of the watershed.

The 2004 Stream Health Report may be viewed on the county website at http://www.clark.wa.gov/water-resources/stream.html.

Available Data
Data and information sources reviewed or summarized as part of this water quality characterization are shown in Table 5.

Table 5: Data and Information Sources

Source	Data and/or Report
Clark County Clean Water Program	2002-2006 Long-term Index Site Project 2004 Stream Health Report and draft reports Salmon Creek Summer 2003 Stream Temperature
Ecology	303(d) List of Impaired Waterbodies

Water Quality Summary

The following water quality summary is based primarily on monthly data collected between May 2002 and December 2006 at Curtin Creek station CUR020, located at NE 139th Street.

The data are presented in terms of a multi-characteristic water quality index, followed by summaries of several individual characteristics. Summarized water temperature data collected from approximately May through September between 2002 and 2006 are also included. Figure 3 shows the approximate locations of Clark County monitoring stations in Curtin Creek.

Oregon Water Quality Index (OWQI) Scores

The OWQI was developed by the Oregon Department of Environmental Quality (ODEQ) as a way to improve understanding of water quality issues by integrating multiple characteristics and generating a score that describes water quality status (Cude, 2001). It is intended to provide a simple and concise method for expressing ambient water quality.

The OWQI integrates eight water quality variables: temperature; dissolved oxygen; biochemical oxygen demand; pH; ammonia plus nitrate nitrogen; total phosphorus; total solids; and fecal coliform. For each sampling event, individual sub-index scores and an overall index score are calculated. Overall index scores are aggregated into low flow (June through September) and high flow (October through May) seasons and a seasonal mean value is then calculated.

Index scores are categorized as follows:

very poor = 0 to 59; poor = 60 to 79; fair = 80 to 84; good = 85 to 89, and; excellent = 90 to 100.

Figure 4 shows seasonal mean OWQI scores for station CUR020 from 2002 through 2006. Among 15 county-wide long-term water quality monitoring stations, Curtin Creek station CUR020 ranked worst in overall water quality during this period (Hutton and Hoxeng, 2007).

Individual monthly OWQI values since 2002 were in the Very Poor or Poor category every month. However, an examination of sub-index scores indicates that these low scores overall were heavily influenced by very low scores for inorganic N and total solids. Monthly sub-index scores for inorganic N were in the very poor range on 47 of 48 sampling occasions, and on 33 of those occasions scored the minimum possible OWQI metric score (10). Total solids scored in the very poor category on 45 of 48 sampling occasions.

Monthly sub-index scores for fecal coliform, pH, and stream temperature were consistently good or excellent, while dissolved oxygen and total phosphorus ranged from poor to excellent and showed wide seasonal variations.

Figure 3: Curtin Creek Watershed Monitoring Stations

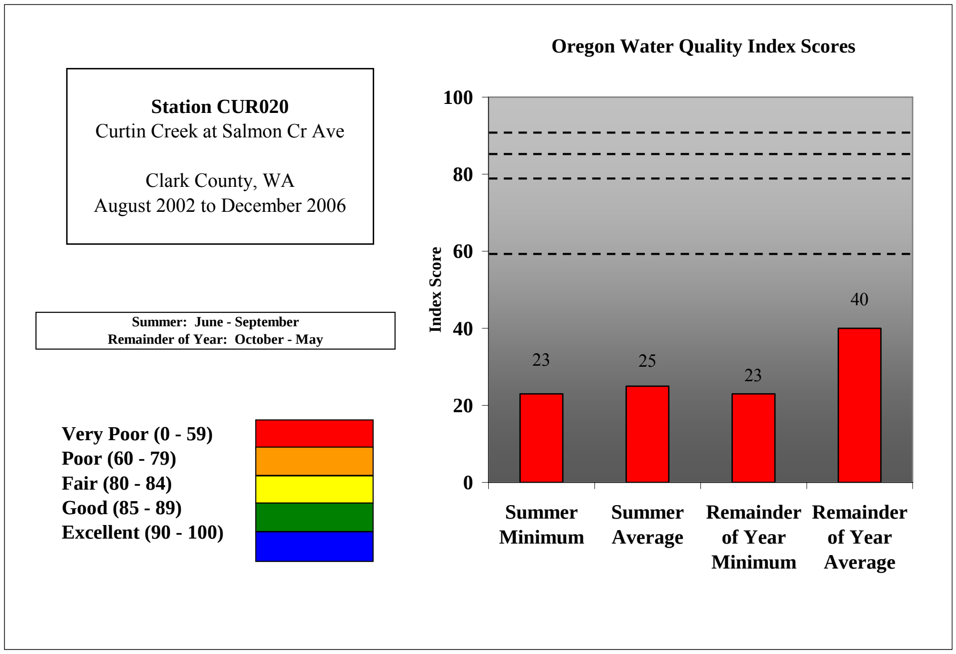


Figure 4: Average Water Quality, Curtin Creek Station CUR020, 2002-2006. Oregon Water Quality Index.

Trends over Time

An analysis of potential statistical trends in OWQI scores based on the 2002 through 2006 dataset found no significant water quality trends at station CUR020 (Hutton and Hoxeng, 2007).

Fecal Coliform Bacteria

The overall range of sample values at station CUR020 was 2 cfu/100mL to 1190 cfu/100mL. Figure 5 shows seasonal geometric mean fecal coliform values from August 2002 through December 2006. Based on 18 sampling events, the summer (June through September) geometric mean was 123 cfu/100mL, slightly out of compliance with the state criterion (100 cfu/100mL). Based on 35 sampling events, the Fall/Winter/Spring (FWS) (October through May) geometric mean was 34 cfu/100mL and in compliance with the state criterion.

Station CUR020 also failed to meet the ten percent criterion during summer, with 22 percent of summer samples exceeding 200 cfu/100mL. Only two of 35 (6 percent) of FWS samples exceeded 200 cfu/100mL.

The ten percent criterion may also be evaluated by examining the 90th percentile values. The criterion is met if the 90th percentile value is 200 or lower. For the CUR020 dataset, the summer and FWS 90th percentile values were 342 and 154 cfu/100mL, respectively.

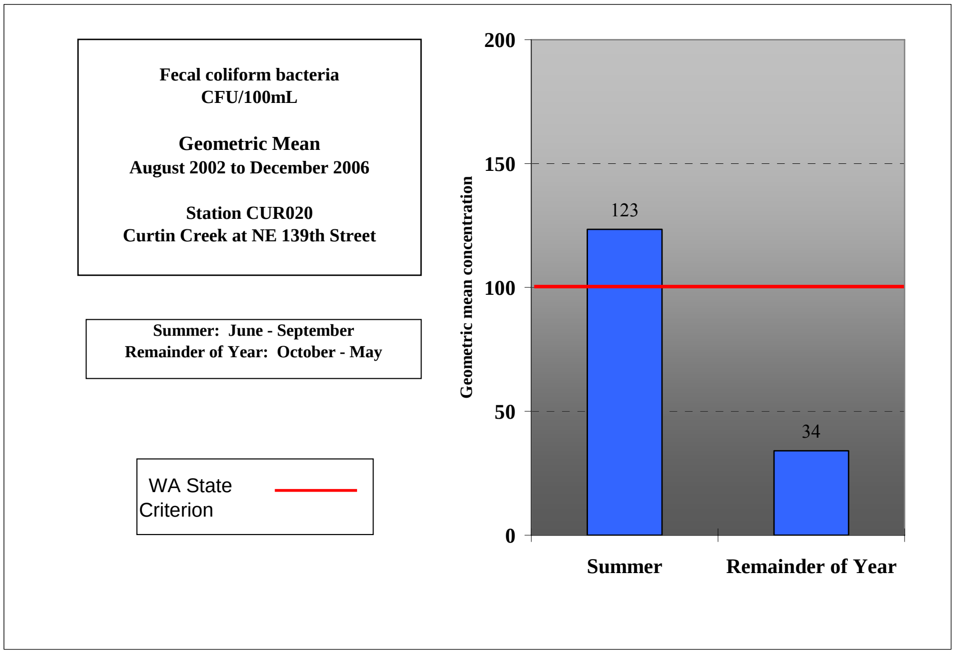


Figure 5: Seasonal geometric mean fecal coliform, Curtin Creek station CUR020, August 2002 through December 2006.

Nutrients

Nutrient criteria are not established for Washington streams. US 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 nitrogen in excess may contribute to elevated levels of algal or plant growth, especially in slower moving, low gradient streams or in downstream water bodies.

Total phosphorus samples from CUR020 between August 2002 and December 2006 ranged from 0.028 mg/L to 0.134 mg/L, and only one out of 53 samples exceeded the EPA criterion of 0.100 mg/L. Total phosphorus concentrations typically vary seasonally in many locations; however, seasonal median values in Curtin Creek are nearly identical:

- Summer median = 0.059 mg/L
- FWS median = 0.055 mg/L

Inorganic nitrogen concentrations ranged from 0.773 mg/L to 6.27 mg/L. The majority of values were in the 3 to 4 mg/L range, typical of many groundwater-dominated streams such as Curtin Creek. Concentrations in this range, though not harmful to human health under EPA criteria, are high enough to substantially affect OWQI scores for the stream.

Turbidity
It is difficult to establish an exact background turbidity level for Curtin Creek because no data exists from a time when Curtin Creek was not impacted by human activities. However, based on data from the least impacted streams monitored by the CWP, 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 Curtin Creek is likely between 5.5 and 7 NTU.

Since August 2002, the median of 53 turbidity samples at CUR020 was 2.2 NTU, with individual samples ranging from 0.8 NTU to 11 NTU. Turbidity varied somewhat seasonally, with the FWS median more than double the summer median:

- Summer median = 1.2 NTU
- FWS median = 3.5 NTU

Among 15 CWP-operated long-term monitoring stations countywide, Curtin Creek station CUR020 ranked 3rd best in average turbidity from 2002 through 2006.

pH
Median pH for both summer and FWS periods from 2002 through 2006 was 6.9 pH units, with only three out of 48 samples not meeting the state criterion during this period.

Dissolved Oxygen
Groundwater is typically fairly low in dissolved oxygen, and though concentrations in Curtin Creek rarely fall below 7 mg/L, the core summer habitat designation of this stream requires consistently high dissolved oxygen (>9.5 mg/L). Only eight of 52 (15 percent) dissolved oxygen measurements from 2002 through 2006 were in compliance with the criterion.

Stream Temperature
In addition to monthly temperature readings incorporated into OWQI calculations, continuous temperature loggers recorded hourly temperature values between May and October during 2002 to 2007 (except no data in 2003). Continuous readings provide a more complete picture of temperature dynamics than monthly grab samples.

Table 6 summarizes the continuous temperature data. The 7-Day average maximum value is the maximum of the seven-day moving average of daily maximum temperatures. The 2006 Ecology standards utilize this metric to determine temperature compliance for protecting salmonid habitat as a beneficial use (Curtin Creek criterion is 60.8° F). Maximum daily ΔT is the maximum daily temperature fluctuation, and gives some indication of the susceptibility of the stream to heat input.

Table 6: Seasonal Maximum, 7-Day Moving Average and Maximum Daily Temperature Change at Curtin Creek Station CUR020			
7-Day average		Maximum daily ΔT	
Date	Maximum	Date	Value
CUR020:			
07/12/02	60.5	07/09/02	6.8
06/05/04	59.6	06/06/04	6.5
05/27/05	61.2	07/28/05	5.5
06/27/06	61.0	06/25/06	5.8
06/01/07	60.3	05/08/07	6.4

Summer stream temperatures at CUR020 were very consistent and the 7DAD-Max remained within a few tenths of a degree of the 2006 state criterion in each year monitored.

Due to the negative effects of chronic high temperatures on salmonids and other cold-water biota, the amount of time spent with elevated temperatures is also of interest. Sixty-four degrees F was the Class A criterion prior to the November 2006 rule changes, and is a threshold above which salmonids are known to suffer deleterious effects. Based on the available dataset, there have been zero days since 2002 when stream temperature exceeded 64 degrees F.

A 2003 CWP investigation of summer stream temperatures at 15 locations in the Salmon Creek watershed also indicated that the CUR020 station had the coldest water temperatures of any sampled station (Schnabel, 2004).

<u>Impacts to Beneficial Uses and Potential Sources</u>
General water quality in Curtin Creek is poor according to the OWQI; however, the low scores are attributable primarily to high nitrate and total solids concentrations, both common in streams with a large amount of groundwater input. Water quality based on most other monitored characteristics is typically in the good to excellent range, with occasional lower scores.

Observed levels of OWQI parameters are not likely to have significant impacts on the listed beneficial uses of Curtin Creek. Several parameters of interest are discussed briefly below.

Fecal Coliform Bacteria
Primary contact recreation is impacted by elevated counts of fecal coliform bacteria which indicate the possible presence of pathogens. Although water contact may take place year-round, elevated bacteria counts are of particular concern during the summer months when the majority of water contact recreation occurs. Although Curtin Creek has no developed swimming or wading areas, it is likely that some local residents; particularly children, utilize the creek for

recreation. Although fecal coliform concentrations are typically low, there is some risk of illness associated with occasional spikes in concentration during the summer months.

pH

There is very little evidence in the 2002 through 2006 dataset to support the continued listing of Curtin Creek for pH on the 303(d) list of impaired water bodies. Clark County did not submit data during the most recent Ecology data solicitation; however, data will likely be submitted for future 303(d) compilations and may result in removal of this listing.

Dissolved Oxygen

Dissolved oxygen concentration consistently fails to meet the state criterion for core summer habitat, which supports continued listing on the 303(d) list of impaired water bodies.

Turbidity and Solids

Curtin Creek exhibits among the lowest routine turbidity levels based on county-wide monitoring data.

Total solids concentrations are fairly high and contribute to low overall OWQI scores. However, the suspended fraction appears to be fairly low, with the dissolved fraction making up the bulk of the total solids concentration. Naturally elevated dissolved solids is likely driven by underlying geology, given the influx of large amounts of groundwater in the stream reach immediately upstream of station CUR020.

Nitrate (inorganic N)

Groundwater in Curtin Creek is high in nitrate. Naturally elevated concentrations stemming from the underlying geology may be augmented by nutrients from fertilizers, leaking septic tanks and sewer infrastructure, wildlife, and direct livestock access.

Although algae and plant growth is significant in lower Curtin Creek during the summer months, the overall turbidity remains very low.

Implications for Stormwater Management

The overall implication for stormwater management is the need to focus on preserving the favorable water quality in Curtin Creek. Listed beneficial uses are currently supported to a large extent; the success or failure of future stormwater management activities will likely have a significant impact on water quality in this rapidly urbanizing subwatershed.

Drainage System Inventory

Clark County's drainage system inventory resides in the StormwaterClk GIS database and is available to users through the county's Department of Assessment and GIS, or through the Digital Atlas located at:

http://gis.clark.wa.gov/imf/imf.jsp?site=digitalatlas&CFID=56651&CFTOKEN=98300052

The drainage system inventory is an ongoing CWP programmatic element focused on populating and updating the StormwaterClk database to include all existing stormwater drainage infrastructure.

Priority effort during 2007 was directed toward identifying and mapping previously un-mapped discharge points and stormwater facility polygons to support the Illicit Discharge Detection and Elimination Screening project (IDDE) and Public Facility Inspection project. Curtin Creek was a high priority for mapping in support of both of these activities. Table 7 indicates the number of features previously inventoried in StormwaterClk prior to 2007 SNAP work, and the number of features added to the database as a result of 2007 SNAP implementation.

The drainage system inventory for the Curtin Creek subwatershed was largely complete at the conclusion of 2007 SNAP implementation; however, it is estimated that existing historical mapping contains many errors. Staff availability was insufficient to complete this task as scheduled. Inventory completion and correction is ongoing in 2008 and 2009 as part of a county-wide inventory update.

Table 7: Drainage System Inventory Results, Curtin Creek

Database Feature Category	Previously Inventoried	Added to Database during 2007 SNAP
Inlet	1806	398
Discharge Point	50	28
Flow Control	33	23
Storage/Treatment	743	138
Manhole	774	167
Filter System	35	30
Channel	280	77
Gravity Main	3631	875
Facilities	187	80

Stormwater Facility Inspection

The Public Stormwater Facility Inspection project is designed to meet requirements of Clark County's 2007 NPDES permit which requires an ongoing inspection program for county stormwater treatment and flow control facilities.

The stormwater facility inspection process includes two components:

- A public stormwater facility inspection using state and county standards.
- An off-site inspection to check for problems such as downstream bank erosion.

Component 1: Public Stormwater Facility Inspection

Purpose

The purpose of the Public Stormwater Facility Inspection project is to verify that maintenance activities are implemented; facilities are properly functioning, and identify possible retrofit projects and major repairs.

Methods

The Public Stormwater Facility Inspection project is derived from 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 that may need repairs, the condition when repair or maintenance is needed, and the expected results. Individual components of a facility are referred to as "facility objects" and are listed in Table 8.

The public stormwater facility inspection process involves inspecting all facility objects to determine if all maintenance is in compliance with the standards. If any facility object does not meet the maintenance standards, the entire facility is not in compliance. Noncompliant stormwater facilities are referred to the appropriate public works departments for repairs or maintenance.

Results

Based on the county's StormwaterCLK database, as of December 2007, there were 85 mapped public stormwater facilities in the Curtin Creek subwatershed.

Figure 6 summarizes notable inspection activities including general facility location, compliant facilities and referrals of noncompliant facilities.

As listed in Table 1, 83 out of the 85 public stormwater facilities were inspected, including facilities in new developments under maintenance warranty bonds. These facilities included a total of 546 facility objects or components that were inspected. Of the 546 facility objects inspected, 437 (80 percent) of the facility objects were in compliance. The remaining 109 (20 percent) of the facility objects were not in compliance.

The inspection process generated 43 referrals: one referral was to the Capital Improvement Program (CIP) for a possible retrofit opportunity; one referral was to the Clark County Public Works Code Enforcement; one referral was to the Clark County Public Works Clean Water Program engineer; and 40 referrals were to Public Works Maintenance and Operations for needed maintenance activities.

Maintenance Referrals

Referrals made to the public works maintenance and operations department have been either brought into compliance, or will be scheduled for repair or maintenance in early 2008. As of December 2007, public works maintenance and operations have brought 16 of the 40 non-compliant facilities into compliance, including a total of 25 facility objects.

Once referrals are addressed, the CWP revisits facilities to conduct a second inspection to ensure compliance.

No major defects or hazardous conditions were discovered; non-compliant issues included excess sediment depth, trash or debris, and lack of signage.

Retrofit Opportunities

The public facility inspection process in the Curtin Creek subwatershed yielded two retrofit opportunities. These opportunities include retrofitting a bioswale, a drainage ditch, and a pond to better treat stormwater runoff.

Management Recommendations

The most common facility objects found out of compliance during the public stormwater facility inspection process were catch basins, StormFilter® treatment vaults, and facility fencing.

Catch basin defects included sediment exceeding 60 percent of sump depth, and storm pipe damaged preventing normal function. StormFilter® defects included sediment accumulation on media and sediment accumulation in vault. Facility fencing defects consisted of missing or unreadable water quality signs. These defects were consistent with inspection results for public stormwater facilities from other subwatersheds.

Maintaining catch basins, StormFilter® vaults, and providing appropriate water quality signs for stormwater facilities will bring most facilities into compliance.

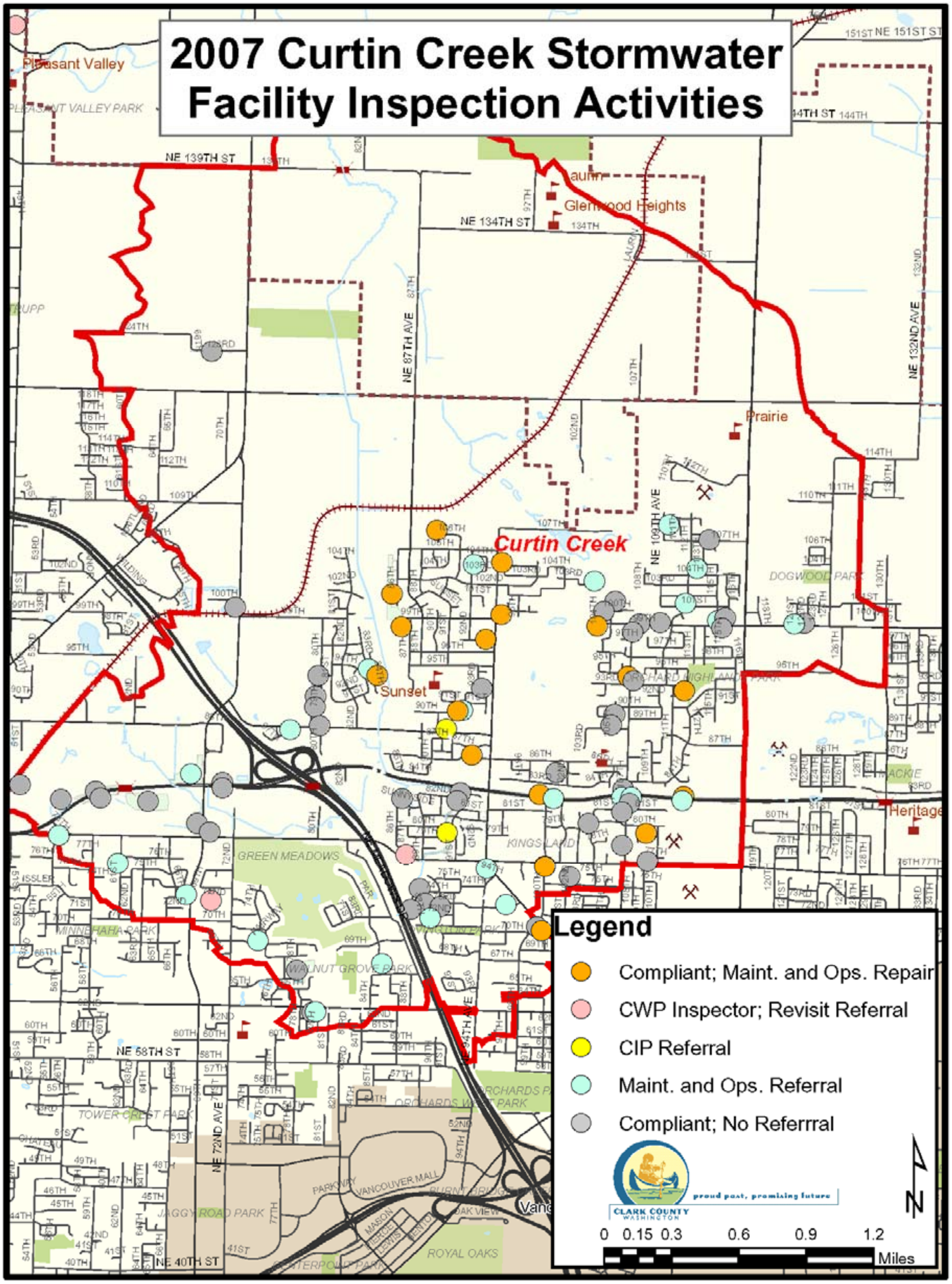


Figure 6: Summary of 2007 Public Stormwater Facility Inspection Activities in the Curtin Creek Watershed

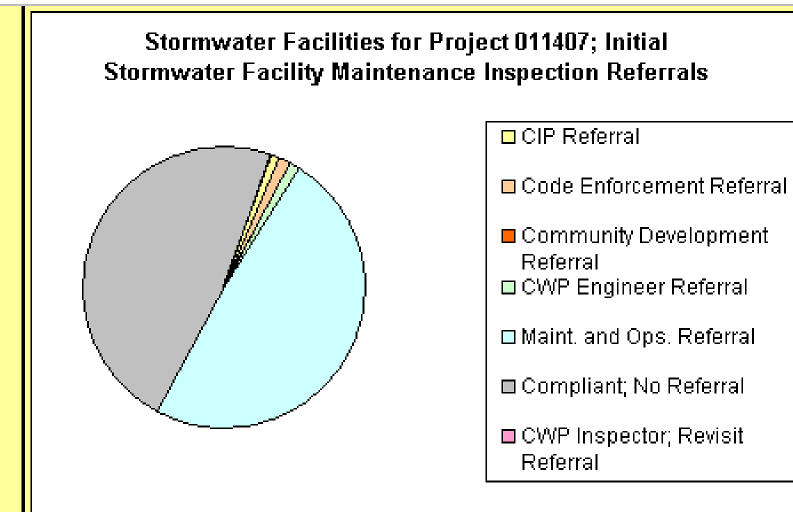
Table 8: 2007 Public Stormwater Facility Inspection Project Activity of the Curtin Creek Watershed

SNAP Public Stormwater Facility Inspections (maintained by Public Works)

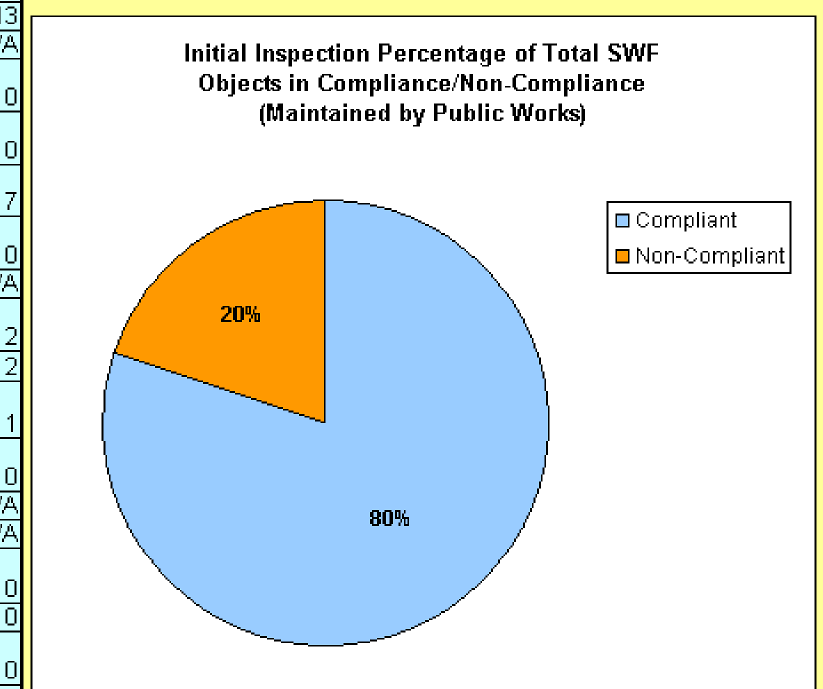
Subject: Curtin Creek Subwatershed; Project 011407 Stormwater Facility Maintenance Inspection Initial Results

Total SNAP SWF Inspections	
Maintained by Public Works	**85**
Compliant	**40**
Non-Compliant	**43**
Not Visited	**2**

Referrals of Non-Compliant Stormwater Facilities		Referral Addressed and Facility Compliant as of December 2007
CIP Referral	1	0
Code Enforcement Referral	1	1
Community Development Referral	0	N/A
CWP Engineer Referral	1	0
Maint. and Ops. Referral	40	16
Compliant; No Referral	40	N/A
CWP Inspector; Revisit Referral	0	N/A



	Initial Inspections				
Facility Objects Inspected	**Compliant**	**Non-Compliant**	**Defect**	**Maintence Trigger**	**Facility Objects Repaired as of December 2007**
Access Road or Easement	92	6	vegetation	vegetation blocking access to personel	
Catch Basin	48	26	sediment & debris	sediment exceeds 60 percent of the sump depth	13
Closed Detention System	N/A	N/A	N/A	N/A	N/A
CONTECH StormFilter	7	7	sediment accumulation in vault	sediment depth exceeds 6-inches in first chamber of vault	0
Control Structure / Flow Restrictor	8	1	sediment & debris	material exceeds 25% of sump depth or 1 foot below orifice plate.	0
Debris Barrier	8	10	trash & debris / litter	trash or debris that is plugging more than 20% of the openings in the debris barrier	7
Detention Pond	13	2	erosion	eroded damage over 2 inches deep on side slope of pond	0
Drainage Trench	11	0	N/A	N/A	N/A
Drywell	43	20	standing water	standing water indicates the drywell is into the water table	2
Energy Dissipater	58	12	rock missing or moved	only one layer of rock exists above native soil	2
Fence, Gate or Water Quality Sign	35	11	sign unreadable	water quality sign is missing or 20% of the surface is unreadable	1
Field Inlet	6	1	Settlement/ Misalignment	failure of basin has created a safety, function, or design problem	0
Infiltration Basin	5	0	N/A	N/A	N/A
Infiltration Trench	9	0	N/A	N/A	N/A
Inlet / outlet storm pipe	18	5	sediment & debris	sediment depth is greater than 20% of pipe diameter	0
Sediment Trap	6	1	Damaged or Missing.	grate missing or broken member(s) of the grate	0
Typical Biofiltration Swale	60	7	erosion / scouring	eroded or scoured swale bottom due to flow channelization	0
Wet Biofiltration Swale	4	0	N/A	N/A	N/A
Wetland	2	0	N/A	N/A	N/A
Wetpond	3	0	N/A	N/A	N/A
Wetvaullt	1	0	N/A	N/A	N/A
Total SWF Objects	**437**	**109**			
Total Percentage	**80**	**20**			



Component 2: Offsite Assessment

Purpose

The purpose of the Offsite Assessment project is to detect possible offsite or downstream problems associated with the county's municipal separate storm sewer system (MS4), particularly from facility outfalls that discharge to critical areas.

Methods

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

- Within 200 feet of a critical area such as a stream channel or landslide hazard area.
- Within 300 feet of a headwater stream.
- Located on public land.
- Discharges stormwater from a public-dedicated facility that is currently under the two year private maintenance warranty bond.

The Offsite Assessment project is based on county and state standards equivalent to the maintenance standards specified in Chapter 4 of Volume V, of the 2005 Stormwater Management Manual for Western Washington. The standards list general design criteria and outfall features critical to reducing the chance of adverse impacts due to concentrated discharges from pipe systems and culverts, both onsite and downstream.

The offsite assessment process involves inspecting all outfalls that discharge into critical areas as well as a 300 foot survey downstream of the outfall to look for any adverse impacts that may be caused by stormwater discharges.

If any assessment does not meet the general outfall design criteria or fails to prevent aggravation or creation of a downstream erosion problem, the outfall is not in compliance. Non-compliant outfalls are referred to the appropriate public works department for maintenance or repair.

Results

Based on the county's StormwaterCLK database, as of August 2007 there were 77 mapped outfalls in Curtin Creek subwatershed that discharged into critical areas. Table 9 summarizes results and Figure 7 summarizes shows the distribution of outfalls and critical areas.

All outfalls that discharged into critical areas were assessed and found to be in compliance.

Potential Projects

No referrals were initiated for the outfall assessment project.

Table 9: 2007 Outfall Assessment Project Activity Summary of Curtin Creek Watershed	
Metric	Number
# of outfalls assessed	77
# of outfalls compliant	77
# of noncompliant outfalls	0
# of referrals initiated	0
# of referrals ongoing	0
# of outfalls fixed	0

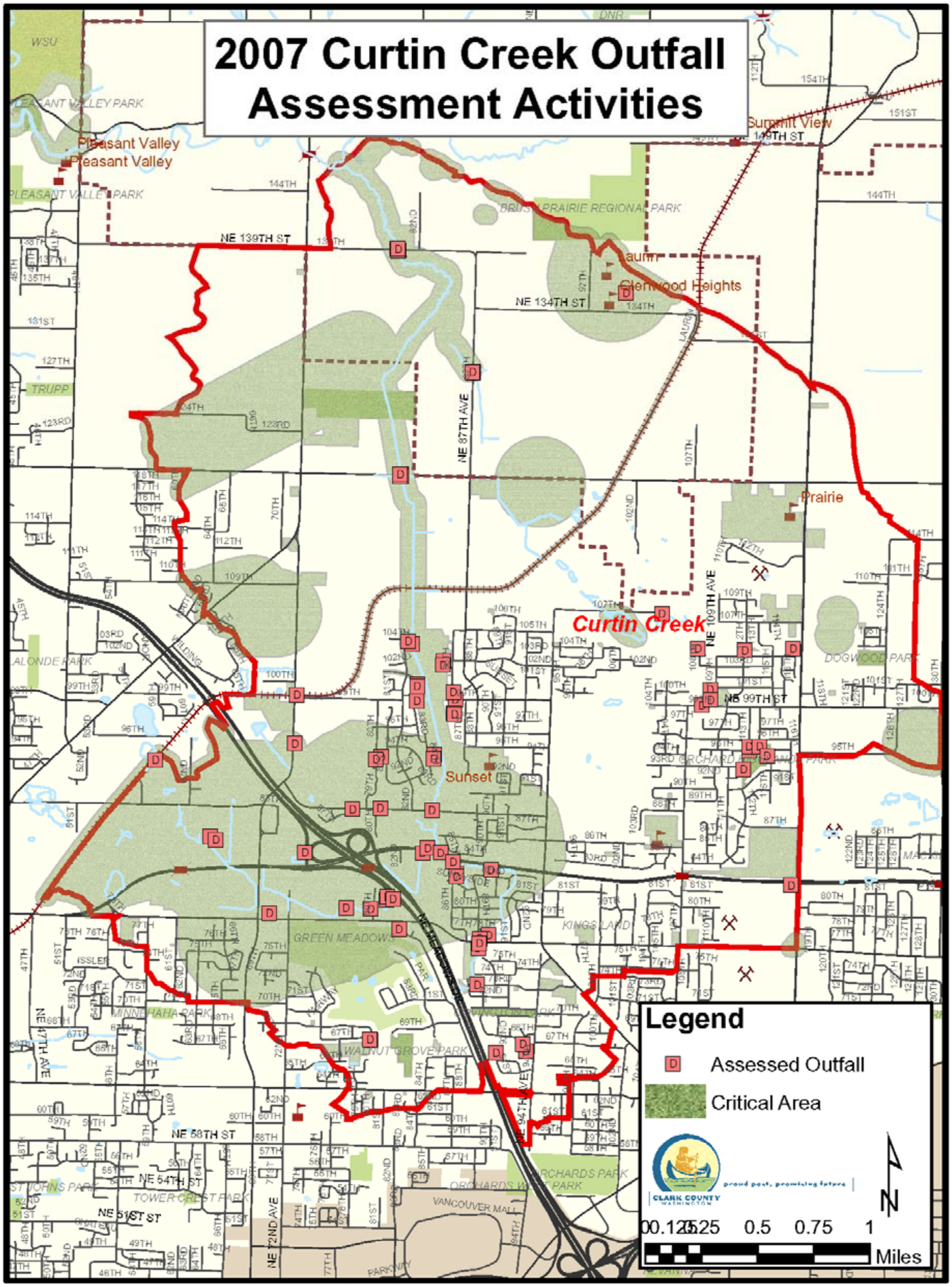


Figure 7: Summary of 2007 Outfall Assessment Activities in Curtin Creek Watershed

Illicit Discharge Detection and Elimination (IDDE) Screening

Purpose

The purpose of the IDDE Screening project is to detect, isolate, and eliminate illicit connections and illicit discharges to Clark County's municipal separate storm sewer system (MS4).

The IDDE screening project is designed to meet the requirements of Clark County's 2007 NPDES permit, which requires identifying and removing illicit connections to the county's MS4.

Methods

IDDE screening includes checking every stormwater outfall for potential illicit discharges, conducting follow-up investigations to track down suspected discharges or connections, and referrals to the proper agencies for termination. Field work is primarily conducted during the dry summer season.

IDDE Screening activities were completed in the Curtin Creek subwatershed during 2007.

Results

Based on the county's StormwaterCLK database, as of August 2007, there were 61 mapped stormwater outfalls in the Curtin Creek subwatershed consisting primarily of pipe outfalls and roadside ditches. Sixteen unmapped outfalls were screened.

Figure 8 summarizes notable screening activities including general outfall locations, outfalls where water samples were collected, follow-up investigations performed, referrals made, and sources removed for Curtin Creek subwatershed.

As summarized in Table 10, 77 outfalls were screened and samples were collected at nine outfalls. Based on laboratory results, follow-up investigations were conducted for two locations. In one investigation, an illicit discharge was confirmed and a source area adequately pinpointed to trigger a referral for removal of the illicit connection. The other investigation confirmed an illicit discharge of fecal coliform and was referred. This referral in ongoing and may be a candidate for fecal source tracking. Fecal source tracking involves using molecular-based methods that utilize host-specific biomarkers to determine if fecal coliform sources are human or animal (non-human).

Table 10: IDDE Screening Project Activity Summary of Curtin Creek Subwatershed as of December 2007	
Metric	Number
# of outfalls screened	77
# of outfalls with sufficient flow to collect water samples	9
# of suspected illicit discharges	2
# of suspected illicit connections	1
# of investigations initiated	2
# of illicit discharge sources located	1
# of illicit connections identified	1
# of outfalls to be re-visited in 2008	2
# of referrals	2
# of illicit discharges removed	0
# of investigations and referrals ongoing	1
# of illicit connections terminated	1
# of cases closed without resolution	0

Samples were collected at nine flowing outfalls as part of the IDDE screening process. Laboratory analysis confirmed illicit discharges from two of the samples. Confirmation of illicit discharges initiated two investigations; investigation ID 76 and investigation ID 75.

Investigation ID 76

A serious illicit discharge for fecal coliform was located and referred to code enforcement through this process. An on-site investigation was coordinated with Clean Water Program section Waste Reduction Specialist, Natural Resources Specialist, and a property owner.

The investigation revealed that based on flowchart analysis of fecal coliform concentration, drainage area investigation, and mapped stormwater conveyance system, a strong possibility that a failing septic tank(s) may be a possible source for the illicit discharge. Removal activities are ongoing for this discharge as of December 2007 (see Case Summary 14248).

Removal activities include education outreach and possible fecal source tracking to determine if fecal coliform sources are human or non-human.

Effectiveness monitoring will be conducted when the illicit discharge is removed in 2008.

Investigation ID 75

A serious illicit discharge for surfactants was located and referred to code enforcement through this process. An on-site investigation was coordinated with CWP section Waste Reduction Specialist, Natural Resources Specialist, and the property owner. The investigation confirmed an illicit connection to a storm drainage ditch disposing of wash water from the private property.

Removal activities were completed in November 2007; all effected catch basins were cleaned out by Clark County Public Works Maintenance and Operations (see Case Summary 802).

Removal activities include education outreach, disconnection of washwater pipe, and removing sediment from the downstream conveyance storm pipe system.

Effectiveness monitoring will be conducted as part of the 2008 IDDE Screening project.

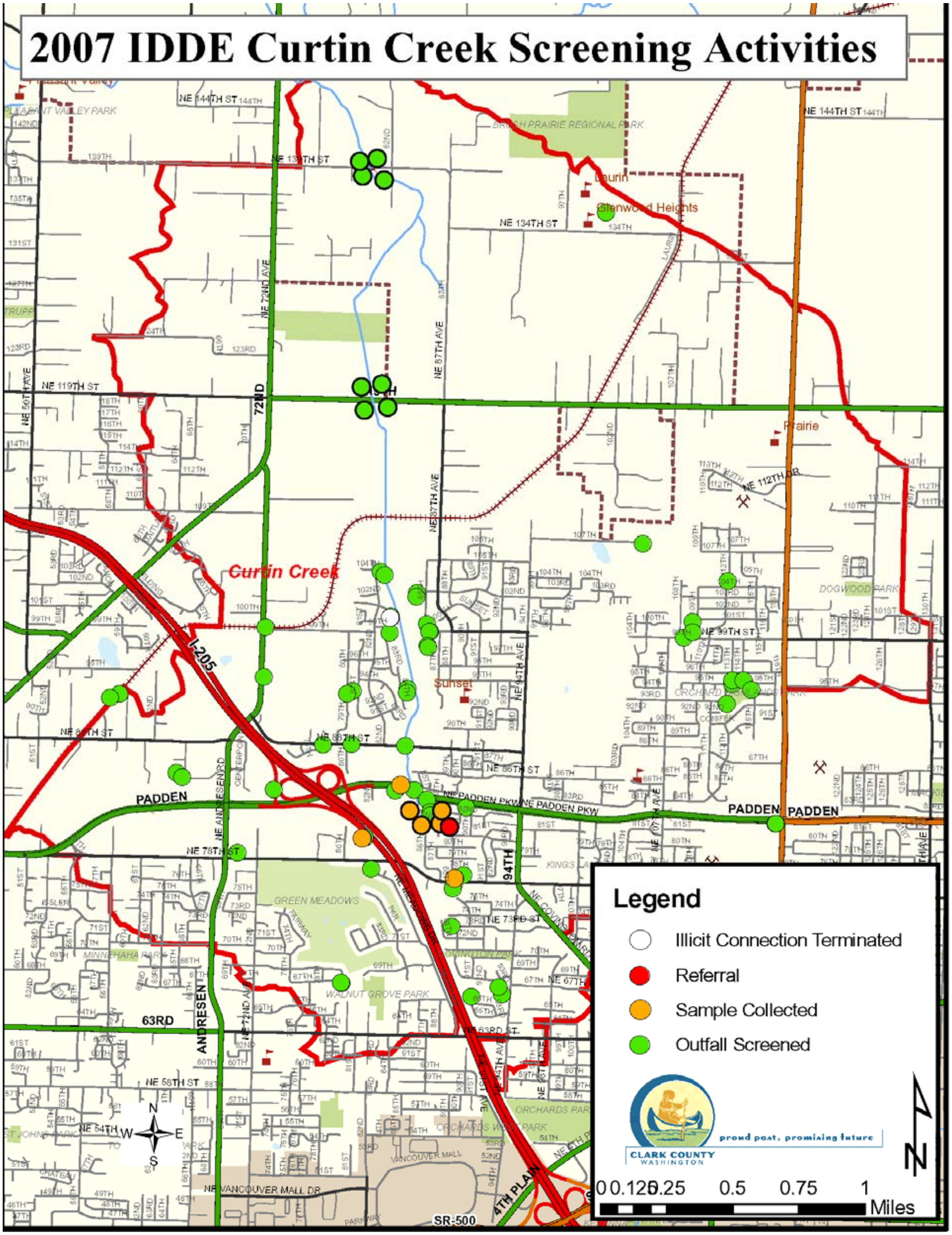


Figure 8: Summary of 2007 IDDE Screening Project Activities in Curtin Creek Subwatershed

IDDE Screening Project
Case Summary: 14248
Date: December 2007

Initial screening location ID: Storm pipe 14248
Location ID Code: Storm Pipe 14248
Investigation ID: 76

Outfall description: Concrete 24”

Drainage area: ~10 ac

Initial Screening
IDDE screening activities were generated by a citizen concern on November 9, 2007.

This pipe outfall was previously screened at an earlier date by the Health Department (Figure 9). Fecal coliform values obtained from the Health Department indicated an illicit discharge (Table 11). Clark County Clean Water Program (CWP) conducted initial IDDE screening activities on December 12, 2007.

Table 11: September 17, 2007

Flowchart	Result	Trigger
Fecal coliform (cfu/100mL)	1,500	>500

Investigation
An onsite investigation was initiated by the Clean Water Program Waste Reduction Specialist and Natural Resources Specialist on December 12, 2007 at multiple sites within the drainage area to isolate possible sources.

Estimated flow at the pipe at the time of sampling was low (~0.02 cfs). Four fecal coliform samples were collected (Figure 10). Sample 1 was taken at the storm pipe outfall. Sample 2 was taken from drainage ditch approximately 300 feet downstream of storm pipe outfall. Sample 3 was taken at the confluence of drainage ditch and Padden Creek. Sample 4 was taken from Padden Creek.

During the investigation, CWP attempted to locate the origin of stormwater pipe with the assistance of private property owners. Private residences indicated failing septic tanks as potential fecal coliform sources.

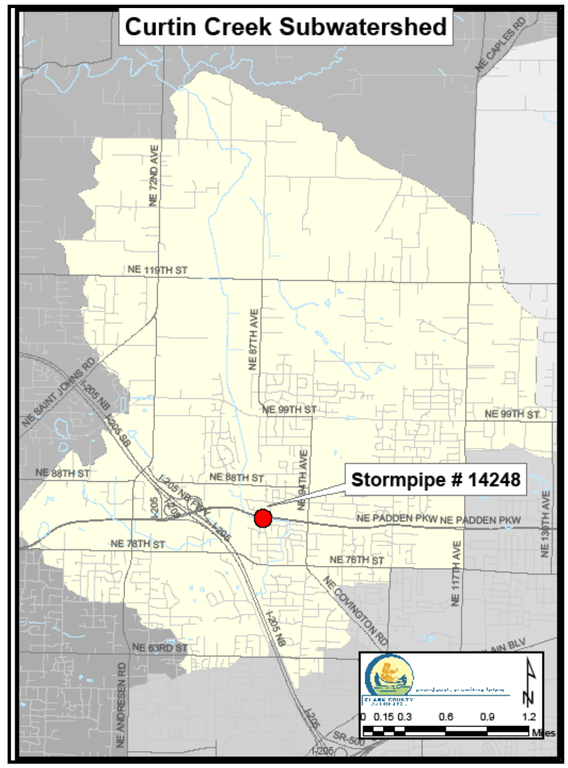


Figure 9: General Location of Storm Pipe #14248

Laboratory results received on December 28, 2007 revealed that fecal coliform values were high for Sample 1 and low for Samples 2, 3, and 4 (Table 12). The investigation indicated, based on flowchart analysis of fecal coliform concentration, drainage area investigation, and mapped stormwater conveyance system, a strong possibility of a sanitary wastewater source.

Referral
The case was referred to the Clean Water Program section Waste Reduction Specialist and to Clark County Health Department for follow-up.

Responsible Party
None at this time.

Corrective Action
None at this time. However, this neighborhood is a potential candidate for direct sanitary sewer hookup.

Table 12: September 17, 2007	
Outfall/Downstream Site	**Fecal Coliform (CFU/100mL)**
Sample 1	5,000
Sample 2	51
Sample 3	46
Sample 4	11

Effectiveness Monitoring
Will be revisited in 2008.

Additional Actions/Discussion:
The Clean Water Program may have fecal source tracking tools in 2008. Fecal source tracking involves using a molecular-based method that utilizes host specific biomarkers to determine if fecal coliform sources are human or non-human. Outfall from storm pipe #14248 will be a candidate for fecal source tracking.

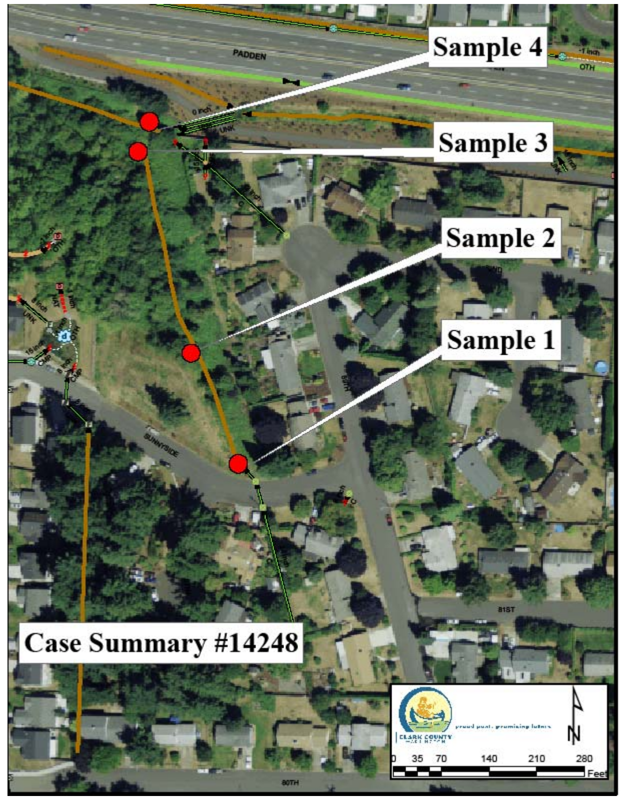


Figure 10: Investigation Map of Storm Pipe #14248

2007 IDDE Screening Project
Case Summary: 802
Date: November 2007

Stormwater Outfall ID: 802
Investigation ID: 75

Stormwater Outfall Description:
Pipe outfall, CMP, 36”

Drainage area: ~30 ac

Initial Screening
Initial screening (Figure 11) was completed on June 27, 2007. Flowchart analysis of surfactants concentration indicated the high possibility of a washwater contamination source (Table 13). Estimated flow at the outfall at the time of sampling was low (< 0.01 cfs).

Table 13: July 13th Laboratory Results

Flowchart	Result (mg/L)	Trigger (mg/L)
Surfactants	1.5	>0.25

Investigation
Laboratory report stating a surfactants value of 1.5 was received on July 13, 2007. New investigation and follow up sampling was conducted by the Clean Water Program on July 23, 2007. Precipitation prevented earlier initiation of investigation.

Outfall #802 was re-sampled on July 23rd for surfactants to confirm the presence of elevated levels. Four additional samples were collected from the storm system upstream from outfall #802 (see Figure 12) as part of a network investigation.

Laboratory results received on August 12th revealed that surfactants concentrations were high at outfall #802 and upstream site “B” on July 23rd (Table 14), suggesting that a continuous illicit discharge was entering the storm sewer along 99th Street.

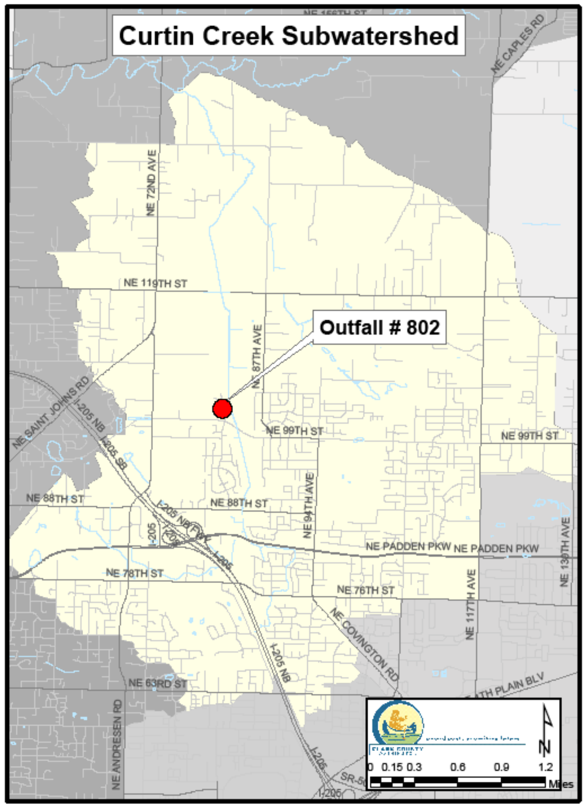


Figure 11: General location of Outfall #802

An ongoing investigation continued for outfall #802 on August 13th. Outfall #802 was re-sampled to further isolate the source of the surfactants discharge. In addition, three additional upstream sites were sampled (Figure 13).

Laboratory results received on August 28th revealed that surfactants concentrations were high at outfall #802, Site E, extremely high at Site F (catch basin), and high at Site G (Table 15). The investigation resulted in the confirmation of surfactants originating from the storm sewer system within the vicinity of 7815 NE 99th Street.

Referral
The case was referred to the Clean Water Program section Waste Reduction Specialist on August 28, 2007.

An on-site investigation was coordinated with Clean Water Program section Waste Reduction Specialist, Natural Resources Specialist, and the private property owner. Investigation confirmed a direct pipe connection to a storm line disposing of washwater from the private property.

Responsible Party
The illicit connection originated from a private residence. The property is located at 7815 NE 99th Street, Vancouver WA, 98662, Tax # 155776-000.

Corrective Action
The washwater line from 7815 NE 99th Street was piped to a roof drain pipe which emptied into a county culvert which drained into the county storm sewer system. The washwater line was disconnected from the roof drain pipe, removed, and plumbed into existing septic system.

Effectiveness Monitoring
Will be revisited in 2008.

Outfall Status
OK

Table 14: August 15th Laboratory Results

Outfall/Upstream Site	Surfactants (mg.L)
802	2.7
A	Non-detect
B	3
C	Non-detect
D	Non-detect

Additional Actions/Discussion:
Clark County Public Works Maintenance and Operations was contacted on November 13th to vacuum out two catch basins between the culvert and outfall #802. Years of this activity accumulated high quantities of surfactant residue (Site F). Maintenance and Operations staff cleaned out both catch basins November 14th.

Table 15: August 28th Laboratory Results

Outfall/Upstream Site	Surfactants (mg.L)
802	0.10
E	0.12t
F	16
G	0.12

Figure 12: Investigation Map of Outfall #802 Conducted on July 23, 2007

Figure 13: Ongoing Investigation Map of Outfall #802 Conducted on August 13, 2007.

Stream Reconnaissance and Feature Inventory

Reach Reconnaissance Survey

No rapid reach assessment was completed for Curtin Creek

Feature Inventory Summary – Curtin Creek Subwatershed

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.

Methods/Limitations

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.

The County, with input from Herrera Environmental Consultants, established geographic scope of the Feature Inventory by 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 16.

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

A GPS position, digital photos, and relevant attribute information were collected for each logged feature. All data and linked photos are stored in the Feature Inventory Geodatabase located on the Clark County server at:

W:\PROJECT\011418, Stream Reconnaissance SNAP\GIS\Data\Geodatabase.

Feature data includes field observations, estimated measurements, and/or notes describing important feature characteristics or potential projects.

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

For additional information pertaining to the Feature Inventory SNAP tool, see Volume 1 of the SNAP.

Study Area

The extent of the completed Feature Inventory in Curtin Creek subwatershed is shown in Figure 14. Approximately 5.3 miles of the stream corridor was assessed in the subwatershed. Within the planned extent of the survey, a total of three notable stream reaches were not assessed. Two of the reaches were omitted based on Clark County's recommendation. Curtin Creek (from NE 99th Street downstream to the railroad bridge crossing) was omitted because this reach is the site of the Curtin Creek Enhancement Area stormwater project currently being constructed by Clark County. Also, the tributary stream commonly referred to as Padden Creek (from NE 82nd Circle downstream to where it exits the culvert north of NE Padden Parkway) was omitted because this reach consists primarily of existing stormwater channels constructed in the county-owned Padden Parkway right-of-way. In addition, the short segment of Curtin Creek within the Interstate 205 (I-205) right-of-way was excluded due to difficult access and safety concerns.

Results/Findings

A total of 98 features were identified in the Curtin Creek subwatershed. A breakdown of recorded features by type is presented in Table 16. Stream crossings were the most prevalent feature type identified, followed by impacted stream buffers, stormwater outfalls, and water quality impacts.

Table 16: Summary of Features Recorded in Curtin Creek Subwatershed

Feature Type	Number of Recorded
AP – Access point	1
ER – Severe bank erosion	2
CM – Channel modification	3
IB – Impacted stream buffer	25
IW – Impacted wetland	1
MI – Miscellaneous point	4
MB – Miscellaneous barrier	3
OT – Stormwater outfall	16
SC – Stream crossing	29
TR – Trash and debris	3
UT – Utility impact	2
WQ – Water quality impact	9
Total	**98**

A map showing the location and type of all recorded features is shown in Figure 15. A larger, poster-sized version of the same map is on file at the County. In addition, specific information collected at each feature can be accessed by using the Feature Inventory Geodatabase.

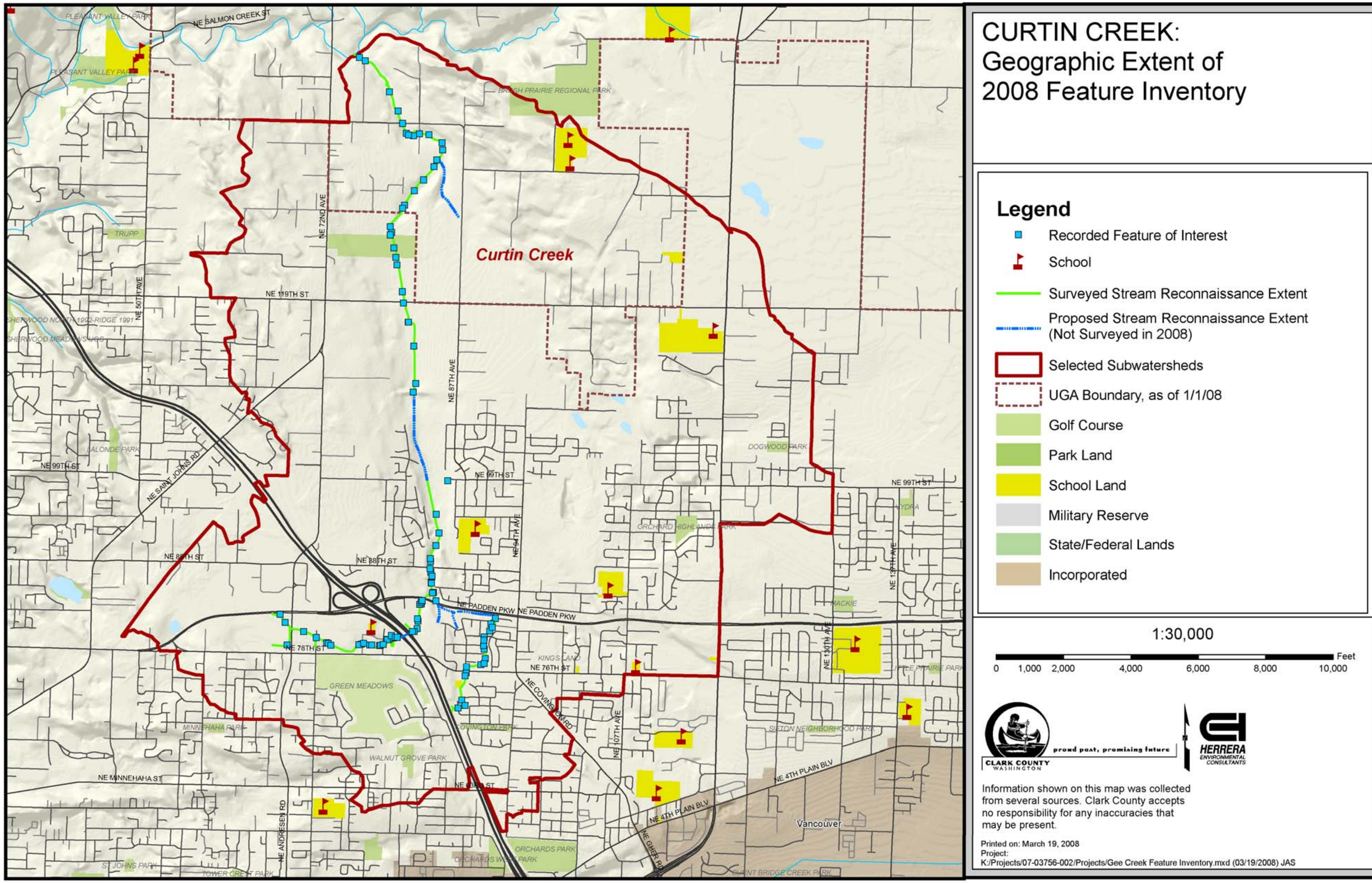


Figure 14: Extent of the Completed Feature Inventory in Curtin Creek

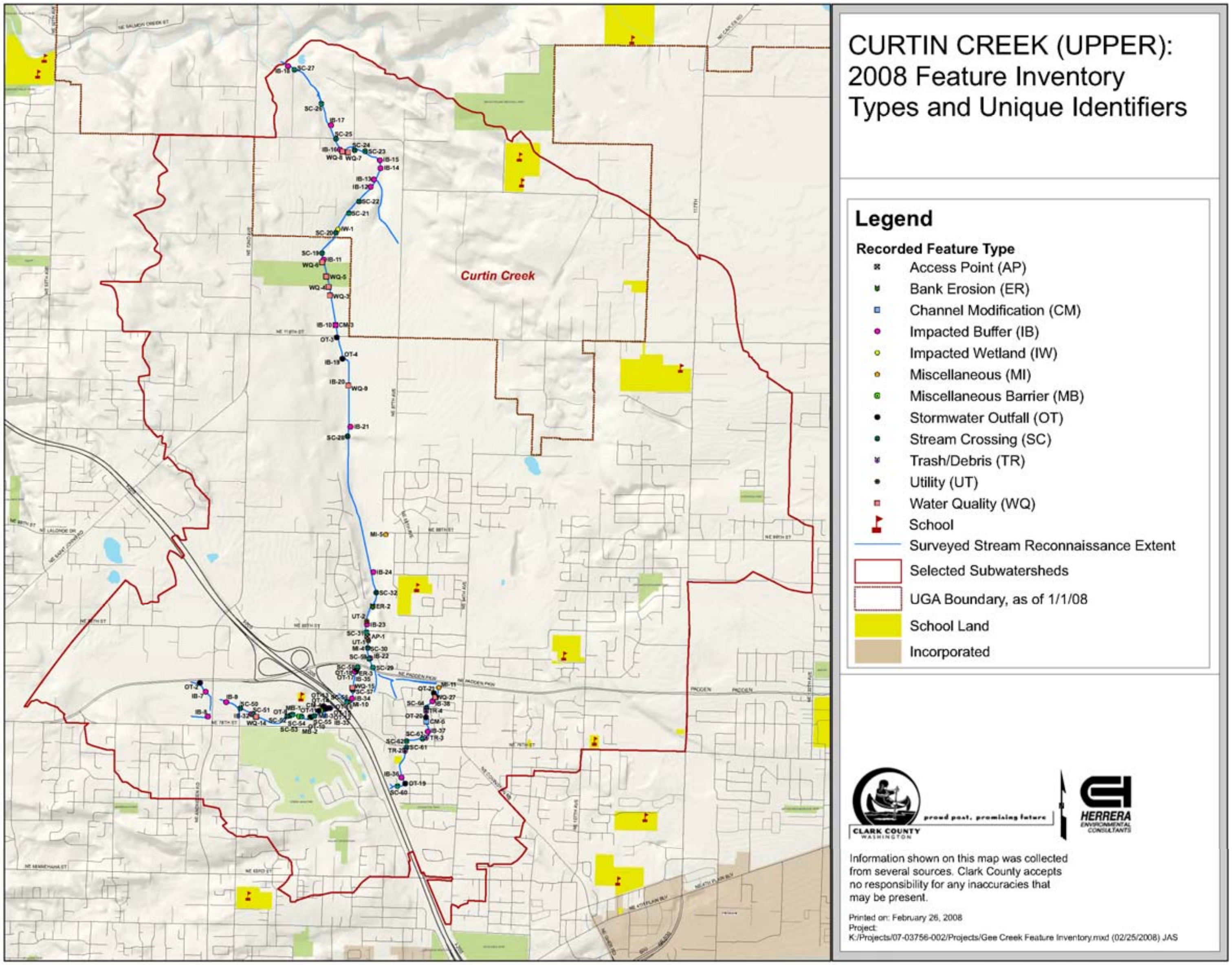


Figure 15: The Location and Type of All Recorded Features in Curtin Creek

The following subsections contain general descriptions of Curtin 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 Curtin Creek and its tributaries is mainly via piped outfalls that drain treated stormwater from engineered stormwater treatment facilities or untreated stormwater directly from the source. Flow in the subwatershed is predominately south to north. The majority of stormwater inputs to Curtin Creek are in the upper subwatershed, south of NE 105th Street. The predominant sources of stormwater in the subwatershed are impervious surfaces related to residential and commercial development, I-205, and NE Padden Parkway.

A function of general topography, outfalls located south of NE Padden Parkway typically drain directly to the stream, while outfalls north of NE Padden Parkway typically drain stormwater to vegetated floodplain or wetland areas adjacent to the stream. One result of this unusual topography is that the Feature Inventory survey, which was generally confined to the vicinity of the stream channel, likely overlooked a number of stormwater outfalls whose discharge points were at the edge of the floodplain corridor, but still as much as 400 feet from the stream.

Riparian Vegetation

Impacted stream buffers are prevalent in the Curtin Creek subwatershed. Riparian vegetation is composed primarily of invasive reed canary grass and blackberry, with a complete lack of mature riparian forest canopy cover, which limits recruitment of woody debris for the stream. Reed canary grass dominates floodplain wetland areas. In many areas, nightshade and reed canary grass are severely encroaching on the channel reducing flow capacity, and severely degrading in-stream habitat.

In some agricultural areas, invasive plant species are being kept in check through grazing. Unfortunately, the heavily grazed areas in the subwatershed are characterized by an overall lack of riparian vegetation.

Excellent wetland restoration potential exists throughout the floodplain areas downstream (north) of NE 90th Street. This area is desirable for restoration because of public land ownership and lack of development within the floodplain. Wetland conditions and water quality would benefit from large-scale invasive species removal and revegetation efforts that strive to reestablish native wetland forest species. Some effort has already gone into restoring portions of this riparian corridor, and additional work should be encouraged. In many instances, these projects would also benefit from channel restoration.

Channel Condition

Generally, stream channels within the surveyed reach are stable, but have a greatly simplified cross-sectional and plan-view geometry. Historically, significant mechanical alteration and construction of stream channels has taken place throughout the watershed to encourage drainage of wet areas for agriculture and development. The southeast tributary commonly referred to as Padden Creek has been straightened and/or excavated multiple times to increase flow capacity. Similar alterations have taken place on Curtin Creek from the headwaters downstream to approximately NE 129th Street.

The channel upstream of the large headcut (ER-3) adjacent to NE Padden Parkway has been extensively modified. The channel is typically very low gradient and exhibits little diversity in bedforms and habitat. Sand and silt deposition were observed in many locations where invasive vegetation is encroaching on the stream and obstructing flow, or manmade obstructions have been constructed. Severe bank erosion was absent from the reach.

From the large headcut (ER-3) adjacent to NE Padden Parkway downstream to NE 92nd Street, the typical channel morphology is planar, and the channel bed is structurally controlled by clay acting as weak bedrock. The gradient is much steeper than that upstream, with numerous randomly distributed vertical steps supported by the well-consolidated and erosion resistant clay bed. Inflections in the profile likely occur along jointing weaknesses. The bed is smooth, with low hydraulic roughness, resulting in supply limited conditions (high transport capacity relative to sediment supply). However, an alluvial veneer in the form of sand and gravel deposition is locally present near areas of increased hydraulic roughness, such as flow obstructions. There was virtually no woody debris present in the channel. The channel exhibits moderate diversity in bedforms and little diversity in habitat. Some bank erosion was present near some of the larger steps in the clay matrix.

The channel has been excavated and heavily modified from NE 92nd Street downstream to NE 119th Street. This is the upstream portion of a narrow, distributary fan that extends downstream (north) to Salmon Creek. Significant sand and silt deposition was observed as a result of a decrease in stream gradient and where invasive vegetation is encroaching on the stream and obstructing flow. The depositional nature of this area gives the channel distributary tendencies.

Downstream of NE 119th Street, there is evidence of significant groundwater adding to stream flows. One landowner mentioned that the stream only stays watered year round downstream of NE 119th Street. The stream has been mechanically widened and channelized downstream to NE 129th Street. Significant sand and silt deposition was observed as a result of invasive vegetation growing throughout the stream channel.

From NE 129th Street to NE 76th Avenue, cross-sectional and plan-view geometry becomes much more complex. Sinuosity increases and the typical channel morphology are best described as an E-type channel (Rosgen 1996) with sand and fine gravel substrate. In other words, it is a stable, single-thread, sinuous channel with typically vertical, fine-grained cohesive banks and a low width-depth ratio. Significant sand and silt deposition was observed in lower velocity areas and sections of channel choked with invasive plants such as nightshade and reed canary grass.

From NE 76th Avenue downstream to Salmon Creek, the channel morphology is plane bed (Montgomery and Buffington 1997) with gravel and cobble substrate. Channel gradient is fairly steep and exhibits little diversity in bedforms and habitat. Sand deposition was observed in a limited number of locations.

The best channel restoration potential exists on Curtin Creek downstream of NE 119th Street. This area is desirable for restoration because of likely minimal conflict with existing landowners and land uses. This area also represents a lengthy, contiguous reach where unfragmented habitat value may be greatly increased for a relatively small investment. Mechanical realignment is necessary to restore fluvial function. Large-scale restoration and reforestation of the adjacent floodplain and riparian corridor is necessary to increase recruitment of woody debris and shading. Engineered structures to facilitate bedform development and capture/sort gravels could improve conditions in the short-term. However, without reforestation and associated recruitment of woody debris from the riparian corridor, installation of engineered structures is not a self-sustaining solution in the long-term.

Additional floodplain wetland restoration potential exists from NE 92nd Street to NE 119th Street.

Additional Results

In other subwatersheds, features of interest were often discovered when field crews ventured up small, first-order tributary channels outside of the area defined by the geographic scope of work. This result indicates that significant stream impairments, potential environmental and safety hazards, and potential project opportunities may exist outside of the geographic scope of this Feature Inventory. However, because almost all first-order tributaries originating in developed or developable areas of the Curtin Creek subwatershed were surveyed, it is unlikely that many additional features of interest are present.

Numerous fences crossing the stream corridor were observed in the Curtin Creek subwatershed. These fences fragment habitat along the riparian corridor and act as a significant navigation hazard for wildlife. In addition, many of the fence crossings accumulate debris at higher flows, causing unfavorable hydraulic conditions, negatively impacting stream morphology and function, and potentially increasing flood hazards.

Potential Project Opportunities

Listed opportunities represent potential projects or project areas. They are concept level projects, and therefore require additional evaluation and development by Clark County or consultant staff prior to submittal to the SCIP process. Identifying potential project opportunities 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 Curtin Creek subwatershed. The CWP will evaluate the potential projects for further development or referral to the appropriate organization. Each potential project is listed in Tables 18 through 23, including the basis for the project and a description of the potential project. The location of each potential project is shown in Figures 16 through 20. Potential project opportunities were categorized into six groups based on the nature of the potential work. A total of 76 potential projects were identified. A summary of identified project opportunities by potential project category is shown in Table 17.

Table 17: Breakdown of Potential Project Opportunities by Category

Potential Project Category	Potential Projects Identified
Emergency/Immediate Actions	5
Stormwater Facility Capital Improvement Projects	10
Stormwater Infrastructure Maintenance Projects	3
Habitat Restoration/Enhancement Projects	1
Property Acquisition for Stormwater Mitigation	0
Referral Projects for other Groups/Agencies	57

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. Emergency/Immediate Actions identified based on the results of the Feature Inventory are described in Table 18.

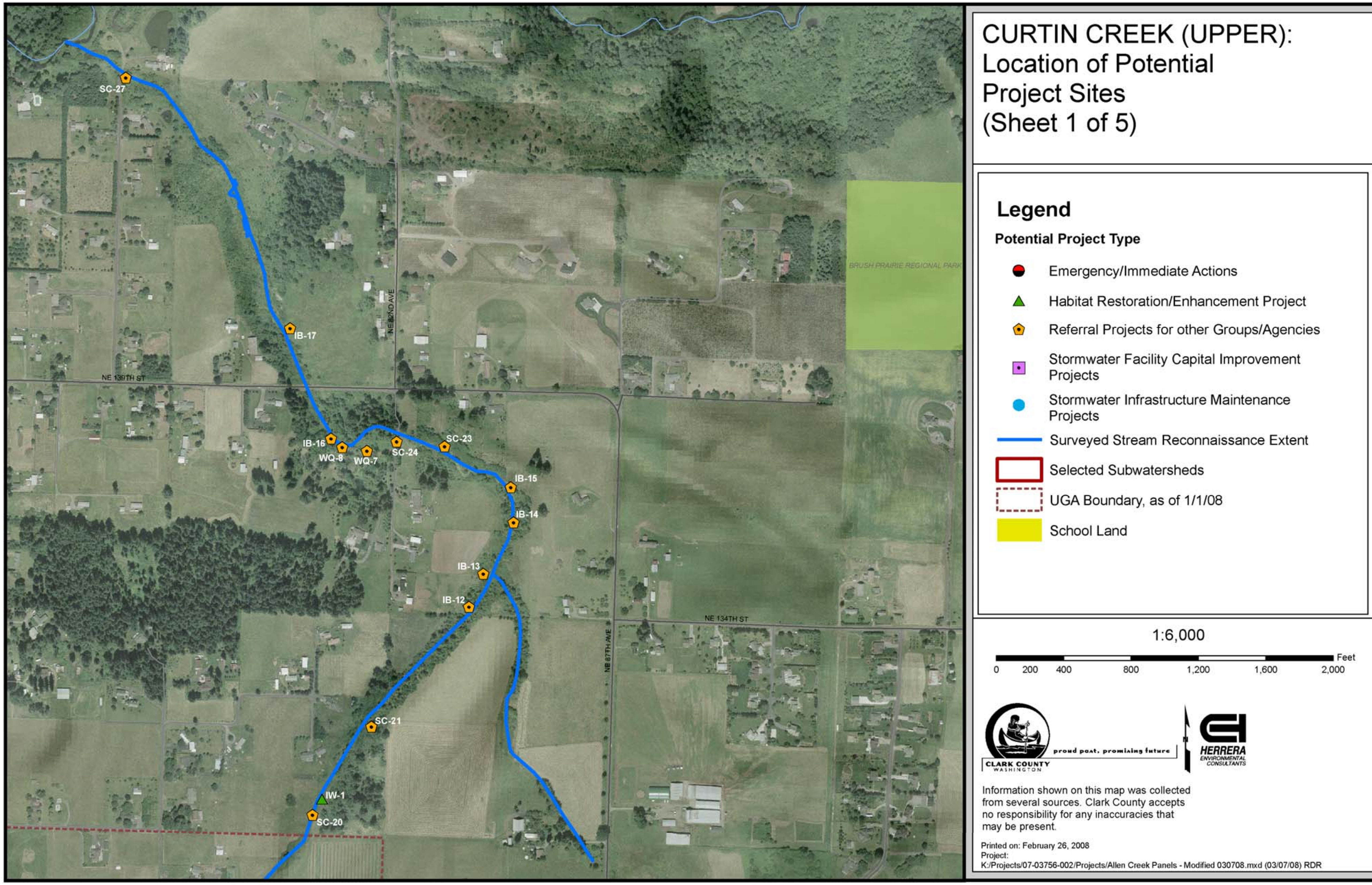


Figure 16: Potential Projects Noted in Feature Inventory

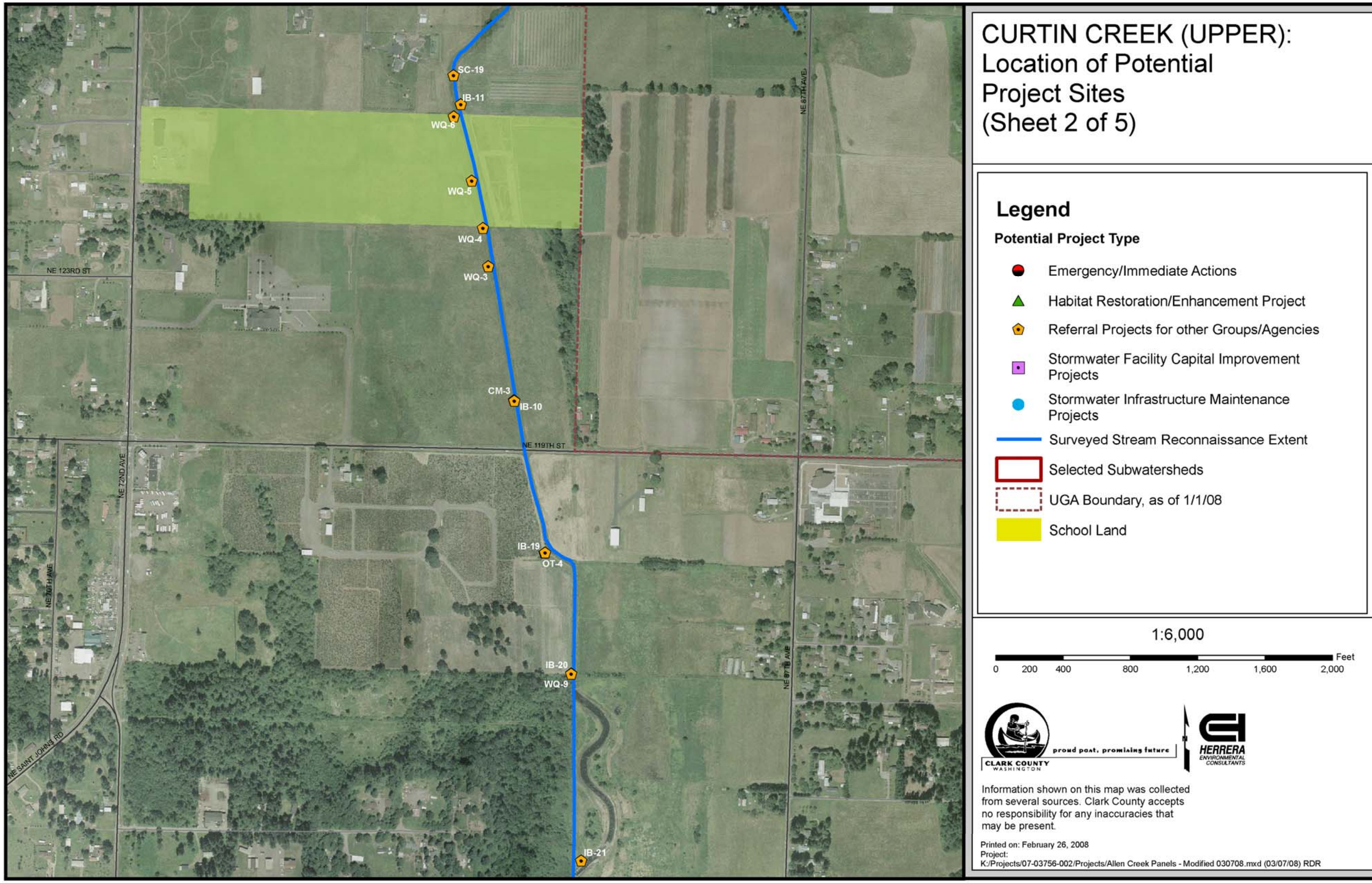


Figure 17: Potential Projects Noted in Feature Inventory.

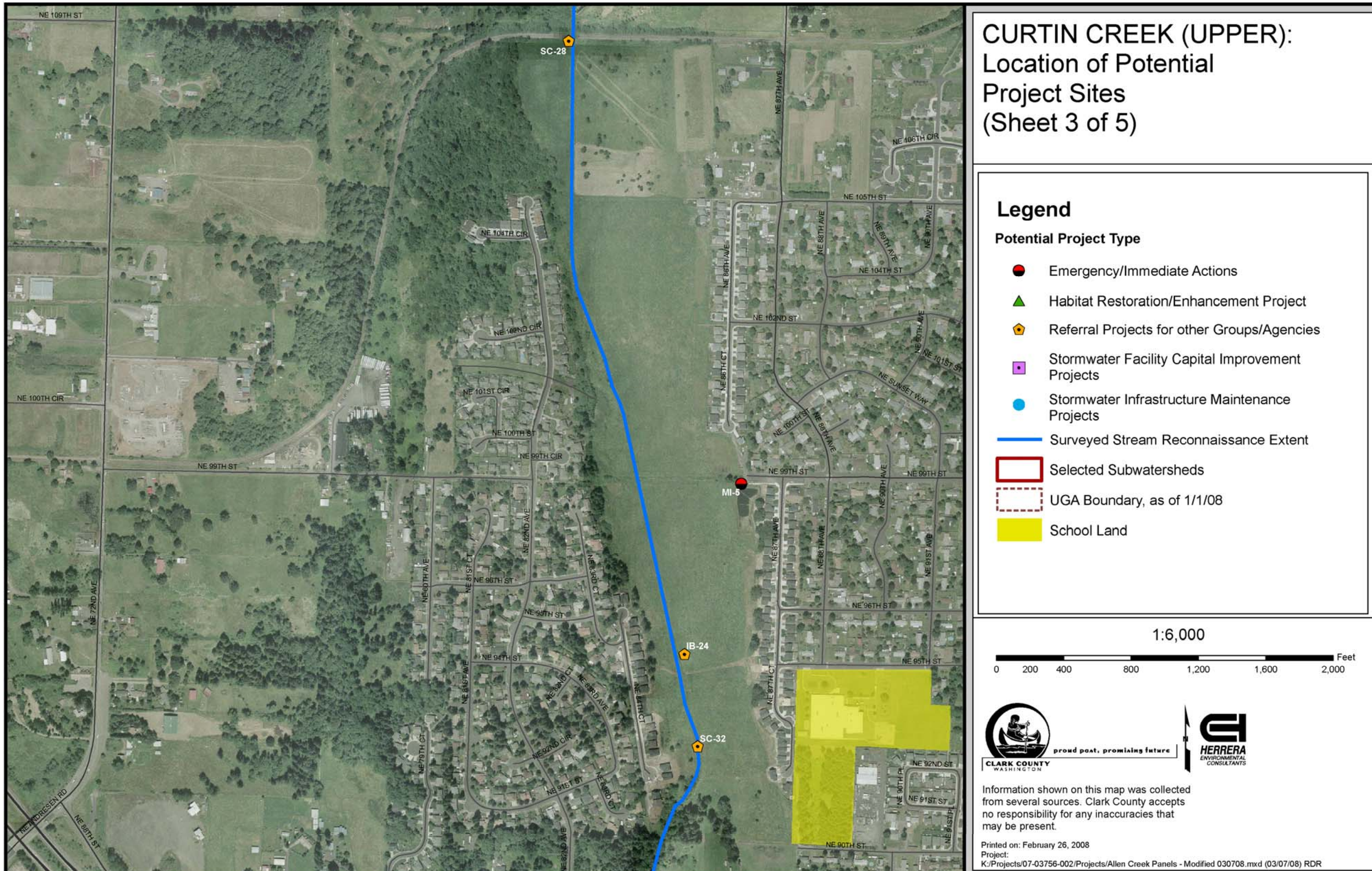


Figure 18: Potential Projects Noted in Feature Inventory

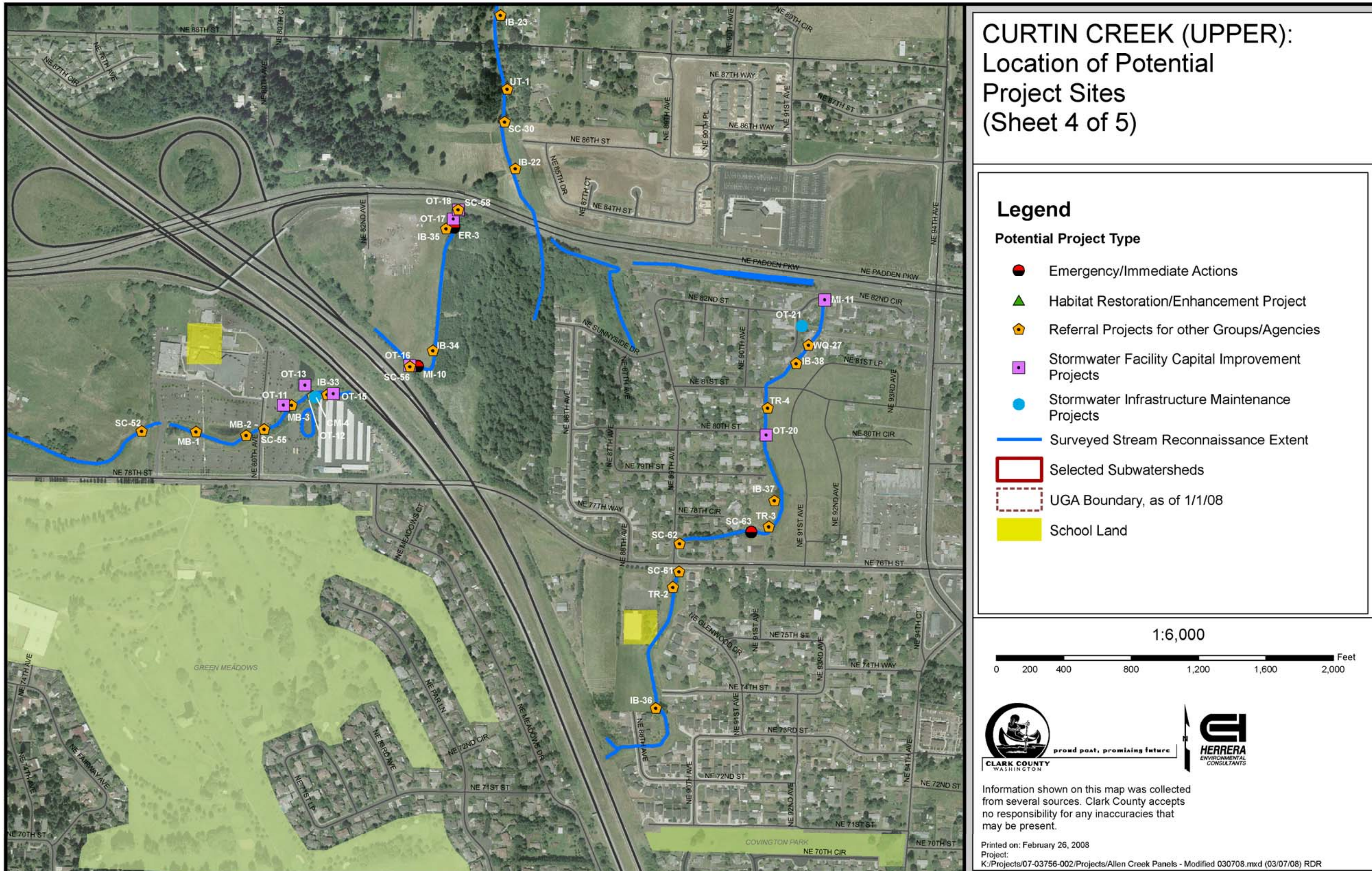


Figure 19: Potential Projects Noted in Feature Inventory

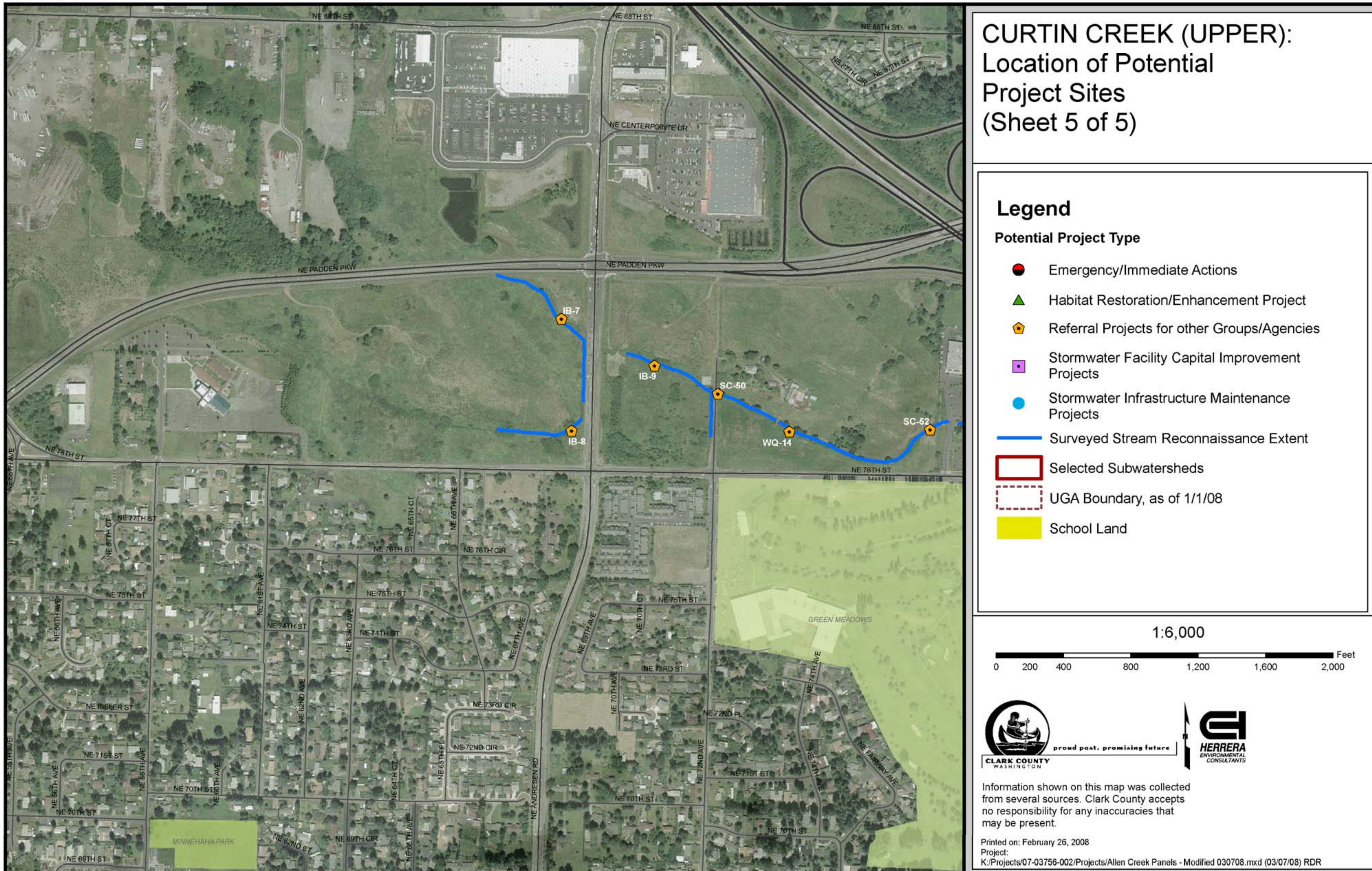


Figure 20: Potential Projects Noted in Feature Inventory

Table 18: Description of Potential Project Opportunities		
ID	**Basis for Project**	**Project Description**
MI-10	On-channel sediment trap is filled with sediment and outlet works are partially clogged with debris. Evidence of flow overtopping and damage to the outlet structure is present.	Immediate site inspection by engineering staff to determine follow-up actions.
WQ-15	Erosion and runoff from large-scale habitat restoration/enhancement project is contributing a significant load of fine sediment to the stream.	Immediate site inspection by engineering staff and personnel familiar with the project to determine follow-up actions that will eliminate erosion and sedimentation hazard.
ER-3	An 8-foot-high headcut progressing upstream at an unknown rate.	Immediate site inspection by engineering and/or consultant staff to determine appropriate course of action.
SC-63	According to adjacent landowner, the County replaced a bridge at this location with the current culverts and promised to maintain them, but has not done so. According to adjacent landowner, culverts commonly clog with debris and are creating a localized flooding hazard.	Immediate site inspection by engineering and/or consultant staff to determine appropriate course of action. County staff should follow up with adjacent landowners immediately to determine their specific concerns.
MI-5	Oily sheen on stormwater runoff at 90-degree curve on newly constructed gravel access road.	Immediate site inspection by engineering and/or consultant staff to determine appropriate course of action to treat polluted stormwater runoff.

<u>Stormwater Facility Capital Improvement Projects</u>

Stormwater Facility Capital Improvement Projects are projects that create new or retrofit existing stormwater flow control and/or treatment facilities. Facility retrofits include 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 identified are based on the results of the Feature Inventory are described in Table 19.

Table19: Description of Potential Project Opportunities		
ID	Basis for Project	Project Description
OT-11	Curb break funneling untreated parking lot runoff into stream via grass swale.	Investigate source of stormwater and modify grass swale or construct a new stormwater facility to detain and treat runoff appropriately.
OT-13	A 1-foot-diameter plastic outfall pipe drains stormwater directly to the stream from storage facility. Stormwater is likely untreated.	Investigate source of stormwater and construct a new stormwater facility to detain and treat runoff appropriately.
OT-15	A 1.25-foot-diameter plastic outfall pipe drains stormwater directly to the stream from storage facility. Stormwater is likely untreated.	Investigate source of stormwater and construct a new stormwater facility to detain and treat runoff appropriately.
OT-16	Open channel appears to be draining stormwater from the northbound lane of I-205. No evidence of a flow control or treatment facility.	Investigate source of stormwater and construct a new stormwater facility to detain and treat runoff appropriately.
OT-17	A 3-foot-diameter corrugated metal pipe stormwater outfall delivering water from an unidentified source to the stream. Outfall is perched approximately 8 feet above the streambed and no dissipater is present. Perched outfall may be the result of headcut ER-3 progressing upstream past the outfall. Rust colored stains in pipe and around outfall.	Investigate source of stormwater and construct a new stormwater facility to detain and treat runoff appropriately. Look at feasibility of constructing a flow dissipater.
OT-18	A 1-foot-diameter plastic outfall pipe drains stormwater directly to the stream from roadside ditch. Stormwater is likely untreated.	Investigate source of stormwater and construct a new stormwater facility to detain and treat runoff appropriately.
OT-13	A 10-inch-diameter plastic pipe delivers stormwater to stream via vegetated swale.	Consider facility retrofit to enhance flow control and treatment capability.
OT-20	Street gutter at terminus of NE 80th Street routes untreated stormwater directly into the stream.	Investigate source of stormwater and construct a new stormwater facility to detain and treat runoff appropriately.
MI-11	Creek enters culvert under NE Padden Parkway. Two stormwater drains with unknown outlets are visible at this location.	Investigate outlet points of stormwater drains. Construct new stormwater facilities to detain and treat runoff appropriately if deemed necessary.
OT-3	Open channel (roadside ditch) draining stormwater from NE 199th Street. No evidence of a flow control or treatment facility.	Investigate source of stormwater and construct a new stormwater facility to detain and treat runoff appropriately.

Stormwater Infrastructure Maintenance Projects

Stormwater Infrastructure Maintenance Projects include potential projects which address and repair maintenance defects affecting existing stormwater infrastructure. Infrastructure maintenance projects are required by the County NPDES municipal stormwater permit. Projects in this category with estimated costs exceeding $25,000 are considered under the SCIP process. Projects addressing simpler maintenance defects are referred directly to the County Public Works Operations and Maintenance staff. Stormwater Infrastructure Maintenance Projects identified based on the results of the Feature Inventory are described in Table 20.

Table 20: Description of Potential Project Opportunities

ID	Basis for Project	Project Description
OT-13	Widespread invasive plant species surrounding stormwater facility. Predominantly blackberry and thistle.	Manage facility to eliminate presence of invasive plant species.
OT-12	Yard debris covering/clogging outfall pipe.	Remove yard debris. Educate landowners to discourage disposal of yard debris in streams or other receiving waters.
OT-21	Bioswale or long, narrow detention pond stormwater facility delivers stormwater directly to channel. Access to facility is limited by fences. Facility does not appear to be functioning properly.	Site inspection by engineering and/or consultant staff to determine if facility is functioning properly. Recommend maintenance or facility retrofit following site inspection.

Habitat Restoration/Enhancement Projects

Habitat Restoration/Enhancement Projects include potential projects which result in the restoration or enhancement of wetlands, upland forest, or riparian habitat. In-stream channel habitat and bank protection projects do not fall within the scope of Clark County's CWP, and are placed under the category of Referral Projects for other Groups/Agencies. Habitat Restoration/Enhancement Projects identified based on the results of the Feature Inventory are described in Table 21.

Table 21: Description of Potential Project Opportunities

ID	Basis for Project	Project Description
IW-1	Impacted riparian wetland is the result of intensive grazing.	Fence riparian area and restore riparian vegetation. Educate landowner on alternative grazing strategies which utilize very short term grazing of the riparian area as a method for managing invasive plant species.

Property Acquisition for Stormwater Mitigation

Property Acquisition for Stormwater Mitigation Projects includes potential acquisition of properties for any purpose that meets permit requirements to mitigate for stormwater impacts. This includes preservation or restoration of upland forest and riparian habitat zones. Due to existing level of development in this subwatershed, no projects of this type were identified in surveyed reaches of the Curtin Creek subwatershed.

Referral Projects for other Groups/Agencies

Referral Projects for other Groups/Agencies includes potential projects that do not fall within the defined scope of Clark County's CWP. This includes, but is not limited to, in-channel restoration, agricultural BMPs, fish-passage barrier removals, and invasive plant management. It also includes referrals within Clark County departments for projects such as trash removal, stream culvert repairs/maintenance, and drainage projects. Referral Projects for other Groups/Agencies identified based on the results of the Feature Inventory are described in Table 22. A number of similar referral projects may be combined into larger efforts, such as all of the property owner education being combined into an outreach program by the Soil and Water Conservation District or Agricultural Extension Service.

Table 22: Description of Potential Project Opportunities

ID	Basis for Project	Project Description
CM-3 WQ-3 WQ-4 WQ-5 WQ-6 IB-10 IB-11 SC-19 SC-20 and IW-1	Channel has been mechanically straightened and widened for agricultural use and flood control. Overall lack of native undergrowth and canopy vegetation on floodplain. Invasive plant species – primarily reed canary grass with some blackberry- growing in and along the channel. Numerous livestock access points. Impacted wetland resulting from overgrazing. Evidence of significant groundwater input to stream. Landowner explained that Curtin Creek remains watered year round downstream of NE 199th Street, and that steelhead used to spawn in the area before the channel was mechanically altered.	Excellent large-scale channel/watershed restoration project opportunity. Excavate and reconstruct a natural channel to improve ability to transport and sort sediment. Combine earth and channel work with LWD placement and an aggressive riparian revegetation program. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-19 IB-20 IB-21 IB-24 MI-5 SC-28 and	Channel has been mechanically straightened and widened for flood control with increasing stormwater inputs to Curtin Creek. Invasive plant species – primarily reed canary grass with some blackberry- growing in and along the channel. Channel is	Excellent large-scale wetland/channel/watershed restoration project opportunity. Excavate and reconstruct a natural channel across greenway corridor to increase distribution of groundwater surface water

Table 22: Description of Potential Project Opportunities		
ID	**Basis for Project**	**Project Description**
SC-32	exhibiting distributary tendencies at upstream end of reach. This area may be a historic alluvial fan feature. The constructed channel runs along the elevated west edge of the greenway corridor. Elevated ground adjacent to the channel is likely the result of channel excavation activities. Area along the greenway corridor is undergoing intense residential development and stormwater volumes will certainly increase, placing additional pressure on the stream and riparian wetlands.	interactions. Construct new and enhance existing wetlands to mitigate flood flows, detain, treat, and infiltrate stormwater. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants enhance riparian habitat, and decrease thermal loading.
SC-50	Culvert is clogged with debris.	Remove debris from culvert.
SC-52	Hydraulic conditions may be limiting fish passage through private culvert crossing.	Conduct additional barrier analysis to determine if culvert removal, retrofit, or replacement is required.
SC-55	Hydraulic conditions may be limiting fish passage through private culvert crossing.	Conduct additional barrier analysis to determine if culvert removal, retrofit, or replacement is required.
SC-56	A 350+ foot long culvert under I-205. Length and hydraulic conditions at both low and high flows may limit fish passage.	Conduct additional barrier analysis to determine if culvert retrofit or replacement is required.
SC-58	A 150+ foot long culvert under NE Padden Parkway. Length and hydraulic conditions at both low and high flows may limit fish passage.	Conduct additional barrier analysis to determine if culvert retrofit or replacement is required.
SC-30	Hydraulic conditions may be limiting fish passage through private culvert crossing.	Conduct additional barrier analysis to determine if culvert removal, retrofit, or replacement is required.
SC-27	Hydraulic conditions may be limiting fish passage through private culvert crossing at end of NE 76th Avenue.	Conduct additional barrier analysis to determine if culvert removal, retrofit, or replacement is required.
WQ-14	Livestock access point with bare banks. Likely source of sediment and nutrients.	Segregate livestock from riparian area and restore riparian vegetation. Investigate quality of agricultural runoff, and apply source control, develop off channel watering, and/or construct appropriate facilities to enhance water quality.

Table 22: Description of Potential Project Opportunities		
ID	**Basis for Project**	**Project Description**
WQ-3	Livestock crossing.	Investigate alternative means for livestock to cross channel to minimize water quality impacts.
WQ-4	Livestock crossing.	Investigate alternative means for livestock to cross channel to minimize water quality impacts.
WQ-5	Livestock crossing.	Investigate alternative means for livestock to cross channel to minimize water quality impacts.
WQ-6	Livestock crossing.	Investigate alternative means for livestock to cross channel to minimize water quality impacts.
IB-7	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly reed canary grass with some blackberry.	Eradicate reed canary grass and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-8	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly reed canary grass with some blackberry.	Eradicate reed canary grass and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-9	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly reed canary grass with some blackberry.	Eradicate reed canary grass and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-10	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly reed canary grass with some blackberry. Irises in the channel.	Eradicate reed canary grass and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-33	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly blackberry.	Eradicate blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-34	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly nightshade and blackberry.	Eradicate nightshade and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.

Table 22: Description of Potential Project Opportunities		
ID	**Basis for Project**	**Project Description**
IB-35	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly blackberry.	Eradicate blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-36	Widespread invasive plant species within and immediately adjacent to the floodplain. Nightshade, reed canary grass, and blackberry.	Eradicate nightshade, reed canary grass, and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
SC-61	Widespread invasive plant species within and immediately adjacent to the floodplain. Nightshade, reed canary grass, and blackberry.	Eradicate nightshade, reed canary grass, and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
SC-62	Hydraulic conditions may be limiting fish passage through private culvert crossing. Widespread invasive plant species within and immediately adjacent to the floodplain. Nightshade, reed canary grass, and blackberry.	Conduct additional barrier analysis to determine if culvert removal, retrofit, or replacement is required. Eradicate nightshade, reed canary grass, and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-37	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass, nightshade, and blackberry. Infestation extends downstream beyond NE 81st Street.	Eradicate reed canary grass, nightshade, and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-38	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass, nightshade, and blackberry.	Eradicate reed canary grass, nightshade, and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-22	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly reed canary grass with some blackberry. Area recently replanted with species	Eradicate reed canary grass and blackberry. Continue maintenance until plantings mature and canopy vegetation on floodplain shades out invasive plants.

Table 22: Description of Potential Project Opportunities		
ID	**Basis for Project**	**Project Description**
	including red osier dogwood, Oregon ash, and cottonwood.	
IB-23	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly blackberry.	Eradicate blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-24	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass.	Eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-21	Widespread invasive plant species within and immediately adjacent to the floodplain. Predominantly reed canary grass. Area recently replanted with species including red osier dogwood as part of a mitigation/enhancement project.	Eradicate reed canary grass. Continue maintenance until plantings mature and canopy vegetation on floodplain shades out invasive plants.
IB-20	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass.	Eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-19	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass.	Eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-11	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass, nightshade, and blackberry.	Eradicate reed canary grass, nightshade, and blackberry. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
SC-21	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass.	Eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-12	Widespread invasive plant species within and immediately adjacent to the	Eradicate reed canary grass. Reestablish native undergrowth

Table 22: Description of Potential Project Opportunities		
ID	**Basis for Project**	**Project Description**
	floodplain. Reed canary grass.	and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-13	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass.	Eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-14	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass and nightshade.	Eradicate reed canary grass and nightshade. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-15	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass and nightshade.	Eradicate reed canary grass and nightshade. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
SC-23	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass and nightshade.	Eradicate reed canary grass and nightshade. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
SC-24	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass and nightshade.	Eradicate reed canary grass and nightshade. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-16	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass and nightshade.	Eradicate reed canary grass and nightshade. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
IB-17	Widespread invasive plant species within and immediately adjacent to the floodplain. Reed canary grass and nightshade.	Eradicate reed canary grass and nightshade. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.
OT-4	A 12-inch-diameter plastic pipe	Investigate source of runoff and

Table 22: Description of Potential Project Opportunities		
ID	**Basis for Project**	**Project Description**
	conveys untreated stormwater flows from Christmas tree farm into open channel, which connects to stream.	apply source control and/or construct appropriate facilities to enhance water quality (new stormwater facility to detain and treat runoff or agricultural water quality BMP).
WQ-9	Open channel drains apparently untreated agricultural runoff to the stream.	Investigate source of runoff and apply source control and/or construct appropriate facilities to enhance water quality (new stormwater facility to detain and treat runoff or agricultural water quality BMP).
WQ-7	Manmade pond drains to stream. Pond may be acting as a source of thermal loading and/or contributing to other water quality impairments.	Investigate the effects of the pond on water quality. Modify facility to achieve improved water quality. Look into modifying pond and using it to treat stormwater.
WQ-8	Manmade pond drains to stream. Pond may be acting as a source of thermal loading and/or contributing to other water quality impairments.	Investigate the effects of the pond on water quality. Modify facility to achieve improved water quality. Look into modifying pond and using it to treat stormwater.
WQ-27	Residential landowner with livestock along stream. Landowner reported oily sheen in the stream after rains.	Educate landowners to discourage activities that negatively impact water quality.
MB-1	Log weir. Hydraulic conditions may limit fish passage.	Conduct additional barrier analysis to determine if structure removal, retrofit, or replacement is required.
MB-2	Log weir. Hydraulic conditions may limit fish passage.	Conduct additional barrier analysis to determine if structure removal, retrofit, or replacement is required.
MB-3	Log weir. Hydraulic conditions may limit fish passage.	Conduct additional barrier analysis to determine if structure removal, retrofit, or replacement is required.
CM-4	Rock grade control structure and wooden fence in the stream channel create hydraulic conditions that may limit fish passage.	Conduct additional barrier analysis to determine if structure removal, retrofit, or replacement is required.
UT-1	Exposed PVC irrigation line exposed on the stream bed.	Investigate alternative solutions with landowner.

Table 22: Description of Potential Project Opportunities

ID	Basis for Project	Project Description
TR-2	Dump site. Material is primarily construction waste.	Remove trash and debris and dispose of properly.
TR-3	Dump site. Material is primarily construction waste.	Remove trash and debris and dispose of properly.
TR-4	Large compost and yard debris pile slumping into the stream channel.	Remove debris and dispose of properly. Educate landowners to discourage disposal of yard debris in streams or other receiving waters.
SC-32	Failing and abandoned bridge constructed of steel and concrete is obstructing channel. Likely a remnant of historic agricultural land use.	Remove bridge debris and dispose of properly. Project may require permits.

Stormwater Management Recommendations

A number of general stormwater management measures should be implemented throughout the Curtin Creek subwatershed:

- In newly developing areas, emphasize stormwater management that focuses first on source control, reduction of runoff, and infiltration and treatment close to the source rather than in centralized facilities.
- Educate private landowners concerning importance of invasive plant removal, and suggest removal techniques.
- Educate private landowners on importance of native riparian vegetation and forest canopy cover for shading streams.
- Provide a list of suggested plants for stream revegetation and local nurseries that stock them for distribution to landowners.
- Educate landowners to discourage disposal of yard debris in streams or other receiving waters.
- In residential areas, encourage landowners to adopt LID or source control solutions, such as disconnecting gutter down spouts that encourage infiltration of stormwater close to the source.
- Encourage transmission of stormwater through open channels such as grass-lined conveyance ditches or bioswales rather than using piped systems.
- Modify ditch maintenance practices to retain some vegetation rather than scraping down to bare earth.
- Post stream identification signs where roads cross streams. Repair or replace deteriorated signs if necessary.
- Restore floodplain wetlands that help treat stormwater runoff and mitigate flood impacts.

Physical Habitat Assessment

Purpose

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

Methods

Physical habitat measurements were made for Curtin Creek at the Long-Term Index Site Project downstream of 139th Street in fall of 2002 using EPA EMAP protocols (Schnabel, December 2003).

Results

Results for the most widely used EMAP metrics are summarized in Table 23. Overall habitat quality is normalized to the best available reference site within the Willamette Valley monitoring by Oregon DEQ. The reference site is a least degraded by human activity rated as marginally acceptable due to obvious human disturbance. The Habitat Quality Index score of 41, compared to the disturbed reference site, suggests that Curtin Creek habitat is relatively poor, degraded by human activities.

Metrics showed poor riparian quality, an unstable stream bed, sparse fish cover and not properly functioning wood debris, and poor stream shade. All of these conditions except the unstable sand substrate can be improved over time by riparian restoration projects.

Interestingly, hydrologic flashiness index indicated little hydrologic impact.

Table 23: EMAP Metrics and Interpretation for Curtin Creek			
Habitat Category	**Index**	**Result**	**Characterization**
Overall habitat	Habitat quality index (HQI)	41	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale.
Overall riparian quality	QR1 index RCOND index	0.49 0.29	Poor Poor
Hydrologic flashiness	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	1.84	Minimal hydrologic impact
	Individual Metric		
Channel morphology	Pool percentage (PCT_POOL) Riffle percentage (as PCT_FAST)	0% 0%	Does not meet recommended pool area Does not meet recommended riffle area
Residual pools	Residual pool volume (TOTPVOL)	26.6m^3	n/a
Substrate composition	Dominant substrate Mean embeddedness (XEMBED) Substrate sand and fines (PCT_SAFN) D_{50} (media particle size, mm)	76% 100% 98% 0.2	Sand "Not properly functioning" Not properly functioning" (22% fines <0.6mm, 76% sand (0.6-2mm) n/a
Bed substrate stability	Bed stability index (LRBS_BW4)	-2.15	Streambed highly unstable
Fish cover	Natural fish cover by area (XFC_NAT)	0.42	Poorly shaded
Large woody debris	Total LWD density (C1W)	127/mile	"Not properly functioning" (low density and no large pieces)
Riparian vegetation cover	Stream shading (XCDENMID)	59%	Poorly shaded
Human disturbance	Riparian human disturbance index (W1_HALL)	0.83	n/a
Invasive plant species	Overall invasive plant proportion (ip_score) (individual species proportion)	1.00	Reed canary grass dominant (English Ivy=0, Him Black=0, Reed Canary=1.00)

Wetland Assessment

Purpose

Wetlands perform important hydrologic, water quality and habitat functions. The primary reason for the wetlands assessment is to:

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

The primary objective of the wetland assessment is to identify sites containing modestly sized, degraded or ditched wetlands where minor construction projects can be used to improve wetland hydrology. Improved wetland function can reduce peak storm discharges, increase groundwater recharge and improve habitat.

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. Detailed field evaluations and extensive review of existing data were not applied in the Curtin Creek watershed.

Stream Reconnaissance and Geomorphology/Hydrology assessments may also discover potential wetland-related project opportunities.

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 with county vacant buildable lands model (VBLM) information to identify possible wetland enhancement opportunities.

Results

Figure 21 shows potential wetland areas within the Curtin Creek subwatershed based on data from the county wetlands atlas, including the Clark County wetland model, National Wetlands Inventory, and high-quality wetlands layer.

Pockets of potential wetlands are widespread in Curtin Creek, with large concentrations of wetland areas near the main creek channel and in the upper watershed to the west of the I-205/Padden Parkway intersection.

Several Clark County facilities and parcels in the upper subwatershed have already been the subject of wetland enhancement or mitigation projects. C-Tran also has an ongoing wetland restoration project at their facility near the intersection of I-205 and Padden Parkway.

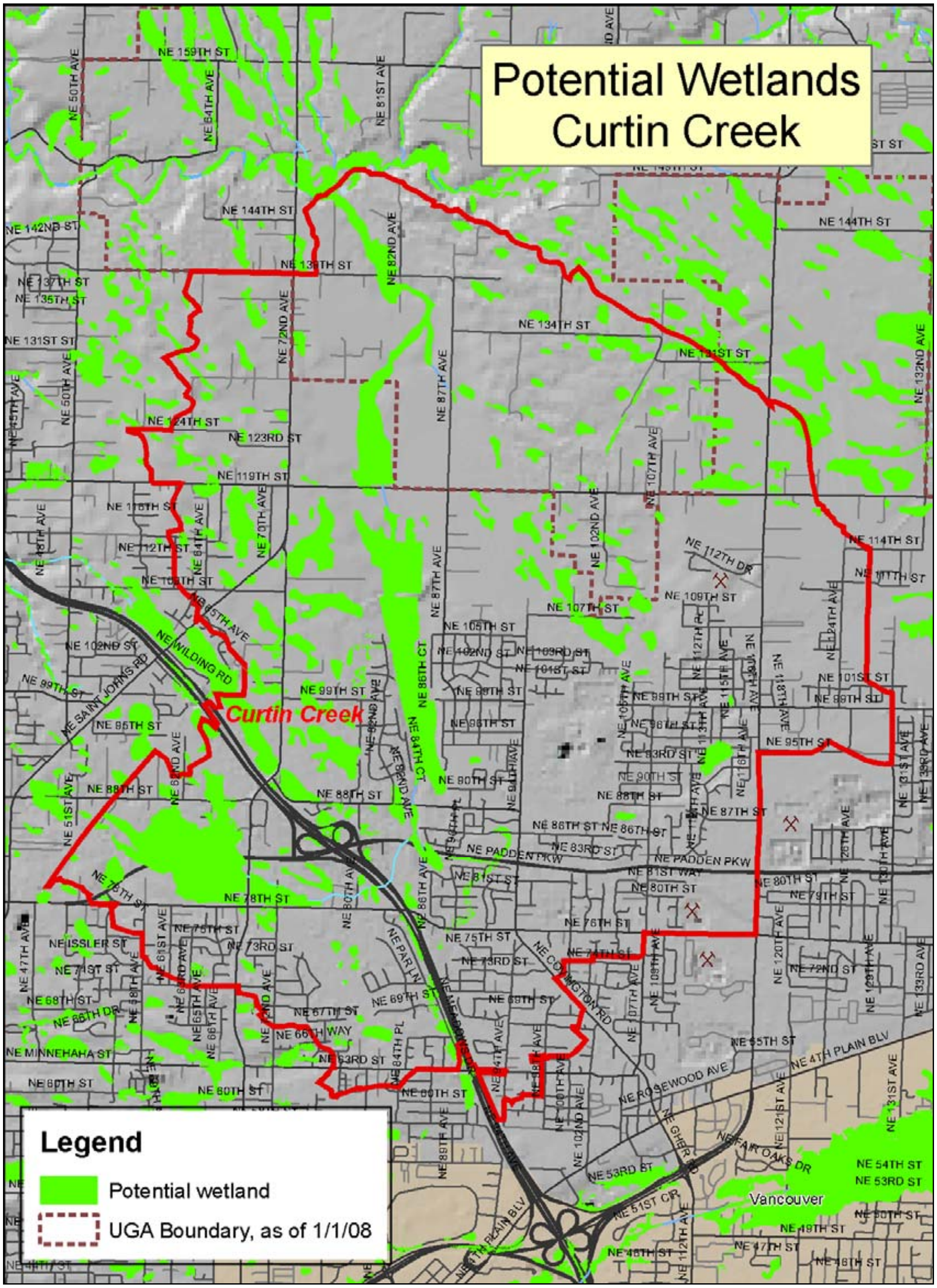


Figure 21: Potential Wetlands in Curtin Creek subwatershed

Draft Watershed Characterization
The Draft Watershed Characterization may be found on the Clark County website at http://www.clark.wa.gov/mitigation/watershed.html. Results pertaining to Curtin Creek are summarized below.

Figure 22 depicts priority areas for protection and restoration of hydrologic processes county-wide based on an analysis of the relative importance and level of alteration in each subwatershed.

In general, green areas have higher levels of importance for watershed 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. Orange to red areas have lower levels of importance for watershed processes and higher levels of alteration and should be considered as more suitable for development. Ecology suggests managing orange areas for both restoration and appropriately sited development.

The Curtin Creek subwatershed is indicated as suitable for both development and restoration (orange) due to a higher level of alteration and a lower level of importance for watershed processes. The Ecology analysis does not consider unique basin characteristics that might preserve hydrologic processes. Specific examples in Curtin Creek are the large amount of stormwater discharge to infiltration and extremely low stream gradient.

Potential Projects
Potential project locations for further exploration based on this wetland assessment include:

- Table 24 includes tax exempt parcels that overlap with potential wetlands from the Clark County wetlands model.

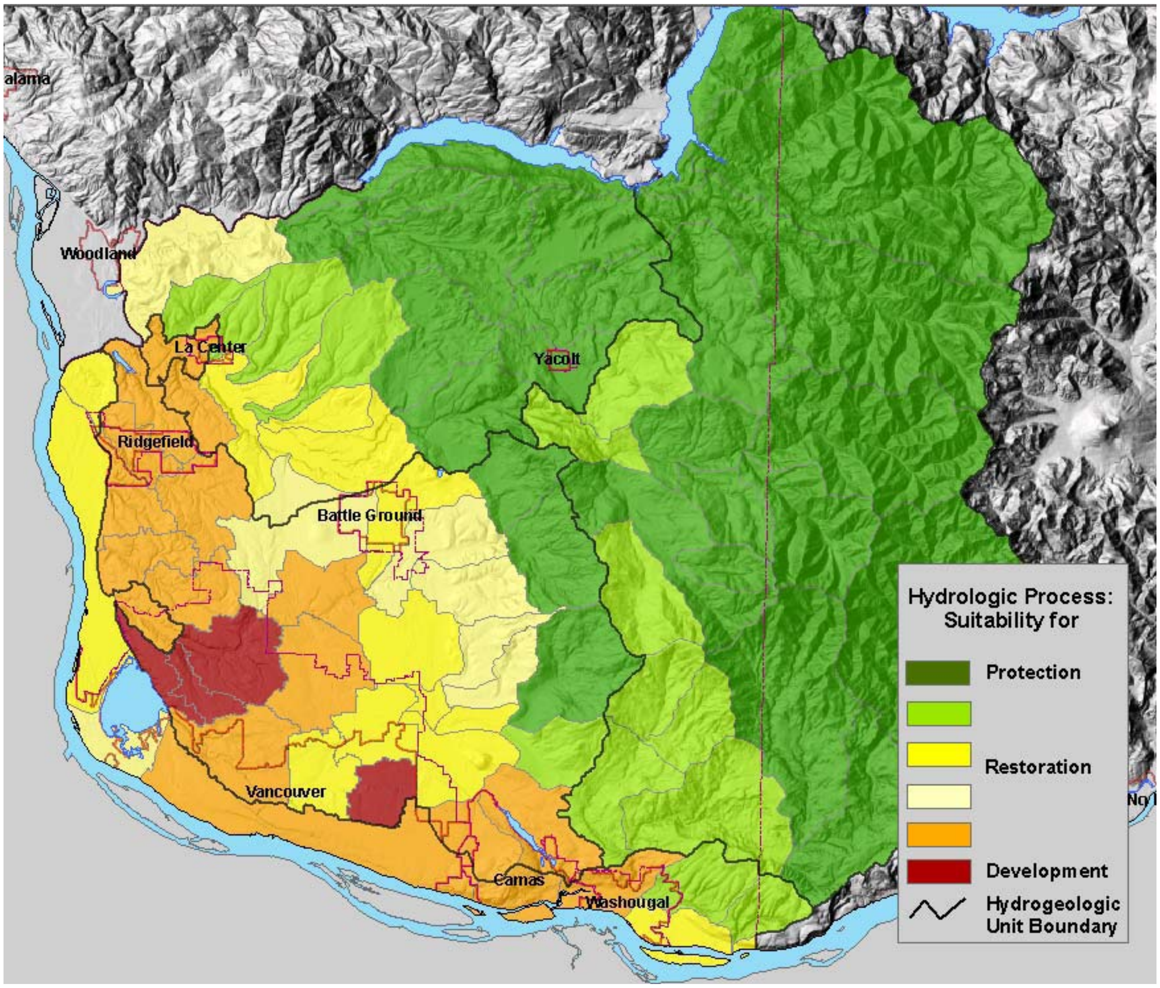


Figure 22: Priorities for suitability of areas for protection and restoration for the hydrologic process (from Draft Watershed Characterization of Clark County (Ecology, 2007)).

Table 24: Tax Exempt Parcels Overlapping Potential Wetlands				
ASSR_SN	**ASSR_AC**	**OWNER**	**PT1DESC**	**Description**
196541000	6.49	Clark County	Unused or vacant	Wetland/floodplain
198555000	38.45	City of Vancouver	Fire station	Channelized stream
155537174	33.08	State of Washington	Zero property value	Mainstem/floodplain
107357138 and two others	~8.5 total	Clark County	Unused timbered	
156244000	8.03	Clark County	Unused or vacant	Upland and potential wetland
156231000	5.89	Clark County	Unused or vacant	Upland and potential wetland
105482000 and three others	Unknown	Clark County	Unused or vacant	Forested land in headwaters
Multiple parcels	Unknown	Clark County	Unused or vacant	Curtin Creek Enhancement Project

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 chronic and acute pollutant sources, hydrology and habitat changes, and high summer water temperatures.

The B-IBI score is an index of ten 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 are often the most sensitive and the 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 Clark County's standardized protocols for macroinvertebrate sampling and analyses (Clark County Public Works Water Resources, June 2003). For example, to maximize the comparability of samples, macroinvertebrate collection is usually from multiple riffle habitats within a single reach. 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 ten individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores from 10 to 24 indicate low biological integrity, from 25 to 39 indicate moderate integrity, and greater than 39 indicate high biological integrity.

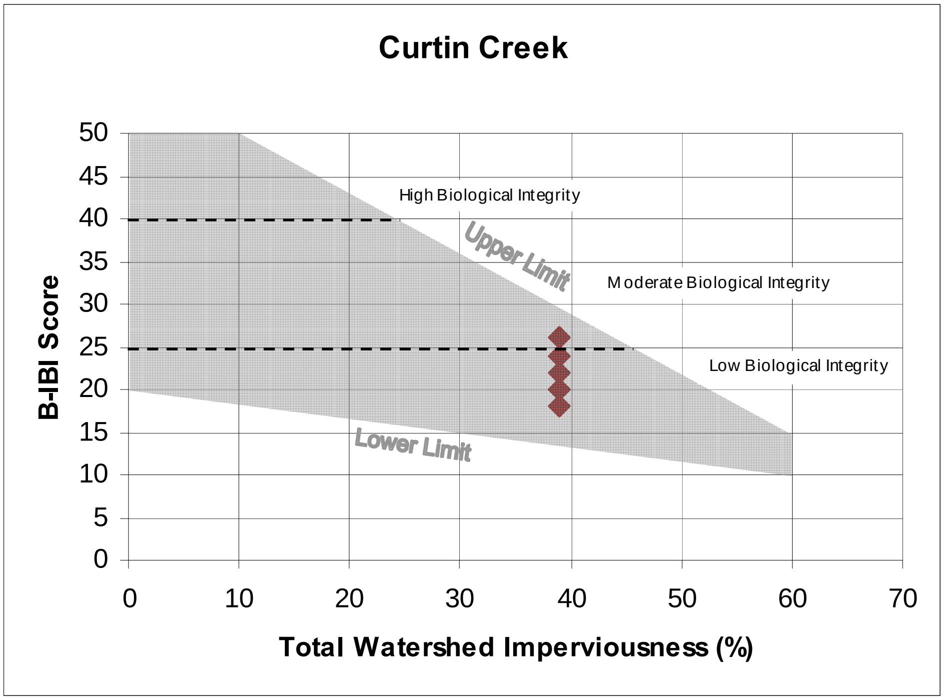
Results are influenced by both cumulative impacts of upstream land use and reach-specific conditions at or upstream of sampling sites. Thus, samples from a reach integrate local and upstream influences. Many of the B-IBI metrics are also influenced by naturally occurring factors in a watershed; for example,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

The Curtin Creek macroinvertebrate samples were collected by the Clean Water Program at station CUR020 downstream of 139th Street.

Results

Results for CUR020 are based on six samples collected from 2001 through 2007. Over this period, the average Total B-IBI score was 20 (Table 1). This B-IBI score falls close to the middle of the low category of biological integrity. With the exception of the eight point difference between 2006 and 2007, all of the yearly Total B-IBI scores were well within typical year-to-year variation of less than five points observed for Puget Sound streams (Karr 1998 and Law 1994).

Figure 23: 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 Total BIBI scores at CUR020 for particular years, vs. estimated 2000 subwatershed TIA.

Table 25: CUR020 Average Annual Macroinvertebrate Community Metrics and Total Score From Within the Period 2001 through 2007			
B-IBI Metrics	CUR020 6-Year Averages		
	Value	Score	Category
Total number of taxa	38.8	3	moderate
Number of Mayfly taxa	2.2	1	low
Number of Stonefly taxa	2.7	1	low
Number of Caddisfly taxa	3.3	1	low
Number of long-lived taxa	3.2	3	moderate
Number of intolerant taxa	0.7	1	low
Percent tolerant taxa	38.3	3	moderate
Percent predator taxa	5.9	1	low
Number of clinger taxa	12.3	3	moderate
Percent dominance (3 taxa)	50.9	3	moderate
Total B-IBI score		20	**low**

Examining the ten individual average annual metric results show that half had low ratings with the remainder being moderate. In particular, the low scoring metrics for Stonefly and intolerant taxa suggest signs of degraded water and habitat quality since they are among the first organisms to disappear as human disturbances increase (Fore, 1999). Also, the sites' low scores for Mayfly, Caddisfly, and percent predators could reflect, respectively, the presence of some chemicals such as heavy metals, less varied stream habitat, and decreasing diversity in prey items.

The Curtin Creek site lacks gravel substrate typical for standard B-IBI samples and their metrics. Lack of gravel substrate normally lowers B-IBI scores.

Booth et al. (2004) found that there is 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). Figure 1 shows that CUR020 station's 2001 through 2007 Total B-IBI scores fall in the middle portion of the range of expected scores (estimated 2000 Total Impervious Area from Wierenga, 2005). By comparing Curtin Creek to the likely range of conditions for watersheds with similar amounts of development measured as impervious area, it is possible to make some general statements about the potential benefits from improving stream habitat.

The range of value seen at the site and expected B-IBI scores at 40 percent TIA imply a relatively limited ability to improve scores into the moderate range. However, actual effective impervious area is much lower but not well described. This, along with the lack of gravel substrate at the sample site suggests that macroinvertebrate scores and TIA are not accurate indicators of stream conditions in Curtin Creek.

Physical Habitat Factors

Curtin Creek is an unstable, sand bottom stream which normally has a lower B-IBI score than gravel bottomed streams. A 2002 field assessment at CUR020 (Clark County, December 2003) rated 'overall riparian quality' as 'poor', and the 'overall habitat quality' rated only 41 out of 100 compared to a significantly degraded Willamette Valley reference stream site. Other generally accepted criteria suggested poor macroinvertebrate habitat include low percentage of riffle habitat, high substrate embeddedness, elevated levels of sand and fine particles, and 'poorly shaded' riparian vegetation. Although the sandy bed is unstable, other metrics rate the stream as having 'minimal hydrologic impact'. Riparian habitat conditions have improved since the 2002 habitat survey due to streamside plantings.

Hydrology

Curtin Creek appears to have less hydrologic alteration than expected for the level of development. The EMAP metrics observed this and hydrologic metrics such as the TQmean support it. Based on continuous monitoring data (2003 through 2006) from a station at 139th Street, Curtin Creek has a relatively moderate average TQmean value of 0.31, indicating a hydrologic setting more similar to suburban and rural watersheds than to urban areas.

Water Quality

While Curtin Creek water quality is somewhat impaired, the cool summer temperatures and large groundwater contribution probably improved habitat conditions. Conditions or results that may either negatively or beneficially impact macroinvertebrate populations include:

- The Ecology 303(d) list includes portions of Curtin Creek as 'Polluted waters that require a TMDL' for dissolved oxygen and pH.
- The Curtin Creek water quality index is poor based on several years of data.
- Continuous summer water temperature monitoring from 2002 through 2006 at CUR020 indicated temperatures met state criteria.

<u>Management Recommendations for Curtin Creek</u>

Channel, wetland and riparian restoration projects along Curtin Creek will likely benefit habitat conditions for salmon rearing and other aquatic wildlife uses compatible with the sandy-bottom stream habitat.

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Appendices

Appendix A — Geomorphology and Hydrology Assessment