Appendix E

# Whipple Creek Watershed-Scale Stormwater Plan Report

## Watershed Areas Appropriate for Special Attention in Regard to Hydrologic and Water Quality Impacts

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# Introduction

Whipple Creek watershed is located in southwest Clark County, draining west from low hills to the Columbia River flood plain (**Error! Reference source not found.**). The watershed's land use was once dominated by rural and agricultural land uses. Currently the watershed is moderately developed with a mix of rural lands, as well as urban and urbanizing areas at the northern edge of the unincorporated Vancouver Urban Growth Area (UGA). The 8.8 square mile upper sub-watershed (including Packard Creek) has approximately 4.4 square miles inside the UGA while the 3.3 square mile lower subwatershed is entirely outside the UGA. Historic land clearing and development impacts have degraded stream habitat and caused areas of severe channel instability and erosion. Impacts on channel stability, water quality, and overall ecological function from urbanization within the watershed are consistent with those documented elsewhere around Washington State.

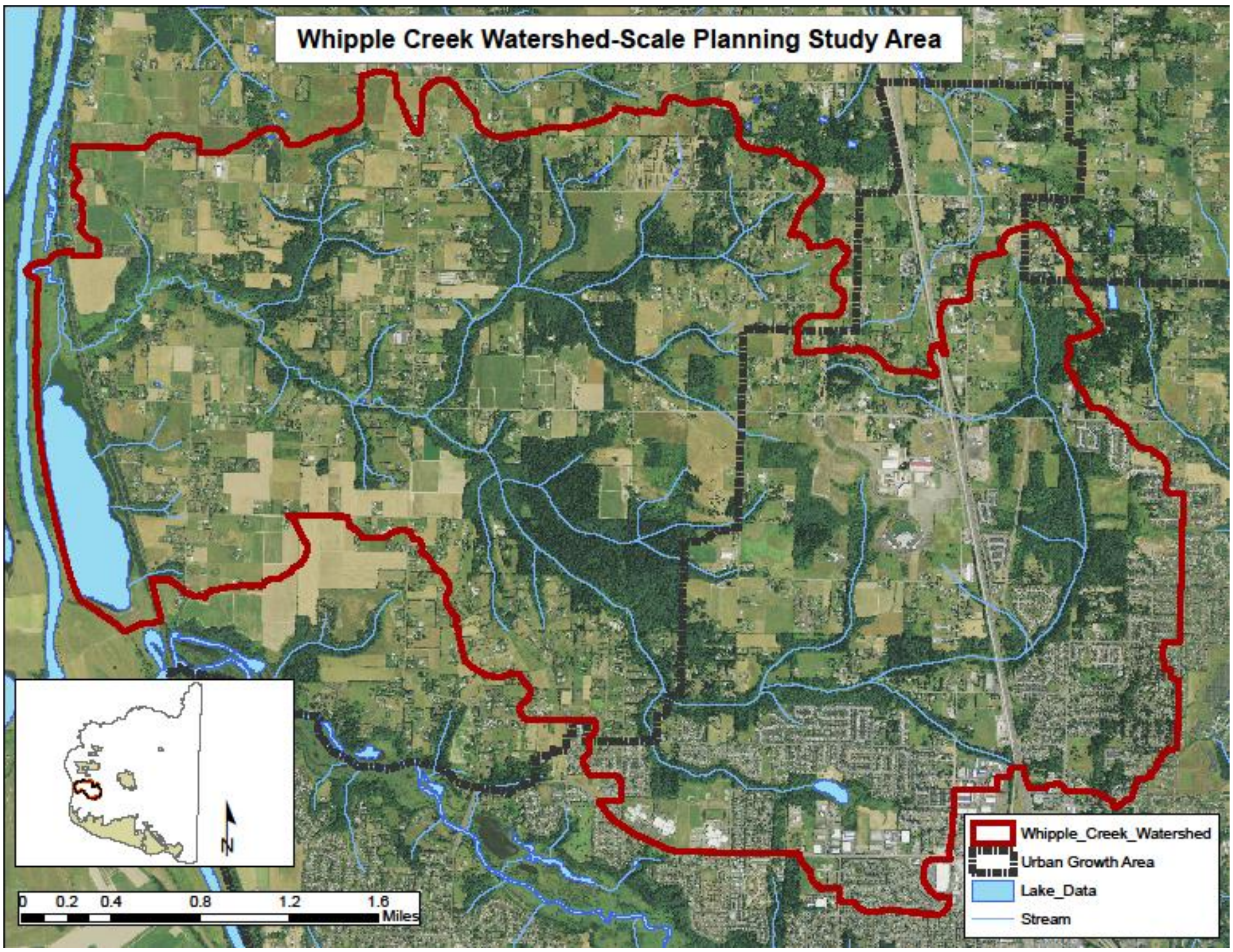


Figure 1 Whipple Creek watershed area map

The Whipple Creek stream system's designated beneficial uses are for: 1) aquatic life use of salmonid spawning, rearing, and migration; and, 2) human use of primary contact recreation and swimming (WAC 173-201A-020). However, it is degraded due to historical clearing and development. Additionally, the Whipple Creek watershed is predicted to become increasingly developed under future conditions, especially within the UGA and along the Interstate 5 corridor.

This chapter presents a review of Whipple Creek watershed historic field observations, existing reports, and geographic information system (GIS) data analyses to identify areas appropriate for special attention in regard to hydrologic and water quality impacts for watershed planning.

This analysis is designed to help address Clark County's 2013-2018 NPDES Phase I Municipal Stormwater Permit (Permit) section S5.C.5.c.ii.2 watershed-scale stormwater planning requirements (WA Dept. of Ecology, 2012). Specifically, areas appropriate for special attention in regard to hydrologic and water quality impacts are identified and mapped. Such areas include riparian buffers, wetlands, hydric soils, floodplains, steep slopes, forests, valuable habitat zones, and other sensitive resource areas. Human caused disturbances and impacts in and around these areas of special attention should be avoided. If disturbance or impacts are unavoidable, they should be minimized through stormwater best management practices to reduce further impacts on channel stability, water quality, and overall ecological function.

## Methods

Review of reports of data for stream reconnaissance was conducted by Clark County Clean Water Division from December 2004 through May 2005. County staff assessed about 25 miles of Whipple creek and its tributaries. Stream reaches were assessed for stormwater impacts and stream enhancement opportunities. The assessment of stream reaches utilized the Unified Stream Assessment (USA) protocol designed by the Center for Watershed Protection (March 2004) for EPA's Office of Water Management. The USA is part of a larger set of protocols developed by the Center as an integrated framework for improving and rehabilitating small urban watersheds. Assessments focused first on the more heavily developed upper watershed stream reaches, followed by the more rural Packard Creek tributary. Stream reconnaissance data were recorded and mapped in the field, then transferred digitally to a shapefile using ESRI ArcMap software.

The current Whipple Creek watershed planning GIS analysis included utilizing existing shapefile data and creating new shapefiles to identify and map areas appropriate for special attention in regard to hydrologic and water quality impacts within the Whipple Creek watershed. Shapefiles were then extracted and a new feature class created as new shapefiles that are within the watershed using the Clip Feature function in ArcMap.

Review of existing county reports fulfills requirements under section S5.C.5.c.ii.1 of the county's Permit which includes Assessments of Existing Conditions (Clark County 2014), Clark County Stream B-IBI Versus Hydrologic Metrics Relationships (Clark County 2015), Status of Whipple Creek Watershed Aquatic Community (Clark County 2015), Water Quality and Land Cover (Clark County 2015). Additionally, the Whipple Creek Hydrology and Hydraulic Modeling (Clark County 2005), Whipple Creek Stormwater Needs Assessment (Clark County 2006) and the Whipple Creek Technical Memo (Inter-Fluve 2006).

## Results

The following figures and associated text identify areas appropriate for special attention in regard to hydrologic and water quality impacts.

## Regulated Critical Areas (Title 40)

Title 40 of the Clark County Code includes limitations on development in critical areas associated with certain natural features. Title 40 includes chapters 40.420 Flood Hazard Areas, 40.430 Geologic Hazard Areas, and 40.440 Habitat Conservation, 40.450 Wetland Protection. Since critical areas are already protected by county code (Figure 2), these areas were not the main focus in the analysis of areas of special attention for Whipple Creek watershed stormwater planning. Instead, areas of special attention were derived from a combination of documented field observations during stream reconnaissance, GIS exploration, and analysis of existing water quality data.

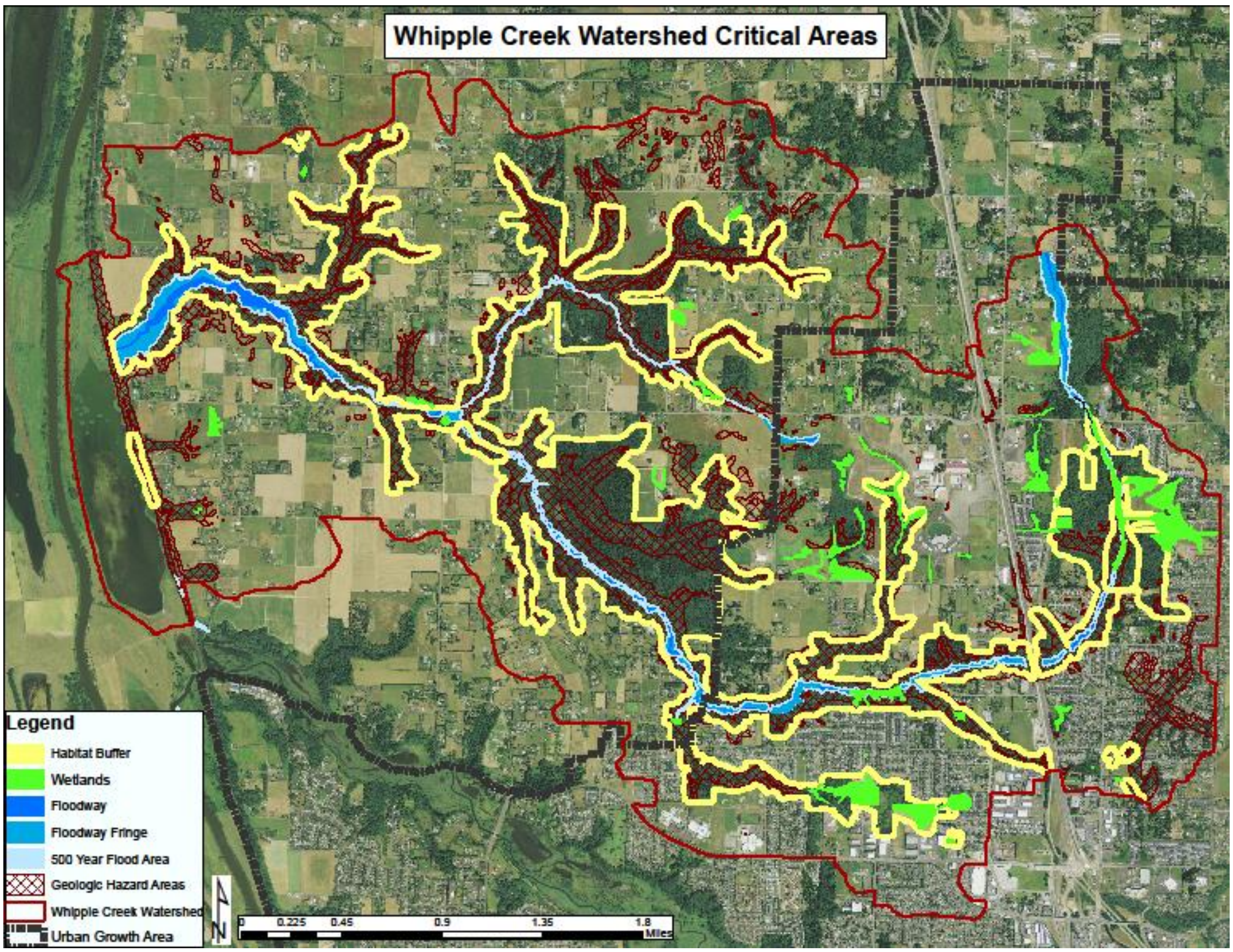


**Figure 2 Whipple Creek critical areas as defined by Clark County Code 40.420 through 40.450.**

## Stream Channel Erosion and Floodplain Disconnection

Within the stream reconnaissance assessed reaches, degraded areas far exceeded those that remained intact. In many assessed reaches, it was evident that increased runoff from historical clearing and development led to substantial stream channel incision, streambank scour, and floodplain disconnection (Clark County, 2006). Observed stream channel erosion reaches mapped during stream reconnaissance efforts are considered one important category for areas of special attention (Figure 3). These areas should be revisited and further assessed for channel enhancement or restoration opportunities.

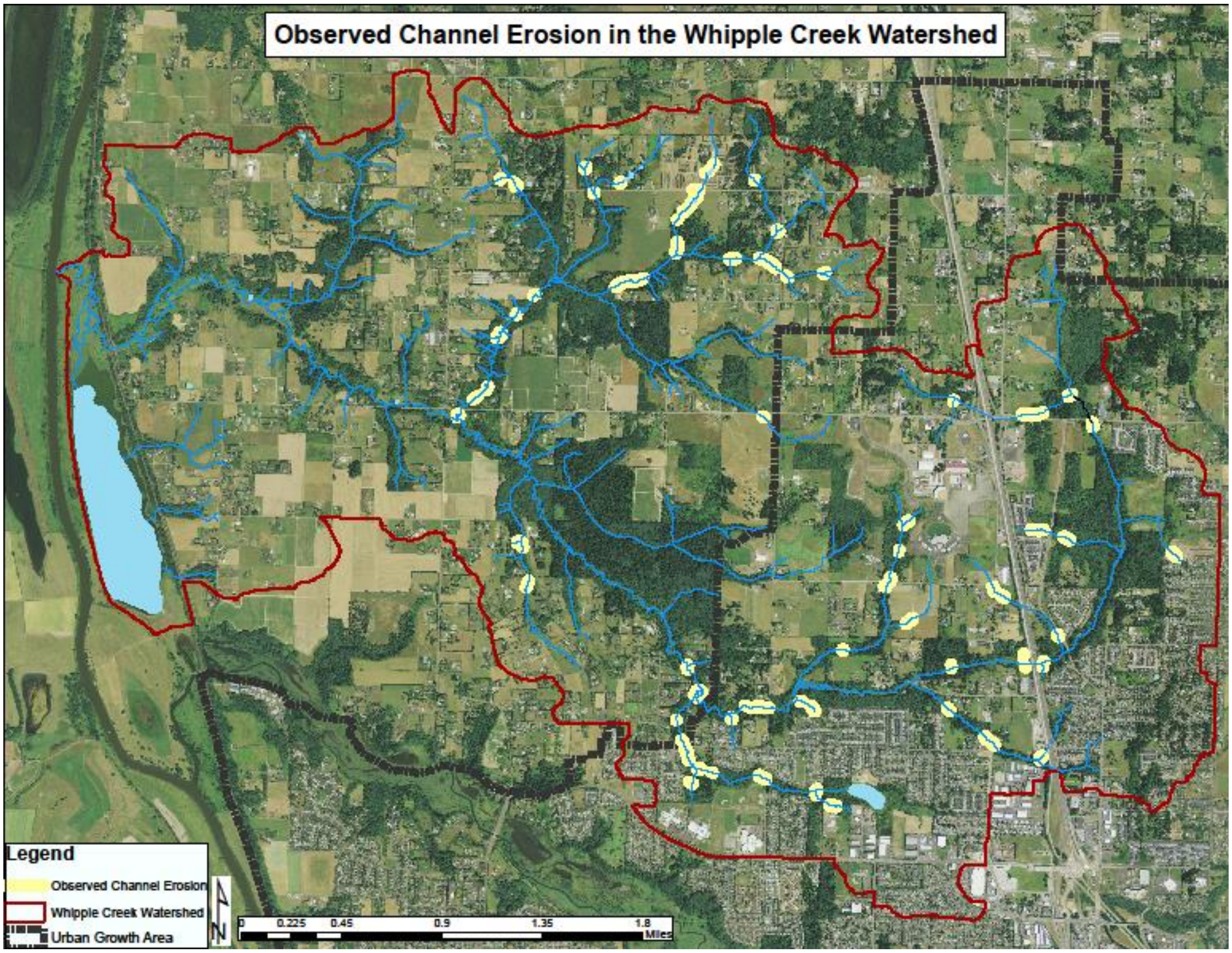


Figure 3  Areas of observed stream channel erosion within the Whipple Creek watershed

## Developed Catchments with No Stormwater Detention

Streambank erosion is a natural process. However, human activities can induce acceleration of this natural process which can cause excessive channel erosion leading to disproportionate sediment supply, stream channel instability, habitat loss, channel incision and other degraded conditions. The effects of excessive channel erosion are pervasive throughout Whipple Creek and most of its tributaries. Poor water quality and impaired biological communities are due, in large part, to the erosion and subsequent habitat degradation caused by urbanization and altered hydrology. Fine sediment from eroded soil and channels gets suspended in the water column which subsequently can degrade habitat by impeding oxygenated flow through salmonid spawning substrate and covering riffle habitat for invertebrates that are an important source of food for many fish.

Channel incision also greatly reduces instream habitat. Since incised channels are straighter, steeper and often wider, larger flows are contained within the channel (as opposed to spilling over into the floodplain) leading to flashier flows and reduced hydraulic retention. As channel incision occurs, stream flood plain interaction is eliminated or greatly reduced, and floodplain wetlands are often dewatered, cleared, filled or destroyed by channel erosion (Shields et. al, 2009). Within Whipple Creek, channel incision has reduced overbank flooding, ultimately disconnecting floodplains in multiple stream reaches and has reduced channel migration (Inter-Flueve, 2006).

Developed catchments within the Urban Growth Area having no stormwater detention best management practices were identified as areas of special attention (Figure 4). These areas of special attention should be evaluated for stormwater flow control retrofit and low impact development (LID) opportunities; especially in areas upstream of observed channel erosion areas.

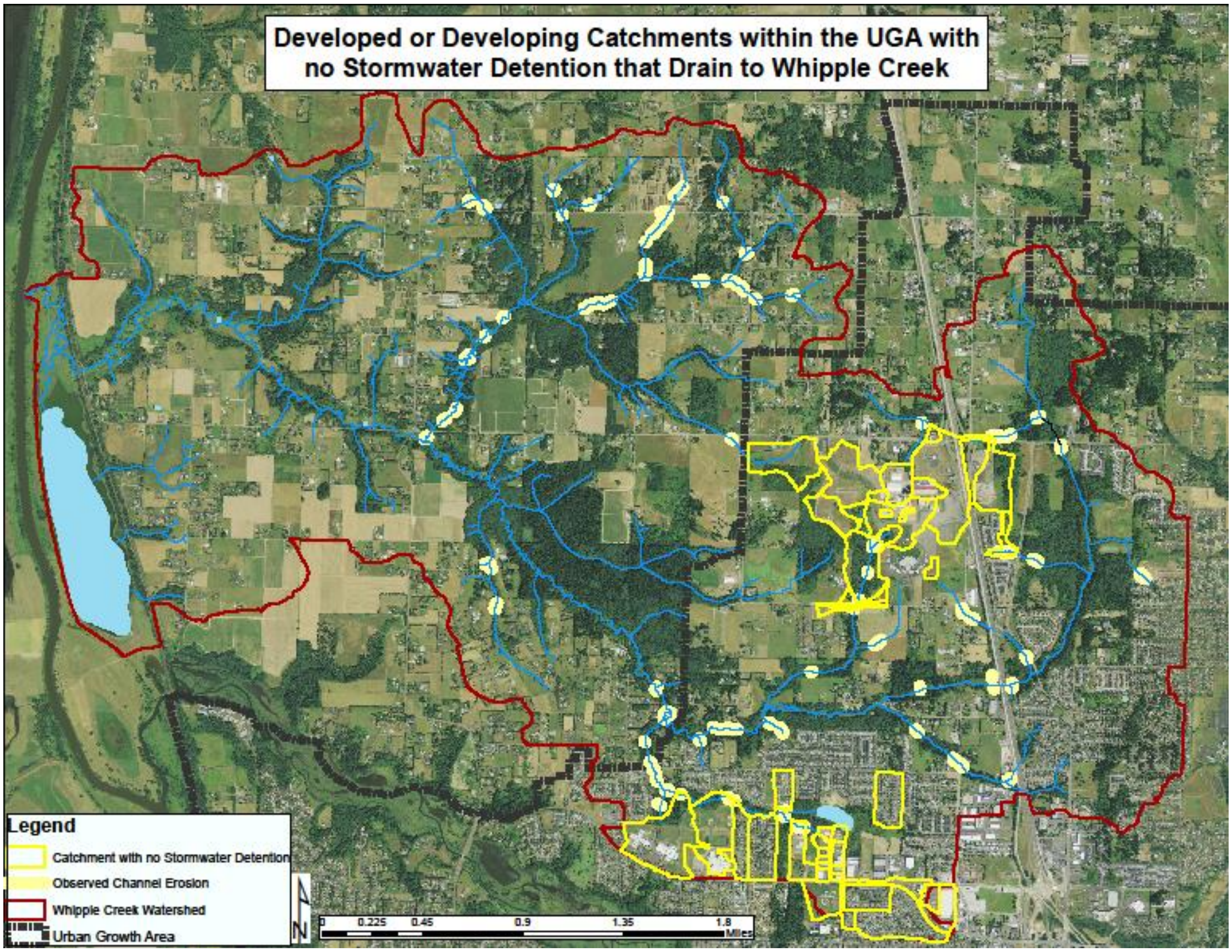


**Figure 4 Catchments with no stormwater runoff detention best management practices within the UGA of the Whipple Creek watershed**

## Suitable Salmon Spawning Habitat and Wetlands of Concern

Within the Whipple Creek watershed, field observations suggest spawning habitat is the greatest limiting factor for salmonids. Importantly, salmonid spawning habitat is already substantially limited due to occurring stream size, topography, and substrate (Inter-Fluve, 2006). Within the basin, channels below 0.5% gradient contain sand and silt substrate that is unsuitable for spawning which leaves only a few isolated areas where conditions are potentially suitable. Protecting observed suitable spawning habitat within the Whipple Creek watershed from the effects of channel erosion will need to be a high priority.

Stream channel incision has already put several wetlands at risk of being drained from migrating headcuts that can deepen and widen the stream channel leading to transporting stored sediment downstream and covering suitable spawning habitat (Inter-Fluve, 2006). Protecting existing wetlands is important because wetlands can slow the velocity of water down which allows for floodplain sediments to settle out of the water column. Suitable spawning habitat for salmonids, wetlands, and wetlands at risk are considered areas of special attention (Figure 5).

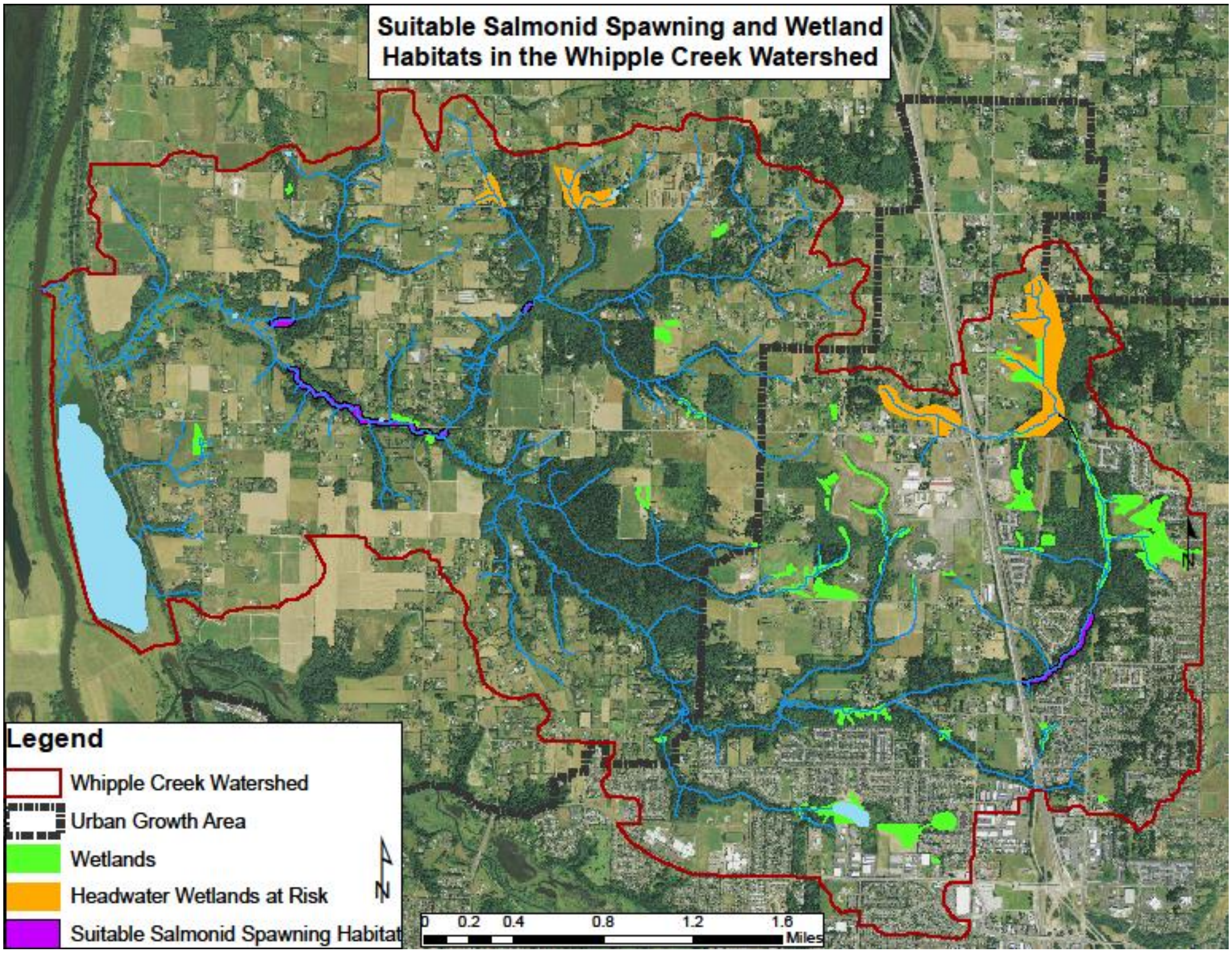


**Figure 5 Field observations of wetlands, headwater wetlands at risk due to channel erosion, and suitable salmonid spawning habitat in the Whipple Creek watershed**

## Whipple Creek Stream Temperatures and Possible Sources of Thermal Refugia

Stream temperature is one of the most important environmental influences on salmon biology. Under the state water quality stream standards, Whipple Creek is designated Salmonid Spawning, Rearing, and Migration and has the Aquatic Life Temperature Criteria Highest 7DADMax temperature of 17.5°C (63.5°F). Continuous summer stream temperature data collected approximately at river mile 3.1 of Whipple Creek (WPL050) show that the 17.5°C criterion is often exceeded; especially in the hotter months of July and August (Figure 6).

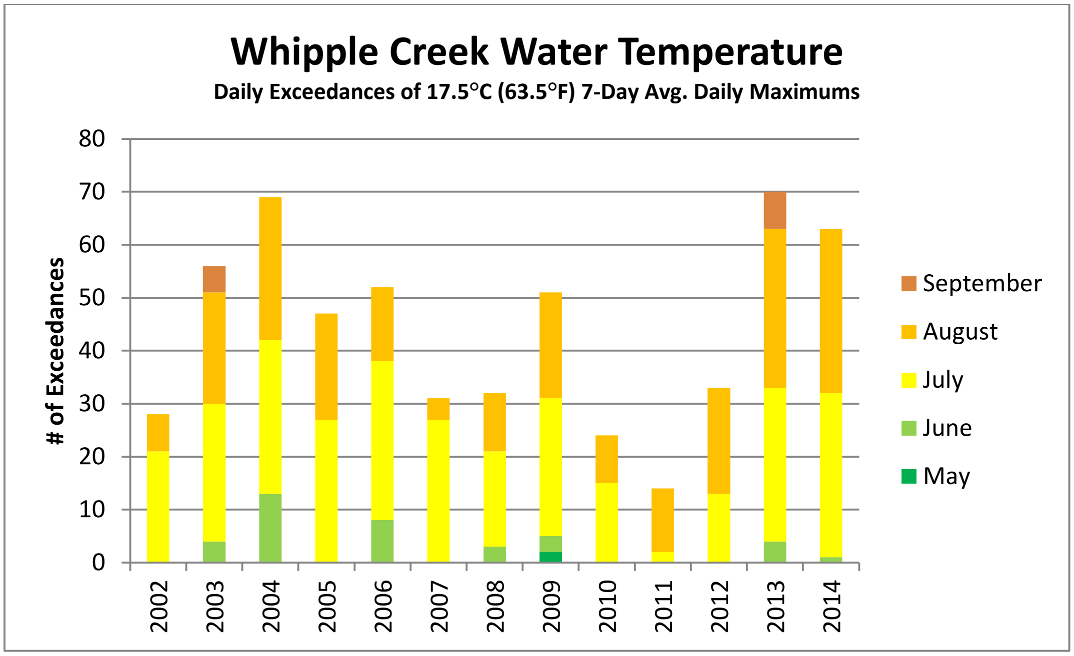


Figure 6 Whipple Creek station WPL050 water temperature exceedances 2002 through 2014

Continuous summer stream temperature data collected from May 2014 through June 22, 2015 at four unnamed tributary stations (WPLT01, WPLT02, WPLT03, and WPLT04), Packard Creek (PCK010), and four Whipple Creek mainstem stations (WPL080, WPL065, WPL050, and WPL010) show that Packard Creek and all mainstem sites exceeded the 17.5°C criterion (Figure 7). Additionally, based on logged daily minimum water temperatures, monitoring stations WPL065 had 26 days where continuous temperature loggers show that the stream temperature never got below the *maximum* 63.5°F: PCK010 - 10 days, WPL050 - 7 days: and WPL010 had 2 days.

When stream temperatures exceed the 17.5°C criterion, thermal refugia can provide important habitat conditions for salmonids survival. Salmonids that are exposed to stressful or lethal temperatures for part of the day can effectively block migration, stress fish, affect reproduction, inhibit smoltification, create disease problems, and alter competitive dominance (Carter, 2005). Tributaries of Whipple Creek may provide thermal refugia for salmonids during the hotter months of summer. Tributaries WPLT01, WPLT02 and WPLT03 did not exceed the 17.5°C criterion during the monitoring timeframe (May 2014 through June 22,). These same tributaries also have relatively intact forested riparian areas. It is possible that other unnamed tributaries not monitored for continuous stream temperature also provide thermal refugia during the hotter months. Stream temperatures and summer base flows from unmonitored tributaries should be further evaluated for areas of special attention that help provide thermal refugia for salmonids.

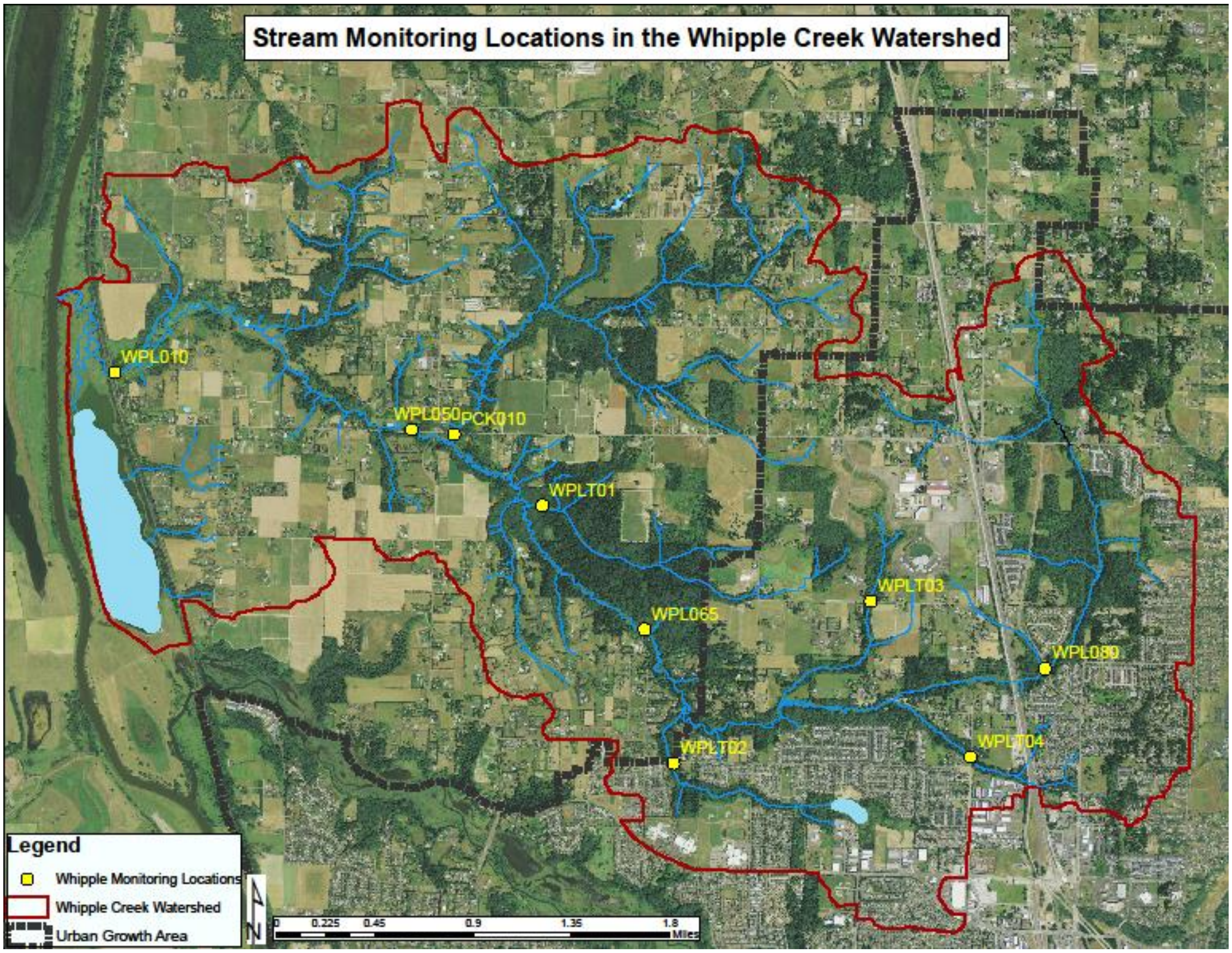


Figure 7  Stream monitoring location within the Whipple Creek Watershed

## County Owned Properties with Stream/Riparian Enhancement Opportunities

County owned properties should be evaluated as areas of special attention that may provide opportunities for riparian and stream channel restoration and enhancement opportunities. Parcels that the county or other regional partners own are considered areas of special attention because they alter beneficial opportunities for implementing stormwater planning (Figure 8). Solar radiation is the primary driver of water temperature. Increasing riparian tree coverage within the Whipple Creek watershed would enhance shading and help reduce sunlight impacted stream temperature. In many areas of the Whipple Creek watershed, invasive species are preventing the natural succession to shade producing coniferous riparian forest (Inter-Flueve, 2006). Riparian restoration activities should include removal of invasive species, planting of native shrubs and trees, fencing where appropriate to prevent livestock access to the creek, and protecting plantings from beaver activity. Channel and habitat enhancement should include large woody debris structures for grade control, recreating historical channel morphologies, reconnection of channels to floodplains, and gravel supplementation where appropriate.

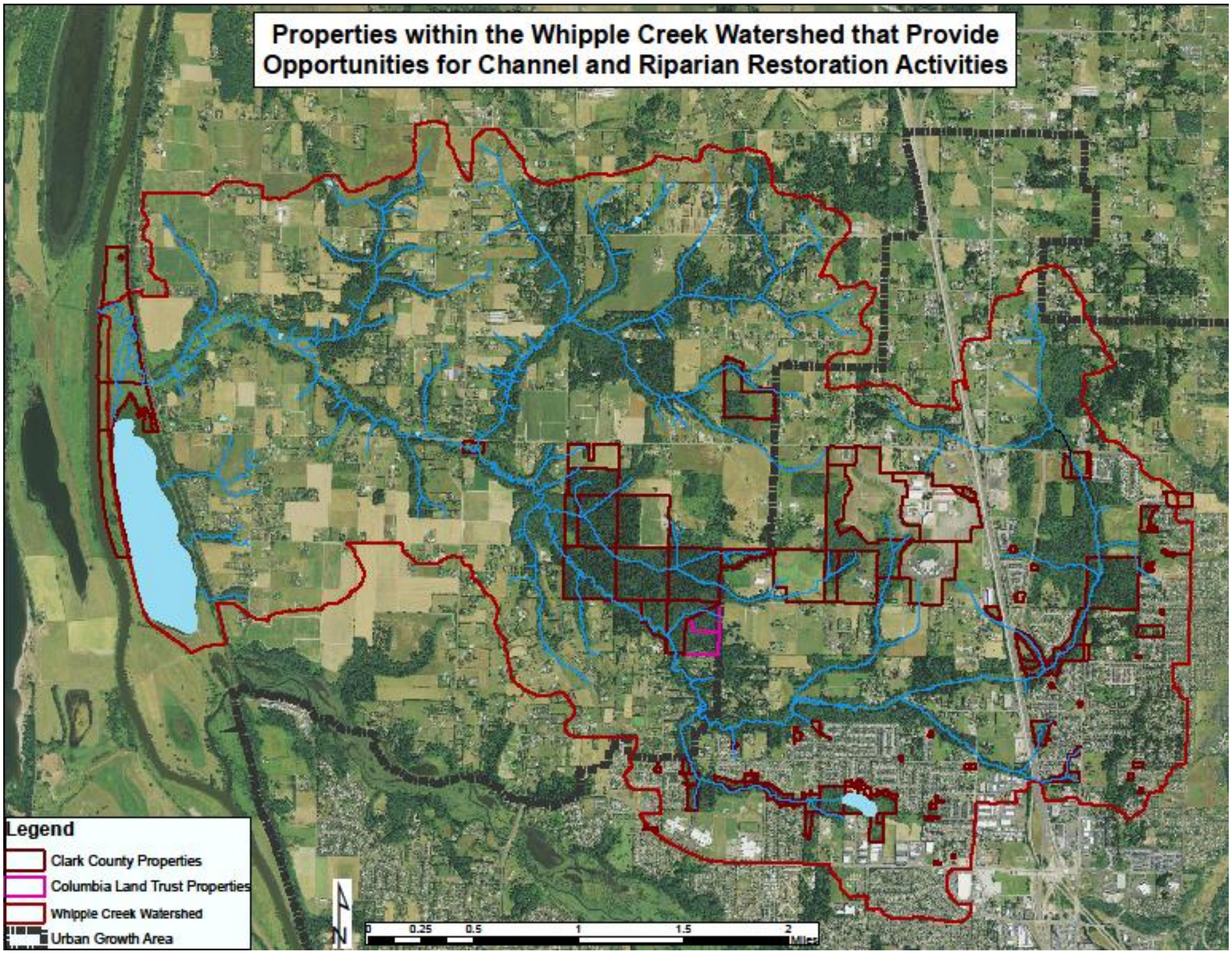


Figure 8  Whipple Creek monitoring locations and associated drainage catchments

## Urban Catchments Lacking Stormwater Treatment

Monthly water quality data collected from a Whipple Creek monitoring site (WPL050) since 2003 indicate that water quality in Whipple Creek is often poor as summarized by the Oregon Water Quality Index (Clark County, 2010, Clark County, 2014). The Oregon Water Quality Index (OWQI) was developed as a way to improve the understanding of water quality issues by integrating multiple characteristics and calculating a score that describes water quality status (Cude, 2001). The OWQI integrates eight water quality variables: temperature; dissolved oxygen; biochemical oxygen demand; pH; ammonia + nitrate nitrogen; total phosphorus; total solids; and fecal coliform.  For each sampling event, individual subindex scores and an overall index score are calculated.  Index scores are aggregated into low flow (June – September) and high flow (October – May) seasons and seasonal mean values are then calculated with the lower of the two scores utilized as the overall water year OWQI score.

Of the four water year 2012 overall OWQI results for multiple stations in Whipple Creek, three were classified as poor and one as very poor. The order from highest to lowest water year 2012 overall seasonal OWQI scores were: WPL080 (74.6, poor), WPL010 (61.3, poor), WPL050 (60.8, poor), and PCK010 (45.0, very poor). Except for WPL080’s excellent fecal coliform (91.8) and fair ammonia and nitrate nitrogen (82.5) subindex scores, all of the water year 2012 overall OWQI scores were pulled down by very poor total solids and nutrients and poor to very poor fecal coliform subindex scores (Clark County, 2014).

In addition to monthly stream data collection, base and storm flow water quality was monitored from July 2014 to October 2015 and compared to land cover data for each catchment (Table 1). These parameters included water temperature, turbidity, pH, fecal coliform, and dissolved zinc and dissolved copper. In general, water temperature and pH median values were similar for both base and storm flow. As expected, turbidity median values were higher during storm flow compared to base flow. This was also true for median fecal coliform values with the exception of WPLT02. The median base flow fecal coliform values for WPLT02 were 780 (CFU/100mL) compared to a storm flow median value of 665 (CFU/100mL).

**Table 1 Whipple Creek mainstem and tributary station water quality data from base and storm flows**

| Whipple Creek Mainstem Catchment Water Quality Medians | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | WPL010 Medians | | | | WPL050 Medians | | | | WPL065 Medians | | | | WPL080 Medians | | | |
| Land Use | Impervious | Forest | Pasture | Grass | Impervious | Forest | Pasture | Grass | Impervious | Forest | Pasture | Grass | Impervious | Forest | Pasture | Grass |
| Percentage | 11 | 30 | 34 | 25 | 12 | 31 | 31 | 26 | 20 | 26 | 19 | 35 | 16 | 32 | 22 | 30 |
| Flow Type | Base | | Storm | | Base | | Storm | | Base | | Storm | | Base | | Storm | |
| Sample Size * | 12 | | 18 | | 12 | | 18 | | 12 | | 18 | | 12 | | 18 | |
| **Parameter (units)** | | | | | | | | | | | | | | | | |
| Water Temperature (degrees C) | 11 | | 13.1 | | 11 | | 13.2 | | 11.4 | | 13.4 | | 10.8 | | 13.3 | |
| Tubidity (NTU) | 8.9 | | 26.8 | | 7.6 | | 30.2 | | 7.6 | | 16.6 | | 6.2 | | 15.3 | |
| pH | 7.48 | | 7.4 | | 7.89 | | 7.53 | | 7.52 | | 7.46 | | 7.54 | | 7.33 | |
| Total Suspended Solides (mg/L) | 5 | | 28 | | 5 | | 29.25 | | 5 | | 22.25 | | 5 | | 13.5 | |
| Dissolved Copper (ug/L) | 0.71 | | 1.23 | | 0.76 | | 1.23 | | 0.9 | | 1.55 | | 0.96 | | 1.48 | |
| Dissolved Zinc (ug/L) | 1.5 | | 0.82 | | 1 | | 1 | | 1.5 | | 2.14 | | 1.4 | | 2.76 | |
| Fecal Coliform (CFU/100 mL) | 340 | | 720 | | 262 | | 1865 | | 203 | | 445 | | 57 | | 440 (17) | |

| Whipple Creek Tributary Catchment Water Quality Medians | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | PCK010 Medians | | | | WPLT01 Medians | | | | WPLT02 Medians | | | | WPLT03 Medians | | | | WPLT04 Medians | | | |
| Monitoring Period | WY12 Monthly, July'14-May '15 | | | | July '14 - May '15 | | | | July '14 - May '15 | | | | July '14 - May '15 | | | | July '14 - May '15 | | | |
| Land Use | Impervious | Forest | Pasture | Grass | Impervious | Forest | Pasture | Grass | Impervious | Forest | Pasture | Grass | Impervious | Forest | Pasture | Grass | Impervious | Forest | Pasture | Grass |
| Flow Type | Base | | Storm | | Base | | Storm | | Base | | Storm | | Base | | Storm | | Base | | Storm | |
| Sample Size * | 12 | | 18 | | 12 | | 18 | | 12 | | 18 | | 8 | | 18 | | 12 | | 18 | |
| **Parameter (units)** | | | | | | | | | | | | | | | | | | | | |
| Water Temperature (degrees C) | 10.8 | | 13 | | 10.5 | | 12.7 | | 11.1 | | 12.9 | | 6.1 | | 12.2 | | 11.5 | | 13.65 | |
| Tubidity (NTU) | 9.6 | | 46.2 | | 11.7 | | 25.8 | | 4.6 | | 25.7 | | 9.9 | | 30.4 | | 9.6 | | 32.4 | |
| pH | 7.69 | | 7.6 | | 7.89 | | 7.65 | | 7.65 | | 7.44 | | 7.46 | | 7.52 | | 7.2 | | 7.37 | |
| Total Suspended Solides (mg/L) | 5 | | 45.25 | | 5 | | 16 | | 5 | | 21.85 | | 5 | | 31 | | 5 | | 29.9 | |
| Dissolved Copper (ug/L) | 0.82 | | 1.49 | | 0.67 | | 0.79 | | 0.74 | | 1.93 | | 1.15 | | 1.85 | | 0.66 | | 2.39 | |
| Dissolved Zinc (ug/L) | 0.8 | | 1 | | 0.5 | | 0.49 | | 1.7 | | 6.1 | | 2.4 | | 2.9 | | 2.1 | | 8 | |
| Fecal Coliform (CFU/100 mL) | 395 | | 3100 (17) | | 485 | | 1170 | | 780 | | 880 (16) | | 31 | | 660 | | 71 | | 870 | |

* Common sample size across all parameters unless noted otherwise in parentheses after median value

The high base flow fecal coliform values at WPLT02 suggests that there may be some ongoing issues within the WPTLT02 catchment that are elevating fecal coliform levels. Such issues may include leaking sewage/septic leaks to the stream or direct wildlife or livestock access to the stream. This catchment should be identified as an area of special attention regarding water quality. Efforts should be made to conduct stream reconnaissance within this catchment to detect potential sources of fecal coliform discharging to the stream.

Median dissolved copper and dissolved zinc values were generally higher for storm flow. Also, analysis of these data via linear regression specifically showed that as developed areas (land cover impervious/grass) approach 25% of the subwatershed's total area, storm flow dissolved zinc median values were significantly higher than those for base flow. Based on the significance of these findings, developed areas within the UGA lacking stormwater treatment are considered areas of special attention, for adding stormwater treatment Best Management Practices (BMP's) to reduce potential impacts from untreated stormwater discharging to Whipple Creek (Figure 9).

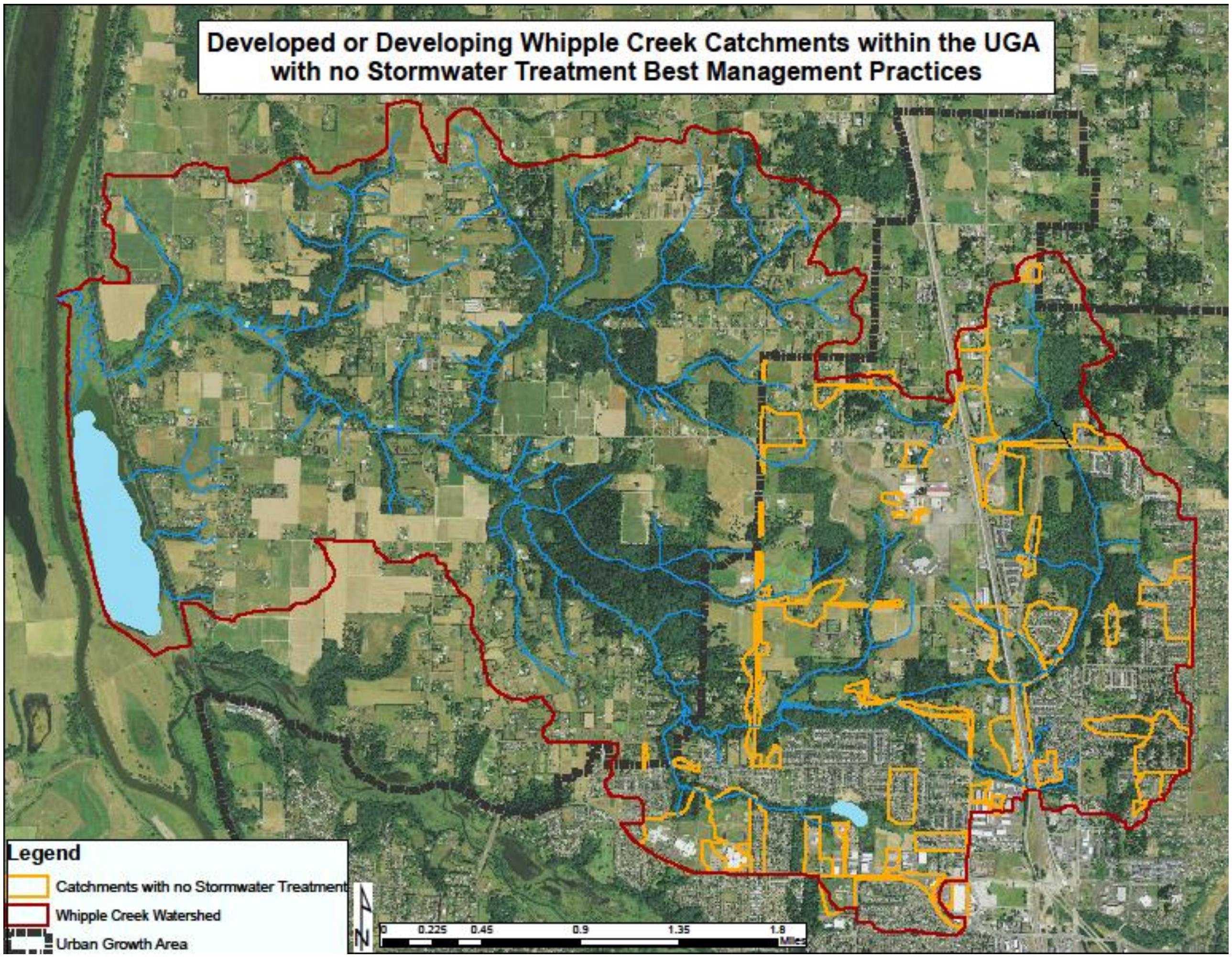


**Figure 9 Urbanized catchments with no stormwater runoff treatment best management practices within the UGA of the Whipple Creek watershed**

## Discussion

This report addresses Clark County's 2013-2018 NPDES Phase I Municipal Stormwater Permit (Permit) section S5.C.5.c.ii.2 watershed-scale stormwater planning requirements to map areas within the Whipple Creek watershed appropriate for special attention in regard to hydrologic and water quality impacts.

Stream hydrology and water quality have been altered dramatically in the Whipple Creek watershed as a result of development that occurred over many decades without stormwater BMPs or with stormwater BMPs that were not designed to today's standards. As a result, the Whipple Creek stream system often does not support its state designated beneficial uses for 1) aquatic life use of salmonid spawning, rearing, and migration and 2) human use for primary contact recreation and swimming (WAC 173-201A-020).

The Whipple Creek watershed is predicted to become increasingly developed in the future, especially within the UGA and along the Interstate 5 corridor. Even to just maintain current degraded conditions within Whipple Creek, new development must meet current county stormwater discharge treatment and hydrologic standards. However, the objective of watershed-scale stormwater planning is to identify a stormwater management strategy or strategies that will result in hydrologic and water quality conditions that fully support for 1) aquatic life use of salmonid spawning, rearing, and migration and 2) human use of primary contact recreation and swimming. To obtain this more stringent objective, watershed restoration strategies will need to be developed, prioritized and implemented that address stormwater flow control, water quality, stream temperature, and degraded stream habitat issues.

Clark County has identified and mapped specific areas within the Whipple Creek watershed appropriate for special attention in regard to hydrologic and water quality impacts where watershed restoration strategies can be implemented, these areas include:

- Observed stream reaches with channel erosion and floodplain disconnection
- Developed catchments with no stormwater detention
- Suitable salmon spawning habitat and wetlands of concern
- Possible sources of thermal refugia for salmonids
- County owned properties with stream/riparian enhancement opportunities
- Urban catchments lacking stormwater treatment

The purpose of restoration strategies within the Whipple Creek watershed is to provide a framework for prioritization, decision making and implementation of stormwater and restoration strategies that help address each area of special attention identified in this document to support the objective of watershed-scale stormwater planning.

## Recommendations

Priority strategies should first focus on restoring hydrologic conditions in the Whipple Creek watershed, especially in areas of special attention identified as “developed catchments with no stormwater detention” and “observed stream reaches with channel erosion and floodplain disconnection”. Stormwater strategies needed to address stormwater for catchments with no detention facilities include Low Impact Development (LID), stormwater retrofits to adhere to current standards, and the building of new stormwater hydrologic BMPs and/or regional stormwater facilities. Restoration strategies for observed stream reaches with channel erosion and floodplain disconnection should include channel grade control, stream bank stabilization, installation of large woody debris (LWD), riparian plantings, wetland restoration, and floodplain reconnection. Additional site-specific investigations and tools are needed to identify appropriate restoration activities in these areas of special attention.

The secondary priority should be improving water quality in the Whipple Creek system. Urban catchments lacking stormwater treatment were identified as areas of special attention regarding water quality and should be further screened for stormwater treatment BMP feasibility. Stormwater strategies that will need to be implemented to treat stormwater include Low Impact Development (LID), stormwater retrofits to adhere to current standards, and the building of new stormwater facilities and/or regional stormwater facilities. Additionally, stream reconnaissance and IDDE efforts should be conducted in stream site catchments that had high fecal coliform values to determine potential sources of fecal coliform pollution.

The third priority should be preserving suitable salmonid spawning habitat and enhance stream, riparian and wetland habitats. Additional investigations and tools are needed to specifically identify appropriate restoration activities, but generally should focus on enhancement/restoration projects in the identified areas of special attention that include county owned properties with stream/riparian enhancement opportunities and suitable salmon spawning habitat and/or wetlands of concern. Further efforts include conducting additional stream temperature studies on unmonitored tributaries to Whipple Creek to assess specific sources and flow volumes for thermal loads of thermal refugia for salmonids.

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