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# **RIPARIAN VEGETATION ASSESSMENT, LITTLE KLICKITAT RIVER AND SWALE CREEK**

## **Water Resource Inventory Area 30**

**Prepared for: WRIA 30 Water Resource Planning and Advisory  
Committee**

Project No. 070024-009-01 • June 30, 2009

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Project funded through Ecology Grant No. G0800548

Prepared in association with  
Watershed Professionals Network LLC



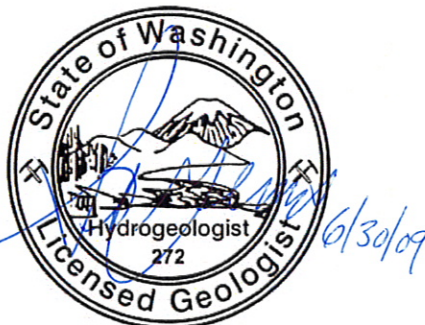
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**Aspect Consulting, LLC**



Steve J. Germiot

**Steve Germiot, LHG, CGWP**  
Sr. Associate Hydrogeologist  
sgermiot@aspectconsulting.com

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# 1 Introduction

Within the Klickitat River Basin (Water Resource Inventory Area [WRIA] 30), major tributaries to the Klickitat River include the Little Klickitat River and Swale Creek (Figure 1). Water temperature has been identified as an issue for both waterbodies.

A Total Maximum Daily Load (TMDL) addressing stream temperature has been developed for portions of the Little Klickitat River. The TMDL sets targets for effective shade. A baseline of streamside vegetation/shade conditions is needed to track progress against the TMDL's detailed implementation plan (Ecology, 2003A) and is identified as a priority in the WRIA 30 Watershed Management Plan (WPN and Aspect Consulting, 2005).

The lower reach of Swale Creek (within Swale Canyon) is on Washington State's list of impaired water bodies (303(d)) as Category 5 for water temperature. Under the state water quality rules, a TMDL is required for Category 5 waterbodies, but one has not yet been developed for Swale Creek. The WRIA 30 Watershed Management Plan identifies as a priority the preparation of a water quality improvement plan for that subbasin; more comprehensive baseline information regarding existing shade levels along Swale Creek is an important component of such a plan. The baseline information will also help in prioritization of future projects intended to improve water temperature.

In support of the WRIA 30 Watershed Management Plan implementation, this assessment includes:

1. Gathering field measurements of riparian canopy cover along Swale Creek (within Swale Canyon) and along Little Klickitat River, in accordance with a project-specific quality assurance project plan (QAPP; WPN, 2008);
2. Developing estimates of current riparian vegetation along both waterbodies using automated geographic information system (GIS) methods calibrated to the available field measurements; and
3. Tracking changes in riparian vegetation extent over time based on analysis of available historical aerial photographic coverage.

The riparian canopy data can then be integrated with existing information on fish distribution, water temperature, and other habitat-related factors to identify candidate areas for potentially planting new streamside vegetation to increase shade or implementing measures to protect the existing riparian vegetation. The assessment provides baseline information for monitoring progress against the Little Klickitat River TMDL goals, and assists with the development of a forthcoming water quality improvement plan for Swale Creek (e.g., identifying priority projects to address water temperature).

This project was funded under Coastal Protection Grant number G0800548 obtained by the WRIA 30 Water Resource Policy and Advisory Committee (WRPAC) from the Washington State Department of Ecology (Ecology).

Because the field data needed to be collected through the first half of June 2009, following a relatively late leaf out, and the project contract needed to be completed by the June 30, 2009, end of state fiscal year, there was not sufficient time for this project report to be reviewed by the WRIA 30 WRPAC. Consequently, it serves as a data report with preliminary conclusions, and further revision may be warranted at a later date following further discussion and coordination with the WRPAC.

The major sections of this report are as follows:

- Project Background;
- Estimates of Current Riparian Vegetation
- Field Data Collection;
- Historical Change in Riparian Vegetation; and
- Conclusions and Recommendations.

## **2 Project Background**

Pertinent background information regarding the Little Klickitat River and Swale Creek is provided below.

### **2.1 Little Klickitat River**

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Six stream segments in the Little Klickitat subbasin were listed as impaired on the 1998 303(d) list due to exceedances of the state temperature criteria in effect that that time (Table 1). The listed segments are located on the West Prong tributary, East Prong tributary, Butler Creek tributary, and the mainstem of the Little Klickitat River near its confluence with the Klickitat River. Some of these segments are located on land regulated under the Forest Practices Act.

Based on the 1998 303(d) listings, a Technical Report supporting development of a TMDL for Little Klickitat River temperature was completed in June 2002 (Brock and Stohr, 2002). In this analysis, effective shade was used as a surrogate measure of heat flux affecting temperature. Load allocations for effective shade were developed using modeling techniques. Load allocations were set between 50 and 95 percent effective shade for all perennial streams in the subbasin (Table 2). Effective shade includes shade created by overhanging vegetation and topographic shading (shade provided by adjacent hill slopes). Those stream segments that were not modeled were assigned a load allocation of 73 percent effective shade.

The TMDL technical report also noted that additional reductions may be achieved through reductions in stream width in some areas and noted that efforts should be made

to protect the cool water in Bloodgood Creek. Other recommendations in the TMDL technical report included the promotion of water use efficiency to increase stream flow and the reduction of sediment loads to address channel widening associated with high sediment inputs.

A TMDL Detailed Implementation Plan (DIP) was released in March 2005 (Anderson, 2005). The TMDL DIP summarizes the types of actions that could be undertaken to reduce stream temperature in the Little Klickitat River. Actions described in the TMDL DIP are voluntary, although some actions are required by other regulations.

Some factors have changed that may have resulted in increases in average streamflow since completion of Ecology's TMDL technical analysis (e.g., City of Goldendale's transfer of their Bloodgood Spring water right to a deep well to the north). The change in flow regime may potentially affect the outcomes of modeling efforts. Additionally, uncertainty exists regarding the attainability of the specified target effective shade levels. Questions have also arisen regarding the effectiveness of some of the actions specified in the TMDL DIP.

The WRIA 30 WRPAC received Ecology grants to install two new continuous-reading streamflow gages on the Little Klickitat River, to better document flow conditions in the river and supplement the existing flow gages operated by Ecology (near the mouth) and by City of Goldendale (at Tom Miller Road). The two new gages are installed at Woodland Road (in upper watershed), and at Olsen Road (roughly midway between Goldendale and the mouth) (Aspect Consulting, 2009a).

The WRIA 30 Watershed Management Plan identifies a need to conduct additional analysis to address uncertainties regarding attainability of the TMDL goals and overall effectiveness of the TMDL actions. This study provides comprehensive analysis of current vegetative conditions along the river as one step in that process.

## 2.2 Swale Creek

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A reach of Swale Creek, roughly 3 miles upstream of the mouth (T4N, R13E, Section 33), is included on the state's 2004 and 2008 303(d) lists (Category 5 listing) for water temperature, and therefore requires action to meet state water quality standards. This action can be implemented through an Ecology-managed TMDL (becoming a Category 4a listing), or an Ecology-approved, locally managed pollution control project (becoming a Category 4b listing).

Ecology's basis statement for listing Swale Creek as Category 5 for water temperature in the 2004 and 2008 Water Quality Assessments is as follows:

"The WRIA 30 Watershed Planning Coordinator provided additional information on Swale Creek for instream flow and temperature, suggesting these impairments were due to natural conditions. However, staff were not able to rule out anthropogenic sources in this area. Because of the uncertainties with respect to the human influences, these listings will remain in the "impaired" status until further study of the watershed can determine the extent of the influence and what might be done to correct or mitigate them. TRS was 04N-14E-19 on 1998 list. -kk

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Continuous temperature measurements were taken, but results reported as single day maximums. Category 5 listing is continued from 1998 assessment based on multiple excursions from continuous monitoring.”

The lack of soils and water within Swale Creek Canyon is a primary limiting factor on the development of riparian vegetation to shade the creek. Much of the Swale Canyon, which encompasses the lower 12 miles of the creek, is bedrock dominated and has little shade, particularly in the upper canyon. The lowermost canyon has perennial pools, somewhat better soils, and more vegetation. In most locations where soil is present, the soils are shallow and overlie bedrock. In large flood events, the riparian vegetation is often uprooted and lost in some areas. In the intervening years between flood events, vegetation starts to re-establish in the disturbed areas where sufficient soil and moisture is present. This dynamic situation represents a challenge to establishing a robust vegetative canopy to provide substantial shade across a broad, shallow creek.

The Watershed Management Plan identified developing a water quality improvement plan, modeled on Ecology’s 4B approach, to address water temperature in Swale Creek. The water quality improvement plan must meet the following criteria to be considered a 4B plan:

- Be waterbody- and problem-specific, and contain enforceable actions stringent enough to attain water quality standards<sup>1</sup>;
- Have reasonable time limits for correcting the specific problem, including interim targets where appropriate;
- Have a monitoring component, with adaptive management built in to allow for future changes in approach if warranted based on the monitoring information;
- Be feasible and have enforceable legal or financial guarantees that implementation will occur; and
- Be actively implemented and show water quality improvement in accordance with the plan.

In accordance with the Watershed Management Plan, it is the intent of the WRIA 30 WRPAC to submit a draft water quality improvement plan for Ecology review to ensure it meets the required criteria. Actions to consider in the water quality improvement plan include:

- Maintain and/or enhance existing shade;
- Evaluate potential to increase shade through modification of the existing railroad bed or placement of instream structures to capture sediment that may support vegetation; and/or
- Augment streamflows through pumping of cooler groundwater during critical low-flow periods.

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<sup>1</sup> When the natural condition exceeds numeric temperature standards, a narrative criterion applies, limiting human sources of warming to cumulatively increase the water temperature by no more than 0.3°C (0.54°F) (WAC 173-201A-200[1][c][i]).

The water quality improvement plan would include evaluation and prioritization of reaches of the stream where action would be expected to provide the greatest instream temperature reduction benefit for the cost expended. The Watershed Management Plan places strong emphasis on cost-effectiveness for actions taken to address Swale Creek water temperature, because it is considered to likely be improving what is primarily a natural condition, rather than restoration of a pre-existing (pre-development) condition. Grant funding has yet to be received to start preparation of the water quality improvement plan.

In addition to this riparian shade assessment, grants have been obtained to date to conduct the following activities related to Swale Creek water temperature:

- Siting and installation of three continuous-reading streamflow gauges on Swale Creek, to document seasonal and long-term flow conditions in the creek, in 2009. The three new gages are installed just upstream of Highway 97 (in upper Swale Valley), just downstream of Warwick (at transition from Swale Valley to Swale Canyon), and near the mouth (Aspect Consulting, 2009a).
- Siting, installation, and instrumentation of a shallow monitoring well in the alluvium of Swale Valley in 2009. The monitoring well continuously measures water levels to provide improved understanding of the relationship between alluvial aquifer groundwater levels in the Swale Valley and streamflows in Swale Canyon downstream of it (Aspect Consulting, 2009b).
- CKCD currently conducts surface water temperature monitoring near the mouth of Swale Creek and upstream at the Harms Road crossing.

This study focuses solely on Swale Canyon, the lower 12-13 miles of the creek downstream of Warwick, which includes the fish-bearing waters of Swale Creek. The upper portion of Swale Creek, within Swale Valley upstream (east) of Warwick, is a broad, grassy valley considered to be non-fish bearing, and is not included in this study.

## 2.3 State Standards for Freshwater Temperature

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Under the state water quality standards (Chapter 173-201A WAC), all surface waters in the state are protected by narrative criteria, designated uses, and an anti-degradation policy. Designated uses are those uses specified in Chapter 173-201A WAC for each water body, regardless of whether or not the uses currently exist. Based on the use designations, numeric and narrative criteria are assigned to protect existing and designated uses of a water body.

Freshwater uses designated by the state include:

- Aquatic life uses, which include six categories based on presence of key aquatic species;
- Recreation uses, which include the three categories of extraordinary primary contact, primary contact, and secondary contact;
- Water supply uses, which include domestic, industrial, agricultural, and stock watering; and

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- Miscellaneous uses, which include wildlife habitat, harvesting, commerce and navigation, boating, and aesthetics.

For freshwater water bodies that do not have designated uses specified in WAC 173-201A-602 (Table 602), the following “default” designated uses apply (per WAC 173-201A-600):

- Salmonid spawning, rearing, and migration;
- Primary contact recreation;
- Domestic, industrial, agricultural and stock water uses; and
- Wildlife habitat, fish harvesting, commerce and navigation, boating, and aesthetic values.

Within the Little Klickitat and Swale Creek subbasins, the Little Klickitat River and all its tributaries above the confluence with Cozy Nook Creek are the only waterbodies listed in WAC 173-201A-602 as having specific designated uses. However, the designated uses listed in that section are the default uses listed above. Therefore, the default water uses and associated water quality criteria apply to all surface waters in the two subbasins. The default temperature standard for aquatic life use (salmonid spawning, rearing, and migration) is 17.5°C (63.5°F).

The state’s surface water quality standards were revised in November 2006, after completion of the WRIA 30 Watershed Management Plan. In the November 2006 revision to Chapter 173-201A WAC, Ecology designated certain WRIA 30 waterbodies as requiring supplemental protection for salmon and trout spawning and incubation. The designation imposes a more stringent water temperature criterion (a 7-day average of daily maximum temperatures [7-DADmax] of 13°C or 55.8°F) during the salmon and trout spawning and incubation season, which is defined as different durations for different waterbodies in the WRIA.

Within the Little Klickitat and Swale Creek subbasins, the following waterbodies are subject to the 13°C spawning/incubation criterion from February 15 to June 1 (see Figure 2):

- Lower 12 miles of Swale Creek (to Harms Road);
- Lowermost 15.3 miles of the Little Klickitat River (below Goldendale), and the lowermost 3.5 miles of the Canyon Creek/Bowman Creek tributary to it; and
- Above Goldendale, a 6-mile stretch of the Little Klickitat River from approximately Jenkins Creek to the “Three Creeks” confluence of East Prong Little Klickitat, West Prong Little Klickitat, and Butler Creek tributaries, in addition to the lowermost reaches of those three tributaries and of Jenkins Creek.

These reaches, excluding the upper 10 miles of Swale Canyon, are designated as steelhead-bearing; the lower 2 miles of Swale Creek is also designated as Chinook and Coho salmon-bearing (Figure 2). Because these stream reaches are subject to the most stringent temperature criteria, our evaluation of historical changes to riparian vegetation/shade is focused on portions of them, as described in Section 5.

## 2.4 Prior Data Collection Efforts and Assessments

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Previous studies related to the project are listed in Table 3 along with a description of the data collected and reported. Extensive information regarding stream temperature, stream flow, geology, and groundwater is developing for the Little Klickitat and Swale Creek subbasins. Shade information is available for the upper reaches of the Little Klickitat subbasin, and summaries of the stream channel and flow conditions present in the mid to late 1800s, as can be gleaned from the Government Land Survey (GLO) notes, are available for some areas.

Published quantitative data regarding canopy cover (shade) characteristics is limited to 9-year old data collected in the upper Little Klickitat basin (Raines et al, 1999), scattered measurements taken during the development of the Little Klickitat TMDL (Brock and Stohr, 2002), and a limited number of measurements taken during the Swale Creek temperature study (WPN, 2004). A comprehensive analysis/estimation of current vegetation/shade conditions along the Little Klickitat River and Swale Creek has not been conducted to date.

## 2.5 Recent Actions Relevant to Stream Temperature

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Descriptions of specific projects are provided in the WRIA 30 Watershed Management Plan and in the WRIA 30 Detailed Implementation Plan. Generally recent activities have included the following:

- Several stream restoration efforts which stabilized the channel and reduced sediment inputs;
- Several projects to fence and/or manage agricultural and grazing activities which reduced sediment inputs to the river;
- Several projects to plant trees along the river;
- Construction of bioswales in the City of Goldendale to reduce sediment inputs;
- An upgrade of the City of Goldendale's water treatment plant which reduced the temperature of the discharge water; and
- Transfer of the City of Goldendale's surface water right for Bloodgood Spring to a deep groundwater source, which increased flow in Bloodgood Creek and, subsequently, the Little Klickitat River.

## 3 Estimates of Current (2006) Riparian Vegetation

A primary goal of this study was to estimate the current riparian vegetative coverage along the Swale Canyon portion of Swale Creek and the Little Klickitat River, which span greater than 12 and 30 river miles, respectively. This information can be compared against water temperature data and distribution of salmonids and aquatic habitat, to better inform decision making regarding stream reaches in which to potentially take actions to

reduce water temperature. The current condition is also used as a baseline to compare historical changes in vegetation (described in Section 5) to further inform decision making.

This study is similar to that conducted for Rock Creek within WRIA 31, relying on GIS analysis and interpretation of vegetated cover from available aerial photographs (Aspect Consulting, 2005). However, the Rock Creek study evaluated current and historical vegetation across the entire valley bottom, including areas far from the current creek alignment (although the study documented significant channel migration in some reaches). This current study focuses more specifically on stream-adjacent vegetation, which will have a more direct effect on stream shading and thus water temperature. The methods for estimating current riparian vegetative cover along each waterbody, and the results are described below.

### 3.1 GIS Methods

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The extent of current riparian vegetative cover along Swale Creek and the Little Klickitat River was estimated using geographic information system (GIS) methods on 2006 digital aerial orthophotography available from the National Agriculture Imagery Program (NAIP). The NAIP, administered by the United States Department of Agriculture (USDA) Farm Service Agency (FSA), acquires aerial imagery during the agricultural growing seasons in the continental U.S., and makes the imagery available to governmental agencies and the public within a year of acquisition.

We initially defined the assumed stream channel location, starting with Washington Department of Natural Resources' (DNR) 1:24,000-scale watercourse data (vector, polyline coverage – converted to shapefile format), and adjusting it based on professional judgment during review of the aerial imagery.

We then divided each stream corridor into segments with arbitrary length of 200 feet, and a pair of widths centered on the inferred stream centerline. The chosen segment widths were 40 feet (20 feet on each side of stream centerline) and 150 feet (75 feet on each side of stream centerline). The 40-foot-wide segment represents streamside vegetation expected to have the greatest effect on stream shade. However, some researchers contend that riparian canopy at farther distances, 75 feet or more from the stream edge, can provide shade, so both widths were analyzed for comparative purposes. Further, because of unavoidable spatial uncertainty in the georectification of the historic aerial photographs, the possible variation and deviation of the actual stream location from the polyline GIS shapefile centerline across much of the streams length, and the uncertainty in vegetated extent this lack of resolution creates, the analysis of historical change in vegetative cover was limited to the 150-foot-wide segments, as described in Section 5.

Each segment was assigned a unique identification number, ordered from the stream mouth upstream (1 through 363 for Swale Creek, and 1 through 737 for Little Klickitat). Forty-foot corridor and 150-foot corridor stream segments have same center line and length for both watercourses and thus share segment numbers.

Estimates of current vegetative cover were initially developed to guide the field data collection effort, allowing field measurements of canopy cover to be collected within segments representing a range of estimated canopy cover conditions (stratified sampling

scheme; see Section 4). The initial estimates of vegetative cover, by segment, for both segment widths were provided for the field effort, along with coordinates for the inferred stream channel in the middle of the segment.

The initial estimates of vegetative cover were derived by analyzing the red band of the aerial photograph for dark pixels. Since vegetation in the study area is reliably green in hue and because much of the surrounding land cover is lighter brown or grey, one is able to isolate green pixels (assumed vegetation) by treating the red band of the aerial photo as a color filter where dark pixels are those for which the red spectrum is not a strong part. As such, by honing in on a range of values from 0 - 255 that reliably discriminate against non-green pixels, a straightforward estimate of likely-vegetated pixels was produced and then used to calculate the estimated vegetation coverage, segment-by-segment.<sup>2</sup>

With some first-cut adjustments, this methodology achieved acceptable vegetation classification estimates that were summarized and communicated to field technicians on a series of field maps, as mentioned above.

## 3.2 Refinement of GIS Estimates

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The automated GIS analysis was calibrated based on the field measurements of canopy cover collected for this study in early- to mid-June 2009. In many cases, the location of the stream channel observed during the field effort deviated from the channel location as inferred from the aerial imagery. By itself, this spatial difference created substantial discrepancies between measured canopy cover and the initial GIS estimates for many segments. Therefore, for the purposes of calibrating the GIS analysis to the field measurements, “field segments” were defined. The field segments were defined between the upstream and downstream limits of the field measurements (based on coordinates collected by GPS), with width equal to the measured wetted width of the stream channel at the time of measurement<sup>3</sup>. The field segments therefore represent as closely as possible the area in which the field measurements were collected.

Upon review of field data and trial-and-error GIS classification adjustments, it was determined that a more refined GIS methodology would be needed to appropriately classify vegetation extent from the 2006 photographs. Replacing the red band color analysis discussed previously, supervised max likelihood GIS classification techniques were employed (using ESRI Spatial Analyst multivariate toolbox) that essentially took manually classified areas that each defined a group of related pixels in the aerial photo and used those manual classifications to derive “signatures” of pixels that fall into various classes (such as vegetation, bare ground, and open water). These signatures were then fed into the GIS system in performing the max likelihood classification – the results of which appeared to have a stronger (yet still tenuous) relationship with field data, as well as better discrimination of vegetation in visual ground-truthing of the aerial photo.

Once the field measurements of canopy cover were collected in June 2009, we further refined the GIS analysis to incorporate that information; however, in general, there was

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<sup>2</sup> See [http://en.wikipedia.org/wiki/RGB\\_color\\_model](http://en.wikipedia.org/wiki/RGB_color_model) for more information on the RGB color model

<sup>3</sup> For each segment in which field measurements were collected, five transects were measured between upstream and downstream limits, and the transect lengths were approximately equal to the wetted channel width observed at the time of measurement. Refer to Section 4.

poor correlation between GIS estimates of vegetated cover and field measurements of vegetation canopy cover. Probable reasons for the relatively poor correlation, and for general uncertainty in these GIS estimates of riparian vegetative cover, include:

- The individual pixels in the NAIP imagery are 1 meter square, relative to measured channel widths commonly only 8 meters (25 feet) or less.
- Inaccuracies in field GPS coordinates that, particularly within canyons or heavily vegetated areas, commonly exceed 10 feet. This imprecision may approach the width of the field segments analyzed (length of field measurement transects), resulting in differences between areas actually measured in the field versus those indicated by the GPS coordinates (and thus compared against GIS estimates).
- Areas of low-lying vegetation (shrubs, grasses) counted by the GIS as vegetative cover which is below the field of view measured in the field by the densiometer. Conversely, open water can have a very dark color, similar to some dense vegetative stands, on the photos, potentially overestimating vegetative cover by GIS analysis.
- Potential differences in vegetation on the ground at the time of June 2009 measurements (following a reportedly late spring), compared to when the 2006 NAIP photos were taken. The NAIP imagery is taken during the growing season, but there is no information on specific dates in 2006 when the photos of Swale Creek and Little Klickitat were taken. There therefore be seasonal differences in leaf out (e.g., June vs. August), and/or emergence or disappearance of vegetation between 2006 and 2009.

Consequently, several iterations of analysis were conducted to provide what appeared, based on combination of analyst professional judgment and the field information, the best overall inclusion of apparent vegetation and exclusion of apparent non-vegetation on the 2006 photoimagery. As expected, when applying an automated analysis to a complex physical situation over a very broad area, the GIS analysis adjustments ultimately involved considerable “push and pull”, whereby some apparent vegetation got excluded from one area when attempting to include vegetation in others, and vice versa. Optimization of the classification involved some compromise as no single classification scheme could manage the details of variation across the entire study area. This compromise was more pronounced for the Little Klickitat River corridor, as it had much more variation in photographic coloration, shadows and general feature/vegetation type disparity.

Ultimately, the chosen analysis that appeared visually to provide the best overall fit involved two different methods: supervised max likelihood classification for all of Swale Creek and the approximately lower 23 miles of Little Klickitat, and red band classification (pixel values 26-95) for the upper 4.5 miles of Little Klickitat, where Ponderosa pine becomes a dominant vegetation type. Appendix B describes in greater detail these refinements to estimate vegetative cover for the project, including graphics depicting selected results from the different analysis methods.

### 3.3 Best Estimates of 2006 Vegetated Cover

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Based on the final chosen GIS analysis, Figures 3A and 3B show the inferred best estimates of riparian vegetative cover percentage for 40- and 150-foot corridors, by segment, along Swale Creek. Because the Little Klickitat River is more than twice as long as the portion of Swale Creek analyzed, its estimates are illustrated on figures for the upstream half (Figures 4A and 4B for 40- and 150-foot corridors, respectively) and downstream half (Figures 5A and 5B). For display purposes at this scale, the vegetated cover estimates on the two figures are color coded into ten categories (0-10%, 10-20%, 20-30%, etc.). On the figures, the segment numbers are listed for every fifth segment on Swale Creek and every tenth segment on Little Klickitat. Tables 4 and 5 provide, for Swale Creek and Little Klickitat respectively, the canopy estimates for both 40-foot and 150-foot corridor widths and the difference between the two widths, by segment.

Not unexpectedly, the analysis indicates somewhat greater vegetative cover within the 40-foot corridor about the stream centerline than within the broader 150-foot corridor, for both waterbodies (i.e., vegetation generally more prevalent in closer proximity to the stream). On average for all segments combined, the 40-foot riparian corridor has 15% greater vegetative cover along Swale Creek, and 18% greater along the Little Klickitat River, than the corresponding 150-foot corridor<sup>4</sup>. However, there is considerable segment-by-segment variability in this statistic along the courses of each stream, as can be seen by comparing data for both segment widths on Tables 4 and 5. In total, 72% (263 of 363) of the individual segments along Swale Creek and 54% (395 of 737) of those along Little Klickitat River had greater estimated vegetated cover in the 40-foot riparian corridor than in the 150-foot corridor.

The estimated distribution of vegetative cover in 2006 for Swale Creek and the Little Klickitat River is described below.

#### **Swale Creek**

Vegetation presence, type, and density vary considerably along the 12 miles of Swale Creek Canyon, as indicated by the GIS. Table 4 tabulates and Figures 3A and 3B illustrate the segment-by-segment vegetative cover estimates.

Downstream of Warwick, the upper reaches of the canyon, trending generally east to west, consists primarily of bare bedrock with minor alluvium and scattered willow and shrubs in and around pools. In the 2006 photo, the GIS analysis classifies portions of the uppermost canyon (segments approximately 355 through 335, upstream to downstream) as highly vegetated when, in fact, much of it is likely shade cast from the south canyon bank. Differentiating open water, dense vegetation, and shade cast by vegetation or topography can be very difficult from the available photos for some areas. Nevertheless, it is an area where the stream appears fairly well shaded. Downstream, between segments approximately 295 and 285, there is negligible cover indicated, for either corridor width.

Where Swale Canyon bends from west to north, Stacker Canyon contributes minor spring-fed discharge into Swale Creek (0.5 cfs or less; Aspect Consulting, 2003). Based

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<sup>4</sup> Because there are positive and negative differences for individual segments, these average differences are calculated from the absolute values of the segment differences.

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on the GIS analysis, vegetated cover on the order of 40 to 70% occurs fairly uniformly in the 40-foot corridor from approximately segment 270 downstream to segment 185; however, the vegetated cover further from the stream, as represented by the 150-foot corridor data, is uniformly less in this reach (typically 10 to 30%). Vegetation in this reach includes willows, alder, and serviceberry.

Further downstream is a nearly 2.5-mile reach with little vegetative cover (averaging about 15% between segments approximately 185 and 122). Water typically occurs in isolated pools separated by areas of dry cobble, with sparse areas of vegetation. Long stretches of stream have little if any vegetative cover in either the 40- or 150-foot corridors (e.g., segments 160 through 137). The stream channel in this reach has shifted over time, likely contributing to the lack of vegetation (WPN, 204). Where present, vegetation in this reach includes willows, alder, and serviceberry, with occasional big leaf maple.

Downstream from where the Warwick Fault<sup>5</sup> crosses Swale Creek (near segment 110) to the alluvial fan near the mouth, limited groundwater discharge sustains year-round pools and some minor late-season flow. Because of the greater year-round moisture and greater abundance of unconsolidated alluvium covering the bedrock, more robust vegetation is established in this reach. Between segments approximately 10 and 100, estimated vegetative cover for the 40-foot corridor typically ranges from 40 to nearly 90%, with isolated segments containing less than 10% cover. Decent vegetative cover also exists across the 150-foot corridor, with estimated segment values typically 10 to 20% less than for the corresponding 40-foot corridor. Alder and willow are dominant vegetation types, with serviceberry, big leaf maple, and generally greater vegetative diversity than observed elsewhere in the canyon (WPN, 2004).

Swale Creek's broad, cobbly alluvial fan begins near where Horseshoe Bend Road crosses the creek (near segment 8). In this area, the creek infiltrates and flows subsurface for extended distances, creating a dry channel, during drier months. The reach has very little vegetative cover, with estimated values ranging from about 0 to 15% for both the 40- and 150-foot corridors.

### ***Little Klickitat River***

The Little Klickitat subbasin has markedly different hydrology from the Swale Creek subbasin because of the Simcoe Mountains, which typically accumulate snowpack at high elevation. Release of snowmelt water during relatively warm winter storms dominates early-season flows in the Little Klickitat. Several large tributaries of the Little Klickitat drain the Simcoe Mountains, and are fed year-round by groundwater discharge from the prolific Simcoe Volcanics aquifer system beneath the mountains. Consequently, the Little Klickitat River has perennial flow through most of its length, excluding in the broad alluvial reaches upstream of Goldendale and Three Creeks where flow commonly goes subsurface in drier months. Springs discharging from the Wanapum Basalt also

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<sup>5</sup> The trace of the Warwick Fault is shown as a thick, dashed black line on Figures 3A and 3B. The hydrogeologic weight of evidence indicates it acts as a hydraulic barrier to groundwater flow in the basalt aquifers, thus limiting groundwater discharge to Swale Creek downgradient (west) of it – i.e. upstream of its intersection with the creek.

contribute flow to the lower reaches of the Little Klickitat River, but it is a small percentage compared to that supplied from the Simcoe Volcanics.

Because of the greater year-round water, and more substantial areas of alluvium lining the channel, the Little Klickitat River has a greater abundance of vegetative cover than does Swale Creek on average. Based on the GIS analysis, the cumulative average vegetative covers within the 40-foot and 150-foot corridors are 56% and 54% for the Little Klickitat, compared to 48% and 35% for Swale Creek. Table 5 tabulates and Figures 4A/4B (upstream half) and 5A/5B (downstream half) illustrate the segment-by-segment vegetative cover estimates along the Little Klickitat River. Note that the (upstream) Figures 4A and 4B are oriented slightly off due north to better fit the page.

Within uppermost 1/3-mile reach of the Little Klickitat analyzed, down to about segment 665, the estimated vegetative cover within the 40-foot corridor ranges widely for individual segments (less than 10% to nearly 100%) but averages approximately 57%, essentially equal to the 56% average estimated for the entire river. Estimated values for the 150-foot corridor are less variable, slightly lower, but comparable. Ponderosa pine and cottonwood are the dominant vegetation in this area.

Moving downstream, the vegetated cover increases on average and stays relatively uniform for the 1.7-mile reach between segments approximately 664 and 620. Throughout this reach, vegetated cover within the 40-foot corridor ranges between about 50 and 90% (averaging about 74%), and between about 20 and 80% for the 150-foot corridor. Dominant vegetation observed in this area during the June 2009 field measurements includes cottonwood, Ponderosa pine, and alder.

At approximately segment 620, the river transitions from a bedrock-dominated channel to one dominated by an alluvial veneer, which persists downstream until approximately segment 515 (based on DNR's 1:100,000 geologic mapping). The estimated vegetated cover within this 4-mile reach is lower, averaging about 45% in the 40-foot corridor (somewhat higher, 53%, in the 150-foot corridor). Alder with lesser Ponderosa pine are dominant species observed in this reach during the June 2009 measurements.

Where the river veers more southerly and flows into Goldendale, the estimated vegetated cover within the 40-foot corridor is again somewhat higher, ranging from 35% to more than 90% and averaging 70%, between approximately segments 513 and 439. The estimated vegetative cover within the broader 150-foot corridor is about the same as in the 40-foot corridor, but with slightly greater variability in individual segments. Alder, transitioning to cottonwood in downstream segments, are dominant vegetative species in the reach.

Somewhat lower average riparian vegetation is indicated as the river flows through the western half of Goldendale, to approximately the City's wastewater treatment plant. The estimated vegetative cover in the 40-foot corridor in this reach (segments 438 to 380) averages about 50%, with individual segments ranging widely from about 10 to 90%. The 150-foot corridor has similar values estimated. Cottonwood and alder are dominant vegetation reported in the reach.

As the river flows to the west, in the area of Esteb and Olsen Roads, the estimated vegetated cover in the 40-foot corridor transitions from a 3.4-mile reach (segments 380 to

290) with substantial variability (nearly 10 to 100%) and moderately high 63% average, to alternating 1-mile reaches of relatively lower cover (averaging 40% between segments 289 and 263) and then more typical cover (averaging 53% for segments 262 through 239). The dominant vegetation types are more variable in these reaches, including alder and reed canary grass, with willow and Hawthorne observed in some segments.

Immediately downstream of the confluence with Spring Creek (approximately segment 238), the Little Klickitat begins to flow across the Simcoe Volcanics bedrock, incising through it into the underlying Wanapum Basalt, and forming a narrow, deepening canyon extending to the confluence with the mainstem Klickitat River. Within this final 9-mile reach, the river channel flows over the Little Klickitat falls (at river mile 6.1), and then through several small meanders. The GIS analysis estimates highly variable vegetated cover in the 40-foot corridor throughout this reach, with values ranging from about 0 to nearly 100%, and averaging about 51%. The 150-foot-wide corridor about the stream centerline includes canyon walls in places, and shows about the same range of variability and essentially same average cover (54%) as estimated for the 40-foot corridor. Extensive reed canary grass dominates areas of the channel in this long reach.

## 4 Field Data Collection

### 4.1 Methods

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#### ***Site Selection***

The initial vegetation cover estimated in the preliminary GIS analysis was divided into 10 strata, each representing a 10 percent range in percent vegetation. Sample sites were selected from each of the vegetation classes. Site access limited the possible set of sample sites. Within the areas where access was possible, reaches were selected randomly within each category.

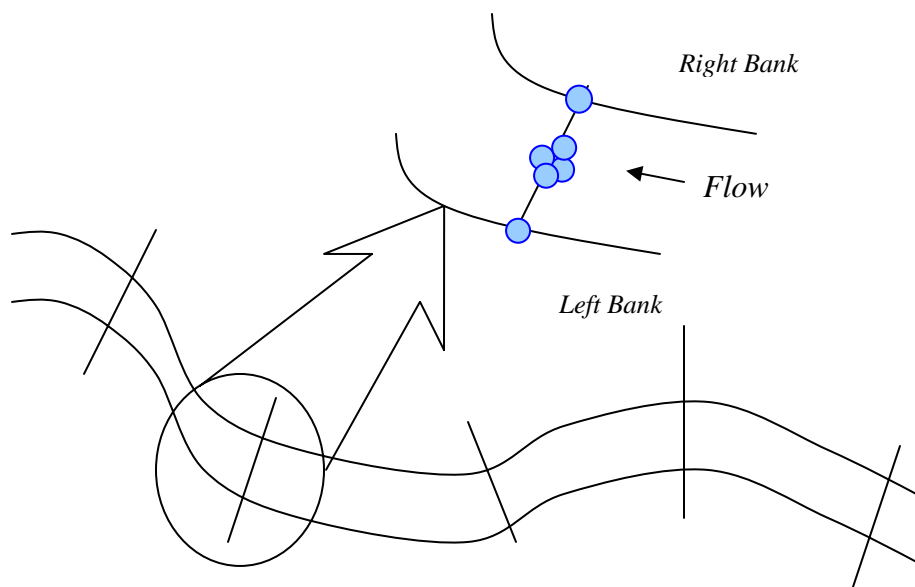
A minimum of five sites was randomly selected from each of the ten strata identified in the preliminary GIS analysis, to assist with refining the GIS analysis model. Stream canopy cover measurements were taken at each site. Riparian forest condition and stream characteristics were also documented. In all, data were collected at 33 sites along the Little Klickitat River and 32 sites along Swale Creek.

#### ***Field Measurements***

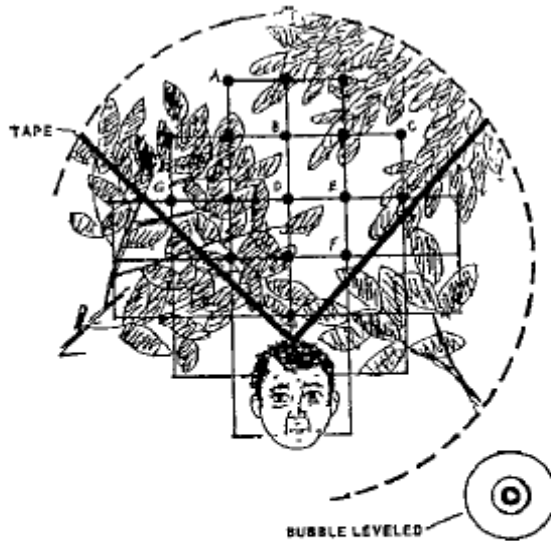
Stream canopy closure was measured between June 1 and 15, 2009, using a handheld densiometer and following the guidelines prescribed by OWEB (1999) (provided in Appendix A of the QAPP [WPN, 2008]). This procedure specifies that a sampling reach be a minimum of 150 feet long and that transects be measured within the sampling reach. Measurements are averaged to estimate average shade within the reach. For this study, measurements were collected along five transects spanning the wetted stream width, within reaches ranging from about 100 to 200 feet, and averaging about 160 feet, in length.

Along each transect, six canopy closure measurements were taken. One measurement each was taken on the right and left banks with the densiometer oriented toward the bank. In the center of the stream, four measurements were taken: 1 facing upstream, 1 facing downstream, 1 facing the left bank and 1 facing the right bank (see Schematic A below). The densiometer was taped off as depicted in Schematic B (below) and the number of intersections that were shaded was recorded for each measurement.

The GPS locations of the upstream and downstream end of each field measurement segment were recorded for each of the sample sites. Date, surveyor initials, reach length, transect interval, right and left bank dominant and subdominant vegetation, and right and left bank vegetation height were recorded for each site. The wetted and bankfull width of the stream, average wetted depth, and stream aspect, were recorded for each of the five transects within the site. Details regarding the data collection procedures are found in the QAPP developed for this project (WPN, 2008).



**Schematic A. Depicts of the division of the sample segment into equal portions to identify transect locations (lower portion of the figure) and the locations where canopy closure measurements were taken along each transect.**



**Schematic B. Schematic of modified convex spherical canopy densiometer. In this example, 10 of the 17 intersections show canopy cover, giving a densiometer reading of 10.**

## 4.2 Data Analysis

After the data were checked for errors, the bankside, center, and total percent canopy closure were estimated as follows:

1. Percent canopy closure for each densiometer measurement was calculated as:  
 $((\text{measurement})/17)*100$ .
2. Bankside canopy closure was estimated by averaging all bankside densiometer measurement (5 transects with 2 measurements at each transect, so 10 measurements typically).
3. Center canopy closure was estimated by averaging all densiometer measurements taken at the center of the stream (5 transects with 4 measurements at each transect, so 20 measurements typically).
4. Total canopy closure was estimated by averaging all densiometer measurements taken in each segment (5 transects with 6 measurements at each transect, so 30 measurements typically).

Table 6 presents the average bankside, center, and total canopy closure measurements, as well as the average wetted channel width and depth and bankfull width measurements, collected for each segment. The average of the center measurements is generally a better measure of actual stream shading, whereas the average of the bank measurements indicates more about riparian condition than shade. For reference, Table 6 also includes

the initial GIS estimates of canopy cover, for 40-foot and 150-foot segment widths, that were the basis for selecting segments to collect data within.

Appendix A includes more detailed tabulations of the field data collected. Table A-1 includes the individual canopy cover measurements along each transect, along with the average and standard deviation of all measurements by segment (representing total canopy). The table also lists stream channel aspect measured at each transect (channel orientation in degrees; 0° = north, 90° = east, 180° = south, 270° = west). Table A-2 includes, for each segment measured, the field-measured (GPS) upstream and downstream coordinates at approximate channel center, as well as the dominant and subdominant vegetation types observed.

## 4.3 Results

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Based on the June 2009 measurements, the average wetted width of the Little Klickitat River was about 30 feet, and the average wetted width of Swale Creek was about 24 feet. Three of the Swale Creek sites were totally dry and four of the sites were partially dry. No bankside densiometer measurements were taken at dry sites. The center measurements were taken at the apparent center of the dry channel.

Based on the measurements, the average bankfull widths for the Little Klickitat River and Swale Creek were about 51 and 41 feet, respectively. Transect-averaged water depth in the Little Klickitat ranged from 0.5 feet to 4.5 with a mean of 1.6 feet. These numbers exclude the depths of three transects which were too deep to wade and one transect with very high flow. Transect-averaged water depth in Swale Creek ranged from 0.0 to 5.0 feet, with a mean of 0.4 feet.

The canopy cover measurements are described with respect to calibrating the GIS analysis in Section 3.2. In aggregate, an average canopy cover of 54% was measured for the segments measured along Swale Creek, excluding segments 106, 139, and 146 for which bank measurements could not be collected. The standard deviation of the measurements within each segment (measure of variability in individual measurements) averaged 23%, and the ratio of standard deviation to average canopy cover averaged 77%, for all the segments. For the Little Klickitat field measurements, the average canopy cover for all segments measured was 44%, with the ratio of standard deviation to average canopy cover averaging 96%, indicating greater variability in individual measurements. In many segments, there was substantial canopy cover measured on the banks but little in the stream center, contributing to relatively high standard deviation of the individual measurements and as a percentage of the average total canopy for the segment (see raw data in Table A-1 of Appendix A).

In the Little Klickitat subbasin, alder and cottonwood were the most common dominant vegetative species, and alder and pacific ninebark were the most common subdominant species. In the Swale Creek subbasin, alder and willow were the most common dominant species, and willow and serviceberry were the most common subdominant species (Table 7).

## 5 Historical Change in Riparian Vegetation

An additional objective of this study was to estimate changes in the extent of riparian vegetative cover along the waterbodies over recent time, using the same stream segments as defined in the estimation of current vegetative cover. The historical comparison analysis was conducted primarily for stream reaches that are subject to the most stringent water temperature criteria (13°C February 15 to June 1, for protection of salmon/trout spawning and incubation; see Section 2.3). The historical analysis was conducted for the following five areas:

- On Swale Creek:
  - The lowermost approximately 4 miles of Swale Creek, in which isolated pools of water persist year-round, sustaining the densest vegetative cover in the canyon (“Reach A”);
  - An approximately 2-mile reach spanning the Stacker Canyon area (“Reach B”); and
  - An approximately 2-mile reach at the upstream end of Swale Canyon, just downstream of Warwick. This reach is upstream of where the 13°C temperature criterion applies, but is at the transition from Swale Valley to Swale Canyon (“Reach C”).
- On Little Klickitat River:
  - The lowermost 8 miles of the Little Klickitat River, to just above Little Klickitat River falls (RM 6.1) (“Reach D”); and
  - A 0.4-mile reach of the upper Little Klickitat River at and just below “Three Creeks” - the confluence of East Prong Little Klickitat, West Prong Little Klickitat, and Butler Creek (“Reach E”). This reach extends to the southern limit of the available 1978 photos, which is only part of the approximately 6-mile stretch of the Little Klickitat subject to the 13°C spawning/incubation temperature criterion.

The historical evaluation spanned periods of 37 years (1969-2006) for Reaches A through D, and 28 years (1978-2006) for Reach E.

Based on streamflow data from the mainstem Klickitat River at Pitt (extending back to 1930s), the two largest-scale floods during the period of record occurred in 1974 and 1996. A somewhat smaller, yet very large, flood event occurred in December 1964, less than 5 years prior to the 1969 photographs. The 1974 and 1964 floods were the two largest flood events documented at the USGS’ gage previously operating near the mouth of the Little Klickitat River; it stopped operation during the 1980s so did not catch the 1996 flood. These periodic large flood events, and more frequent but smaller peak flows, influence the distribution and density of riparian vegetation in the Swale Creek and Little Klickitat River subbasins.

## 5.1 Methods

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We obtained permission from Natural Resource Conservation District (NRCS) and the Farm Service Agency (FSA) to borrow historic aerial photographs (paper copies) from their Goldendale office, for the purposes of this project. The intent was to obtain photos covering the longest period of record readily available, recognizing that photos do not exist to document “pre-development” vegetation conditions (prior to European settlement). The years of the photo sets obtained included a combination of 1938, 1940, and 1941 (black and white), 1945 (black and white), and 1978 (color). Only the 1978 set included an index (map) showing the layout of the photos, requiring the other photo sets to be manually aligned to search for coverage of the reaches of interest.

The spatial coverage of the available photos turned out to be variable, with limited or no coverage for reaches of interest, depending on the photo set. Many of the 1938 and 1940s-vintage photos also have markings and labels from past work done with them. The NRCS apparently obtained the 1978 set from Boise Cascade, since the set covers only their lands (now Western Timber) in the Simcoe Mountains.

To assess availability of historic photos for the reaches of interest, several other potential sources for photos were searched. This included Washington Department of Transportation (WSDOT) Geographic Services Division, who have a fairly complete set of original photographic negatives covering the area for a series of years dating back to 1969. WSDOT produces digital copies of the photos from the original photographic negatives, which proved to be of considerably better resolution than the paper photos obtained; the digital images were not georeferenced however. We purchased from WSDOT a digital set of 1969 (black and white) photos covering all reaches of interest except Reach E (Three Creeks area). Comparison of the digital 1969 photos against the digitally scanned older photos demonstrated the superior resolution of the 1969 photo set. Because the photos were available for the complete reaches of interest, and provided high resolution, it was decided to rely on the 1969 set for the historical analysis. Because good quality color photos from 1978 were available for Reach E, they were used in lieu of the 1969 photos for this analysis.

All aerial photographs have spatial distortion away from the photograph center (parallax) that must be corrected for if using the photo to measure distances or areas.

Georeferencing refers to the process of adjusting the image (or portions of it, in this case) to match known location control points, and was conducted using ESRI’s ArcGIS georeferencing module. This is not the same as true photogrammetric image correction and georeferencing, but this was unavailable for the archived imagery. We were able to georeference the imagery sufficiently to make meaningful vegetation change analyses for the time period in the study. The georeferencing focused on aligning the immediate area of the stream channel, rather than areas away from it. The 2006 NAIP digital images are georeferenced and were the reference data set for georeferencing the historic photos.

Because of the uncertainty in precisely aligning the stream alignment in both the 2006 and historic figures, and the tight tolerance required by a 40-foot-wide riparian corridor, it was decided to limit the analysis of historic change in riparian vegetative cover to the 150-foot-wide corridor.

Like the 2006 aerial photos, the 1969 and 1978 georectified images were classified using supervised max likelihood classification techniques. After georectification, the historic photos were manually examined to define groups of pixels that made up certain classes of interest (varying shades of vegetation, open water, bare ground, etc). These class definitions were used as an input in creating pixel “signatures” of particular classes of interest. These were then used to run the GIS max likelihood classification, separating the photos into pixel groups representing the various classes. Classes in the varying shades of vegetation that were determined to adequately represent the vegetation coverage were re-classified (grouped) to produce a pixel-by-pixel estimate of vegetation for each historic photo.

Since the scanned historic photos still had artifacts of the photos themselves (such as printed ID numbers and black borders), stream corridor segments for which the historic photo was adequate for analysis were isolated for each individual photo. Total vegetation coverage as estimated by GIS classification was then summed for each corridor segment and averaged for any segments analyzed on more than one photo (photo overlap). These percent vegetation estimates were then compared to the 2006 analysis on a segment-by-segment basis to estimate change in vegetated cover between the two years.

## 5.2 Results

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Results from evaluation of recent historical changes to riparian vegetative cover within the 150-foot riparian corridor are presented below for Swale Creek and Little Klickitat River.

### **Swale Creek**

The estimated changes to vegetative cover between 1969 and 2006 for the aforementioned three reaches of Swale Creek are described below. Table 8 lists the estimated vegetated cover percentage in 1969 and 2006, and the change between those years, for each segment analyzed in each of the three reaches. Figures 6, 7, and 8 illustrate the estimated % change for the respective three reaches, color coded by the following categories:

- Loss exceeding -30%: red
- Loss between -10 and -30%: light red
- Same (between -10 and +10%<sup>6</sup>): yellow
- Gain between 10 and 30%: light green
- Gain exceeding 30%: dark green

### **Lowermost 4 Miles (Reach A)**

During the 37-year period between 1969 and 2006, the average vegetated cover in the lowermost 4 miles of Swale Creek has increased slightly (from 28 to 38% for the reach as a total). The changes within the 103 individual segments analyzed vary substantially, ranging from nearly -50% to +40%.

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<sup>6</sup> Changes, either loss or gain, within 10% are considered within the resolution of the GIS analysis.

The lowermost  $\frac{3}{4}$  mile of the creek (segments 1 to 19) is the primary area where vegetation loss is indicated, covering the creek's alluvial fan and several hundred feet upstream. This is a broad, high energy area in which the channel migrates over time. Further upstream, the area of vegetative cover has been generally stable or increasing in this time period (Figure 6).

The 2004 Swale Creek water temperature study (WPN, 2004) evaluated historical changes to stream channel and riparian vegetation conditions in Swale Canyon over the preceding 50 years, based on review of aerial photographs from years 1954, 1969, 1979, 1991, and 1996. Although vegetative cover was not estimated quantitatively as in the 2004 study, it provided focused review of a few specific locations over multiple years. From the photo review, it was concluded that riparian vegetation in Swale Creek is cyclical, likely increasing and decreasing over periods of 10 to 20 years. Whether this is a natural cycling of willows and shrubs, or due to grazing or other human impacts, is uncertain. However, the photo evidence indicated vegetation removal attributable to large-scale floods that occurred within the period of photographic record.

The photo review documented that vegetation near the mouth of Swale Creek is highly dynamic, even over time periods as short as five or ten years.

#### **Near Stacker Canyon (Reach B)**

Between 1969 and 2006, the total vegetated cover in this reach is estimated to have increased from about 24% to 41%. The downstream, northerly-trending portion of the reach shows consistent increase, whereas the areas of decreased or stable cover occur within the westerly-trending upstream portion (Figure 7).

Reportedly, portions of the railroad grade near Stacker Canyon washed out in the 1974 flood, and the railroad owners subsequently removed large boulders from the stream channel, apparently reducing the abundance of larger pools thereafter (WPN, 2004). There is limited human activity currently within this reach of Swale Canyon, so large floods, like those of 1974 and 1996 (both within the time period represented in this change analysis), are probable major factors in vegetation loss. Inter Fluve (2002) concluded that construction and long-term maintenance of the existing railroad grade, built in 1902 and running along the entire length of Swale Canyon, has degraded the stream channel, principally by reducing the width of the channel and thus increasing the stream's erosive energy, particularly during flood events and particularly in the upper reaches of the canyon (e.g., Reach B).

#### **Near Warwick (Reach C)**

The total vegetated cover in this reach is estimated to have increased on average between 1969 and 2006 (24% net gain, from 35% to 59%). Generally stable or declining vegetative cover is estimated to have occurred in isolated segments at the upstream and downstream ends of the reach, with a long stretch of vegetation gain in the center of it (Figure 8).

## ***Little Klickitat River***

### **Lowermost 8 Miles (Reach D)**

Between 1969 and 2006, a slight increase in total vegetated cover is estimated across the 8-mile canyon reach extending from the mouth of the Little Klickitat to about 2 miles upstream of Little Klickitat falls (11% increase, from 48% to 59% on average). Because of the reach length, it is broken into two segments for illustration on Figure 9.

The magnitude of estimated change (loss or gain) is small across most of the reach, with only 16% of the segments having estimated changes exceeding 30%. Three segments, including segment 1 at the mouth, have estimated losses exceeding 30%, while there are 38 segments with estimated gains exceeding 30%.

### **Near Three Creeks (Reach E)**

Between 1978 and 2006, a small increase in total vegetative cover is estimated for the short reach of the Little Klickitat River around Three Creeks (15% percent increase, from 34% to 49%, on average). Vegetative losses are estimated in the upstream end of the reach, at and above Three Creeks, with three segments (710, 709, 708) adjacent Highway 97 showing losses exceeding 30% (Figure 10). Downstream of those three segments, increasing or stable vegetative cover is predicted for all segments in the reach (averaging 27% increase). A 1/3-mile stretch in Section 29 (segments 669 through 661) shows gains on the order of 50%.

The headwater tributaries of the Little Klickitat, from West Prong and Butler Creek on the east to Bowman Creek/Canyon Creek on the west, largely run through commercially owned forest lands, which are regulated under the Forest Practices Rules (Chapter 222 WAC). The Forests and Fish Report, prepared for the Forest Practices Board and the state's Salmon Recovery Office, and the attendant Forest Practices Rules, establish riparian buffers within which logging is prohibited. As such, it is expected that riparian vegetation will continue to increase in most of the headwater tributaries of the river.

## **6 Conclusions and Recommendations**

In very general terms, and based on 2006 information, vegetation covers roughly 50% of the streamside (40-foot wide) riparian corridor, on average, for the entire lengths of Swale Creek and the Little Klickitat River. Within an assumed narrow (40-foot-wide) riparian corridor, the Little Klickitat River has somewhat higher average vegetative cover estimated than does Swale Creek. Somewhat lower average vegetative cover is estimated in a wider (150-foot) corridor around each stream. The vegetative cover estimated by the GIS analysis is extremely variable throughout the course of each stream, with only general patterns of higher vs. lower cover apparent along certain reaches.

The degree to which the vegetative cover effectively shades the stream varies based on type and height of vegetation and its position relative to the stream and sun. In the Little Klickitat subbasin, alder and cottonwood were the most common dominant vegetative species, and alder and pacific ninebark were the most common subdominant species. In

the Swale Creek subbasin, alder, and willow were the most common dominant species, and willow and serviceberry were the most common subdominant species.

In general, the extent of vegetative cover has increased along the riparian corridors of Swale Creek and Little Klickitat River over the past 30 to 40 years. Both waterbodies, and particularly Swale Creek, are subject to dramatic changes in riparian condition due to periodic flooding. Substantial changes to the stream channel and associated riparian vegetation can occur in a single year, so that the historic analysis results are specific to the year of the historic photo chosen, and can yield different results for different reaches of each stream. Nevertheless, in aggregate for Swale Creek and for Little Klickitat, an overall pattern of gradually increasing vegetative cover is indicated from the analysis. This is consistent with the overall pattern of increasing vegetative cover observed for the Rock Creek drainage in WRIA 31, the next drainage east of Swale Creek and Little Klickitat (Aspect Consulting, 2005). The general increases in vegetation may be attributable to increasingly effective fire suppression, as well as increasingly stringent regulatory restrictions on activities within riparian areas.

For Swale Creek, we recommend that evaluation of potential actions to reduce water temperature focus on its lowermost 3 to 4 miles. The reach is designated habitat for Chinook and Coho salmon and steelhead, and is subject to the most stringent water temperature criterion. In this reach, pools of water are sustained throughout the late season by limited groundwater discharge. The availability of year-round water, even if limited, results in the most robust vegetative cover in this area of the creek. As in the rest of the subbasin, the vegetation density in this reach varies over time, largely as a result of recurring flood events that can remove vegetation and change the course of the stream channel. Actions to reduce water temperature in this lowermost reach could include enhancing riparian vegetation and/or other means, including augmenting flow. Better defining the scope and feasibility of such actions would be a primary focus of the planned Swale Creek water quality improvement plan, to be completed in close coordination with the WRIA 30 WRPAC and other stakeholders in accordance with the WRIA 30 Watershed Management Plan.

For the Little Klickitat River, actions to reduce water temperature can focus initially on the river's lowest 6 miles, below Little Klickitat falls, including the major tributaries to that reach (Bowman/Canyon Creek, Mill Creek, and Blockhouse Creek). The reach is designated steelhead habitat and is subject to the most stringent water temperature criterion. The river above the falls is designated the same, but there is uncertainty regarding how passable the falls are. In addition, sources have indicated Coho salmon below but not above the falls (Klickitat Lead Entity, 2003). While much of this lower reach has considerable vegetated cover, there are extensive areas where the banks are inundated with reed canary grass, an invasive species that provides negligible effective shade. The feasibility of removing the grass and establishing a shade-producing dominant vegetative species can be considered. In addition, opportunities to increase shade in the lower reaches of Bowman, Mill, and Blockhouse Creeks can be coordinated with local land owners.

If riparian plantings are selected as an action to enhance effective shade and thereby reduce water temperature, we recommend that the Central Klickitat Conservation District participate in the planning and implementation, to take advantage of their direct

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experience to date in this watershed. Plantings have been conducted at various locations throughout these subbasins, and there is an evolving base of local experience to draw upon to provide the best chance for success with new plantings.

It is also recommended that the Forests and Fish Report and the attendant Forest Practices Rules serve as the plan for addressing water temperature in forested areas that are subject to the Forest Practices Rules (e.g., higher elevation tributaries to the Little Klickitat).

As stated in Section 1, there was not sufficient time for this project report to be reviewed by the WRIA 30 WRPAC prior to its issuance. Consequently, the data in this report, and implications for potentially reducing water temperatures in Swale Creek and Little Klickitat River, should be discussed in detail with the WRPAC and other stakeholders to define the appropriate path forward.

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- Watershed Professionals Network (WPN), 2004, WRIA 30 Swale Creek Temperature Study; 2004. Appendix E to WRIA 30 Watershed Assessment. September 2004.
- Watershed Professionals Network (WPN) and Aspect Consulting, 2005, Klickitat River Watershed Management Plan, May 3, 2005.
- Watershed Professionals Network (WPN), 2008, Quality Assurance Project Plan for Shade Study for Swale Creek and Little Klickitat River, September 2008.

**Table 1 - Waterbodies in the Little Klickitat Subbasin on the 1998 303(d) List for Water Temperature**

<b>Water Body</b>	<b>Stream Segment ID</b>	<b>Township, Range, Section</b>
Butler Creek	YU86SG	05N, 17E, 17
Little Klickitat River Mainstem	AY21LB	04N, 14E, 09
Little Klickitat River, East Prong	AG85MX	05N, 17E, 16
	PW77VQ	05N, 17E, 10
	PW77VQ	05N, 17E, 03
	PW77VQ	05N, 17E, 09
	PU81CT	06N, 17E, 35
Little Klickitat River, West Prong	XU61EK	05N, 17E, 18

**Table 2 - Estimated Current and Target Effective Shade for Streams in the Little Klickitat Subbasin (from Anderson, 2005)**

Tributary	Current Effective Shade (%)	Target Effective Shade (%)
Butler	55.0	95
East Prong	62.3	94
West Prong	77.5	93
Spring Creek	38.6	73
Blockhouse Creek	68.1	73
Mill Creek	59.2	73
Bowman Creek	50.7	73
Un-modeled tributaries		73

Little Klickitat River (river mile from mouth)	Current Effective Shade (%)	Target Effective Shade (%)
0	48.1	50
0.6	49.7	51
1.6	51.1	52
2.6	48.0	53
3.6	52.3	54
4.7	56.0	60
5.7	58.0	62
6.7	55.9	61
7.7	50.7	59
8.7	50.8	62
9.7	30.0	62
10.7	30.0	62
11.7	30.0	63
12.7	30.0	66
13.7	30.0	71
14.7	30.0	74
15.7	30.0	76
16.7	30.0	74
17.7	30.0	72
18.7	30.0	71
19.8	20.4	75
20.8	29.4	77
21.8	24.8	78
22.8	18.9	76
23.8	46.4	82
24.8	66.7	86
25.8	66.6	86
26.8	60.2	82
27.8	42.1	77
28.8	60.0	81
29.8	57.4	79
30.8	51.5	83
31.8	55.1	83
32.8	37.2	82
33.8	17.8	83
34.8	33.5	79
35.9	47.4	80
36.9	43.7	81
37.9	50.0	74
38.9	34.9	76
39.9	59.4	79
40.9	54.4	79
41.9	58.7	78

**Table 3 - Prior Studies Addressing Stream Temperature and Riparian Condition in the Little Klickitat River and Swale Creek Basins**

Study	Citation/Source	General Description of Data
Multipurpose Water Storage Screening Assessment Report	Aspect Consulting, 2003. Multipurpose water storage screening assessment report. WRIA 30. Prepared for WRIA 30 Planning Unit. Project No. 020070-002-05. Bainbridge Island, WA. (www.klickitatcounty.org/planning)	Includes discussion of geology affecting flows in the Little Klickitat River and Swale Creek, assessment of groundwater inputs to Swale Creek.
Upper Little Klickitat Watershed Analysis.	Raines et al 1999. Upper Little Klickitat Watershed Analysis. Boise Cascade Corporation, Yakima, WA. Available through WDNR geologic library.	Covers upper ½ of the Little Klickitat River basin. Includes: <ul style="list-style-type: none"> <li>§ A quantitative evaluation of sediment inputs from roads, surface erosion, and land slides,</li> <li>§ Quantitative data regarding channel conditions and fish habitat conditions in representative reaches (pools, wood, substrate condition),</li> <li>§ Estimates of stream flow, including 2-yr, 10-yr- 25-yr and 100-yr flood events</li> <li>§ Shade levels along fish bearing waters</li> </ul>
Little Klickitat River Watershed Temperature total Maximum Daily Load	Brock, S. and A. Stohr. 2002. Little Klickitat River Watershed Temperature Total Maximum Daily	Temperature and shade data for the Little Klickitat River
Little Klickitat River Watershed Temperature Total Maximum Daily Load (Water Cleanup Plan). Detailed Implementation Plan.	Anderson, R. 2005. Publ. No. 04-10-075. Washington Dept. Ecology. Olympia, WA.	Temperature and shade data for the Little Klickitat River
Klickitat River Watershed Assessment	WRIA 30 Watershed Assessment. 2005. Prepared for Klickitat County Planning Department and WRIA 30 Planning Unit. (www.klickitatcounty.org/planning)	<ul style="list-style-type: none"> <li>§ Summaries and maps of climate data</li> <li>§ Estimates of stream flow including 50-yr and 90-yr flows and flood flows for various subbasins</li> <li>§ Summaries of geologic conditions</li> <li>§ Descriptions of aquifers</li> <li>§ Estimates of water use</li> <li>§ Water budgets</li> <li>§ Summaries of existing water quality data</li> <li>§ Summaries of existing fish distribution and habitat data</li> </ul>
Swale Creek Temperature Study	WRIA 30 Swale Creek Temperature Study; 2004. Appendix E to WRIA 30 Watershed Assessment. Prepared for Klickitat County Planning Department and WRIA 30 Planning Unit. (www.klickitatcounty.org/planning)	Swale Creek temperature data, including data collected for the study, summaries of previous Central Klickitat Conservation District temperature data and Yakama Fisheries temperature data. Shade measurement. Stream flow information. Assessment of effect of geology on stream flows and groundwater inputs. Also contains summaries of the GLO notes regarding pre-development conditions of channels, flow, and vegetation in the 1860s.
Ground-Water Occurrence in the Goldendale Area, Klickitat County	Luzier, J. 1969. Ground-Water Occurrence in the Goldendale Area, Klickitat County, Washington.	Groundwater distribution and aquifers in the Klickitat basin
Klickitat/Yakima Fisheries Project, Klickitat Only Monitoring and Evaluation	Sampson and Evenson, 2003. Project No. 199506335, \BPA Report DOE/BP-00005934-1	<ul style="list-style-type: none"> <li>§ Sediment data (gravel) collected at 17 sites from 1998 to 2002. (Not all sites monitored in all years).</li> <li>§ 2002 temperature data collected throughout the watershed</li> <li>§ Results of spot measurements of other water quality parameters at several locations in the watershed</li> </ul>
Klickitat/Yakima Fisheries Project, Klickitat Only Monitoring and Evaluation	Evenson, Zendt and Sampson, 2004. Project No. 199506335, \BPA Report DOE/BP-00014033-1	<ul style="list-style-type: none"> <li>§ Sediment (gravel) samples at 11 sites 1998-2003</li> <li>§ Summaries of temperature data collected in 2003</li> </ul>
Swale Creek Channel Assessment Project	Inter-Fluve, 2002. Project No: 199705600	Estimates of flow and encroachment of old railroad bed on floodplain. Some channel cross-section information included.
Swale Creek Stream Gages	Aspect Consulting, 2009a.	Installation of 3 continuous-reading stream gages on Swale Ck.
Swale Valley Monitoring Well	Aspect Consulting, 2009b.	Installation of shallow monitoring well, with continuous water level monitoring, for Alluvium aquifer near east end of Swale Valley.

**Table 4 - Estimated 2006 Vegetative Cover by Segment, Swale Creek**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
1	0%	2%	-2%
2	0%	0%	0%
3	1%	3%	-2%
4	3%	2%	1%
5	10%	11%	-1%
6	12%	12%	0%
7	12%	13%	-1%
8	16%	12%	4%
9	12%	10%	2%
10	53%	26%	27%
11	27%	25%	2%
12	39%	19%	20%
13	55%	28%	27%
14	37%	17%	20%
15	66%	49%	17%
16	51%	44%	7%
17	69%	43%	26%
18	67%	48%	19%
19	50%	44%	6%
20	61%	39%	22%
21	70%	48%	22%
22	71%	64%	7%
23	39%	38%	1%
24	64%	56%	8%
25	69%	54%	15%
26	71%	47%	24%
27	73%	54%	19%
28	89%	70%	19%
29	63%	50%	13%
30	69%	67%	2%
31	79%	62%	17%
32	79%	42%	37%
33	67%	33%	34%
34	58%	26%	32%
35	63%	41%	22%
36	53%	34%	19%
37	68%	50%	18%
38	66%	41%	25%
39	38%	19%	19%
40	1%	7%	-6%
41	23%	21%	2%
42	65%	25%	40%
43	60%	31%	29%
44	87%	59%	28%
45	77%	60%	17%
46	81%	57%	24%
47	78%	44%	34%
48	38%	26%	12%
49	59%	43%	16%
50	66%	58%	8%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
51	67%	48%	19%
52	76%	45%	31%
53	63%	34%	29%
54	53%	20%	33%
55	61%	25%	36%
56	67%	34%	33%
57	74%	41%	33%
58	61%	47%	14%
59	77%	66%	11%
60	63%	41%	22%
61	52%	38%	14%
62	56%	44%	12%
63	64%	47%	17%
64	53%	35%	18%
65	60%	48%	12%
66	65%	52%	13%
67	63%	39%	24%
68	66%	49%	17%
69	69%	42%	27%
70	60%	38%	22%
71	61%	35%	26%
72	44%	39%	5%
73	63%	49%	14%
74	57%	41%	16%
75	66%	46%	20%
76	55%	57%	-2%
77	57%	55%	2%
78	31%	34%	-3%
79	52%	34%	18%
80	54%	41%	13%
81	29%	27%	2%
82	52%	34%	18%
83	40%	35%	5%
84	40%	22%	18%
85	47%	46%	1%
86	35%	42%	-7%
87	37%	42%	-5%
88	57%	47%	10%
89	45%	45%	0%
90	38%	46%	-8%
91	51%	47%	4%
92	60%	49%	11%
93	53%	43%	10%
94	50%	40%	10%
95	63%	40%	23%
96	63%	41%	22%
97	61%	45%	16%
98	29%	33%	-4%
99	33%	38%	-5%
100	57%	44%	13%

**Table 4 - Estimated 2006 Vegetative Cover by Segment, Swale Creek**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
101	45%	35%	10%
102	48%	35%	13%
103	54%	27%	27%
104	31%	12%	19%
105	0%	0%	0%
106	27%	13%	14%
107	6%	3%	3%
108	0%	4%	-4%
109	7%	7%	0%
110	16%	13%	3%
111	22%	16%	6%
112	25%	32%	-7%
113	39%	33%	6%
114	78%	56%	22%
115	70%	45%	25%
116	69%	42%	27%
117	50%	26%	24%
118	49%	46%	3%
119	26%	30%	-4%
120	52%	39%	13%
121	47%	26%	21%
122	1%	2%	-1%
123	0%	5%	-5%
124	3%	1%	2%
125	9%	6%	3%
126	7%	3%	4%
127	31%	12%	19%
128	20%	8%	12%
129	38%	13%	25%
130	12%	12%	0%
131	7%	4%	3%
132	29%	20%	9%
133	19%	22%	-3%
134	39%	38%	1%
135	56%	34%	22%
136	29%	25%	4%
137	1%	0%	1%
138	0%	0%	0%
139	0%	1%	-1%
140	0%	1%	-1%
141	5%	6%	-1%
142	0%	3%	-3%
143	6%	2%	4%
144	0%	5%	-5%
145	0%	0%	0%
146	4%	4%	0%
147	0%	1%	-1%
148	0%	0%	0%
149	1%	2%	-1%
150	0%	2%	-2%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
151	7%	8%	-1%
152	3%	1%	2%
153	2%	2%	0%
154	0%	1%	-1%
155	3%	4%	-1%
156	0%	3%	-3%
157	0%	4%	-4%
158	0%	5%	-5%
159	2%	19%	-17%
160	3%	6%	-3%
161	37%	33%	4%
162	41%	25%	16%
163	57%	35%	22%
164	38%	34%	4%
165	18%	22%	-4%
166	24%	32%	-8%
167	58%	65%	-7%
168	49%	68%	-19%
169	4%	16%	-12%
170	16%	25%	-9%
171	14%	26%	-12%
172	14%	20%	-6%
173	7%	25%	-18%
174	22%	42%	-20%
175	31%	49%	-18%
176	13%	16%	-3%
177	13%	8%	5%
178	0%	4%	-4%
179	3%	5%	-2%
180	26%	12%	14%
181	15%	11%	4%
182	2%	15%	-13%
183	20%	21%	-1%
184	61%	34%	27%
185	87%	54%	33%
186	51%	29%	22%
187	75%	46%	29%
188	78%	45%	33%
189	59%	39%	20%
190	64%	47%	17%
191	42%	15%	27%
192	31%	24%	7%
193	64%	63%	1%
194	59%	63%	-4%
195	63%	71%	-8%
196	53%	52%	1%
197	58%	66%	-8%
198	73%	65%	8%
199	69%	52%	17%
200	66%	43%	23%

**Table 4 - Estimated 2006 Vegetative Cover by Segment, Swale Creek**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
201	48%	33%	15%
202	19%	21%	-2%
203	15%	19%	-4%
204	57%	42%	15%
205	68%	64%	4%
206	52%	58%	-6%
207	53%	59%	-6%
208	38%	52%	-14%
209	52%	51%	1%
210	50%	60%	-10%
211	67%	46%	21%
212	52%	48%	4%
213	67%	48%	19%
214	76%	49%	27%
215	61%	59%	2%
216	71%	71%	0%
217	87%	48%	39%
218	82%	34%	48%
219	65%	39%	26%
220	67%	41%	26%
221	65%	42%	23%
222	67%	47%	20%
223	58%	47%	11%
224	44%	30%	14%
225	61%	36%	25%
226	68%	55%	13%
227	63%	42%	21%
228	50%	28%	22%
229	41%	27%	14%
230	59%	39%	20%
231	54%	30%	24%
232	27%	21%	6%
233	53%	36%	17%
234	63%	42%	21%
235	68%	23%	45%
236	48%	31%	17%
237	57%	27%	30%
238	69%	34%	35%
239	52%	30%	22%
240	60%	37%	23%
241	58%	38%	20%
242	71%	59%	12%
243	74%	76%	-2%
244	60%	65%	-5%
245	61%	64%	-3%
246	51%	49%	2%
247	64%	64%	0%
248	69%	57%	12%
249	92%	59%	33%
250	58%	53%	5%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
251	58%	39%	19%
252	70%	41%	29%
253	57%	23%	34%
254	65%	37%	28%
255	93%	57%	36%
256	72%	37%	35%
257	45%	19%	26%
258	51%	22%	29%
259	35%	11%	24%
260	43%	19%	24%
261	7%	4%	3%
262	42%	23%	19%
263	49%	40%	9%
264	59%	43%	16%
265	73%	35%	38%
266	65%	37%	28%
267	71%	32%	39%
268	89%	34%	55%
269	56%	22%	34%
270	41%	20%	21%
271	52%	18%	34%
272	21%	9%	12%
273	36%	13%	23%
274	27%	11%	16%
275	46%	14%	32%
276	23%	9%	14%
277	61%	31%	30%
278	69%	37%	32%
279	56%	50%	6%
280	52%	53%	-1%
281	50%	47%	3%
282	75%	50%	25%
283	44%	29%	15%
284	20%	12%	8%
285	4%	5%	-1%
286	2%	2%	0%
287	2%	2%	0%
288	2%	1%	1%
289	9%	5%	4%
290	5%	3%	2%
291	0%	0%	0%
292	1%	0%	1%
293	0%	0%	0%
294	0%	0%	0%
295	0%	3%	-3%
296	8%	13%	-5%
297	18%	26%	-8%
298	61%	22%	39%
299	91%	42%	49%
300	56%	30%	26%

**Table 4 - Estimated 2006 Vegetative Cover by Segment, Swale Creek**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
301	66%	24%	42%
302	28%	9%	19%
303	39%	11%	28%
304	65%	22%	43%
305	75%	22%	53%
306	88%	38%	50%
307	90%	35%	55%
308	75%	31%	44%
309	87%	55%	32%
310	90%	56%	34%
311	83%	42%	41%
312	56%	41%	15%
313	53%	24%	29%
314	37%	26%	11%
315	62%	26%	36%
316	59%	26%	33%
317	93%	48%	45%
318	81%	45%	36%
319	96%	47%	49%
320	95%	48%	47%
321	87%	38%	49%
322	60%	20%	40%
323	0%	1%	-1%
324	0%	0%	0%
325	0%	1%	-1%
326	67%	47%	20%
327	60%	47%	13%
328	89%	75%	14%
329	90%	87%	3%
330	96%	89%	7%
331	51%	66%	-15%
332	27%	39%	-12%
333	6%	20%	-14%
334	18%	28%	-10%
335	15%	14%	1%
336	69%	36%	33%
337	99%	79%	20%
338	98%	93%	5%
339	94%	73%	21%
340	79%	60%	19%
341	73%	73%	0%
342	81%	65%	16%
343	90%	66%	24%
344	84%	61%	23%
345	99%	90%	9%
346	100%	98%	2%
347	100%	98%	2%
348	99%	97%	2%
349	100%	93%	7%
350	100%	94%	6%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
351	99%	97%	2%
352	100%	99%	1%
353	100%	96%	4%
354	99%	79%	20%
355	99%	93%	6%
356	100%	95%	5%
357	74%	83%	-9%
358	89%	89%	0%
359	41%	53%	-12%
360	15%	50%	-35%
361	27%	48%	-21%
362	12%	42%	-30%
363	28%	55%	-27%

**Averages:**      **48%**      **35%**      **15%**

# of segments where 40-ft vegetated % > 150-ft vegetated %: <b>263</b> = <b>72%</b> of all segments
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Notes:

The average for the differences uses the absolute value of the individual differences (+ or -).

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
1	3%	8%	-5%
2	10%	40%	-30%
3	30%	54%	-24%
4	41%	36%	5%
5	85%	69%	16%
6	70%	87%	-17%
7	76%	69%	7%
8	28%	22%	6%
9	7%	8%	-1%
10	27%	36%	-9%
11	27%	55%	-28%
12	59%	61%	-2%
13	50%	73%	-23%
14	48%	79%	-31%
15	70%	82%	-12%
16	30%	59%	-29%
17	50%	71%	-21%
18	39%	67%	-28%
19	45%	69%	-24%
20	36%	61%	-25%
21	71%	84%	-13%
22	76%	79%	-3%
23	67%	68%	-1%
24	66%	69%	-3%
25	76%	65%	11%
26	47%	49%	-2%
27	59%	46%	13%
28	39%	28%	11%
29	26%	41%	-15%
30	32%	32%	0%
31	77%	61%	16%
32	51%	61%	-10%
33	44%	64%	-20%
34	54%	65%	-11%
35	49%	60%	-11%
36	48%	51%	-3%
37	36%	37%	-1%
38	37%	38%	-1%
39	52%	62%	-10%
40	63%	72%	-9%
41	73%	82%	-9%
42	41%	40%	1%
43	65%	43%	22%
44	52%	67%	-15%
45	45%	74%	-29%
46	42%	61%	-19%
47	71%	77%	-6%
48	40%	38%	2%
49	27%	21%	6%
50	38%	43%	-5%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
51	47%	39%	8%
52	57%	60%	-3%
53	49%	44%	5%
54	74%	55%	19%
55	44%	60%	-16%
56	58%	80%	-22%
57	71%	77%	-6%
58	60%	72%	-12%
59	88%	88%	0%
60	86%	85%	1%
61	62%	87%	-25%
62	84%	91%	-7%
63	91%	83%	8%
64	76%	69%	7%
65	75%	55%	20%
66	50%	49%	1%
67	29%	21%	8%
68	31%	23%	8%
69	60%	48%	12%
70	59%	39%	20%
71	35%	23%	12%
72	90%	61%	29%
73	63%	38%	25%
74	41%	18%	23%
75	18%	5%	13%
76	56%	29%	27%
77	44%	36%	8%
78	50%	50%	0%
79	28%	23%	5%
80	22%	13%	9%
81	58%	48%	10%
82	30%	34%	-4%
83	5%	16%	-11%
84	30%	48%	-18%
85	73%	51%	22%
86	96%	71%	25%
87	53%	56%	-3%
88	65%	54%	11%
89	87%	75%	12%
90	76%	68%	8%
91	66%	57%	9%
92	60%	41%	19%
93	46%	50%	-4%
94	73%	49%	24%
95	45%	27%	18%
96	31%	24%	7%
97	21%	33%	-12%
98	57%	60%	-3%
99	63%	40%	23%
100	40%	29%	11%

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
101	66%	56%	10%
102	84%	67%	17%
103	65%	66%	-1%
104	89%	88%	1%
105	94%	79%	15%
106	68%	64%	4%
107	76%	68%	8%
108	44%	40%	4%
109	69%	55%	14%
110	94%	63%	31%
111	74%	88%	-14%
112	82%	70%	12%
113	88%	61%	27%
114	59%	56%	3%
115	76%	69%	7%
116	16%	38%	-22%
117	46%	47%	-1%
118	73%	79%	-6%
119	75%	86%	-11%
120	62%	63%	-1%
121	63%	61%	2%
122	82%	59%	23%
123	85%	68%	17%
124	29%	32%	-3%
125	46%	45%	1%
126	52%	54%	-2%
127	46%	53%	-7%
128	66%	84%	-18%
129	60%	58%	2%
130	51%	51%	0%
131	37%	51%	-14%
132	29%	53%	-24%
133	17%	44%	-27%
134	65%	57%	8%
135	53%	59%	-6%
136	43%	56%	-13%
137	58%	78%	-20%
138	45%	45%	0%
139	34%	47%	-13%
140	35%	66%	-31%
141	61%	57%	4%
142	42%	57%	-15%
143	28%	70%	-42%
144	57%	70%	-13%
145	21%	56%	-35%
146	32%	62%	-30%
147	35%	61%	-26%
148	36%	62%	-26%
149	33%	56%	-23%
150	48%	61%	-13%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
151	46%	48%	-2%
152	26%	20%	6%
153	60%	28%	32%
154	64%	41%	23%
155	54%	49%	5%
156	62%	41%	21%
157	60%	65%	-5%
158	48%	74%	-26%
159	47%	28%	19%
160	52%	37%	15%
161	34%	27%	7%
162	48%	25%	23%
163	40%	28%	12%
164	36%	19%	17%
165	42%	22%	20%
166	52%	38%	14%
167	23%	52%	-29%
168	43%	50%	-7%
169	63%	55%	8%
170	89%	63%	26%
171	84%	65%	19%
172	44%	45%	-1%
173	61%	28%	33%
174	69%	49%	20%
175	65%	72%	-7%
176	45%	63%	-18%
177	43%	60%	-17%
178	33%	43%	-10%
179	29%	56%	-27%
180	35%	66%	-31%
181	25%	44%	-19%
182	55%	31%	24%
183	69%	61%	8%
184	53%	68%	-15%
185	58%	72%	-14%
186	42%	63%	-21%
187	60%	79%	-19%
188	22%	70%	-48%
189	35%	60%	-25%
190	42%	28%	14%
191	33%	39%	-6%
192	36%	54%	-18%
193	25%	21%	4%
194	17%	8%	9%
195	43%	26%	17%
196	35%	58%	-23%
197	28%	17%	11%
198	53%	68%	-15%
199	63%	74%	-11%
200	19%	70%	-51%

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
201	25%	58%	-33%
202	34%	48%	-14%
203	55%	67%	-12%
204	55%	67%	-12%
205	26%	43%	-17%
206	17%	25%	-8%
207	59%	32%	27%
208	72%	48%	24%
209	45%	36%	9%
210	29%	28%	1%
211	39%	38%	1%
212	53%	46%	7%
213	66%	69%	-3%
214	60%	64%	-4%
215	49%	74%	-25%
216	54%	72%	-18%
217	34%	80%	-46%
218	28%	72%	-44%
219	28%	66%	-38%
220	58%	69%	-11%
221	39%	78%	-39%
222	84%	93%	-9%
223	48%	80%	-32%
224	58%	75%	-17%
225	63%	77%	-14%
226	48%	71%	-23%
227	55%	64%	-9%
228	59%	66%	-7%
229	40%	65%	-25%
230	52%	58%	-6%
231	75%	52%	23%
232	92%	86%	6%
233	80%	70%	10%
234	70%	63%	7%
235	73%	49%	24%
236	44%	22%	22%
237	40%	20%	20%
238	42%	34%	8%
239	75%	43%	32%
240	67%	45%	22%
241	75%	52%	23%
242	81%	48%	33%
243	70%	40%	30%
244	62%	42%	20%
245	77%	48%	29%
246	52%	47%	5%
247	60%	38%	22%
248	54%	42%	12%
249	66%	42%	24%
250	69%	40%	29%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
251	84%	55%	29%
252	79%	58%	21%
253	72%	43%	29%
254	72%	45%	27%
255	80%	48%	32%
256	86%	48%	38%
257	49%	41%	8%
258	44%	44%	0%
259	69%	44%	25%
260	64%	46%	18%
261	62%	31%	31%
262	67%	57%	10%
263	49%	48%	1%
264	45%	36%	9%
265	59%	31%	28%
266	38%	35%	3%
267	24%	44%	-20%
268	45%	43%	2%
269	60%	46%	14%
270	69%	57%	12%
271	45%	48%	-3%
272	34%	54%	-20%
273	42%	53%	-11%
274	24%	32%	-8%
275	30%	31%	-1%
276	48%	61%	-13%
277	25%	49%	-24%
278	42%	32%	10%
279	44%	34%	10%
280	45%	42%	3%
281	41%	58%	-17%
282	34%	33%	1%
283	29%	31%	-2%
284	44%	51%	-7%
285	32%	41%	-9%
286	45%	51%	-6%
287	44%	60%	-16%
288	29%	43%	-14%
289	25%	23%	2%
290	76%	51%	25%
291	89%	54%	35%
292	74%	51%	23%
293	69%	43%	26%
294	75%	50%	25%
295	63%	45%	18%
296	44%	28%	16%
297	50%	66%	-16%
298	63%	53%	10%
299	87%	56%	31%
300	47%	55%	-8%

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
301	69%	39%	30%
302	54%	72%	-18%
303	79%	59%	20%
304	59%	40%	19%
305	55%	58%	-3%
306	67%	83%	-16%
307	60%	75%	-15%
308	41%	65%	-24%
309	63%	72%	-9%
310	81%	92%	-11%
311	66%	70%	-4%
312	81%	85%	-4%
313	89%	75%	14%
314	96%	80%	16%
315	68%	35%	33%
316	70%	47%	23%
317	79%	52%	27%
318	84%	60%	24%
319	77%	42%	35%
320	52%	37%	15%
321	42%	29%	13%
322	32%	40%	-8%
323	39%	38%	1%
324	68%	42%	26%
325	70%	59%	11%
326	90%	69%	21%
327	49%	63%	-14%
328	77%	47%	30%
329	57%	45%	12%
330	52%	49%	3%
331	65%	74%	-9%
332	65%	62%	3%
333	48%	61%	-13%
334	55%	72%	-17%
335	41%	56%	-15%
336	54%	34%	20%
337	25%	48%	-23%
338	60%	47%	13%
339	74%	50%	24%
340	67%	51%	16%
341	14%	31%	-17%
342	64%	40%	24%
343	60%	41%	19%
344	62%	51%	11%
345	50%	65%	-15%
346	17%	48%	-31%
347	52%	23%	29%
348	27%	53%	-26%
349	23%	57%	-34%
350	38%	52%	-14%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
351	52%	52%	0%
352	77%	59%	18%
353	70%	41%	29%
354	80%	45%	35%
355	45%	59%	-14%
356	76%	75%	1%
357	53%	59%	-6%
358	56%	53%	3%
359	65%	38%	27%
360	35%	42%	-7%
361	59%	43%	16%
362	92%	66%	26%
363	78%	52%	26%
364	74%	68%	6%
365	85%	51%	34%
366	68%	38%	30%
367	77%	66%	11%
368	54%	48%	6%
369	66%	49%	17%
370	74%	72%	2%
371	79%	54%	25%
372	68%	34%	34%
373	87%	47%	40%
374	67%	52%	15%
375	74%	48%	26%
376	72%	61%	11%
377	81%	42%	39%
378	63%	31%	32%
379	88%	55%	33%
380	56%	63%	-7%
381	40%	62%	-22%
382	50%	31%	19%
383	45%	64%	-19%
384	46%	60%	-14%
385	32%	42%	-10%
386	43%	52%	-9%
387	25%	30%	-5%
388	18%	32%	-14%
389	20%	28%	-8%
390	44%	31%	13%
391	41%	46%	-5%
392	39%	54%	-15%
393	36%	36%	0%
394	73%	54%	19%
395	72%	55%	17%
396	94%	60%	34%
397	71%	41%	30%
398	53%	38%	15%
399	42%	31%	11%
400	38%	19%	19%

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
401	15%	7%	8%
402	11%	29%	-18%
403	37%	32%	5%
404	54%	44%	10%
405	37%	28%	9%
406	76%	37%	39%
407	90%	50%	40%
408	46%	58%	-12%
409	44%	40%	4%
410	42%	38%	4%
411	47%	49%	-2%
412	45%	45%	0%
413	51%	45%	6%
414	77%	68%	9%
415	40%	64%	-24%
416	55%	59%	-4%
417	51%	73%	-22%
418	33%	41%	-8%
419	58%	61%	-3%
420	50%	66%	-16%
421	42%	46%	-4%
422	70%	76%	-6%
423	56%	71%	-15%
424	50%	49%	1%
425	64%	45%	19%
426	39%	56%	-17%
427	55%	49%	6%
428	82%	68%	14%
429	55%	59%	-4%
430	42%	63%	-21%
431	37%	39%	-2%
432	80%	72%	8%
433	71%	71%	0%
434	71%	56%	15%
435	74%	71%	3%
436	88%	78%	10%
437	47%	70%	-23%
438	42%	61%	-19%
439	64%	61%	3%
440	56%	44%	12%
441	61%	54%	7%
442	84%	91%	-7%
443	84%	65%	19%
444	66%	68%	-2%
445	76%	81%	-5%
446	51%	55%	-4%
447	51%	47%	4%
448	64%	74%	-10%
449	35%	29%	6%
450	88%	76%	12%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
451	76%	62%	14%
452	49%	50%	-1%
453	90%	85%	5%
454	70%	84%	-14%
455	66%	82%	-16%
456	87%	90%	-3%
457	86%	80%	6%
458	49%	79%	-30%
459	65%	74%	-9%
460	90%	95%	-5%
461	58%	67%	-9%
462	82%	72%	10%
463	37%	77%	-40%
464	60%	69%	-9%
465	61%	81%	-20%
466	80%	72%	8%
467	78%	49%	29%
468	63%	44%	19%
469	85%	61%	24%
470	81%	65%	16%
471	79%	75%	4%
472	49%	68%	-19%
473	63%	53%	10%
474	74%	69%	5%
475	68%	56%	12%
476	80%	68%	12%
477	54%	46%	8%
478	62%	48%	14%
479	78%	44%	34%
480	64%	36%	28%
481	75%	48%	27%
482	82%	46%	36%
483	89%	51%	38%
484	83%	44%	39%
485	72%	69%	3%
486	70%	60%	10%
487	86%	75%	11%
488	82%	85%	-3%
489	83%	78%	5%
490	71%	69%	2%
491	79%	70%	9%
492	63%	54%	9%
493	67%	84%	-17%
494	70%	90%	-20%
495	79%	90%	-11%
496	76%	89%	-13%
497	53%	83%	-30%
498	47%	85%	-38%
499	66%	56%	10%
500	70%	46%	24%

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
501	85%	49%	36%
502	84%	53%	31%
503	87%	79%	8%
504	64%	77%	-13%
505	62%	71%	-9%
506	80%	74%	6%
507	75%	78%	-3%
508	73%	88%	-15%
509	82%	94%	-12%
510	93%	98%	-5%
511	72%	89%	-17%
512	60%	87%	-27%
513	64%	81%	-17%
514	28%	66%	-38%
515	45%	69%	-24%
516	51%	45%	6%
517	50%	65%	-15%
518	37%	72%	-35%
519	53%	67%	-14%
520	27%	62%	-35%
521	21%	36%	-15%
522	40%	78%	-38%
523	60%	77%	-17%
524	55%	73%	-18%
525	51%	85%	-34%
526	44%	77%	-33%
527	40%	53%	-13%
528	19%	16%	3%
529	21%	20%	1%
530	26%	42%	-16%
531	28%	56%	-28%
532	42%	70%	-28%
533	19%	49%	-30%
534	46%	67%	-21%
535	43%	67%	-24%
536	48%	38%	10%
537	38%	35%	3%
538	79%	88%	-9%
539	45%	66%	-21%
540	56%	45%	11%
541	38%	45%	-7%
542	59%	72%	-13%
543	63%	77%	-14%
544	60%	65%	-5%
545	38%	38%	0%
546	58%	51%	7%
547	41%	62%	-21%
548	23%	60%	-37%
549	56%	42%	14%
550	47%	70%	-23%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
551	47%	74%	-27%
552	41%	35%	6%
553	42%	58%	-16%
554	54%	37%	17%
555	50%	28%	22%
556	46%	63%	-17%
557	42%	52%	-10%
558	49%	54%	-5%
559	38%	60%	-22%
560	42%	47%	-5%
561	36%	28%	8%
562	49%	71%	-22%
563	37%	30%	7%
564	34%	51%	-17%
565	62%	47%	15%
566	57%	60%	-3%
567	62%	77%	-15%
568	66%	85%	-19%
569	32%	43%	-11%
570	21%	33%	-12%
571	42%	47%	-5%
572	44%	47%	-3%
573	32%	28%	4%
574	55%	49%	6%
575	43%	25%	18%
576	34%	32%	2%
577	61%	34%	27%
578	54%	46%	8%
579	51%	46%	5%
580	64%	49%	15%
581	52%	35%	17%
582	57%	40%	17%
583	66%	48%	18%
584	60%	64%	-4%
585	37%	47%	-10%
586	29%	42%	-13%
587	27%	35%	-8%
588	20%	45%	-25%
589	34%	59%	-25%
590	65%	44%	21%
591	36%	38%	-2%
592	46%	50%	-4%
593	45%	39%	6%
594	72%	68%	4%
595	62%	52%	10%
596	16%	22%	-6%
597	68%	61%	7%
598	61%	58%	3%
599	75%	61%	14%
600	78%	72%	6%

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
601	83%	67%	16%
602	75%	70%	5%
603	46%	45%	1%
604	48%	73%	-25%
605	45%	64%	-19%
606	42%	39%	3%
607	54%	58%	-4%
608	29%	32%	-3%
609	61%	74%	-13%
610	44%	73%	-29%
611	19%	41%	-22%
612	44%	38%	6%
613	30%	33%	-3%
614	53%	66%	-13%
615	34%	62%	-28%
616	15%	28%	-13%
617	16%	36%	-20%
618	32%	50%	-18%
619	33%	36%	-3%
620	82%	39%	43%
621	86%	55%	31%
622	71%	52%	19%
623	76%	61%	15%
624	74%	56%	18%
625	82%	67%	15%
626	67%	73%	-6%
627	70%	61%	9%
628	71%	74%	-3%
629	84%	64%	20%
630	80%	71%	9%
631	83%	77%	6%
632	80%	73%	7%
633	66%	72%	-6%
634	82%	73%	9%
635	86%	74%	12%
636	74%	59%	15%
637	73%	54%	19%
638	69%	71%	-2%
639	78%	66%	12%
640	74%	61%	13%
641	83%	44%	39%
642	80%	42%	38%
643	62%	46%	16%
644	61%	27%	34%
645	54%	50%	4%
646	52%	22%	30%
647	50%	30%	20%
648	51%	20%	31%
649	58%	36%	22%
650	63%	24%	39%

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
651	64%	38%	26%
652	36%	14%	22%
653	50%	31%	19%
654	55%	29%	26%
655	47%	36%	11%
656	53%	41%	12%
657	57%	34%	23%
658	70%	30%	40%
659	70%	38%	32%
660	65%	45%	20%
661	71%	61%	10%
662	83%	62%	21%
663	98%	75%	23%
664	94%	77%	17%
665	63%	66%	-3%
666	26%	42%	-16%
667	35%	56%	-21%
668	80%	75%	5%
669	43%	63%	-20%
670	35%	48%	-13%
671	50%	52%	-2%
672	70%	59%	11%
673	43%	40%	3%
674	22%	42%	-20%
675	56%	69%	-13%
676	41%	58%	-17%
677	35%	25%	10%
678	70%	45%	25%
679	52%	28%	24%
680	55%	24%	31%
681	48%	27%	21%
682	66%	54%	12%
683	76%	72%	4%
684	98%	76%	22%
685	90%	68%	22%
686	91%	76%	15%
687	91%	78%	13%
688	87%	71%	16%
689	84%	75%	9%
690	42%	45%	-3%
691	84%	62%	22%
692	87%	69%	18%
693	94%	78%	16%
694	63%	57%	6%
695	63%	49%	14%
696	56%	49%	7%
697	17%	22%	-5%
698	61%	43%	18%
699	35%	25%	10%
700	33%	40%	-7%

**Table 5 - Estimated 2006 Vegetative Cover by Segment, Little Klickitat River**

WRIA 30 Riparian Vegetation Study

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference
701	65%	64%	1%
702	90%	56%	34%
703	98%	74%	24%
704	91%	68%	23%
705	86%	71%	15%
706	56%	46%	10%
707	62%	56%	6%
708	55%	28%	27%
709	45%	29%	16%
710	31%	23%	8%
711	76%	50%	26%
712	71%	70%	1%
713	51%	59%	-8%
714	55%	58%	-3%
715	75%	58%	17%
716	39%	46%	-7%
717	28%	44%	-16%
718	24%	30%	-6%
719	16%	26%	-10%
720	7%	34%	-27%
721	20%	27%	-7%
722	66%	71%	-5%
723	60%	61%	-1%
724	50%	59%	-9%
725	41%	54%	-13%
726	29%	57%	-28%
727	53%	59%	-6%
728	61%	51%	10%
729	41%	53%	-12%
730	49%	41%	8%
731	42%	27%	15%
732	23%	45%	-22%
733	49%	48%	1%
734	64%	48%	16%
735	54%	40%	14%
736	72%	47%	25%
737	83%	40%	43%
<b>Averages:</b>	<b>56%</b>	<b>54%</b>	<b>15%</b>

Segment No.	% Vegetated Cover		
	40-foot width	150-foot width	Difference

# of segments where 40-ft vegetated % > 150-ft vegetated %:	395	=	54%	of all segments
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Notes:

The average for the differences uses the absolute value of the individual differences (+ or -).

**Table 6 - Field Measurements of Canopy Cover and Stream Channel**

Segment No.	Initial GIS Estimates of Veg Cover		Field Data					
	150-ft Segment Width	40-ft Segment Width	Avg. of Total Canopy	Avg. Of Bank Canopy	Avg. Of Center Canopy	Avg. Bankfull Width (ft)	Avg. Wetted Width (ft)	Avg. Wetted Depth (ft)
<b>Swale Creek</b>								
11	23%	0%	78%	95%	70%	55.0	19.5	0.7
16	65%	84%	95%	93%	96%	59.8	21.6	0.4
18	65%	76%	78%	97%	69%	52.5	38.7	0.3
22	59%	16%	90%	96%	88%	47.8	14.6	0.3
25	50%	61%	82%	94%	76%	46.6	20.6	0.4
35	40%	45%	89%	95%	86%	33.1	18.1	0.3
47	21%	17%	82%	100%	73%	53.2	17.1	0.5
57	63%	71%	100%	100%	100%	38.7	16.1	0.4
66	57%	94%	97%	99%	96%	37.8	15.4	0.5
72	75%	97%	94%	98%	91%	39.3	22.3	0.3
95	60%	52%	88%	89%	87%	27.8	290.6	0.4
96	47%	31%	49%	74%	37%	33.6	18.1	0.6
100	46%	50%	56%	66%	51%	30.6	13.4	0.9
106	1%	2%			0%	44.6	0.0	0.0
119	59%	92%	84%	99%	76%	34.0	18.2	1.3
123	3%	0%	0%	0%	1%	28.4	1.1	0.0
128	18%	4%	11%	33%	0%	68.2	45.2	0.7
135	31%	30%	34%	55%	23%	40.6	20.3	0.5
139	1%	0%			0%	29.3	0.0	0.0
146	1%	0%			0%	40.0	0.0	0.0
174	47%	32%	23%	56%	8%	44.1	14.3	0.2
181	9%	2%	14%	27%	8%	27.6	15.6	0.4
182	19%	21%	27%	48%	14%	32.3	6.4	0.1
190	19%	39%	67%	75%	48%	38.9	2.8	0.1
204	77%	92%	66%	88%	56%	50.0	18.0	0.5
236	50%	66%	89%	100%	84%	36.4	6.5	0.6
250	50%	71%	43%	97%	60%	29.9	5.9	0.3
260	24%	26%	9%	25%	1%	27.7	13.6	0.3
291	23%	30%	0%	0%	0%	52.8	22.6	0.3
294	13%	22%	0%	0%	0%	54.3	17.0	0.4
304	39%	96%	22%	24%	21%	19.8	9.1	0.6
323	11%	19%	0%	0%	0%	61.3	18.5	0.2

**Table 6 - Field Measurements of Canopy Cover and Stream Channel**

Segment No.	Initial GIS Estimates of Veg Cover		Field Data					
	150-ft Segment Width	40-ft Segment Width	Avg. of Total Canopy	Avg. Of Bank Canopy	Avg. Of Center Canopy	Avg. Bankfull Width (ft)	Avg. Wetted Width (ft)	Avg. Wetted Depth (ft)
<b>Little Klickitat River</b>								
2	36%	55%	23%	60%	5%	136.0	74.2	1.6
9	14%	44%	33%	100%	0%	42.4	29.4	2.1
247	48%	47%	30%	69%	10%	58.0	38.6	1.4
248	45%	40%	41%	85%	19%	63.0	27.9	1.3
250	39%	43%	53%	95%	31%	63.0	26.3	1.3
254	47%	47%	20%	45%	7%	102.9	30.4	1.7
256	63%	67%	31%	50%	21%	102.8	36.4	1.0
259	55%	55%	16%	49%	0%	48.4	30.7	2.2
260	47%	40%	22%	58%	3%	79.3	38.3	1.3
350	67%	88%	3%	10%	0%	41.2	35.5	2.0
351	98%	102%	29%	88%	0%	33.8	28.3	4.5
411	81%	98%	47%	99%	21%	37.6	27.0	2.2
435	71%	91%	56%	73%	48%	45.0	26.9	1.8
436	74%	81%	86%	94%	82%	35.2	26.8	1.5
442	96%	98%	83%	96%	76%	56.3	38.2	0.7
444	61%	81%	54%	86%	38%	62.3	31.4	1.6
445	52%	63%	64%	82%	54%	34.4	21.4	1.7
446	66%	48%	59%	83%	48%	41.1	24.9	1.0
447	58%	66%	28%	49%	18%	42.5	24.3	1.5
459	46%	27%	50%	95%	27%	47.3	32.5	0.9
460	44%	37%	67%	95%	53%	43.7	28.1	1.0
462	49%	34%	60%	93%	44%	45.6	35.2	0.9
500	61%	61%	32%	76%	10%	44.4	31.6	1.8
502	56%	76%	47%	88%	27%	31.1	22.7	1.2
506	58%	62%	45%	84%	25%	41.4	28.5	1.2
508	72%	70%	64%	96%	47%	41.5	27.2	1.0
570	79%	76%	18%	38%	17%	34.8	23.9	1.7
571	46%	52%	27%	60%	11%	53.2	28.6	1.8
572	62%	96%	37%	76%	21%	52.9	34.4	2.0
573	61%	88%	43%	76%	26%	33.7	21.3	1.8
578	45%	80%	57%	76%	47%	34.0	23.0	1.3
626	66%	79%	74%	81%	71%	33.9	21.4	1.5
628	61%	69%	50%	87%	31%	36.3	22.5	1.3

Notes:

All measurements collected between June 1-15, 2009.

Only average canopy measurements for each segment are presented. Appendix A provides the raw measurements for each transect, including locational coordinates and stream aspect for segments measured.

Initial estimates of vegetative cover used to develop stratified sampling scheme, collecting measurements within a range of canopy conditions.

**Table 7 - Dominant and Subdominant Riparian Vegetation Observed during Field Measurements**

Dominant Vegetation Type	Percent of Samples with each dominant vegetation type		Subdominant Vegetation Type	Percent of samples with each sub-dominant vegetation type	
	<i>Little Klickitat</i>	<i>Swale</i>		<i>Little Klickitat</i>	<i>Swale</i>
None	0%	2%	None	6%	3%
Alder	48%	3%	Alder	8%	0%
Black Cottonwood	14%	0%	Big Leaf Maple	0%	5%
Cottonwood	12%	0%	Black Cottonwood	5%	0%
Grass	2%	3%	Cherry	2%	0%
Hawthorne	3%	5%	Dogwood	3%	2%
Ponderosa Pine	5%	0%	Grass	0%	3%
Pacific Willow	2%	0%	Hawthorne	0%	3%
Red Alder	0%	41%	Meadow Grass	3%	0%
Reed Canary Grass	6%	0%	Mock Orange	2%	0%
Serviceberry	0%	13%	N/A	0%	8%
White Alder	6%	0%	Ninebark	9%	0%
Willow	3%	34%	Red Alder	2%	6%
			Salix prolixa	3%	0%
			Serviceberry	0%	28%
			Snowberry	3%	0%
			Spirea	5%	0%
			White alder	15%	0%
			Willow	36%	42%

Notes:

Observations made June 1-15, 2009.

Appendix A provides details regarding vegetation observed in each segment.

**Table 8 - Estimated Historical Change in Vegetative Cover by Segment, Swale Creek**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek

Reach A (Lowermost 4 Miles), 1969-2006							
Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change	Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
1	42%	2%	-40%	54	19%	20%	1%
2	31%	0%	-31%	55	16%	25%	9%
3	43%	3%	-40%	56	12%	34%	22%
4	28%	2%	-26%	57	23%	41%	18%
5	35%	11%	-24%	58	26%	47%	21%
6	53%	12%	-41%	59	22%	66%	44%
7	39%	13%	-26%	60	16%	41%	25%
8	43%	12%	-31%	61	22%	38%	16%
9	34%	10%	-24%	62	12%	44%	32%
10	28%	26%	-2%	63	9%	47%	38%
11	31%	25%	-6%	64	10%	35%	25%
12	8%	19%	11%	65	15%	48%	33%
13	19%	28%	9%	66	15%	52%	37%
14	31%	17%	-14%	67	12%	39%	27%
15	64%	49%	-15%	68	7%	49%	42%
16	77%	44%	-33%	69	3%	42%	39%
17	72%	43%	-29%	70	1%	38%	37%
18	61%	48%	-13%	71	9%	35%	26%
19	73%	44%	-29%	72	9%	39%	30%
20	41%	39%	-2%	73	16%	49%	33%
21	40%	48%	8%	74	0%	41%	41%
22	47%	64%	17%	75	2%	46%	44%
23	27%	38%	11%	76	17%	57%	40%
24	27%	56%	29%	77	9%	55%	46%
25	43%	54%	11%	78	30%	34%	4%
26	41%	47%	6%	79	25%	34%	9%
27	59%	54%	-5%	80	21%	41%	20%
28	61%	70%	9%	81	16%	27%	11%
29	56%	50%	-6%	82	20%	34%	14%
30	41%	67%	26%	83	13%	35%	22%
31	57%	62%	5%	84	20%	22%	2%
32	not analyzed			85	45%	46%	1%
33	38%	33%	-5%	86	43%	42%	-1%
34	16%	26%	10%	87	41%	42%	1%
35	24%	41%	17%	88	30%	47%	17%
36	25%	34%	9%	89	27%	45%	18%
37	41%	50%	9%	90	38%	46%	8%
38	41%	41%	0%	91	32%	47%	15%
39	20%	19%	-1%	92	18%	49%	31%
40	27%	7%	-20%	93	26%	43%	17%
41	18%	21%	3%	94	24%	40%	16%
42	19%	25%	6%	95	24%	40%	16%
43	22%	31%	9%	96	17%	41%	24%
44	20%	59%	39%	97	26%	45%	19%
45	20%	60%	40%	98	36%	33%	-3%
46	14%	57%	43%	99	34%	38%	4%
47	12%	44%	32%	100	34%	44%	10%
48	6%	26%	20%	101	26%	35%	9%
49	19%	43%	24%	102	24%	35%	11%
50	24%	58%	34%	103	25%	27%	2%
51	32%	48%	16%	<b>Reach A</b>			
52	22%	45%	23%	<b>Averages:</b>	<b>28%</b>	<b>38%</b>	<b>10%</b>
53	21%	34%	13%				

**Table 8 - Estimated Historical Change in Vegetative Cover by Segment, Swale Creek**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek

Reach B (Near Stacker Canyon), 1969-2006			
Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
208	17%	52%	35%
209	1%	51%	50%
210	2%	60%	58%
211	6%	46%	40%
212	9%	48%	39%
213	6%	48%	42%
214	8%	49%	41%
215	1%	59%	58%
216	4%	71%	67%
217	9%	48%	39%
218	18%	34%	16%
219	13%	39%	26%
220	8%	41%	33%
221	15%	42%	27%
222	11%	47%	36%
223	7%	47%	40%
224	7%	30%	23%
225	4%	36%	32%
226	11%	55%	44%
227	9%	42%	33%
228	4%	28%	24%
229	8%	27%	19%
230	10%	39%	29%
231	9%	30%	21%
232	12%	21%	9%
233	15%	36%	21%
234	30%	42%	12%
235	7%	23%	16%
236	19%	31%	12%
237	17%	27%	10%
238	17%	34%	17%
239	3%	30%	27%
240	7%	37%	30%
241	18%	38%	20%
242	70%	59%	-11%
243	85%	76%	-9%
244	87%	65%	-22%
245	73%	64%	-9%
246	73%	49%	-24%
247	67%	64%	-3%
248	51%	57%	6%
249	36%	59%	23%
250	17%	53%	36%

Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
251	18%	39%	21%
252	18%	41%	23%
253	8%	23%	15%
254	13%	37%	24%
255	13%	57%	44%
256	29%	37%	8%
257	20%	19%	-1%
258	30%	22%	-8%
259	48%	11%	-37%
260	51%	19%	-32%
261	47%	4%	-43%
262	59%	23%	-36%
263	59%	40%	-19%
264	33%	43%	10%
265	34%	35%	1%
266	36%	37%	1%
<b>Reach B Averages:</b>	<b>24%</b>	<b>41%</b>	<b>17%</b>

**Table 8 - Estimated Historical Change in Vegetative Cover by Segment, Swale Creek**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek

Reach C (Near Warwick), 1969-2006			
Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
312	55%	41%	-14%
313	31%	24%	-7%
314	35%	26%	-9%
315	23%	26%	3%
316	24%	26%	2%
317	41%	48%	7%
318	36%	45%	9%
319	38%	47%	9%
320	43%	48%	5%
321	41%	38%	-3%
322	31%	20%	-11%
323	17%	1%	-16%
324	9%	0%	-9%
325	8%	1%	-7%
326	19%	47%	28%
327	17%	47%	30%
328	22%	75%	53%
329	23%	87%	64%
330	23%	89%	66%
331	19%	66%	47%
332	16%	39%	23%
333	11%	20%	9%
334	12%	28%	16%
335	16%	14%	-2%
336	12%	36%	24%
337	11%	79%	68%
338	33%	93%	60%
339	30%	73%	43%
340	26%	60%	34%
341	28%	73%	45%
342	31%	65%	34%
343	33%	66%	33%
344	25%	61%	36%
345	19%	90%	71%
346	28%	98%	70%
347	27%	98%	71%
348	28%	97%	69%
349	62%	93%	31%
350	57%	94%	37%
351	55%	97%	42%
352	57%	99%	42%
353	56%	96%	40%
354	47%	79%	32%

Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
355	55%	93%	38%
356	62%	95%	33%
357	60%	83%	23%
358	54%	89%	35%
359	72%	53%	-19%
360	60%	50%	-10%
361	54%	48%	-6%
362	51%	42%	-9%
363	52%	55%	3%
<b>Reach C Averages:</b>	<b>35%</b>	<b>59%</b>	<b>24%</b>

Note:

Estimates are for the 150-foot-wide corridor.

**Table 9 - Estimated Historical Change in Vegetative Cover by Segment, Little Klickitat River**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek

Reach D (Lowermost 8 Miles), 1969-2006							
Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change	Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
1	68%	8%	-60%	54	46%	60%	14%
2	65%	43%	-22%	55	68%	65%	-3%
3	48%	58%	10%	56	75%	85%	10%
4	30%	37%	7%	57	83%	84%	1%
5	49%	71%	22%	58	61%	80%	19%
6	43%	89%	46%	59	65%	90%	25%
7	55%	68%	13%	60	71%	86%	15%
8	49%	22%	-27%	61	68%	93%	25%
9	33%	8%	-25%	62	45%	95%	50%
10	51%	39%	-12%	63	53%	84%	31%
11	48%	59%	11%	64	55%	73%	18%
12	54%	62%	8%	65	42%	57%	15%
13	54%	81%	27%	66	47%	55%	8%
14	70%	85%	15%	67	37%	27%	-10%
15	52%	85%	33%	68	23%	26%	3%
16	52%	69%	17%	69	31%	49%	18%
17	53%	73%	20%	70	31%	39%	8%
18	49%	76%	27%	71	35%	25%	-10%
19	66%	77%	11%	72	39%	62%	23%
20	59%	72%	13%	73	40%	40%	0%
21	64%	92%	28%	74	32%	20%	-12%
22	62%	88%	26%	75	24%	5%	-19%
23	66%	79%	13%	76	20%	30%	10%
24	63%	76%	13%	77	40%	47%	7%
25	37%	67%	30%	78	50%	50%	0%
26	37%	52%	15%	79	37%	24%	-13%
27	36%	53%	17%	80	36%	16%	-20%
28	32%	29%	-3%	81	42%	50%	8%
29	26%	40%	14%	82	39%	36%	-3%
30	37%	38%	1%	83	52%	18%	-34%
31	48%	64%	16%	84	61%	54%	-7%
32	51%	63%	12%	85	47%	54%	7%
33	56%	67%	11%	86	51%	73%	22%
34	47%	69%	22%	87	62%	58%	-4%
35	37%	68%	31%	88	68%	60%	-8%
36	60%	57%	-3%	89	47%	76%	29%
37	32%	38%	6%	90	50%	72%	22%
38	55%	41%	-14%	91	49%	59%	10%
39	54%	66%	12%	92	36%	48%	12%
40	78%	77%	-1%	93	44%	54%	10%
41	82%	86%	4%	94	51%	48%	-3%
42	66%	40%	-26%	95	43%	27%	-16%
43	49%	49%	0%	96	46%	24%	-22%
44	85%	77%	-8%	97	56%	36%	-20%
45	86%	87%	1%	98	56%	61%	5%
46	84%	72%	-12%	99	49%	39%	-10%
47	74%	84%	10%	100	51%	32%	-19%
48	43%	47%	4%	101	66%	62%	-4%
49	48%	25%	-23%	102	71%	71%	0%
50	72%	48%	-24%	103	58%	74%	16%
51	48%	42%	-6%	104	43%	90%	47%
52	37%	69%	32%	105	39%	79%	40%
53	49%	54%	5%	106	49%	64%	15%

**Table 9 - Estimated Historical Change in Vegetative Cover by Segment, Little Klickitat River**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek

Reach D (Lower 8 Miles), 1969-2006, continued							
Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change	Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
107	43%	73%	30%	150	58%	67%	9%
108	28%	46%	18%	151	58%	57%	-1%
109	35%	57%	22%	152	47%	26%	-21%
110	52%	64%	12%	153	43%	33%	-10%
111	59%	93%	34%	154	45%	49%	4%
112	52%	73%	21%	155	53%	56%	3%
113	55%	65%	10%	156	63%	46%	-17%
114	60%	61%	1%	157	72%	73%	1%
115	49%	72%	23%	158	81%	89%	8%
116	31%	39%	8%	159	69%	35%	-34%
117	33%	48%	15%	160	11%	42%	31%
118	36%	83%	47%	161	27%	34%	7%
119	20%	91%	71%	162	8%	30%	22%
120	27%	66%	39%	163	17%	32%	15%
121	20%	67%	47%	164	30%	21%	-9%
122	27%	63%	36%	165	28%	29%	1%
123	16%	69%	53%	166	39%	43%	4%
124	27%	37%	10%	167	46%	71%	25%
125	48%	50%	2%	168	50%	59%	9%
126	48%	57%	9%	169	36%	60%	24%
127	62%	59%	-3%	170	37%	67%	30%
128	64%	92%	28%	171	41%	67%	26%
129	62%	67%	5%	172	19%	51%	32%
130	59%	56%	-3%	173	13%	31%	18%
131	65%	62%	-3%	174	26%	50%	24%
132	61%	63%	2%	175	52%	81%	29%
133	41%	52%	11%	176	49%	76%	27%
134	28%	64%	36%	177	39%	71%	32%
135	39%	66%	27%	178	53%	52%	-1%
136	40%	60%	20%	179	42%	60%	18%
137	60%	87%	27%	180	44%	78%	34%
138	61%	57%	-4%	181	41%	57%	16%
139	62%	59%	-3%	182	19%	33%	14%
140	49%	82%	33%	183	30%	68%	38%
141	66%	63%	-3%	184	59%	82%	23%
142	57%	68%	11%	185	64%	86%	22%
143	54%	82%	28%	186	44%	72%	28%
144	58%	75%	17%	187	51%	83%	32%
145	55%	68%	13%	188	52%	75%	23%
146	59%	75%	16%	189	45%	65%	20%
147	74%	73%	-1%	190	33%	31%	-2%
148	57%	73%	16%	191	59%	44%	-15%
149	58%	68%	10%	192	64%	57%	-7%

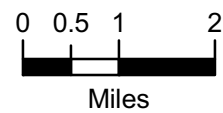
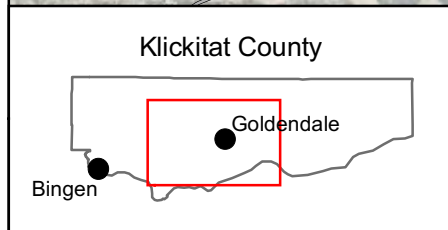
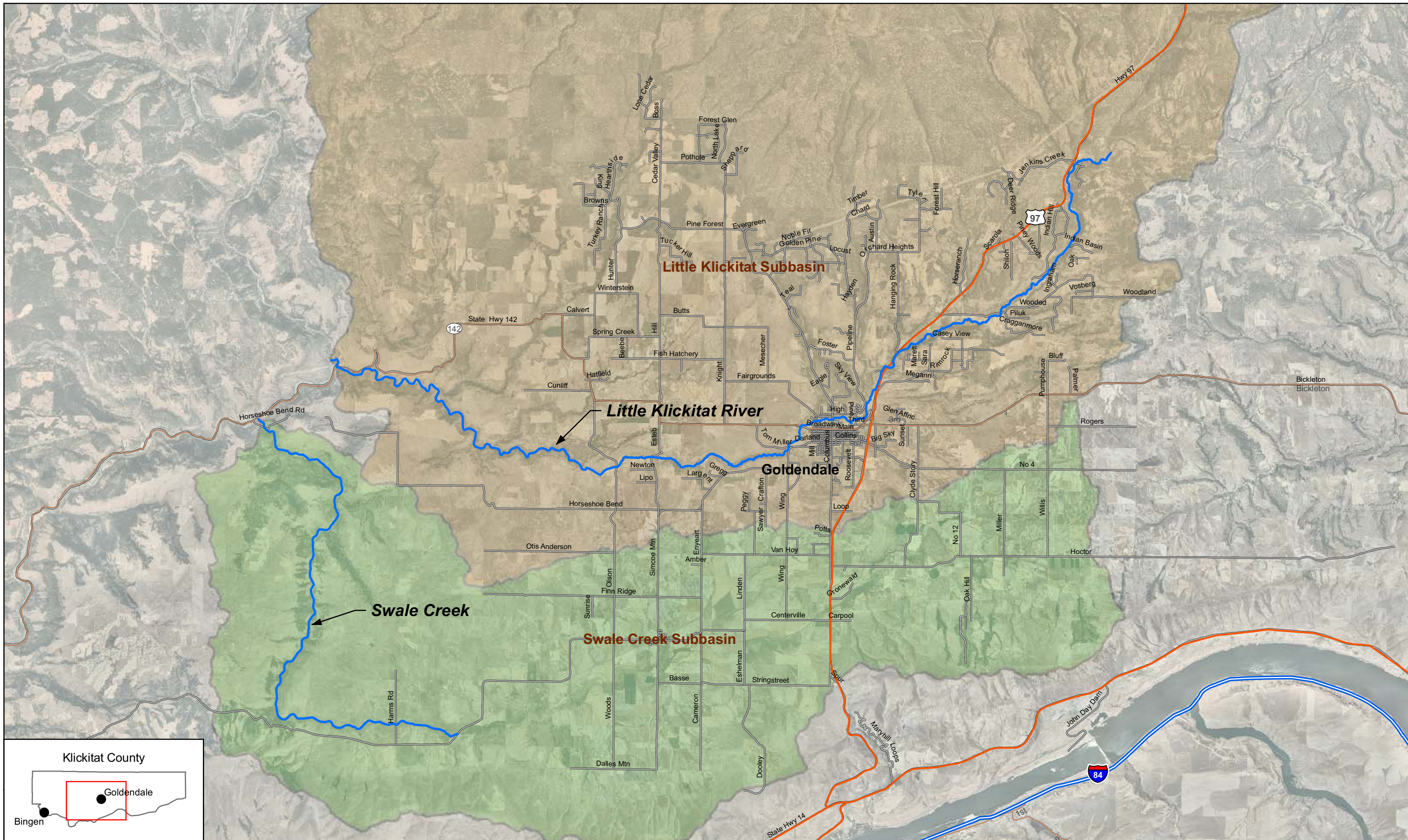
**Table 9 - Estimated Historical Change in Vegetative Cover by Segment, Little Klickitat River**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek

Reach D (Lower 8 Miles), 1969-2006, continued							
Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change	Segment No.	1969 % Vegetated Cover	2006 % Vegetated Cover	Change
193	45%	25%	-20%	236	16%	23%	7%
194	34%	10%	-24%	237	19%	22%	3%
195	48%	29%	-19%	238	34%	41%	7%
196	70%	65%	-5%	239	29%	47%	18%
197	33%	20%	-13%	240	52%	48%	-4%
198	49%	76%	27%	241	66%	57%	-9%
199	70%	83%	13%	242	59%	53%	-6%
200	77%	92%	15%	243	47%	46%	-1%
201	77%	76%	-1%	244	54%	51%	-3%
202	72%	64%	-8%	245	62%	55%	-7%
203	68%	78%	10%	246	70%	59%	-11%
204	64%	80%	16%	247	62%	49%	-13%
205	56%	58%	2%	248	56%	54%	-2%
206	44%	33%	-11%	249	57%	51%	-6%
207	31%	50%	19%	<b>Reach D</b>			
208	36%	41%	5%	<b>Averages:</b>	<b>48%</b>	<b>59%</b>	<b>11%</b>
209	32%	32%	0%				
210	32%	44%	12%				
211	50%	55%	5%				
212	28%	74%	46%				
213	62%	84%	22%				
214	63%	84%	21%				
215	62%	91%	29%				
216	56%	85%	29%				
217	50%	75%	25%				
218	47%	79%	32%				
219	43%	91%	48%				
220	35%	95%	60%				
221	40%	90%	50%				
222	27%	81%	54%				
223	36%	81%	45%				
224	30%	76%	46%				
225	32%	69%	37%				
226	30%	71%	41%				
227	32%	70%	38%				
228	49%	65%	16%				
229	51%	58%	7%				
230	35%	86%	51%				
231	38%	72%	34%				
232	28%	65%	37%				
233	19%	49%	30%				
234	28%	65%	37%				
235	19%	49%	30%				

**Table 9 - Estimated Historical Change in Vegetative Cover by Segment, Little Klickitat River**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek

Reach E (Near Three Creeks), 1978-2006							
Segment No.	1978 % Vegetated Cover	2006 % Vegetated Cover	Change	Segment No.	1978 % Vegetated Cover	2006 % Vegetated Cover	Change
636	23%	59%	36%	687	66%	78%	12%
637	17%	54%	37%	688	26%	71%	45%
638	43%	71%	28%	689	40%	75%	35%
639	19%	66%	47%	690	30%	45%	15%
640	15%	61%	46%	691	42%	62%	20%
641	18%	44%	26%	692	50%	69%	19%
642	12%	42%	30%	693	60%	78%	18%
643	15%	46%	31%	694	41%	57%	16%
644	10%	27%	17%	695	18%	49%	31%
645	7%	50%	43%	696	20%	49%	29%
646	8%	22%	14%	697	9%	22%	13%
647	6%	30%	24%	698	38%	43%	5%
648	7%	20%	13%	699	17%	25%	8%
649	9%	36%	27%	700	12%	40%	28%
650	8%	24%	16%	701	31%	64%	33%
651	8%	38%	30%	702	15%	56%	41%
652	2%	14%	12%	703	51%	74%	23%
653	7%	31%	24%	704	54%	68%	14%
654	7%	29%	22%	705	48%	71%	23%
655	6%	36%	30%	706	19%	46%	27%
656	4%	41%	37%	707	40%	56%	16%
657	6%	34%	28%	708	66%	28%	-38%
658	3%	30%	27%	709	64%	29%	-35%
659	6%	38%	32%	710	72%	23%	-49%
660	8%	45%	37%	711	77%	50%	-27%
661	13%	61%	48%	712	84%	70%	-14%
662	10%	62%	52%	713	75%	59%	-16%
663	19%	75%	56%	714	68%	58%	-10%
664	19%	77%	58%	715	58%	58%	0%
665	6%	66%	60%	716	48%	46%	-2%
666	6%	42%	36%	717	25%	44%	19%
667	14%	56%	42%	718	40%	30%	-10%
668	15%	75%	60%	719	37%	26%	-11%
669	12%	63%	51%	720	29%	34%	5%
670	10%	48%	38%	721	38%	27%	-11%
671	42%	52%	10%	722	75%	71%	-4%
672	30%	59%	29%	723	71%	61%	-10%
673	21%	40%	19%	724	66%	59%	-7%
674	37%	42%	5%	725	58%	54%	-4%
675	54%	69%	15%	726	68%	57%	-11%
676	32%	58%	26%	727	62%	59%	-3%
677	30%	25%	-5%	728	65%	51%	-14%
678	23%	45%	22%	729	79%	53%	-26%
679	11%	28%	17%	730	53%	41%	-12%
680	20%	24%	4%	731	46%	27%	-19%
681	25%	27%	2%	732	51%	45%	-6%
682	47%	54%	7%	733	60%	48%	-12%
683	59%	72%	13%	734	69%	48%	-21%
684	41%	76%	35%	735	62%	40%	-22%
685	36%	68%	32%	736	67%	47%	-20%
686	77%	76%	-1%	737	68%	40%	-28%
<b>Reach E Averages:</b>					<b>34%</b>	<b>49%</b>	<b>15%</b>

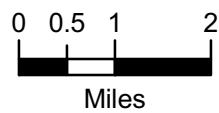
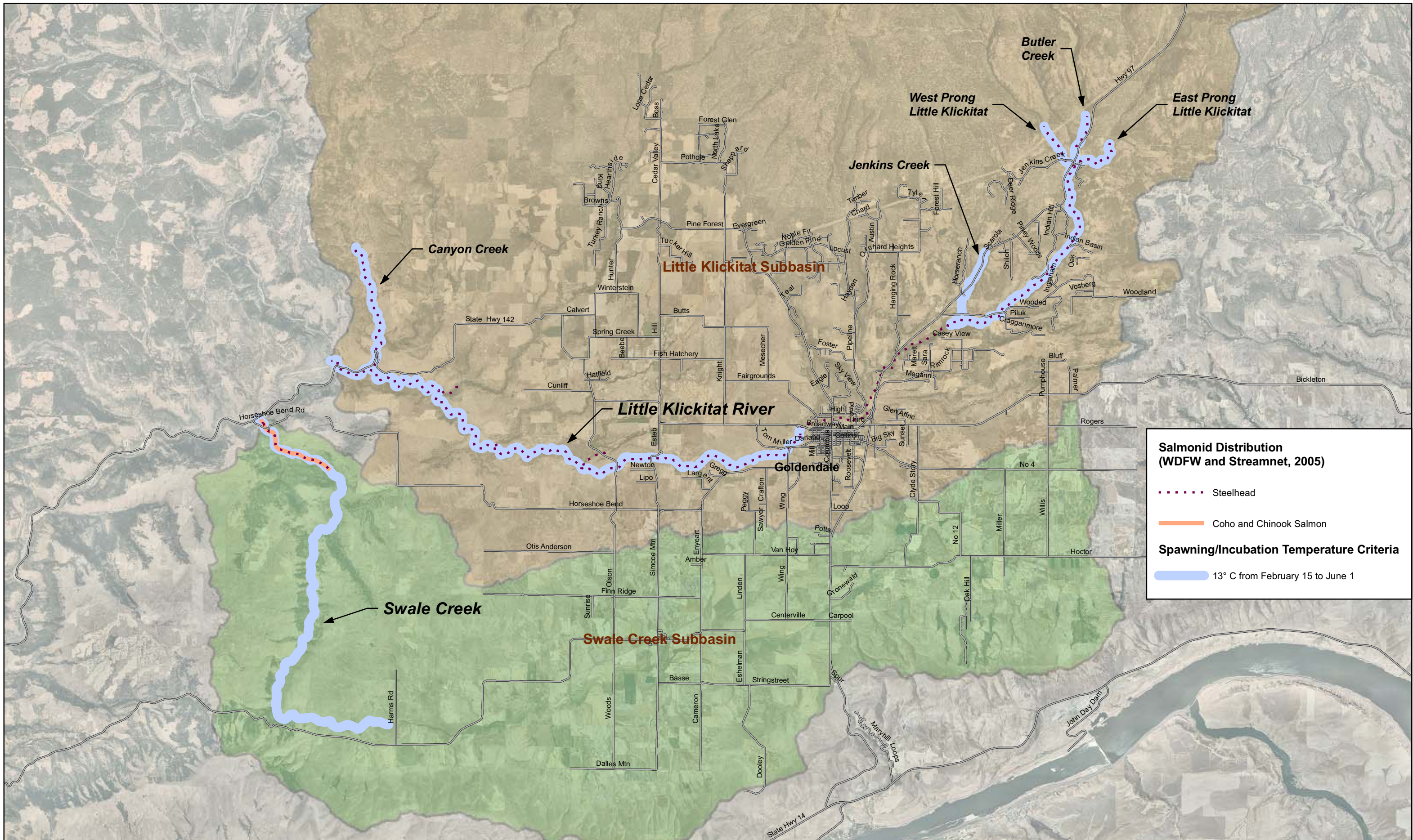
Note:  
 Estimates are for the 150-foot-wide corridor.



**Site Vicinity Map**

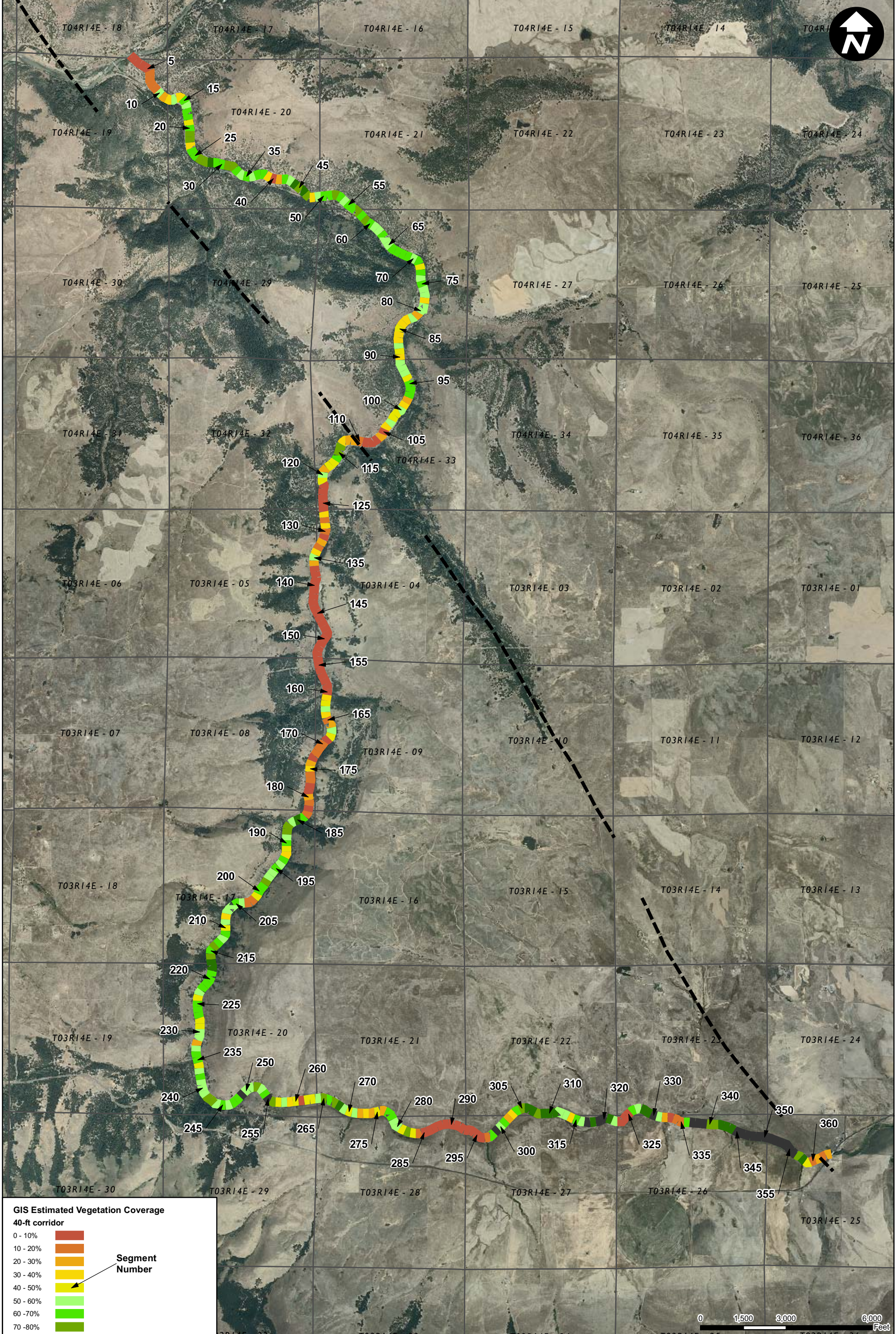
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
 WRIA 30, Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: SCC	
DRAWN BY: SCC	FIGURE NO. 1
REVISED BY:	



**Salmonid Distribution and Stream Reaches Subject to Most Stringent Temperature Criteria**  
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30, Klickitat County, Washington

DATE:	June 2009	PROJECT NO.	070024-009
DESIGNED BY:	SCC	DRAWN BY:	SCC
REVISOR:		FIGURE NO.	2



**GIS Estimated Vegetation Coverage  
40-ft corridor**

0 - 10%	Red
10 - 20%	Orange
20 - 30%	Yellow-Orange
30 - 40%	Yellow
40 - 50%	Light Green
50 - 60%	Green
60 - 70%	Dark Green
70 - 80%	Very Dark Green
80 - 90%	Black
90 - 100%	Black

**Segment Number**

Warwick Fault (WA DNR 1:100,000 Coverage)

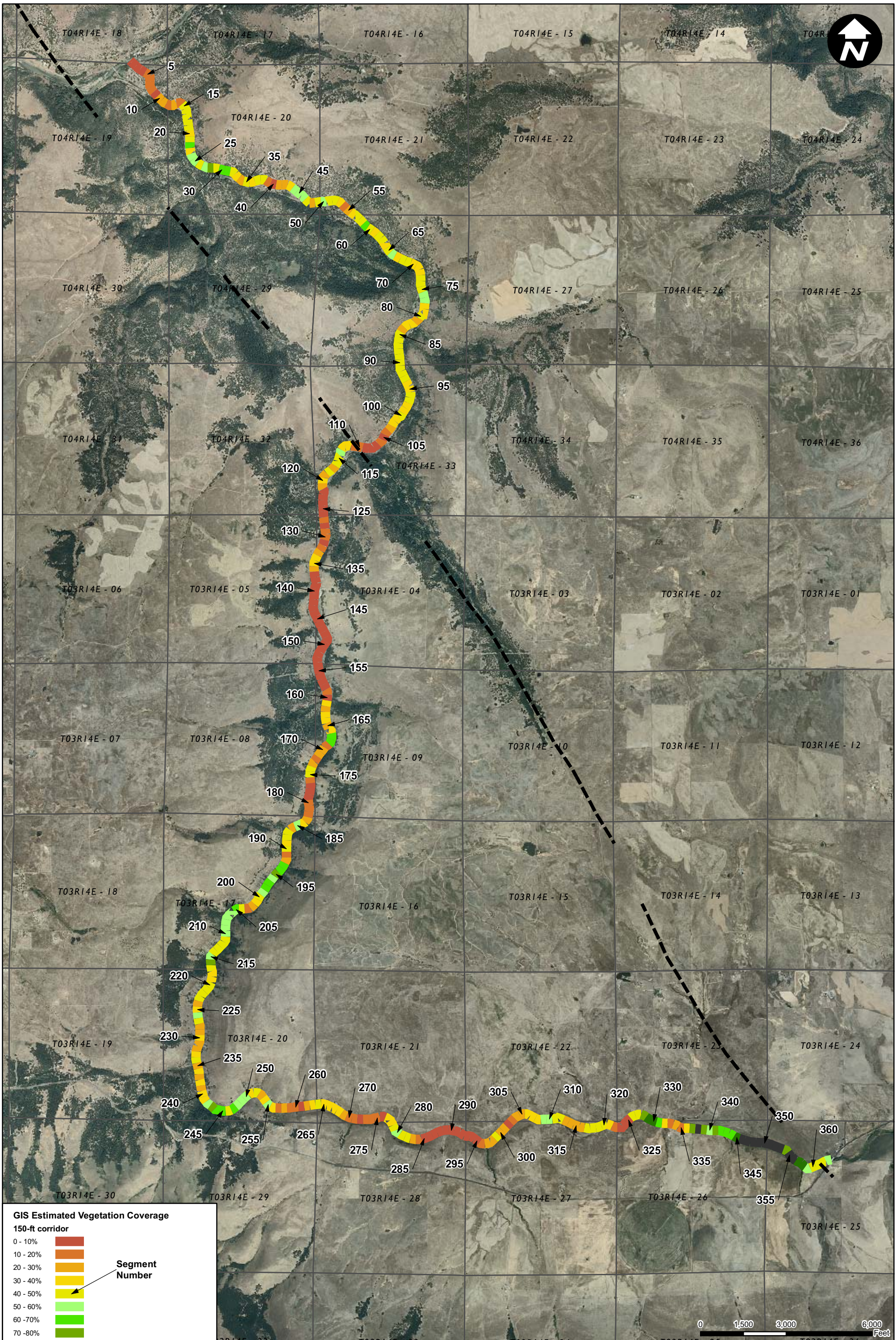
Sections

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**2006 Riparian Vegetation Estimates  
Swale Creek (40-ft Corridor)**  
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30 - Klickitat County, Washington

DATE:	June 2009	PROJECT NO.	070024-009
DESIGNED BY:	PPW	DRAWN BY:	PPW
REVISOR BY:		FIGURE NO.	3A

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**GIS Estimated Vegetation Coverage**  
150-ft corridor

0 - 10%	Red
10 - 20%	Orange
20 - 30%	Yellow-Orange
30 - 40%	Yellow
40 - 50%	Light Green
50 - 60%	Green
60 - 70%	Dark Green
70 - 80%	Very Dark Green
80 - 90%	Black
90 - 100%	Black

**Segment Number**

Warwick Fault

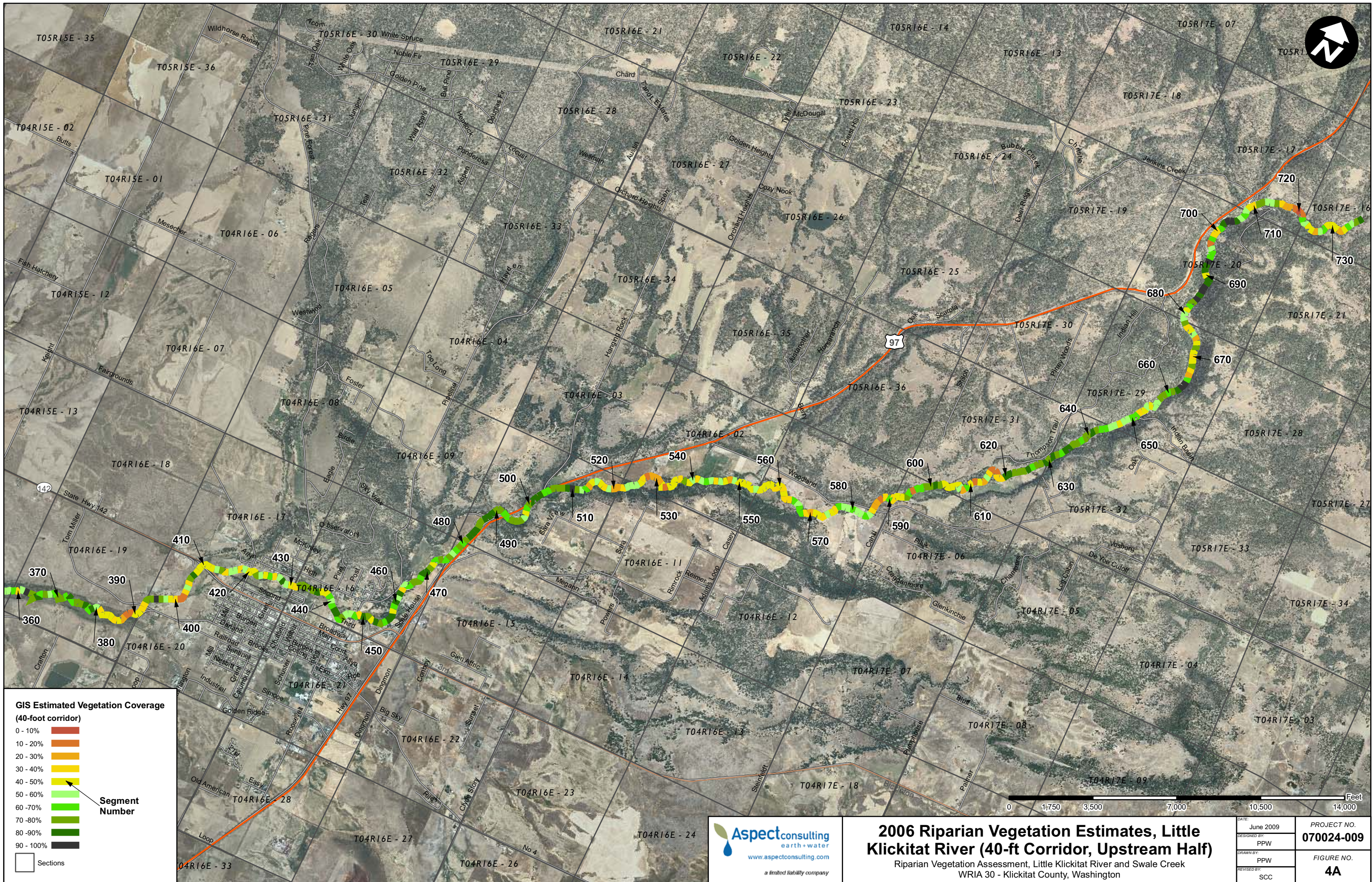
Sections

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**2006 Riparian Vegetation Estimates**  
**Swale Creek (150-ft Corridor)**  
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30 - Klickitat County, Washington

DATE:	June 2009	PROJECT NO.	070024-009
DESIGNED BY:	PPW	DRAWN BY:	PPW
REVISOR:	SCC	FIGURE NO.	3B

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**GIS Estimated Vegetation Coverage (40-foot corridor)**

0 - 10%	Red
10 - 20%	Orange
20 - 30%	Yellow-Orange
30 - 40%	Yellow
40 - 50%	Light Green
50 - 60%	Light Green
60 - 70%	Green
70 - 80%	Dark Green
80 - 90%	Dark Green
90 - 100%	Black

**Segment Number**

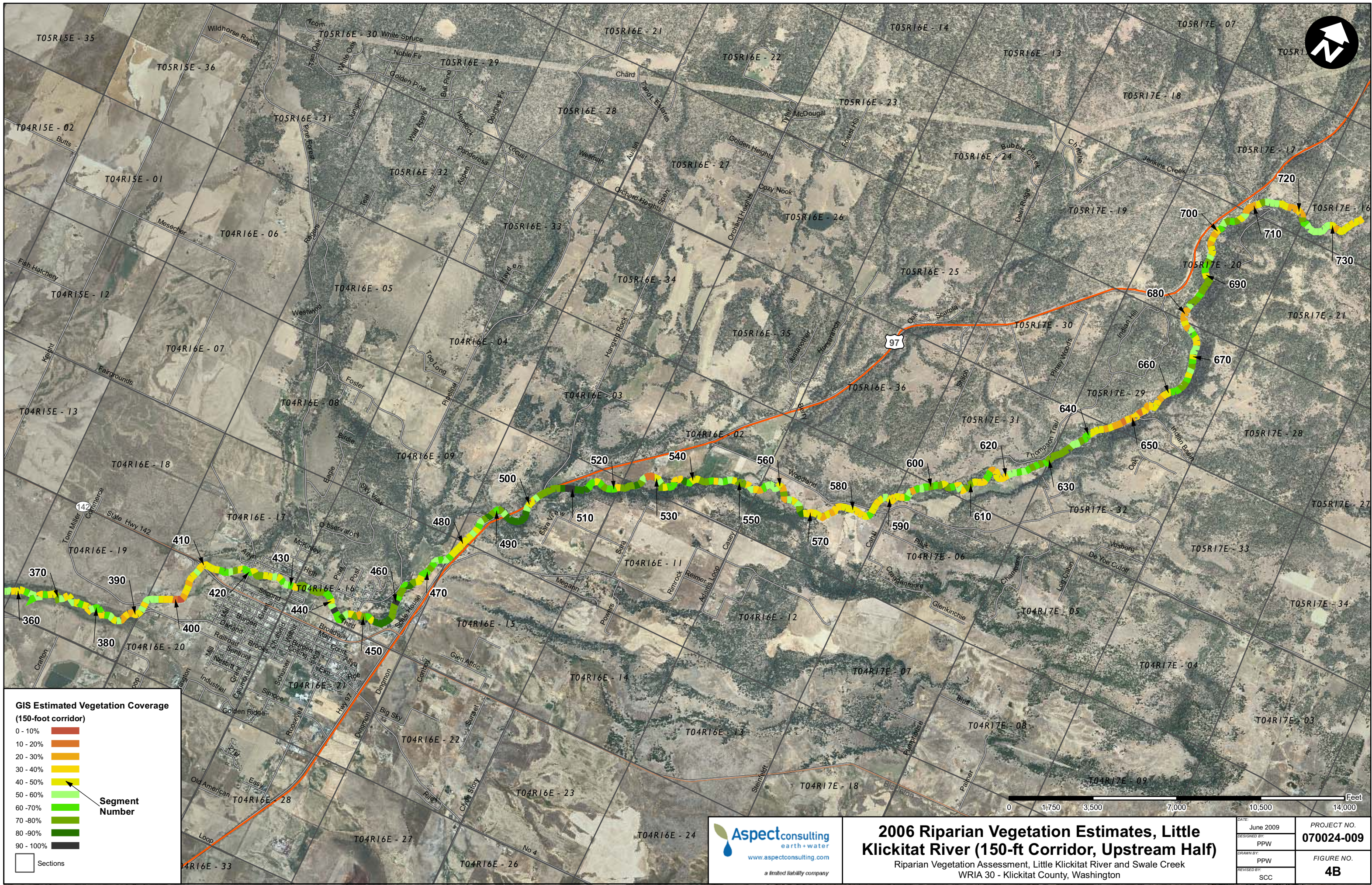
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**2006 Riparian Vegetation Estimates, Little Klickitat River (40-ft Corridor, Upstream Half)**  
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30 - Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 4A
REVISED BY: SCC	

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**GIS Estimated Vegetation Coverage (150-foot corridor)**

0 - 10%	Red
10 - 20%	Orange
20 - 30%	Yellow-Orange
30 - 40%	Yellow
40 - 50%	Light Green
50 - 60%	Light Green
60 - 70%	Green
70 - 80%	Dark Green
80 - 90%	Dark Green
90 - 100%	Black

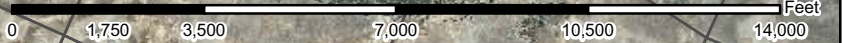
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□ Sections

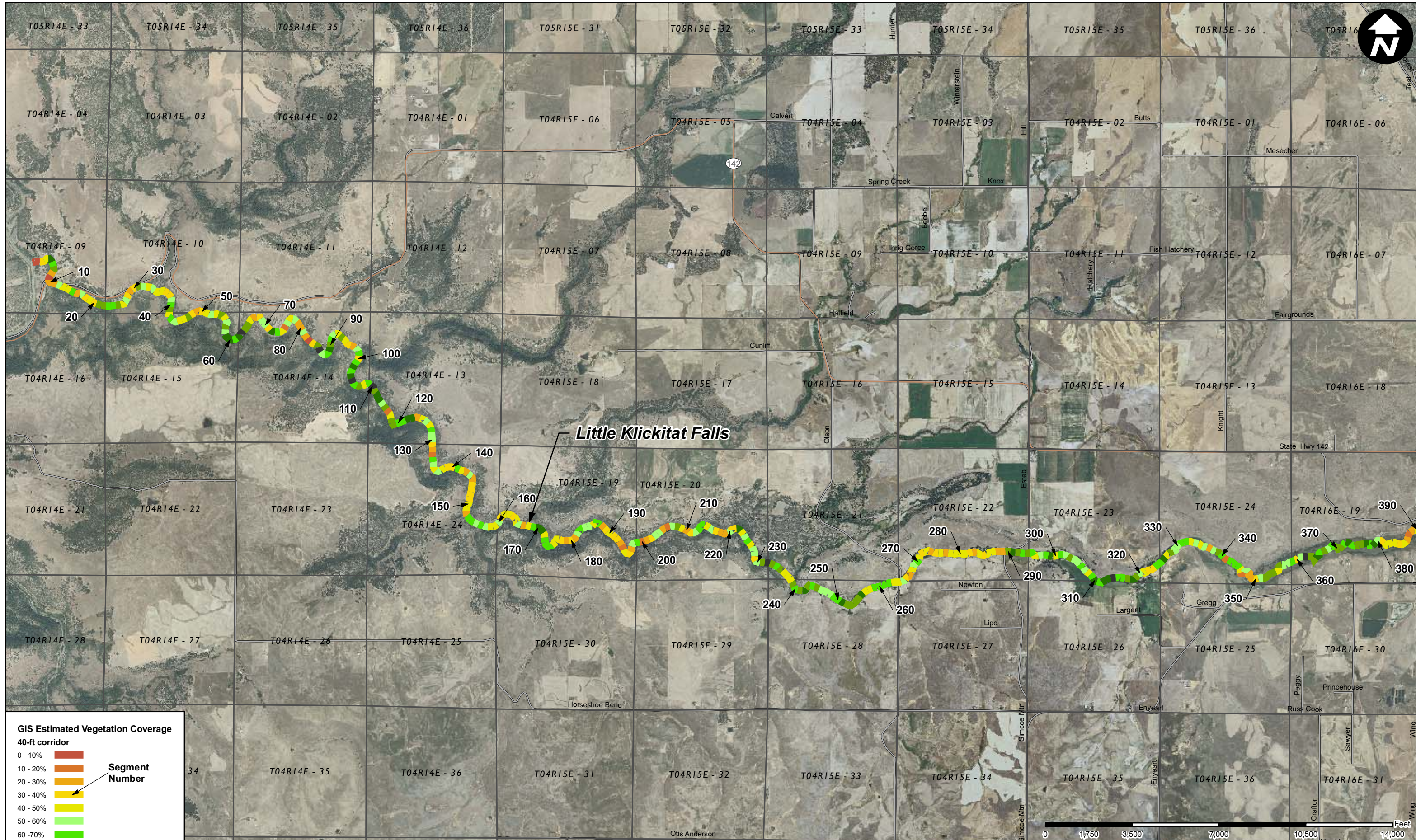
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**2006 Riparian Vegetation Estimates, Little Klickitat River (150-ft Corridor, Upstream Half)**  
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30 - Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
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DRAWN BY: PPW	FIGURE NO. 4B
REVISED BY: SCC	



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**GIS Estimated Vegetation Coverage**  
40-ft corridor

0 - 10%	Red
10 - 20%	Orange
20 - 30%	Yellow-Orange
30 - 40%	Yellow
40 - 50%	Light Green
50 - 60%	Light Green
60 - 70%	Green
70 - 80%	Dark Green
80 - 90%	Dark Green
90 - 100%	Black

Segment Number

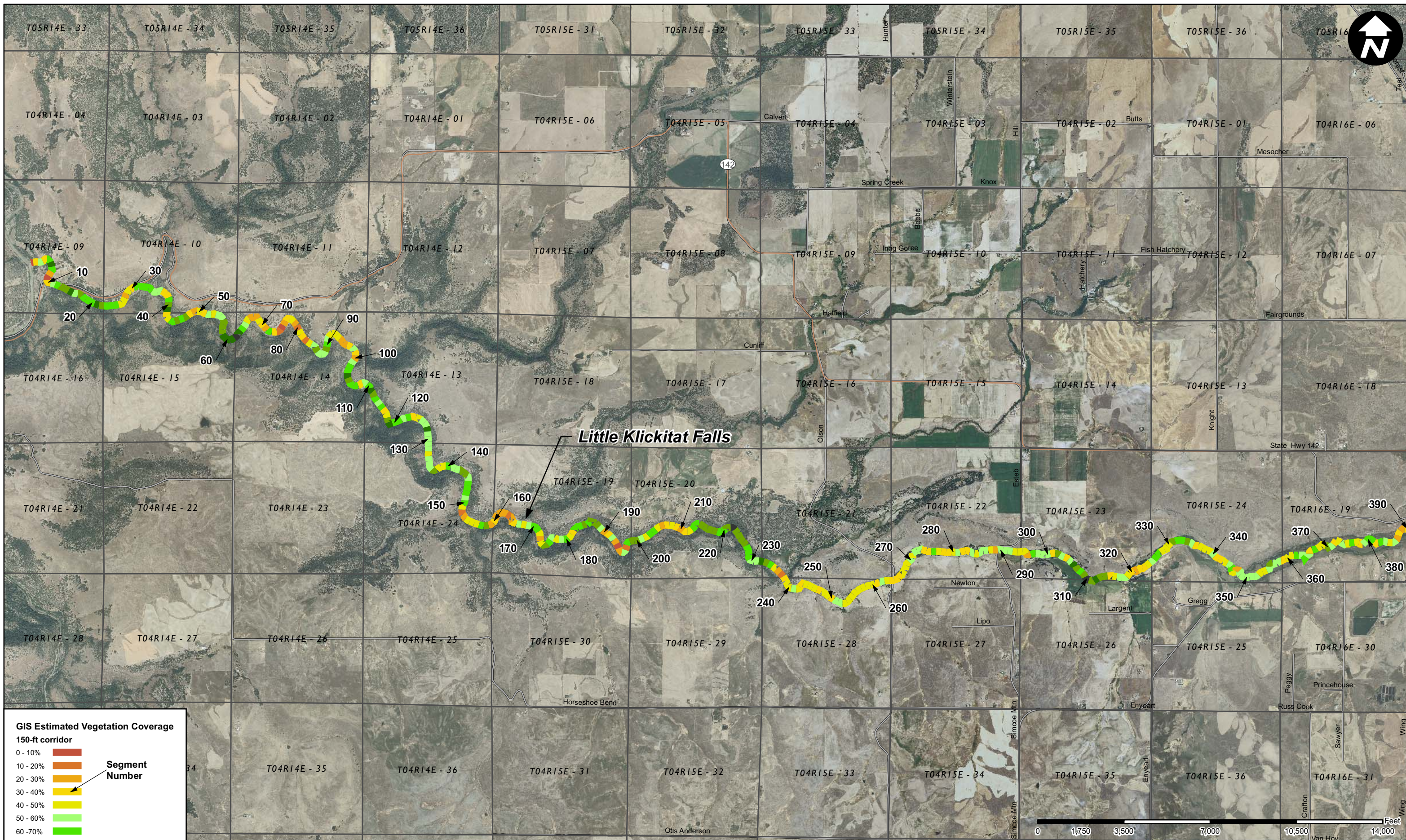
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**2006 Riparian Vegetation Estimates, Little Klickitat River (40-ft Corridor, Downstream Half)**  
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30 - Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 5A
REVISED BY: SCC	

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**GIS Estimated Vegetation Coverage**  
150-ft corridor

0 - 10%	Red
10 - 20%	Orange
20 - 30%	Yellow-Orange
30 - 40%	Yellow
40 - 50%	Light Green
50 - 60%	Light Green
60 - 70%	Green
70 - 80%	Dark Green
80 - 90%	Dark Green
90 - 100%	Black

Segment Number

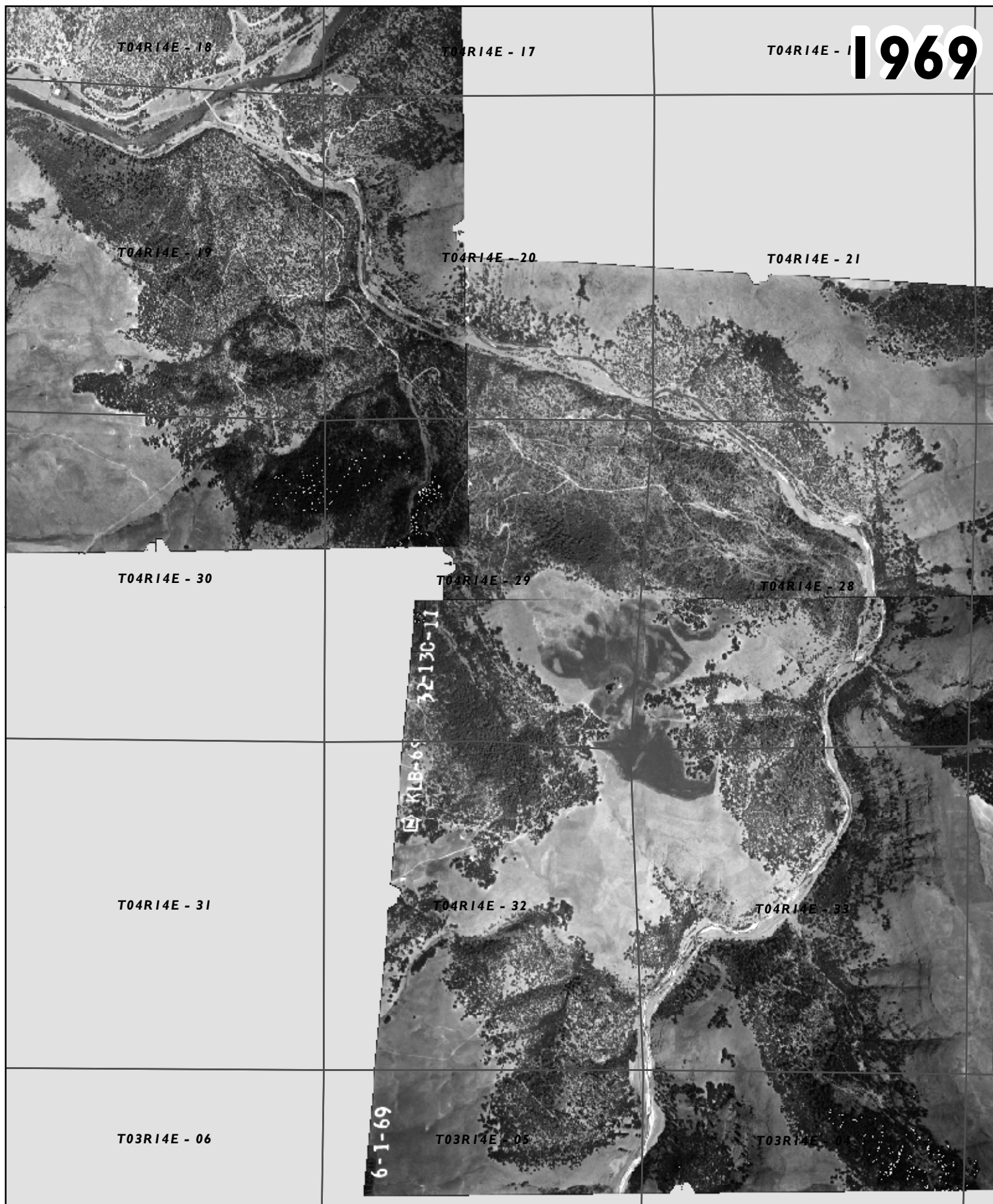
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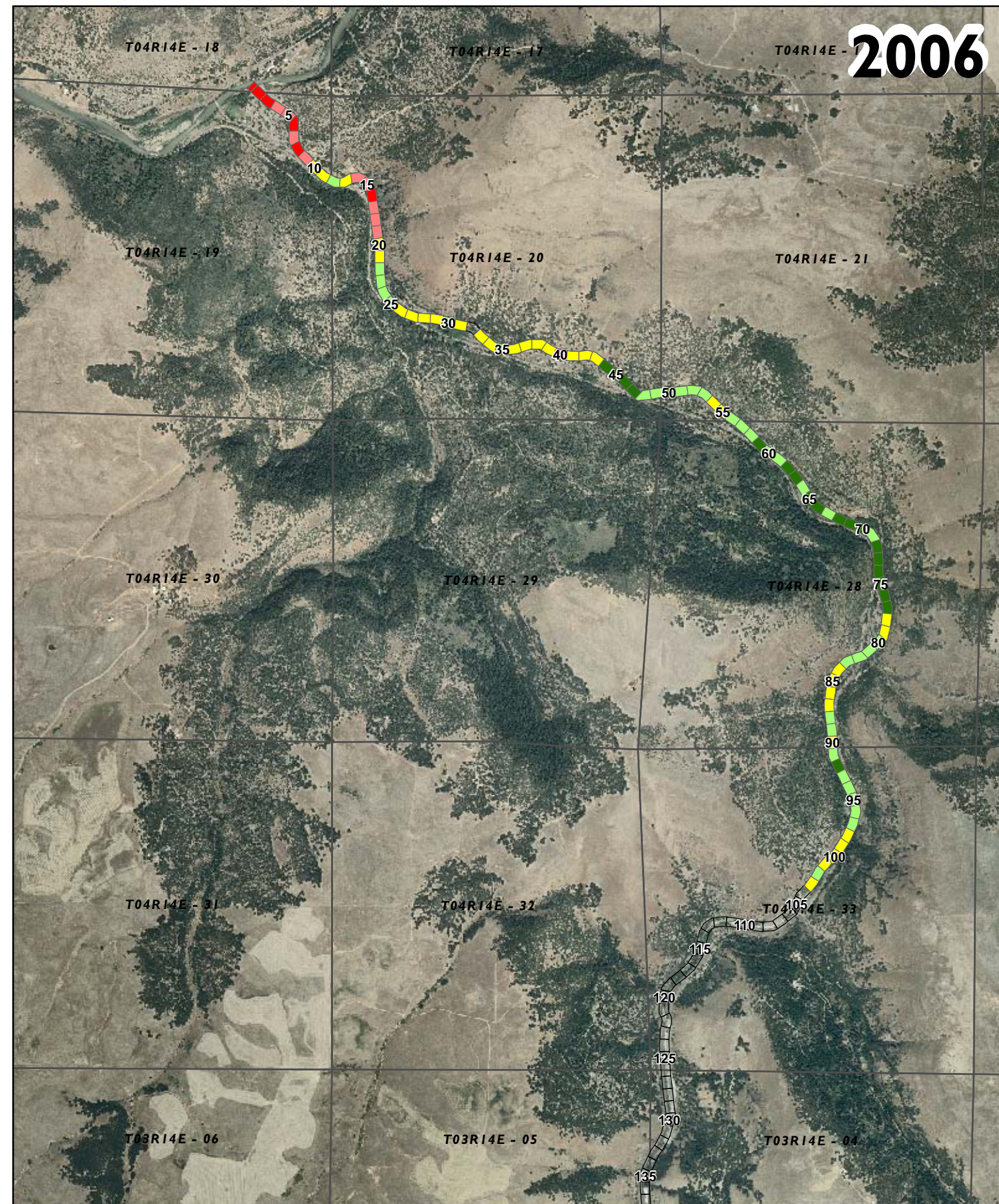
**2006 Riparian Vegetation Estimates, Little Klickitat River (150-ft Corridor, Downstream Half)**  
Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30 - Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: PPW	
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REVISED BY: SCC	

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1969



2006

GIS-Estimated % Change in Riparian Vegetation 1969-2006

- Loss >30%
- Gain 10-30%
- Loss 10-30%
- Gain >30%
- No change (-10 to 10%)
- Segment not analyzed

0 1,000 2,000 4,000 Feet



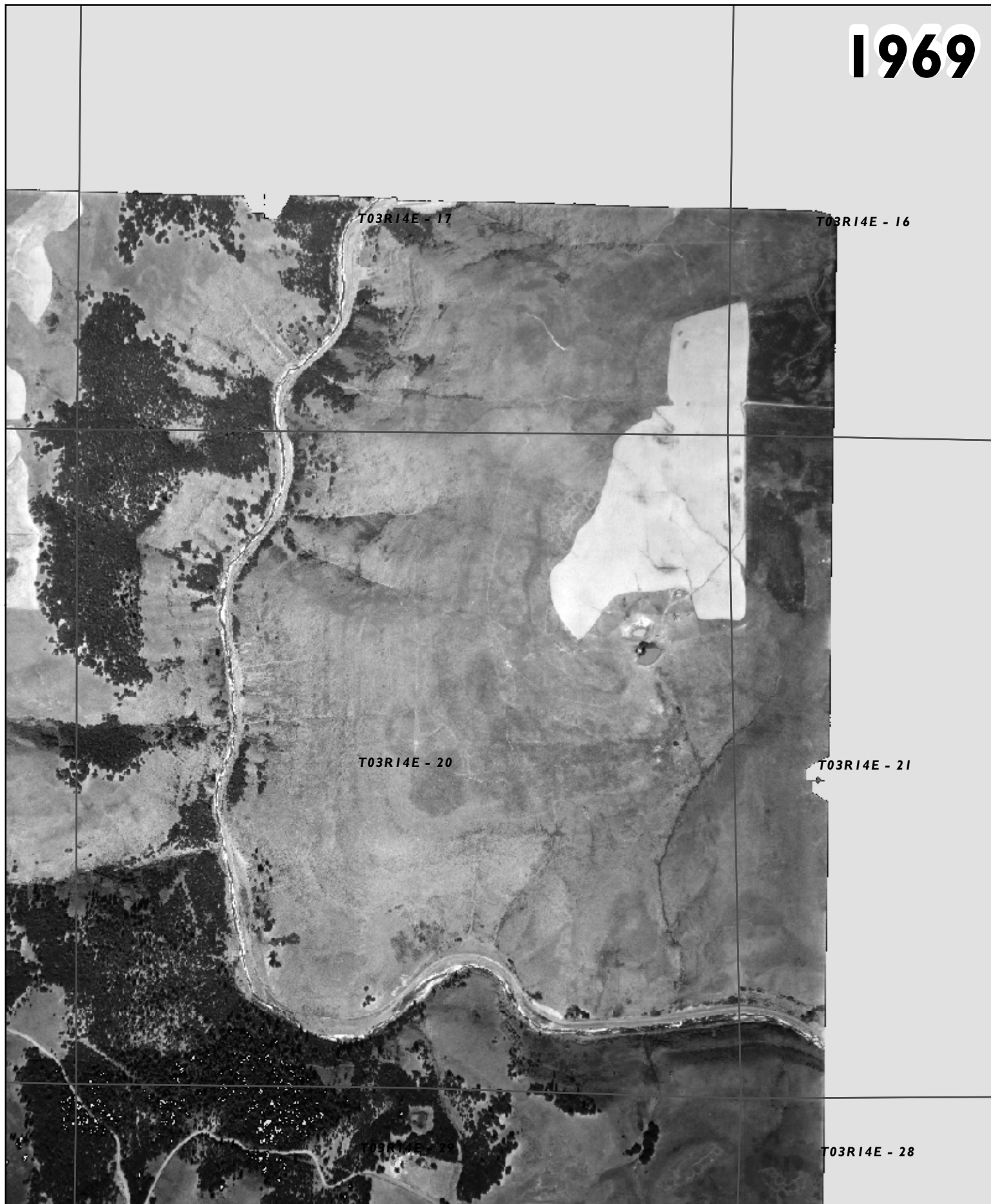
### Estimated Changes in Riparian Vegetation for Lowermost Swale Creek, 1969-2006

Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
WRIA 30, Klickitat County, Washington

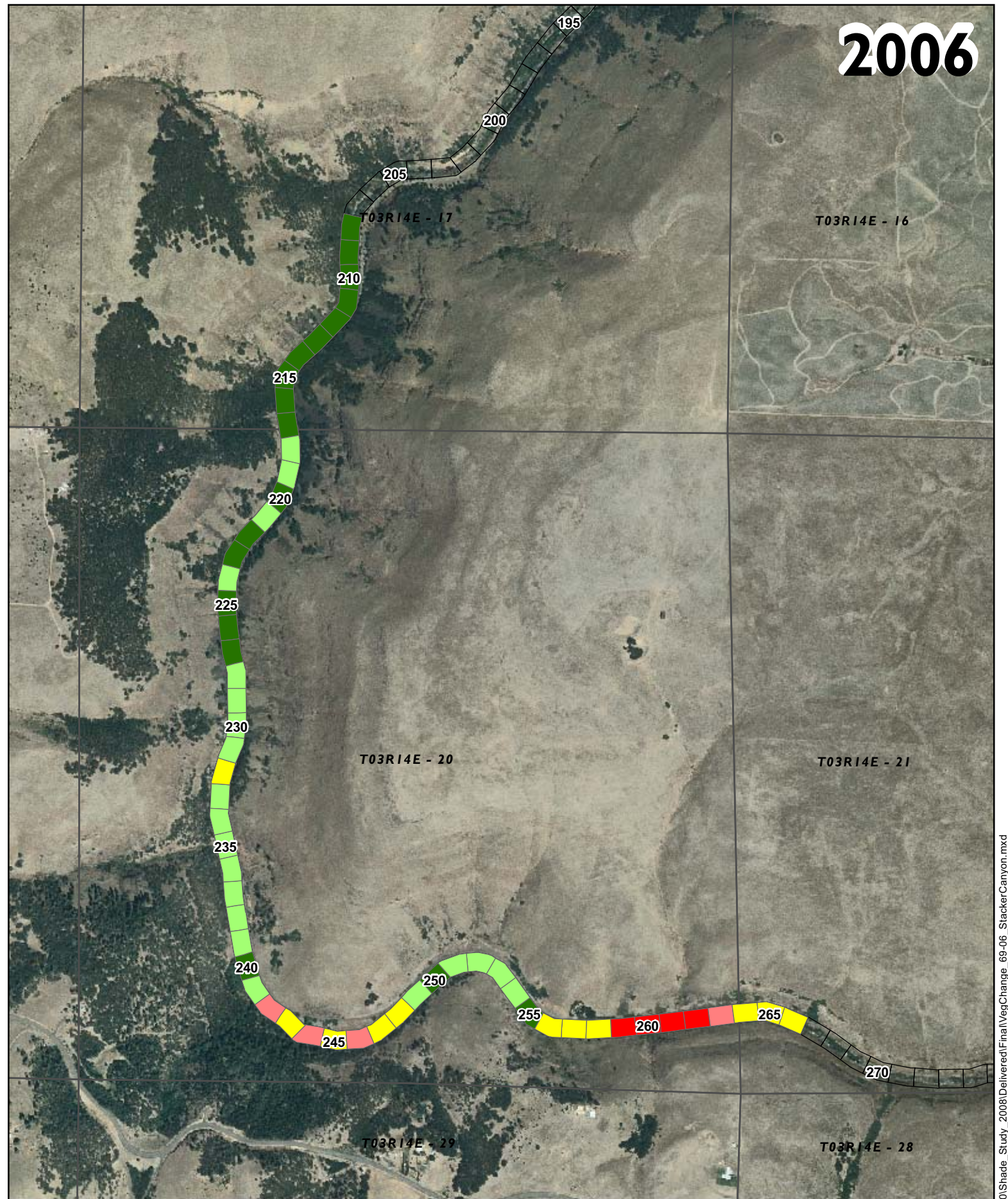
DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: SCC	FIGURE NO. 6
DRAWN BY: SCC	
REVISED BY: PPW	

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# 1969



# 2006



GIS-Estimated % Change in Riparian Vegetation 1969-2006

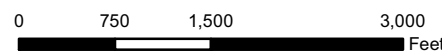
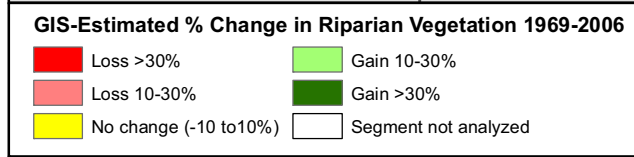
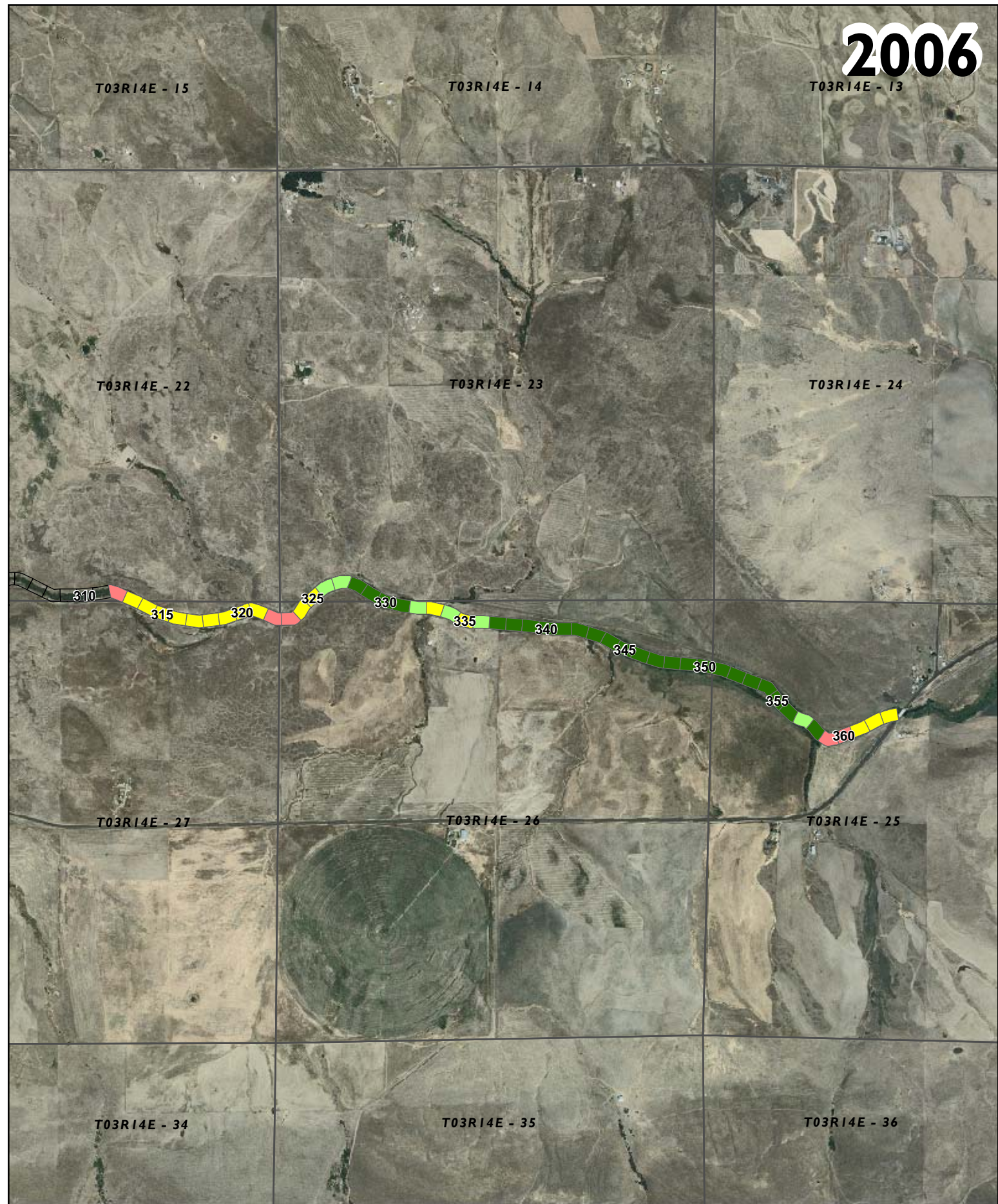
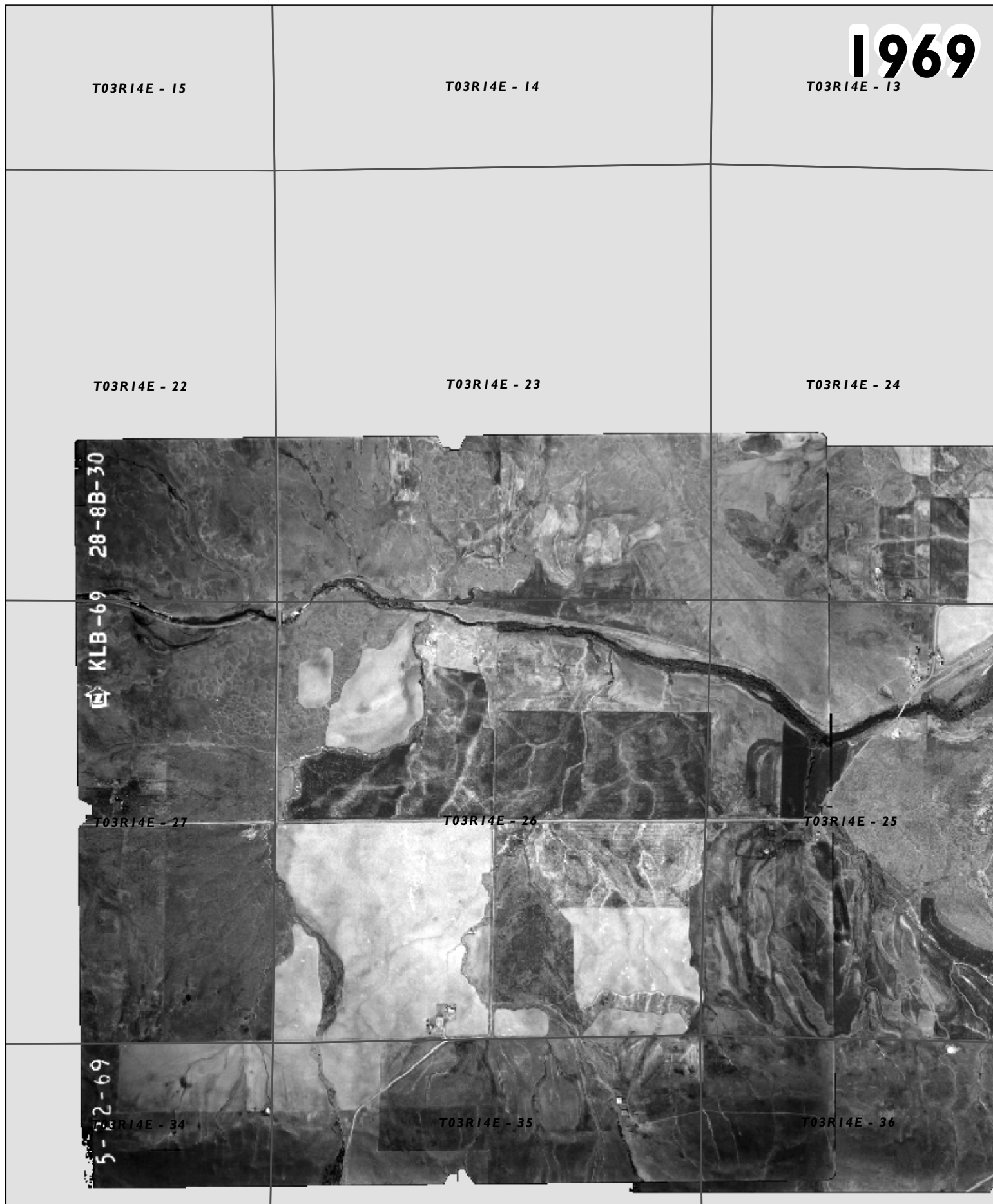
- Loss >30%
- Gain 10-30%
- Loss 10-30%
- Gain >30%
- No change (-10 to 10%)
- Segment not analyzed

0 500 1,000 2,000 Feet



**Estimated Changes in Riparian Vegetation for Swale Creek near Stacker Canyon, 1969-2006**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
 WRIA 30, Klickitat County, Washington

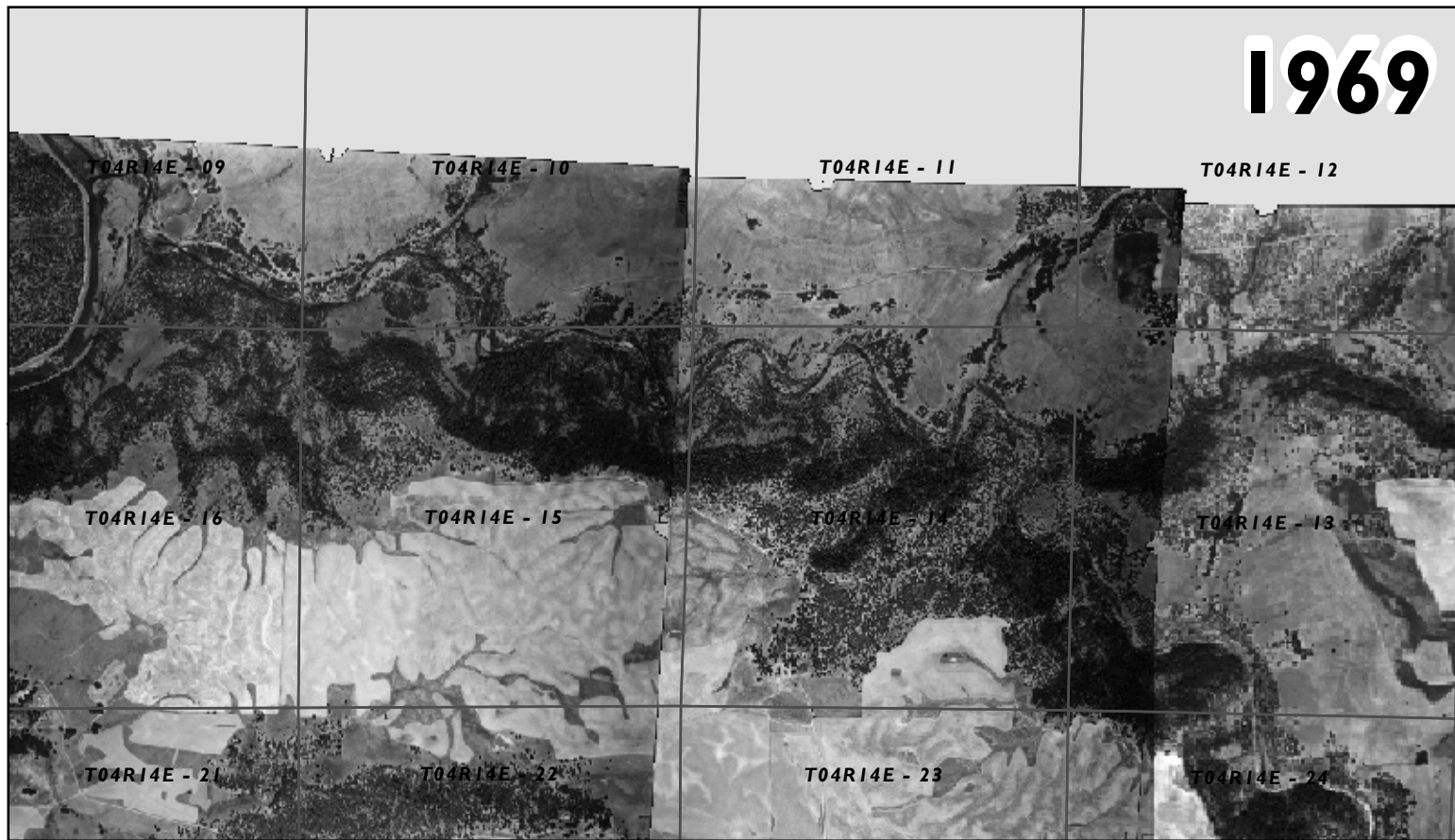
DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: SCC	
DRAWN BY: SCC	FIGURE NO. 7
REVISED BY: PPW	



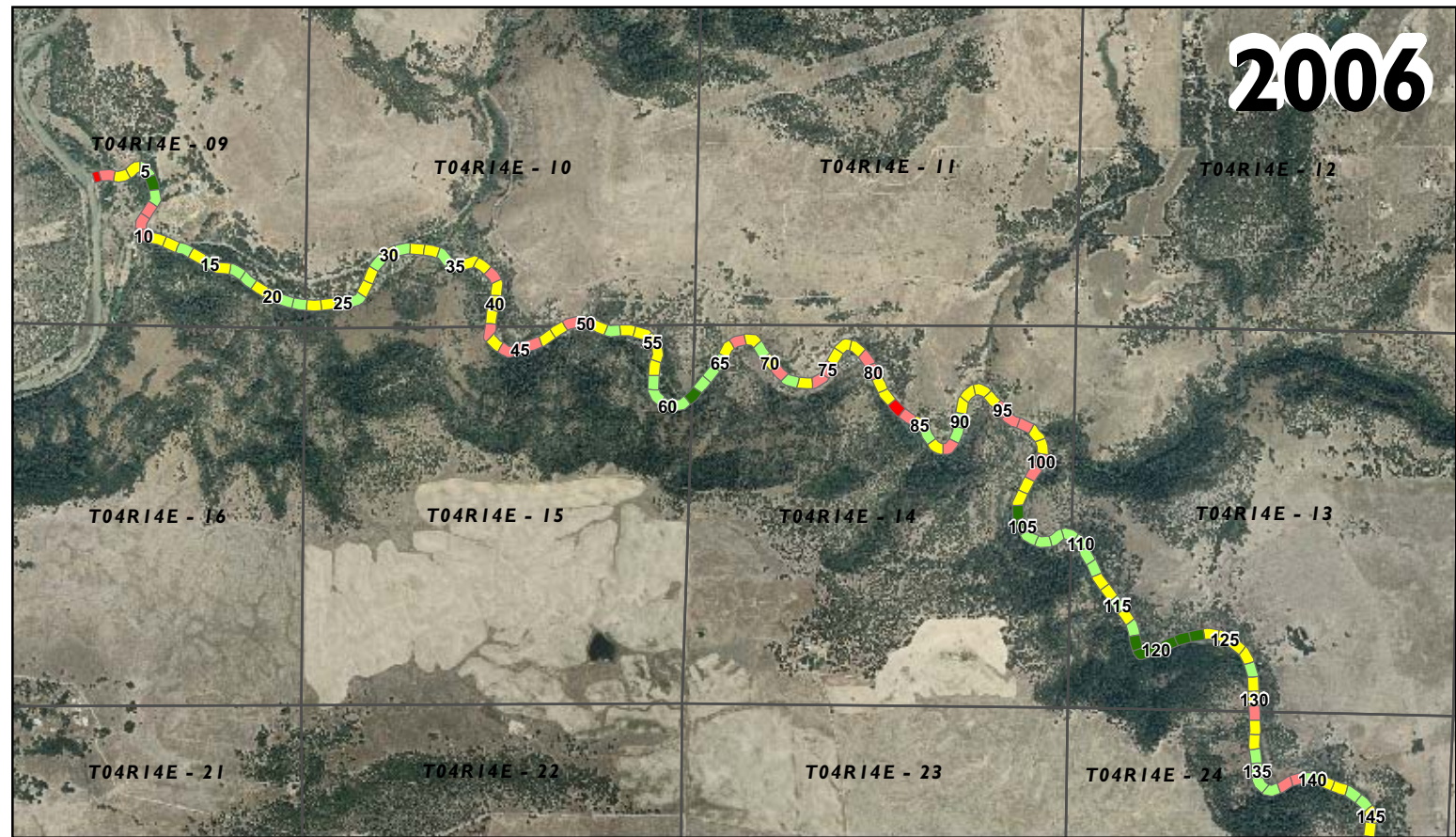
**Estimated Changes in Riparian Vegetation for Swale Creek near Warwick, 1969-2006**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
 WRIA 30, Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: SCC	
DRAWN BY: SCC	FIGURE NO. 8
REVISED BY: PPW	

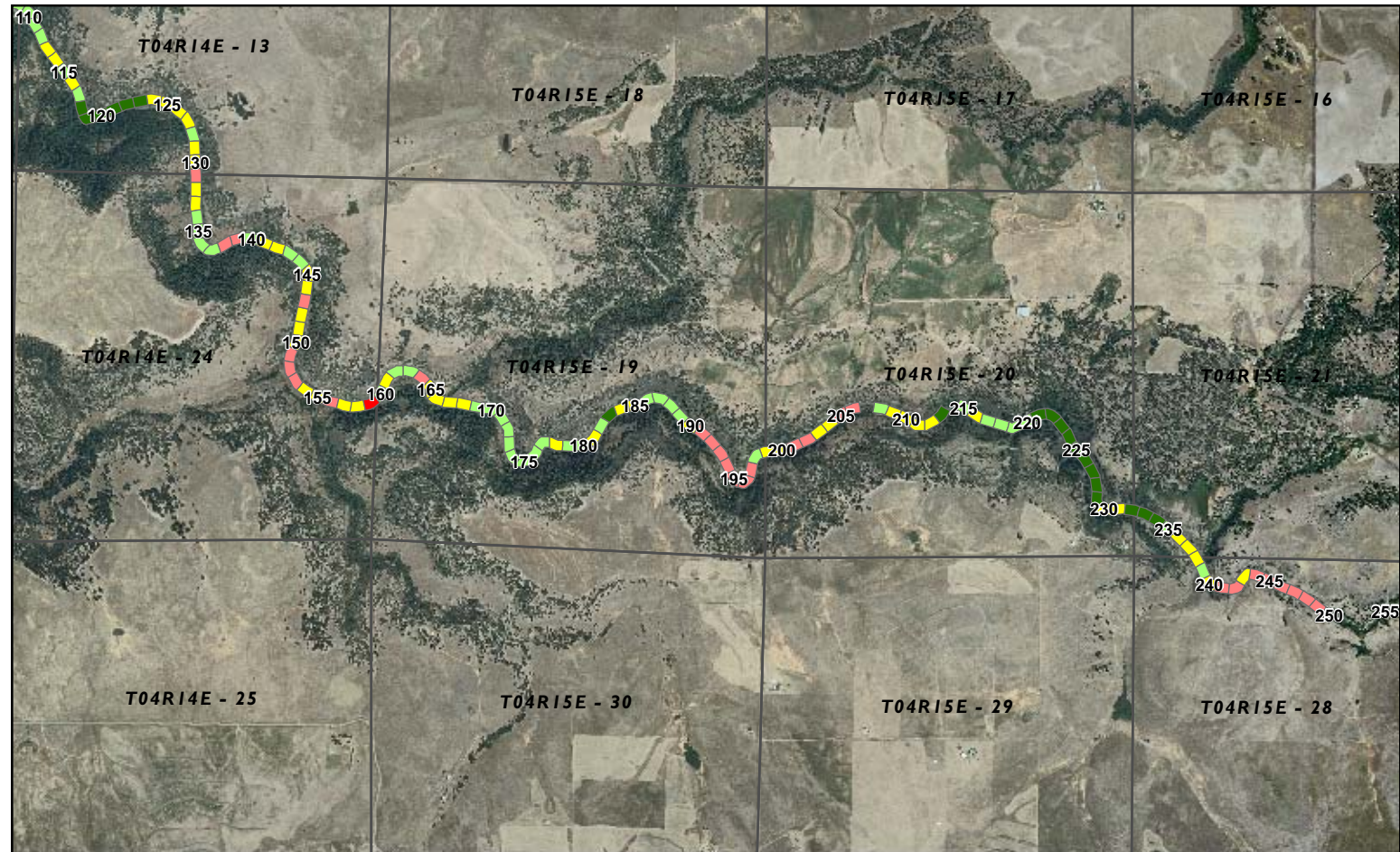
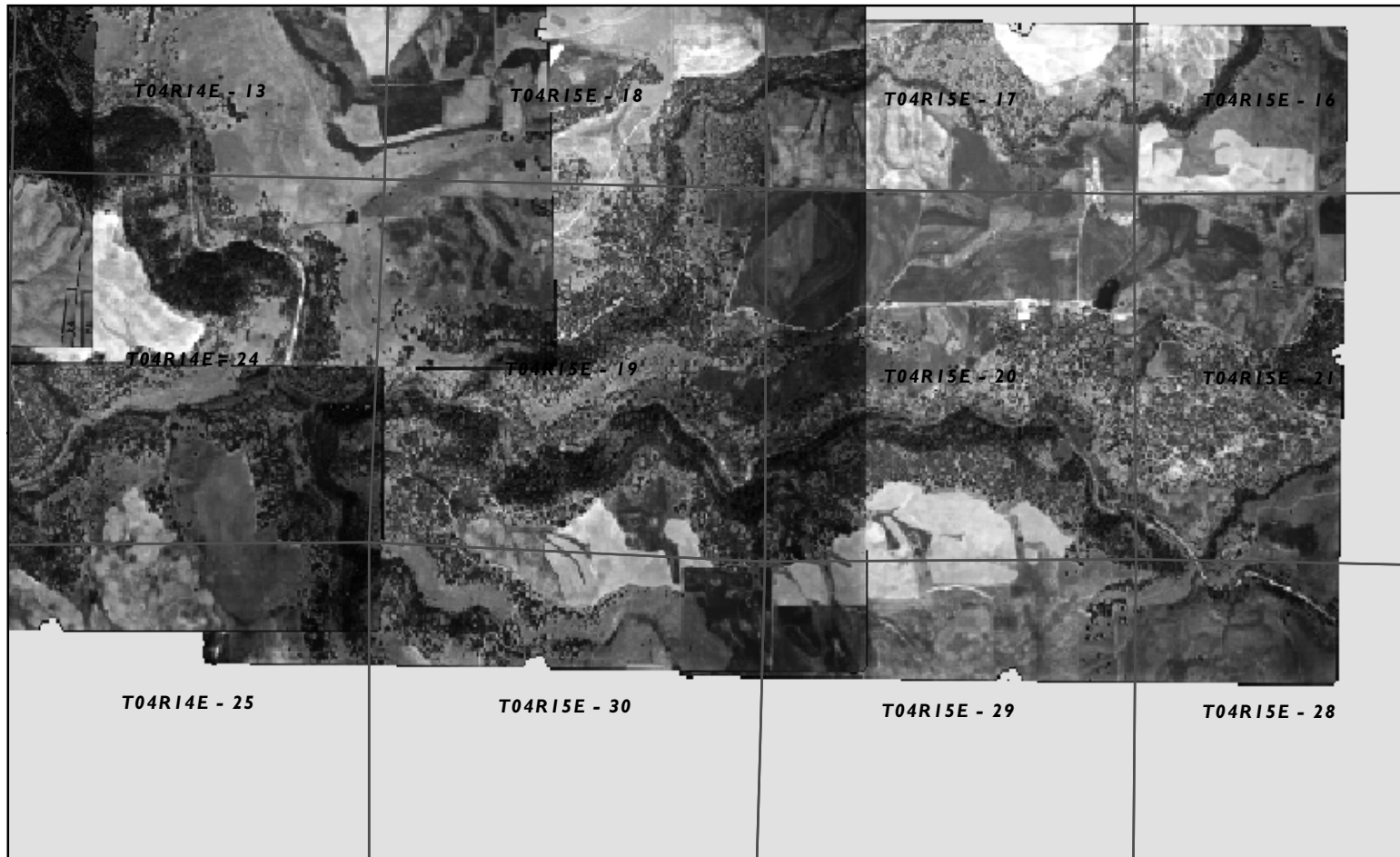
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1969



2006



GIS-Estimated % Change in Riparian Vegetation 1969-2006

- Loss >30%
- Gain 10 - 30%
- Loss 10-30%
- Gain >30%
- No change (-10 to 10%)

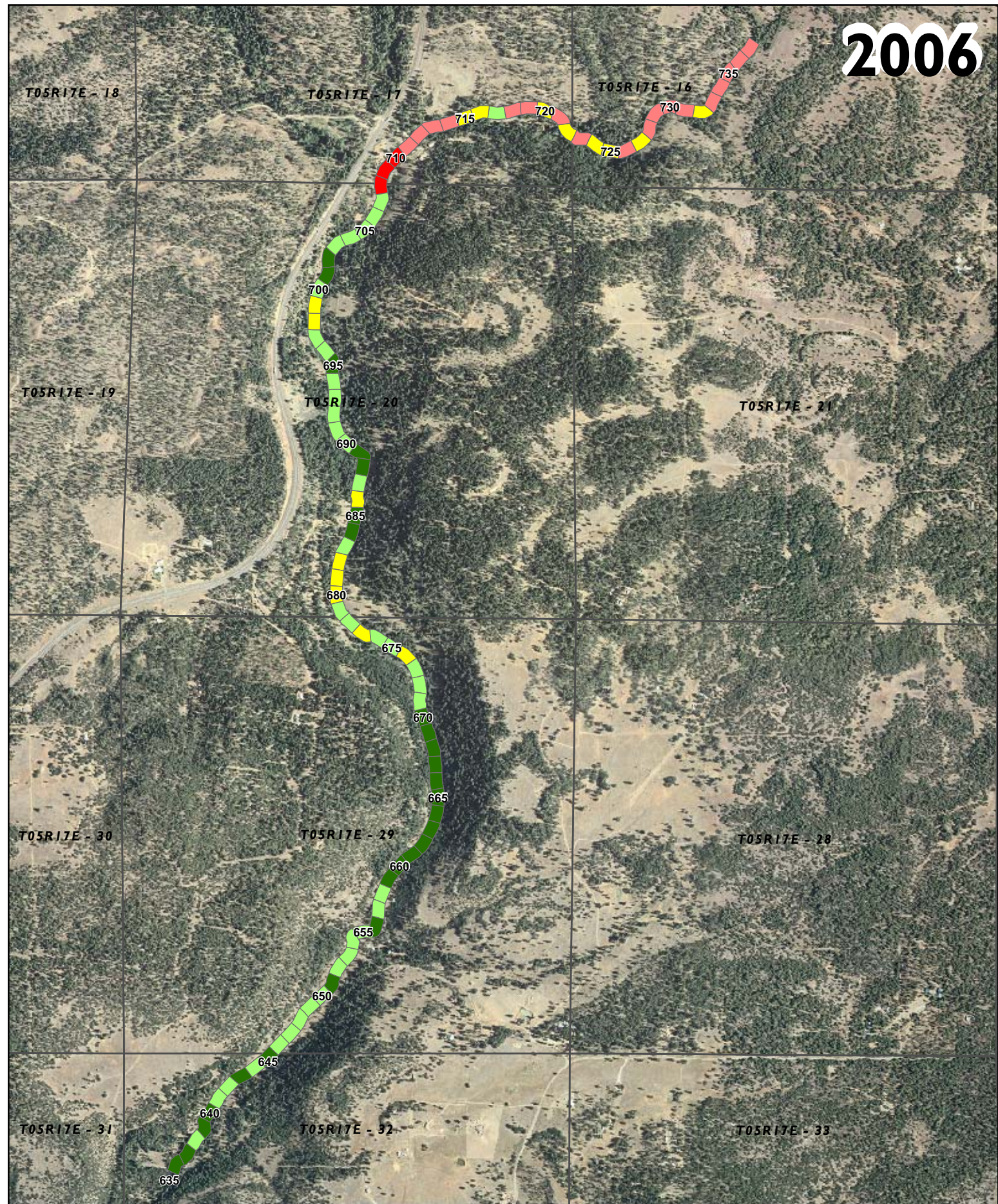
0 1,250 2,500 5,000 Feet








**Estimated Changes in Riparian Vegetation for Lowermost Little Klickitat River, 1969-2006**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
 WRIA 30, Klickitat County, Washington

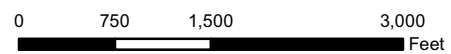
DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: SCC	
DRAWN BY: SCC	FIGURE NO. 9
REVISED BY: PPW	

T:\projects\_8\WRIA30\Shade\_Study\_2008\Delivered\Final\VegChange\_69-06\_LowerLittleKlick.mxd



**GIS-Estimated % Change in Riparian Vegetation 1978-2006**

 Loss >30%	 Gain 10-30%
 Loss 10-30%	 Gain >30%
 No change (-10 to 10%)	



**Estimated Changes in Riparian Vegetation for Little Klickitat River Near 3 Creeks, 1978-2006**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
 WRIA 30, Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: SCC	
DRAWN BY: SCC	FIGURE NO. 10
REVISED BY: PPW	

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## **APPENDIX A**

### **Tabulations of Raw Field Data**

**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densimeter (max = 17)					Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments	
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center down-stream	Canopy center-left					Canopy right bank
<b>Swale Creek</b>																	
Swale Creek	11	6/11/09	1	112	24	77	0.6	17	3	6	6	7	16	<b>78%</b>	<b>33%</b>	<b>43%</b>	
Swale Creek	11	6/11/09	2	112	24	62	0.8	17	5	5	3	14	9				
Swale Creek	11	6/11/09	3	101	20	58	1.0	17	17	1	17	17	17				
Swale Creek	11	6/11/09	4	110	19	33	0.6	17	17	17	17	17	17				
Swale Creek	11	6/11/09	5	108	12	45	0.8	17	17	17	17	17	17				
Swale Creek	16	6/11/09	1	179	17	62	0.3	17	17	14	16	17	10	<b>95%</b>	<b>9%</b>	<b>10%</b>	
Swale Creek	16	6/11/09	2	180	22	62	0.3	17	17	14	14	17	14				
Swale Creek	16	6/11/09	3	179	27	60	0.7	17	17	17	17	17	15				
Swale Creek	16	6/11/09	4	178	20	62	0.3	17	16	17	17	17	17				
Swale Creek	16	6/11/09	5	178	23	54	0.3	17	17	17	16	17	17				
Swale Creek	18	6/11/09	1	168	25	57	0.4	16	7	17	10	6	17	<b>78%</b>	<b>23%</b>	<b>30%</b>	
Swale Creek	18	6/11/09	2	172	35	60	0.2	17	15	4	14	17	15				
Swale Creek	18	6/11/09	3	168	53	31	0.3	17	15	11	10	17	15				
Swale Creek	18	6/11/09	4	170	38	51	0.3	17	10	14	7	13	17				
Swale Creek	18	6/11/09	5	170	43	64	0.3	17	9	11	10	16	17				
Swale Creek	22	6/11/09	1	179	10	59	0.4	17	17	17	17	17	17	<b>90%</b>	<b>22%</b>	<b>25%</b>	
Swale Creek	22	6/11/09	2	180	11	41	0.2	17	17	17	17	17	17				
Swale Creek	22	6/11/09	3	179	12	51	0.2	17	17	17	17	17	17				
Swale Creek	22	6/11/09	4	179	16	45	0.4	17	17	17	17	17	17				
Swale Creek	22	6/11/09	5	181	24	43	0.2	17	5	7	7	7	10				
Swale Creek	25	6/11/09	1	118	20	42	0.3	17	17	17	16	16	17	<b>82%</b>	<b>27%</b>	<b>33%</b>	
Swale Creek	25	6/11/09	2	120	25	38	0.4	17	14	14	13	16	17				
Swale Creek	25	6/11/09	3	118	22	48	0.5	16	15	13	12	14	17				
Swale Creek	25	6/11/09	4	119	20	57	0.3	17	17	17	17	17	17				
Swale Creek	25	6/11/09	5	128	16	48	0.5	8	4	5	4	2	17				
Swale Creek	35	6/12/09	1	80	11	22	0.5	17	14	10	15	17	12	<b>89%</b>	<b>17%</b>	<b>20%</b>	
Swale Creek	35	6/12/09	2	76	17	30	0.2	17	17	16	17	17	17				
Swale Creek	35	6/12/09	3	70	17	37	0.3	16	14	13	14	17	17				
Swale Creek	35	6/12/09	4	78	20	43	0.2	17	14	16	7	6	14				
Swale Creek	35	6/12/09	5	80	26	33	0.3	17	17	17	17	17	17				
Swale Creek	47	6/12/09	1	94	12	39	0.7	17	6	0	9	16	17	<b>82%</b>	<b>31%</b>	<b>38%</b>	
Swale Creek	47	6/12/09	2	84	16	43	1.3	17	14	17	17	17	17				
Swale Creek	47	6/12/09	3	88	19	44	0.4	17	5	1	15	11	17				
Swale Creek	47	6/12/09	4	82	13	64	0.2	17	17	12	5	17	17				
Swale Creek	47	6/12/09	5	64	27	77	0.1	17	17	17	17	17	17				
Swale Creek	57	6/12/09	1	144	13	28	0.5	17	17	17	17	17	17	<b>100%</b>	<b>0%</b>	<b>0%</b>	
Swale Creek	57	6/12/09	2	138	13	26	0.3	17	17	17	17	17	17				
Swale Creek	57	6/12/09	3	134	14	31	0.4	17	17	17	17	17	17				
Swale Creek	57	6/12/09	4	132	22	37	0.1	17	17	17	17	17	17				
Swale Creek	57	6/12/09	5	132	18	72	0.5	17	17	17	17	17	17				
Swale Creek	66	6/12/09	1	118	15	48	0.5	17	15	17	17	16	16	<b>97%</b>	<b>6%</b>	<b>6%</b>	
Swale Creek	66	6/12/09	2	115	20	43	0.5	17	17	17	17	17	17				
Swale Creek	66	6/12/09	3	105	18	32	0.8	17	15	16	16	12	17				
Swale Creek	66	6/12/09	4	112	14	38	0.4	17	17	17	17	17	17				
Swale Creek	66	6/12/09	5	111	12	28	0.1	17	17	17	17	17	17				

**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densiometer (max = 17)					Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments			
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center-downstream	Canopy center-left					Canopy right bank		
Swale Creek	72	6/12/09	1	180	23	43	0.2	17	16	16	17	17	17	94%	10%	11%			
Swale Creek	72	6/12/09	2	184	27	45	0.3	14	11	14	11	16	17						
Swale Creek	72	6/12/09	3	188	22	35	0.2	17	16	16	16	17	17						
Swale Creek	72	6/12/09	4	182	16	41	0.3	17	17	17	17	17	17						
Swale Creek	72	6/12/09	5	185	23	33	0.4	17	13	15	16	15	17						
Swale Creek	95	6/12/09	1	180	10	34	0.5	7	17	17	17	13	17	88%	21%	23%			
Swale Creek	95	6/12/09	2	200	1401	28	0.5	11	12	5	12	17	17						
Swale Creek	95	6/12/09	3	212	18	26	0.4	17	15	16	6	17	17						
Swale Creek	95	6/12/09	4	206	16	28	0.4	15	16	15	17	17	17						
Swale Creek	95	6/12/09	5	202	9	24	0.2	17	17	17	17	17	17						
Swale Creek	96	6/12/09	1	207	29	38	0.2	17	13	17	12	17	17	49%	36%	74%			
Swale Creek	96	6/12/09	2	205	12	36	0.2	17	4	4	2	9	17						
Swale Creek	96	6/12/09	3	205	15	35	0.2	3	0	14	6	2	12						
Swale Creek	96	6/12/09	4	205	20	27	2.0	7	5	3	0	5	12						
Swale Creek	96	6/12/09	5	200	15	33	0.6	6	1	4	0	7	17						
Swale Creek	100	6/12/09	1	208	15	45	1.5	0	0	0	5	14	0	56%	36%	65%			
Swale Creek	100	6/12/09	2	210	13	31	0.2	17	17	17	17	17	16						
Swale Creek	100	6/12/09	3	211	19	25	1.4	13	4	13	0	8	17						
Swale Creek	100	6/12/09	4	220	10	26	0.5	13	3	5	6	14	14						
Swale Creek	100	6/12/09	5	220	10	25	0.9	9	4	11	8	11	14						
Swale Creek	106	6/12/09	1	236	0	40	0.0		0	0	0	1		0%	1%	N/A			
Swale Creek	106	6/12/09	2	234	0	40	0.0		0	0	0	0							
Swale Creek	106	6/12/09	3	246	0	35	0.0		0	0	0	0							
Swale Creek	106	6/12/09	4	244	0	55	0.0		0	0	0	0							
Swale Creek	106	6/12/09	5	244	0	53	0.0		0	0	0	0							
Swale Creek	119	6/14/09	1	208	13	40	0.1	17	17	17	17	17	17	84%	33%	40%			
Swale Creek	119	6/14/09	2	186	9	37	0.5	17	17	17	17	17	17						
Swale Creek	119	6/14/09	3	191	28	40	0.8	17	13	9	12	17	17						
Swale Creek	119	6/14/09	4	185	37	38	5.0	17	0	2	0	1	17						
Swale Creek	119	6/14/09	5	171	6	17	0.2	17	17	17	17	17	16						
Swale Creek	123	6/14/09	1	178	6	27	0.1	0	0	0	0	0	0	1%	3%	N/A			
Swale Creek	123	6/14/09	2	175	0	29	0.0		0	0	0	0							
Swale Creek	123	6/14/09	3	180	0	34	0.0		0	0	0	0							
Swale Creek	123	6/14/09	4	190	0	29	0.0		0	0	0	2							
Swale Creek	123	6/14/09	5	178	0	23	0.0		0	0	0	0							
Swale Creek	128	6/14/09	1	170	23	105	0.1	0	0	0	0	0	0	11%	26%	241%			
Swale Creek	128	6/14/09	2	184	54	63	0.2	4	0	0	0	0	0						
Swale Creek	128	6/14/09	3	182	49	57	0.9	16	0	0	0	0	17						
Swale Creek	128	6/14/09	4	185	52	62	0.9	10	0	0	0	0	3						
Swale Creek	128	6/14/09	5	191	48	56	1.4	2	0	0	0	0	4						
Swale Creek	135	6/14/09	1	178	19	46	0.2	17	17	17	17	17	17	34%	45%	132%			
Swale Creek	135	6/14/09	2	174	19	47	0.2	17	1	3	3	0	7						
Swale Creek	135	6/14/09	3	170	31	43	0.3	17	0	3	0	0	1						
Swale Creek	135	6/14/09	4	168	20	34	0.9	0	0	1	0	0	1						
Swale Creek	135	6/14/09	5	164	12	34	0.7	17	0	0	0	0	0						
Swale Creek	139	6/14/09	1	180	0	23	0.0		0	0	0	0		0%	0%	N/A			
Swale Creek	139	6/14/09	2	182	0	32	0.0		0	0	0	0							
Swale Creek	139	6/14/09	3	190	0	32	0.0		0	0	0	0							
Swale Creek	139	6/14/09	4	180	0	32	0.0		0	0	0	0							
Swale Creek	139	6/14/09	5	180	0	27	0.0		0	0	0	0							

**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densiometer (max = 17)						Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments		
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center-downstream	Canopy center-left	Canopy right bank						
Swale Creek	146	6/14/09	1	147	0	43	0.0		0	0	0	0		0%	0%	N/A			
Swale Creek	146	6/14/09	2	144	0	41	0.0		0	0	0	0							
Swale Creek	146	6/14/09	3	148	0	34	0.0		0	0	0	0							
Swale Creek	146	6/14/09	4	150	0	29	0.0		0	0	0	0							
Swale Creek	146	6/14/09	5	150	0	53	0.0		0	0	0	0							
Swale Creek	174	6/15/09	1	187	0	43	0.0		2	0	0	7		23%	35%	155%			
Swale Creek	174	6/15/09	2	185	18	45	0.1	15	3	1	0	3	4						
Swale Creek	174	6/15/09	3	186	20	43	0.1	2	0	0	0	2	4						
Swale Creek	174	6/15/09	4	184	17	48	0.6	17	1	0	0	6	17						
Swale Creek	174	6/15/09	5	184	17	42	0.2	0	0	0	0	1	17						
Swale Creek	181	6/15/09	1	206	23	46	0.2	1	0	0	8	0	17	14%	25%	178%			
Swale Creek	181	6/15/09	2	206	23	37	0.4	0	0	0	0	0	4						
Swale Creek	181	6/15/09	3	181	14	20	0.6	10	3	0	0	0	5						
Swale Creek	181	6/15/09	4	201	12	23	0.8	9	0	0	0	6	0						
Swale Creek	181	6/15/09	5	196	6	13	0.2	0	10	0	0	0	0						
Swale Creek	182	6/15/09	1	210	7	24	0.1	10	2	2	6	11	12	22%	28%	130%			
Swale Creek	182	6/15/09	2	230	0	30	0.0		1	5	5	2							
Swale Creek	182	6/15/09	3	230	0	30	0.0		0	0	0	0							
Swale Creek	182	6/15/09	4	243	14	39	0.2	10	0	0	1	0	0						
Swale Creek	182	6/15/09	5	254	11	40	0.1	0	0	8	0	4	17						
Swale Creek	190	6/15/09	1	170	10	22	0.1	17	17	17	17	17	17	53%	41%	78%			
Swale Creek	190	6/15/09	2	186	0	23	0.0		5	15	5	8							
Swale Creek	190	6/15/09	3	189	4	24	0.1	0	12	1	2	2	17						
Swale Creek	190	6/15/09	4	180	0	66	0.0		1	14	4	14							
Swale Creek	190	6/15/09	5	178	0	60	0.0		0	1	1	11							
Swale Creek	204	6/15/09	1	240	30	53	0.8	15	0	0	0	0	17	66%	41%	61%			
Swale Creek	204	6/15/09	2	250	23	54	0.6	17	7	6	13	16	17						
Swale Creek	204	6/15/09	3	133	12	54	0.2	17	17	17	17	17	17						
Swale Creek	204	6/15/09	4	148	17	48	0.9	8	0	0	3	9	13						
Swale Creek	204	6/15/09	5	144	9	41	0.1	11	17	17	17	17	17						
Swale Creek	236	6/15/09	1	176	9	23	0.7	17	13	10	2	9	17	89%	24%	26%			
Swale Creek	236	6/15/09	2	180	7	46	0.2	17	17	17	17	17	17						Estimated values due to intense, thick brush - impenetrable
Swale Creek	236	6/15/09	3	179	6	45	0.4	17	17	17	17	17	17						
Swale Creek	236	6/15/09	4	171	2	29	0.2	17	17	17	17	17	17						
Swale Creek	236	6/15/09	5	170	9	40	1.3	17	3	15	14	15	17						
Swale Creek	250	6/15/09	1	75	16	37	1.0	17	0	0	2	1	17	66%	42%	64%			
Swale Creek	250	6/15/09	2	69	0	30	0.0		10	12	12	12							
Swale Creek	250	6/15/09	3	78	0	33	0.0		17	17	17	17							
Swale Creek	250	6/15/09	4	81	14	26	0.4	15	0	0	16	2	17						
Swale Creek	250	6/15/09	5	80	0	24	0.0		17	17	17	17							
Swale Creek	260	6/15/09	1	80	17	37	0.3	2	0	0	0	0	17	9%	25%	275%			
Swale Creek	260	6/15/09	2	79	11	36	0.3	1	0	0	0	0	0						
Swale Creek	260	6/15/09	3	79	16	22	0.4	0	0	2	0	0	17						
Swale Creek	260	6/15/09	4	83	8	16	0.1	0	0	3	0	0	4						
Swale Creek	260	6/15/09	5	82	16	28	0.2	0	0	0	0	0	1						
Swale Creek	291	6/9/09	1	123	31	50	0.5	0	0	0	0	0	0	0%	0%	N/A			
Swale Creek	291	6/9/09	2	128	12	60	0.1	0	0	0	0	0	0						
Swale Creek	291	6/9/09	3	122	37	49	0.2	0	0	0	0	0	0						
Swale Creek	291	6/9/09	4	118	24	49	0.2	0	0	0	0	0	0						
Swale Creek	291	6/9/09	5	120	9	56	0.4	0	0	0	0	0	0						

Aspect Consulting

6/30/09

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Table A-1

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**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densiometer (max = 17)					Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center down-stream	Canopy center-left				
Swale Creek	294	6/9/09	1	143	20	58	0.3	0	0	0	0	0	0%	0%	N/A	
Swale Creek	294	6/9/09	2	127	24	49	0.6	0	0	0	0	0				
Swale Creek	294	6/9/09	3	125	15	47	0.4	0	0	0	0	0				
Swale Creek	294	6/9/09	4	117	19	40	0.4	0	0	0	0	0				
Swale Creek	294	6/9/09	5	122	6	78	0.2	0	0	0	0	0				
Swale Creek	304	6/9/09	1	77	8	18	0.6	0	0	0	0	0	22%	36%	165%	
Swale Creek	304	6/9/09	2	70	15	17	0.9	4	0	0	0	0				
Swale Creek	304	6/9/09	3	80	5	19	0.4	0	9	17	17	1				17
Swale Creek	304	6/9/09	4	58	2	14	0.2	4	7	15	3	2				16
Swale Creek	304	6/9/09	5	90	15	31	0.8	0	0	0	0	0				0
Swale Creek	323	6/9/09	1	35	25	82	0.3	0	0	0	0	0	0%	0%	N/A	
Swale Creek	323	6/9/09	2	37	5	93	0.1	0	0	0	0	0				
Swale Creek	323	6/9/09	3	47	39	55	0.1	0	0	0	0	0				
Swale Creek	323	6/9/09	4	55	9	41	0.1	0	0	0	0	0				
Swale Creek	323	6/9/09	5	44	15	36	0.2	0	0	0	0	0				
<b>Average for All Swale Creek Segments Measured:</b>												<b>54%</b>	<b>23%</b>	<b>77%</b>		

**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densimeter (max = 17)					Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments	
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center down-stream	Canopy center-left					Canopy right bank
<b>Little Klickitat River</b>																	
Little Klickitat	2	6/11/09	1	66	76	155	2.0	17	0	0	0	0	0	23%	40%	171%	
Little Klickitat	2	6/11/09	2	70	74	110	2.2	17	0	0	2	0	0				Island in center of channel, close to confluence with Klickitat, LB bankful may overlap Klickitat bankful
Little Klickitat	2	6/11/09	3	74	71	175	1.6	17	0	0	0	0	0				close to confluence with Klickitat, LB bankful may overlap Klickitat bankful
Little Klickitat	2	6/11/09	4	72	72	112	1.2	17	0	0	0	5	0				
Little Klickitat	2	6/11/09	5	90	78	128	1.2	17	2	5	0	3	17				
Little Klickitat	9	6/11/09	1	168	39	49	2.5	17	0	0	0	0	17	33%	48%	144%	Too deep to cross, last measurement on right bank estimated
Little Klickitat	9	6/11/09	2	220	40	50	1.6	17	0	0	0	0	17				
Little Klickitat	9	6/11/09	3	194	25	30	2.3	17	0	0	0	0	17				Values estimated, too deep and fast to cross
Little Klickitat	9	6/11/09	4	186	25	35	2.3	17	0	0	0	0	17				
Little Klickitat	9	6/11/09	5	196	18	48	2.0	17	0	0	0	0	17				
Little Klickitat	247	6/11/09	1	102	34	73	1.2	15	1	0	0	5	10	30%	34%	115%	
Little Klickitat	247	6/11/09	2	106	69	28	1.2	6	1	0	0	4	4				
Little Klickitat	247	6/11/09	3	101	29	49	1.7	11	2	0	0	7	9				
Little Klickitat	247	6/11/09	4	92	31	70	1.7	17	0	1	0	6	16				
Little Klickitat	247	6/11/09	5	100	31	71	1.2	17	1	0	0	6	13				started 40' downs from T1 or 248
Little Klickitat	248	6/11/09	1	110	27	52	1.1	17	6	4	0	14	17	41%	40%	99%	
Little Klickitat	248	6/11/09	2	100	23	63	1.3	15	0	2	1	1	17				
Little Klickitat	248	6/11/09	3	115	34	60	1.1	3	0	0	0	1	16				
Little Klickitat	248	6/11/09	4	108	25	85	1.6	8	6	6	0	9	17				
Little Klickitat	248	6/11/09	5	118	31	55	1.4	17	2	0	2	11	17				
Little Klickitat	250	6/11/09	1	110	27	62	1.3	17	2	9	6	13	16	53%	39%	74%	
Little Klickitat	250	6/11/09	2	111	24	54	1.2	17	1	7	0	6	17				
Little Klickitat	250	6/11/09	3	107	31	70	1.2	17	1	0	0	9	17				
Little Klickitat	250	6/11/09	4	111	29	58	1.4	16	2	4	2	13	16				
Little Klickitat	250	6/11/09	5	111	21	71	1.6	17	3	3	9	17	12				
Little Klickitat	254	6/10/09	1	28	30	113	0.9	0	0	0	0	0	16	20%	40%	203%	
Little Klickitat	254	6/10/09	2	31	26	94	1.9	0	0	0	0	0	17				
Little Klickitat	254	6/10/09	3	29	32	116	2.5	1	0	1	0	0	17				right bank measurement estimated, water too deep the wade
Little Klickitat	254	6/10/09	4	29	38	102	2.2	3	0	14	0	0	16				
Little Klickitat	254	6/10/09	5	32	27	90	1.3	0	7	2	0	0	7				
Little Klickitat	256	6/10/09	1	23	25	70	1.1	1	0	4	0	0	17	31%	37%	120%	
Little Klickitat	256	6/10/09	2	11	38	112	0.7	2	3	5	0	0	17				Low island in middle
Little Klickitat	256	6/10/09	3	31	39	112	0.8	0	6	11	0	0	17				
Little Klickitat	256	6/10/09	4	35	43	109	1.2	0	5	12	9	0	14				
Little Klickitat	256	6/10/09	5	43	37	111	1.2	0	0	12	6	0	17				
Little Klickitat	259	6/10/09	1	58	30	48	2.6		0	0	0	0	9	15%	29%	195%	too deep to measure right bank
Little Klickitat	259	6/10/09	2	68	28	52	2.1	10	0	0	0	0	17				
Little Klickitat	259	6/10/09	3	64	20	37	1.8	3					6				Swift, deep spot, could not get measurements
Little Klickitat	259	6/10/09	4	66	26	47	2.4	0	0	0	0	0	6				
Little Klickitat	259	6/10/09	5	70	50	58											Located at base of rapids, could not get data; start T5 40 feet downstream of T1 of 260
Little Klickitat	260	6/10/09	1	50	22	35								18%	34%	190%	Too deep and fast to collect data
Little Klickitat	260	6/10/09	2	70	47	101	0.9	17	0	3	0	2	17				
Little Klickitat	260	6/10/09	3	63	47	87	1.3	0	0	2	0	0	17				
Little Klickitat	260	6/10/09	4	67	45	89	1.4	0	0	0	0	0	8				
Little Klickitat	260	6/10/09	5	60	31	84	1.7		0	0	0	0	5				Side channel, 5' wetted width, stagnant water 1.4' deep not counted in wetted width
Little Klickitat	350	6/1/09	1	80	31	32	3.5	0	0	0	0	0	0	3%	18%	N/A	
Little Klickitat	350	6/1/09	2	84	40	47	2.4	0	0	0	0	0	17				
Little Klickitat	350	6/1/09	3	90	47	57	1.3	0	0	0	0	0	0				
Little Klickitat	350	6/1/09	4	93	31	37	1.8	0	0	0	0	0	0				
Little Klickitat	350	6/1/09	5	101	28	33	1.2	0	0	0	0	0	0				

**Aspect Consulting**

6/30/09

V:\070024 WRIA 30 Phase 4\Deliverables\009 Shade Study\Appendix A tables - raw field data

**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densimeter (max = 17)					Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments	
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center down-stream	Canopy center-left					Canopy right bank
Little Klickitat	351	6/1/09	1	98	29	33	4.5	15	0	0	0	0	16	29%	45%	151%	Too deep to collect data in middle of creek; but it was clear that no canopy closure was present
Little Klickitat	351	6/1/09	2	78	29	37	4.5	17	0	0	0	0	16				Too deep to collect data in middle of creek; but it was clear that no canopy closure was present
Little Klickitat	351	6/1/09	3	65	29	32	4.5	3	0	0	0	0	16				Too deep to collect data in middle of creek; but it was clear that no canopy closure was present
Little Klickitat	351	6/1/09	4	88	29	34	4.5	17	0	0	0	0	16				Too deep to collect data in middle of creek; but it was clear that no canopy closure was present
Little Klickitat	351	6/1/09	5	82	26	33	4.5	17	0	0	0	0	17				Too deep to collect data in middle of creek; but it was clear that no canopy closure was present
Little Klickitat	411	6/10/09	1	70	27	34	2.8	17	0	0	0	0	17	47%	47%	98%	Too deep to wade, values estimated
Little Klickitat	411	6/10/09	2	70	35	38	2.0	17	0	0	1	3	17				
Little Klickitat	411	6/10/09	3	100	20	41	1.9	16	3	16	15	0	17				
Little Klickitat	411	6/10/09	4	110	28	42	1.3	17	0	1	0	2	17				
Little Klickitat	411	6/10/09	5	110	25	33	2.8	17	1	9	4	17	17				
Little Klickitat	435	6/8/09	1	60	26	44	1.0	11	4	4	4	0	8	56%	31%	54%	
Little Klickitat	435	6/8/09	2	80	31	40	1.2	16	11	14	3	13	15				
Little Klickitat	435	6/8/09	3	92	24	41	2.9	9	6	12	6	3	17				
Little Klickitat	435	6/8/09	4	100	24	58	3.0	13	9	17	8	5	17				Too deep, values estimated for this transect
Little Klickitat	435	6/8/09	5	86	31	43	1.1	1	11	16	8	9	17				
Little Klickitat	436	6/8/09	1	75	27	32	0.8	17	11	16	5	6	7	86%	20%	23%	
Little Klickitat	436	6/8/09	2	75	31	38	1.3	17	17	17	13	14	17				
Little Klickitat	436	6/8/09	3	75	31	40	2.2	17	13	17	14	16	17				
Little Klickitat	436	6/8/09	4	85	26	32	1.4	17	12	16	13	17	17				
Little Klickitat	436	6/8/09	5	65	21	36	1.6	17	15	15	14	17	16				
Little Klickitat	442	6/8/09	1	120	33	54	0.7	16	14	11	8	13	16	83%	20%	24%	
Little Klickitat	442	6/8/09	2	130	39	53	0.7	17	16	14	14	17	17				
Little Klickitat	442	6/8/09	3	140	42	61	0.7	17	14	17	17	17	17				
Little Klickitat	442	6/8/09	4	130	43	60	0.7	17	9	11	7	16	13				
Little Klickitat	442	6/8/09	5	125	35	54	0.9	17	9	12	7	16	17				
Little Klickitat	444	6/9/09	1	150	25	48	1.0	16	8	16	13	16	17	54%	40%	73%	T2 had an island that was subtracted from wetted width
Little Klickitat	444	6/9/09	2	150	29	66	1.3	17	6	16	15	12	17				
Little Klickitat	444	6/9/09	3	150	40	67	1.1	16	0	6	3	1	17				
Little Klickitat	444	6/9/09	4	170	40	55	3.5	15	0	3	1	1	13				Transect was a deep pool, values estimated
Little Klickitat	444	6/9/09	5	80	23	76	1.1	17	5	2	2	3	2				
Little Klickitat	445	6/9/09	1	80	15	35	2.2	17	12	9	8	17	5	64%	28%	44%	Wetted width to bank, location had an additional 3 feet of undercut bank
Little Klickitat	445	6/9/09	2	40	18	23	1.8	17	6	8	10	17	9				
Little Klickitat	445	6/9/09	3	40	22	40	1.5	12	2	9	4	7	15				
Little Klickitat	445	6/9/09	4	15	26	44	0.8	14	5	10	6	7	17				island and dry channel present; dry channel included in bankfull width but not wetted width
Little Klickitat	445	6/9/09	5	15	25	31	2.2	17	6	15	10	16	17				island and dry channel present; dry channel included in bankfull width but not wetted width
Little Klickitat	446	6/9/09	1	15	24	29	1.2	16	8	12	4	13	17	59%	32%	54%	T-1 had beaver chewed shrubs
Little Klickitat	446	6/9/09	2	15	25	43	0.7	17	7	15	1	7	15				
Little Klickitat	446	6/9/09	3	35	21	38	1.3	7	7	16	10	7	17				
Little Klickitat	446	6/9/09	4	35	34	42	0.9	17	3	17	13	4	7				
Little Klickitat	446	6/9/09	5	35	21	54	0.9	11	1	10	4	3	17				T5 has small dry channel on right bank
Little Klickitat	447	6/9/09	1	45	25	54	1.6	7	1	5	9	4	17	28%	28%	98%	Established T1 40 ft upstream of T5 of reach 446
Little Klickitat	447	6/9/09	2	70	20	34	0.9	7	0	9	0	3	13				
Little Klickitat	447	6/9/09	3	70	29	31	1.4	7	0	3	2	1	0				Cement blocks and logs cabled together on right bank
Little Klickitat	447	6/9/09	4	70	21	33	1.8	10	1	5	0	6	4				
Little Klickitat	447	6/9/09	5	100	23	31	1.4	17	5	2	1	5	1				
Little Klickitat	459	6/10/09	1	350	35	45	1.0	15	0	5	1	4	17	50%	38%	76%	
Little Klickitat	459	6/10/09	2	350	34	50	0.7	15	1	6	1	2	17				
Little Klickitat	459	6/10/09	3	350	34	45	0.8	17	2	13	5	7	17				
Little Klickitat	459	6/10/09	4	350	34	48	1.0	16	3	14	4	6	17				
Little Klickitat	459	6/10/09	5	350	27	48	0.9	16	2	8	0	8	14				

**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densimeter (max = 17)					Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments	
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center down-stream	Canopy center left					Canopy right bank
Little Klickitat	460	6/10/09	1	350	26	46	1.4	17	2	12	3	7	17	67%	35%	52%	Established T1 40 feet from T5 in reach 459
Little Klickitat	460	6/10/09	2	350	25	42	1.4	13	5	15	2	0	17				
Little Klickitat	460	6/10/09	3	350	31	38	1.0	13	17	17	6	6	17				
Little Klickitat	460	6/10/09	4	360	33	44	0.5	17	14	17	4	11	17				
Little Klickitat	460	6/10/09	5	360	26	49	0.8	17	15	16	8	4	17				
Little Klickitat	462	6/10/09	1	360	24	39	0.7	5	3	15	3	3	17	60%	35%	59%	
Little Klickitat	462	6/10/09	2	360	38	46	0.8	17	4	15	5	6	17				
Little Klickitat	462	6/10/09	3	360	44	51	0.8	17	4	16	5	2	17				
Little Klickitat	462	6/10/09	4	360	35	46	1.1	17	11	12	2	3	17				
Little Klickitat	462	6/10/09	5	360	35	46	0.9	17	8	7	12	13	17				
Little Klickitat	500	6/8/09	1	343	34	39	1.7	17	0	9	4	0	17	32%	38%	119%	
Little Klickitat	500	6/8/09	2	337	36	47	1.6	7	0	5	0	2	17				
Little Klickitat	500	6/8/09	3	353	27	46	1.4	5	0	1	0	1	15				
Little Klickitat	500	6/8/09	4	357	31	45	2.0	5	0	3	0	2	17				
Little Klickitat	500	6/8/09	5	360	30	45	2.5	12	0	6	0	1	17				
Right bank canopy measurement approximated, deep hole next to bank																	
Little Klickitat	502	6/8/09	1	8	22	32	1.2	17	4	9	2	9	17	47%	40%	83%	
Little Klickitat	502	6/8/09	2	14	24	32	1.3	17	6	3	2	14	10				
Little Klickitat	502	6/8/09	3	10	21	31	1.2	17	0	0	0	0	3				
Little Klickitat	502	6/8/09	4	12	24	31	1.0	17	5	15	3	10	17				
Little Klickitat	502	6/8/09	5	12	23	30	1.3	17	0	3	1	7	17				
Little Klickitat	506	6/8/09	1	29	31	42	1.0	17	0	7	0	7	17	45%	36%	82%	
Little Klickitat	506	6/8/09	2	29	27	43	1.3	17	0	6	3	3	17				
Little Klickitat	506	6/8/09	3	37	28	39	1.6	9	0	13	1	0	16				
Little Klickitat	506	6/8/09	4	39	25	42	1.3	10	5	13	1	8	17				
Little Klickitat	506	6/8/09	5	41	31	41	0.8	11	2	4	2	9	12				
Little Klickitat	508	6/9/09	1	54	26	40	1.0	17	16	16	6	10	17	64%	34%	54%	
Little Klickitat	508	6/9/09	2	55	27	39	1.0	17	2	10	8	3	17				
Little Klickitat	508	6/9/09	3	52	26	42	1.2	17	2	7	4	5	15				
Little Klickitat	508	6/9/09	4	48	27	40	0.7	17	2	6	1	12	17				
Little Klickitat	508	6/9/09	5	54	31	47	0.9	15	12	17	14	8	15				
Little Klickitat	570	6/9/09	1	56	25	36	1.8	17	1	0	0	8	1	24%	34%	145%	
Little Klickitat	570	6/9/09	2	52	25	35	2.9		16	1	1	11	0				
Little Klickitat	570	6/9/09	3	38	26	36	1.1	2	1	1	0	0	1				
Little Klickitat	570	6/9/09	4	49	25	37	1.2	13	0	3	0	1	5				
Little Klickitat	570	6/9/09	5	44	19	30	1.4	17	0	1	0	12					
Deep pool, left bank, couldn't get canopy closure at that point deep pool just downstream 0.411764706 0.167647059																	
Little Klickitat	571	6/9/09	1	50	22	25	1.0	11	0	0	0	0	2	27%	35%	126%	40 ft upstream from T5 of 570; within restoration
Little Klickitat	571	6/9/09	2	58	15	75	2.2	0	0	11	0	1	17				
Little Klickitat	571	6/9/09	3	71	40	65	1.1	5	0	0	0	2	15				
Little Klickitat	571	6/9/09	4	770	37	55	2.3	5	2	6	1	4	17				
Little Klickitat	571	6/9/09	5	68	29	46	2.2	16	1	3	1	6	14				
40 ft upstream from T5 of 570; within restoration segment is within and just above a restoration area with a side channel, wide bankfull reflects side of Above restoration rt bank measurement of canopy estimated																	
Little Klickitat	572	6/9/09	1	71	40	65	1.1	5	0	0	0	2	15	38%	35%	92%	
Little Klickitat	572	6/9/09	2	70	37	55	2.3	5	2	6	1	4	17				
Little Klickitat	572	6/9/09	3	68	29	46	2.3	16	1	3	1	6	14				
Little Klickitat	572	6/9/09	4	75	33	53	1.9	14	2	7	0	12	17				
Little Klickitat	572	6/9/09	5	76	33	45	2.1		5	7	0	12	12				
rt bank measurement of canopy estimated																	
Little Klickitat	573	6/9/09	1	79	25	33	1.9	6	2	5	0	5	10	39%	33%	85%	T1 of 573 is 40' up from T5 of 572
Little Klickitat	573	6/9/09	2	89	20	35	2.1	13	2	13	2	7	16				
Little Klickitat	573	6/9/09	3	82	19	25	2.7	17	1	13	4	9	17				
Little Klickitat	573	6/9/09	4	70	19	26	1.6	17	0	7	0	3	8				
Little Klickitat	573	6/9/09	5	52	24	50	0.8	0	5	5	6	0					
Willow covered gravel bar, right bank, encompassing about 1/2 wetted width, T5 is 15.5 ft upstream c																	

**Table A-1. Raw Field Measurements of Canopy Cover**

Stream	Segment No.	Measurement Date	Transect	Stream Aspect (degrees azimuth)	Avg. Wetted Width (ft)	Avg. Bankfull Width (ft)	Avg. Wetted Depth (ft)	No. Shaded Intersections on Densimeter (max = 17)					Avg. % Canopy Cover for Segment	Std. Deviation of % Canopy Cover Data for Segment	Std Dev / Average	Comments	
								Canopy left bank	Canopy center-upstream	Canopy center-right	Canopy Center down-stream	Canopy center-left					Canopy right bank
Little Klickitat	578	6/10/09	1		32	45	1.0	17	5	3	1	12	17	57%	37%	65%	
Little Klickitat	578	6/10/09	2	50	20	26	1.9	17	3	13	3	14	17				Deep fast hole on right bank filling 1/2 wetted width; depth assumed >2.5' for 1/2 wetted width
Little Klickitat	578	6/10/09	3	58	26	33	1.2	9	7	15	6	1	17				
Little Klickitat	578	6/10/09	4	53	20	38	1.3	4	17	16	17	12	17				RB canopy estimated, swift current on bank
Little Klickitat	578	6/10/09	5	26	18	28	1.3	6	2	11	2	0	17				RB canopy estimated; deep fast pool on right bank
Little Klickitat	626	6/10/09	1	26	23	36	1.3	16	6	17	15	6	17	74%	26%	35%	
Little Klickitat	626	6/10/09	2	24	21	38	1.8	16	13	17	9	11	17				
Little Klickitat	626	6/10/09	3	28	18	33	1.8	13	13	17	16	16	17				
Little Klickitat	626	6/10/09	4	38	25	34	1.2	17	10	5	15	15	9				
Little Klickitat	626	6/10/09	5	39	21	29	1.4	14	9	13	6	12	2				
Little Klickitat	628	6/10/09	1	21	33	37								50%	36%	72%	Too deep to collect data
Little Klickitat	628	6/10/09	2														Too deep to collect data
Little Klickitat	628	6/10/09	3	212	22	43	1.1	10	1	4	3	0	14				
Little Klickitat	628	6/10/09	4	20	21	39	1.4	17	6	14	1	5	17				
Little Klickitat	628	6/10/09	5	16	15	27	1.5	15	6	15	4	5	16				
<b>Average for All Little Klickitat Segments Measured:</b>												<b>44%</b>	<b>35%</b>	<b>96%</b>			

Notes:

Average for Swale Creek segments excludes segments 106, 139, and 144, for which no bank measurements were collected.

**Table A-2. Field Measurement Locations and Vegetation Observations**

Stream	Segment No.	GPS upstream (NAD27) easting	GPS upstream (NAD27), northing	GPS downstream (NAD27) easting	GPS downstream (NAD27), northing	Date	Surveyors	Field Reach Length (ft)	Transect interval	Right bank dominant veg	Left bank dominant veg	Right bank sub-dominant veg	Left bank sub-dominant veg	Right bank veg height (ft)	Left bank veg height (ft)	Comments
<b>Swale Creek</b>																
Swale Creek	11	648270	5075728	648226	5075756	6/11/09	DLR/SH	171	40	Red Alder	Red Alder	Willow	Willow	20	20	Overflow channel on right bank creates wide bankfull in all transects except T4
Swale Creek	16	648459	5075592	648465	5075647	6/11/09	DLR/SH	182	40	Red Alder	Red Alder	Big Leaf Maple	Dogwood	27	25	
Swale Creek	18	648483	5075485	648474	5075537	6/11/09	DLR/SH	173	40	Red Alder	Red Alder	Willow	Willow	24	32	
Swale Creek	25	648625	5075094	648575	5075131	6/11/09	DLR/SH	169	40	Alder	Alder	Willow	Willow	30	27	
Swale Creek	22	648507	5075252	648499	5075303	6/11/09	DLR/SH	204	40	Red Alder	Red Alder	Willow	Willow	20	21	
Swale Creek	35	649152	5074928	649111	5074931	6/12/09	DLR/SH	135	40	Red Alder	Red Alder	Willow	Willow	35	25	
Swale Creek	47	649839	5074746	649789	5074728	6/12/09	DLR/SH	174	40	Willow	Willow	Red Alder	Red Alder	7	23	
Swale Creek	57	650364	5074542	650319	5074579	6/12/09	DLR/SH	191	40	Red Alder	Red Alder	N/A	Willow	30	26	
Swale Creek	66	650757	5074178	650726	5074097	6/12/09	DLR/SH	119	40	Red Alder	Red Alder	N/A	N/A	30	27	
Swale Creek	72	650991	5073937	650994	5073992	6/12/09	DLR/SH	181	40	Red Alder	Red Alder	Serviceberry	Serviceberry	33	30	
Swale Creek	96	650893	5072612	650914	5072674	6/12/09	DLR/SH	200	40	Red Alder	Red Alder	Willow	Willow	28	22	
Swale Creek	95	650900	5072962	650913	5072741	6/12/09	DLR/SH	215	40	Red Alder	Red Alder	Willow	Willow	26	33	Trout and dace observed
Swale Creek	100	650757	5072430	650785	5072470	6/12/09	DLR/SH	160	40	Red Alder	Red Alder	Willow	Big Leaf Maple	12	25	6" salmonids observed
Swale Creek	106	650540	5072149	650587	5072189	6/12/09	DLR/SH	203	40	Willow	Willow	Serviceberry	Serviceberry	5	8	dry channel, estimated channel center for densiometer readings, cic not estimate wetted edge. Held densiometer 0.3 m above channel bottom. Flow resumes immediately downstream of segment
Swale Creek	119	650002	5071743	650007	5071796	6/14/09	DLR/SH	175	40	Red Alder	Red Alder	Serviceberry	Serviceberry	25	25	
Swale Creek	123	650021	5071512	650015	5071556	6/14/09	DLR/SH	146	40	Serviceberry	Serviceberry	Willow	Willow	4	4	
Swale Creek	128	650068	5071208	650052	5071259	6/14/09	DLR/SH	175	40	Serviceberry	Serviceberry	Willow	Willow	6	7	
Swale Creek	135	649945	5070806	649941	5070856	6/14/09	DLR/SH	165	40	Willow	Willow	Red Alder	Serviceberry	5	6	
Swale Creek	139	649952	5070577	649955	5070627	6/14/19	DLR/SH	164	40	Serviceberry	Serviceberry	Big Leaf Maple	Willow	4	3	Side channel on right bank about 100 feet from main channel, both channels are dry
Swale Creek	146	650064	5070178	650045	5070209	6/14/09	DLR/SH	119	40	Serviceberry	Serviceberry	None	Willow	3	3	
Swale Creek	174	649963	5068625	649959	5068675	6/15/09	DLR/SH	165	40	Willow	Willow	Serviceberry	Serviceberry	3	3	
Swale Creek	182	649922	5068138	649951	5068187	6/15/09	DLR/SH	187	40	Willow	Willow	Serviceberry	Serviceberry	5	4	
Swale Creek	181			649955	5068244	6/15/09	DLR/SH	187	40	Willow	Willow	Serviceberry	Serviceberry	4	2	
Swale Creek	190	649714	5067808	649722	5067818	6/15/09	DLR/SH	200	40	Willow	Willow	Serviceberry	Serviceberry	5	5	
Swale Creek	204	649198	5067180	649234	5067205	6/15/09	DLR/SH	144	40	Red Alder	Red Alder	Willow	Willow	16	14	
Swale Creek	236	648874	5065373	648870	5065397	6/15/09	DLR/SH	80	40	Willow	Willow	Serviceberry	Red Alder	7	7	
Swale Creek	250	649448	5065248	649408	5065226	6/15/09	DLR/SH	150	40	Willow	Willow	N/A	N/A	6	6	
Swale Creek	260	649983	5065118	649934	5065111	6/15/09	DLR/SH	162	40	Willow	Willow	Serviceberry	Serviceberry	6	2	
Swale Creek	291	651690	5064851	651660	5064880	6/9/09	DLR/SH	137	40	Hawthorne	Hawthorne	Willow	Willow	5	4.5	
Swale Creek	294	651868	5064783	651828	5064812	6/9/09	DLR/SH	162	40	None	Hawthorne	None	Willow	0	15	Riparian trees are sparse, in the distant floodplain o the left bank
Swale Creek	304	652338	5065097	652298	5065083	6/9/09	DLR/SH	139	40	Willow	Willow	Hawthorne	Hawthorne	6	6	
Swale Creek	323	653432	5065045	653402	5064997	6/9/09	DLR/SH	186	40	Grass	Grass	Grass	Grass	1	1	
<b>Little Klickitat River</b>																
Little Klickitat	2	650551	5078479	650503	5078474	6/11/09	NN/JR	158	40	Grass	Alder	Alder	Mockorange	5	55	Crew indicated an error range of +/- 15 to 21 feet on GPS location
Little Klickitat	9	650689	5078283	650720	5078329	6/11/09	NN/JR	182	40	ed Canary Grass	ed Canary Grass	None	None	6	6	
Little Klickitat	247	660346	5074682			6/11/09	NN/JR	97	40	Alder	Alder	Willow	Willow	15	25	
Little Klickitat	248	660395	5074656	660357	5074680	6/11/09	NN/JR	147	40	Alder	Alder	Willow	Willow	30	25	
Little Klickitat	250	660488	5074593	660451	5074620	6/11/09	NN/JR	150	40	Alder	Alder	Willow	Willow	25	25	
Little Klickitat	254	660701	5074580	660670	5074541	6/10/09	NN/JR	163	40	Alder	Alder	Dogwood	None	25	5	Grazed on left bank - sparsely vegetated
Little Klickitat	256	660776	5074675	660748	5074634	6/10/09	NN/JR	163	40	Willow	Willow	Alder	Alder	20	5	Left bank grazed
Little Klickitat	259	660936	5074756	660890	5074744	6/10/09	NN/JR	156	40	Alder	Alder	Cherry	Willow	25	10	Area has loads of reed canary grass on both banks, left bank is grazed
Little Klickitat	260	660998	5074774	660947	5074757	6/10/09	NN/JR	176	40	Alder	Alder	Willow	Willow	30	10	
Little Klickitat	350	665624	5074989			6/1/09	DG/JC/DLR	90	40	Hawthorne	Hawthorne	spirea	Willow	20	21	
Little Klickitat	351	665677	5075000	665631	5074992	6/1/09	DG/JC/DLR	153	40	ed Canary Grass	ed Canary Grass	Meadow Grass	Meadow Grass	2.5	2.5	few scattered hawthornes

**Table A-2. Field Measurement Locations and Vegetation Observations**

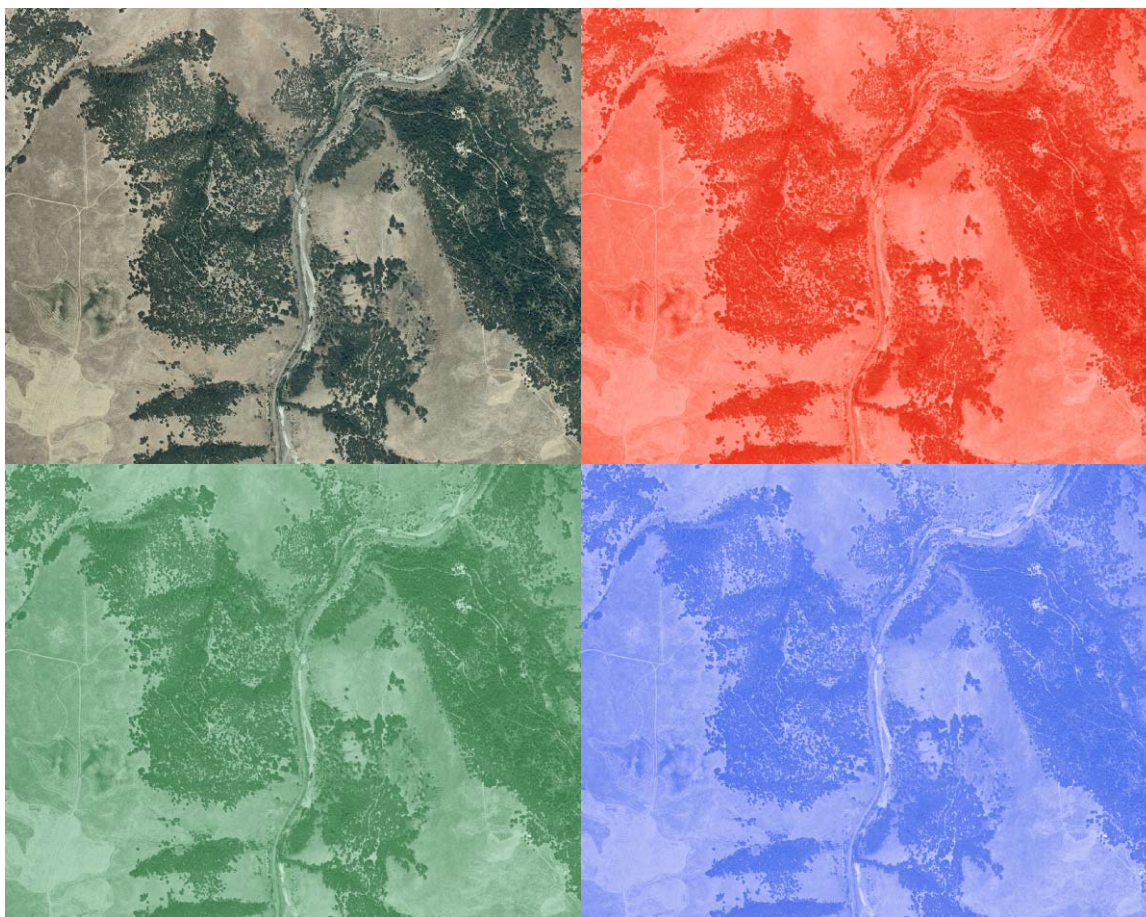
Stream	Segment No.	GPS upstream (NAD27) easting	GPS upstream (NAD27), northing	GPS downstream (NAD27) easting	GPS downstream (NAD27), northing	Date	Surveyors	Field Reach Length (ft)	Transect interval	Right bank dominant veg	Left bank dominant veg	Right bank sub-dominant veg	Left bank sub-dominant veg	Right bank veg height (ft)	Left bank veg height (ft)	Comments
Little Klickitat	411	668131	5076606	668088	5076604	6/10/09	BLW/NO	141	40	Alder	Alder	Willow	Willow	20	25	Small stream joins river just upstream of T3. Beaver activity in area, culvert at T2
Little Klickitat	435	669461	5076923	669416	5076922	6/8/09	ALL	148	40	Cottonwood	Cottonwood	Willow	Willow	80	30	
Little Klickitat	436	669527	5076931	669481	5076928	6/8/09	BLW/NO	151	40	Cottonwood	Cottonwood	White alder	White Alder	80	65	
Little Klickitat	442	669821	5076810	669779	5076845	6/8/09	BLW/NO	179	40	Cottonwood	Cottonwood	White alder	White Alder	100	100	
Little Klickitat	444	669914	5076744	669883	5076784	6/9/09	BLW/NO	166	40	White Alder	White Alder	Black Cottonwood	Black Cottonwood	15	30	
Little Klickitat	445	669954	5076798	669926	5076746	6/9/09	BLW/NO	194	40	Black cottonwood	Black cottonwood	Salix prolixa	White alder	40	50	
Little Klickitat	446	669981	5076843	669966	5076813	6/9/09	BLW/NO	110	40	Black cottonwood	White Alder	White alder	Red Alder	50	40	
Little Klickitat	447	670040	5076876	669987	5076859	6/9/09	BLW/NO	183	40	Black cottonwood	Black cottonwood	Salix prolixa	Alder	20	30	
Little Klickitat	459	670474	5077194	670494	5077138	6/10/09	BLW/NO	195	40	Black cottonwood	Black cottonwood	White alder	White Alder	70	50	Beaver sign throughout
Little Klickitat	460	670468	5077253	670478	5077209	6/10/09	BLW/NO	148	40	Black cottonwood	Black cottonwood	White alder	White Alder	45	45	established transect 1 by measuring 40 feet from T5 of reach 459
Little Klickitat	462	670472	5077379	670478	5077331	6/10/09	BLW/NO	159	40	White Alder	Pacific Willow	Black Cottonwood	Ninebark	40	25	
Little Klickitat	500	671428	5079122	671427	5079073	6/8/09	NN/JR	161	40	Alder	Alder	Willow	Snowberry	20	15	
Little Klickitat	502	671466	5079240	671447	5079192	6/8/09	NN/JR	169	40	Alder	Alder	Ninebark	Willow	20	20	
Little Klickitat	506	671610	5079445	671574	5079410	6/8/09	NN/JR	165	40	Alder	Alder	Willow	Willow	25	35	
Little Klickitat	508	671712	5079503	671660	5079475	6/9/09	NN/JR	194	40	Alder	Alder	Ninebark	Ninebark	30	25	
Little Klickitat	570	674668	5080636	674627	5080603	6/9/09	NN/JR	173	40	Ponderosa Pine	Alder	None	Willow	0	25	P. pine located far back from stream, recent channel restoration at site. Way points took us to side channel created by beaver dam and 50 ft south of active channel, we measured active channel
Little Klickitat	571	674760	5080657	674676	5080647	6/9/09	NN/JR	180	40	Alder	Alder	Willow	Willow	10	10	Recent restoration completed at site
Little Klickitat	572	674756	5080659	674730	5080657	6/9/09	NN/JR	86	40	Alder	Alder	Willow	spirea	50	30	
Little Klickitat	573	674823	5080656	674769	5080655	6/9/09	NN/JR	177	40	Ponderosa Pine	Alder	Willow	Willow	150	10	alder 15 ft, p pine within 50 foot of channel
Little Klickitat	578	674987	5080884	674952	5080857	6/10/09	NN/JR	145	40	Alder	Alder	dogwood	spirea	45	30	
Little Klickitat	626	676920	5082397	676893	5082345	6/10/09	NN/JR	192	40	Ponderosa Pine	Cottonwood	Alder	Snowberry	100	60	
Little Klickitat	628	676999	5082488	676970	5082451	6/10/09	NN/JR	154	40	Cottonwood	Alder	Ninebark	Ninebark	35	30	

## **APPENDIX B**

### **Details Regarding GIS Analysis**

Various methods and method calibrations were used in the course of aerial photo vegetation classification.

At the outset of the project, to provide information to the field program, classification using the red color band of the 2006 NAIP orthophoto was utilized as a succinct method for isolating green (dark) pixels that were taken to represent vegetation coverage. This classification scheme relies on the notion that each band (red, green, and blue) of the raster image functions as a “filter” for that constituent color. That is, for pixels that are made up of very little red, the red band of the raster for that given pixel will have a low (dark) value. The figure below illustrates the red/green/blue raster band composite of an aerial photo for illustrative purposes.

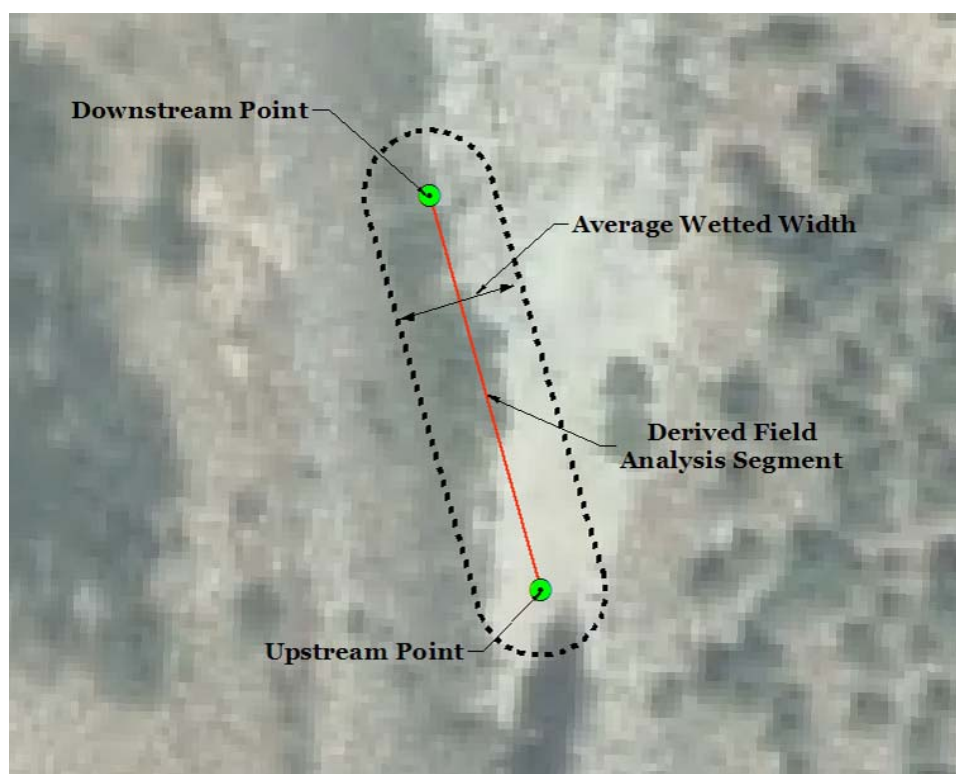


**Figure B1. Color Aerial Photo Raster and Constituent RGB Color Bands**

To isolate pixels thought to represent the greenest or most vegetated, multiple iterations of raster reclassification were performed on the red band raster, looking for a “sweet spot” that effectively discriminated between vegetation and non-vegetation. Further, the classification had to sufficiently distinguish very dark pixels that were taken to be open water in the stream channel. After a number of trial-and-error iterations an operational classification range of red band pixel values between 26 (high enough to cut out most all dark open water areas) and 95 (low enough to separate out bare ground for light

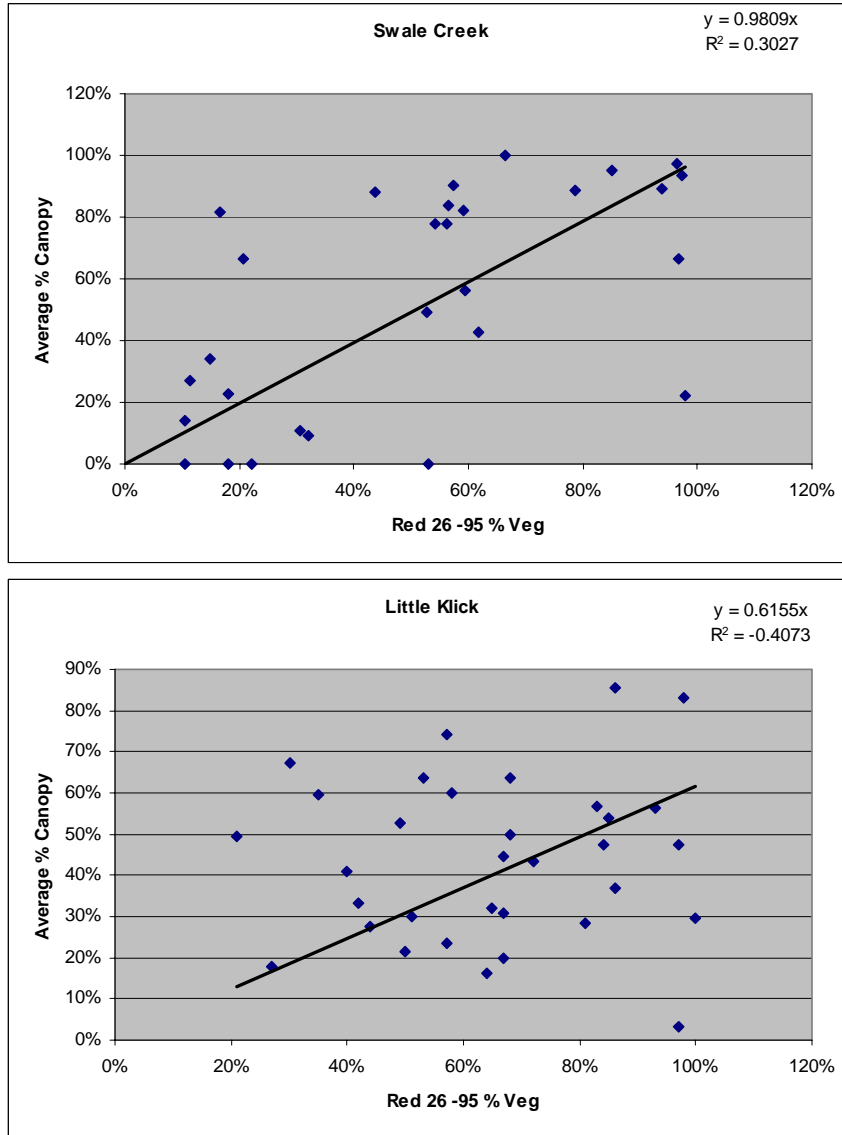
vegetation) was employed. While somewhat coarse, this methodology functioned effectively enough to provide first-cut estimates of vegetation coverage provided to the project field team. However, because of its reliance on the color bands, it would be a method ill-equipped for use on black and white historical photos.

After the field measurements were reported, careful correlations between these measurements and the GIS analysis were made to move towards refinement of the GIS analysis process (see report text for discussion). Since the actual field measured area did not correspond exactly to the prepared 200-ft long, 40- and 150-ft stream corridor analysis segments, polygonal sections representing each of the field-measured areas were created by taking the GPS'd upstream and downstream coordinates of the stream center for each given set of field measurements, drawing a line between the two and buffering that line to match the average measured wetted width for that segment (Figure B2).



**Figure B2. Field Analysis Segment Diagram**

Each of these derived polygons segments were analyzed for the percent classified vegetation in each and compared to the field measurements. Initial red band classification schemes showed an average absolute difference of 21% from field measurements for Swale Creek and 29% for Little Klickitat. The following scatter plot figures show the tenuous relationship between field measurements and initial GIS estimates.



**Figure B3. Field-Measured Average Total Canopy against GIS-Estimated Vegetation Using Red Band Method**

After review of the GIS/field measurement relationship and a general assessment of the quality of classification provided by the red band color analysis method, it was decided that a more sophisticated, supervised maximum likelihood classification (MLC) scheme should be employed to analyze the aerial photos. Further, since color band classification would be inadequate for black and white historical photos, consistency in methodology between photo years would be beneficial.

Taking advantage of available utilities in ESRI’s Spatial Analyst Multivariate toolbox, supervised MLC is a multi-step process that first involves manually categorizing sample swatches of an image to allow the GIS system to analyze the spectral signatures of each. That is, a GIS analyst manually delineates a vector polygon shapefile that represents

examples of the classes (see Figure B4) and uses that shapefile and the image itself to create an ASCII signature file that defines the characteristics of a given class.

From ESRI's MLC online documentation:

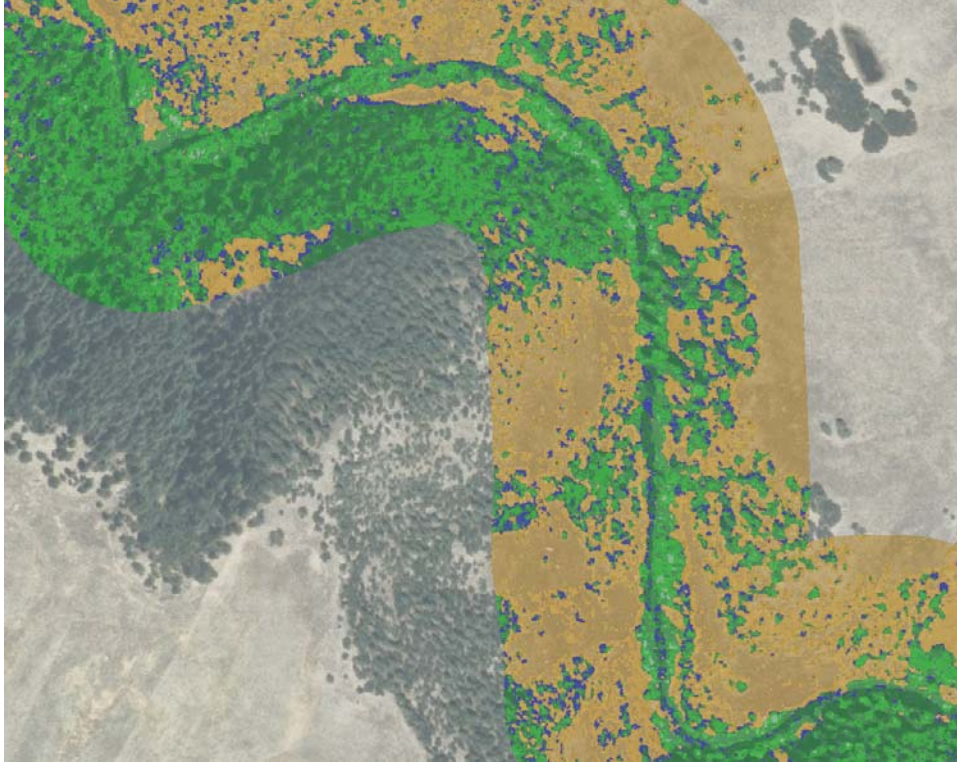
*The Maximum Likelihood Classification tool considers both the variances and covariances of the class signatures when assigning each cell to one of the classes represented in the signature file. With the assumption that the distribution of a class sample is normal, a class can be characterized by the mean vector and the covariance matrix. Given these two characteristics for each cell value, the statistical probability is computed for each class to determine the membership of the cells to the class.<sup>1</sup>*



**Figure B4. Example MLC classes**

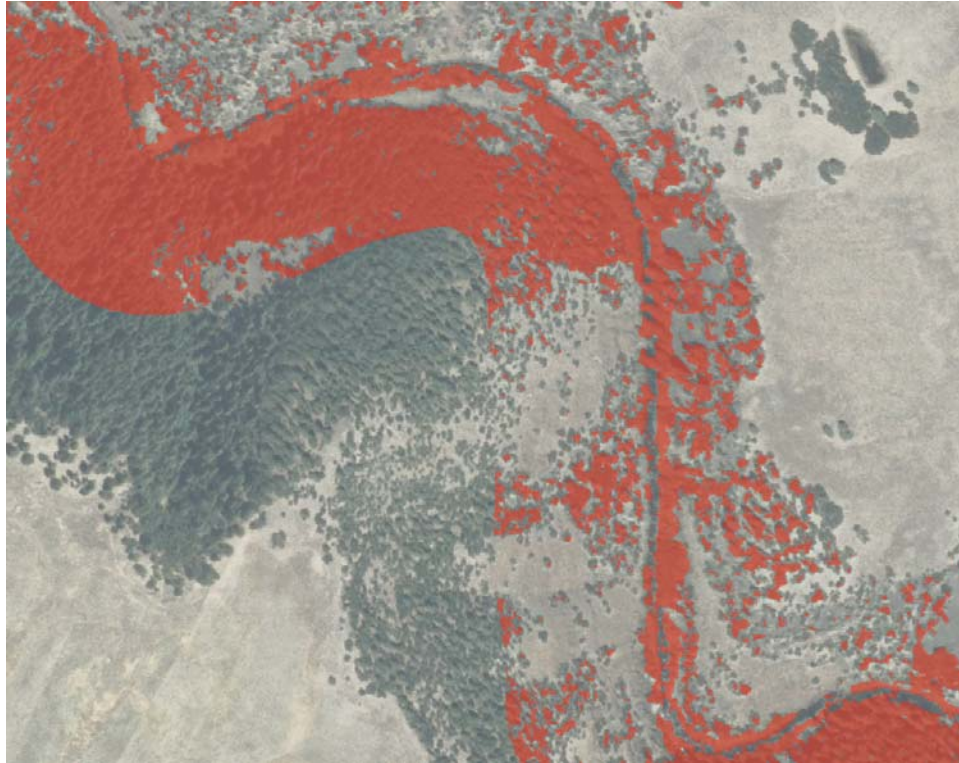
After creating a signature file the Spatial Analyst Multivariate Maximum Likelihood Classification tool was then run using the aerial photo and signature file as inputs. The output of this process is a classified raster where each pixel that the system is able to classify has a value corresponding to that class.

<sup>1</sup> <http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=How%20Maximum%20Likelihood%20Classification%20works>



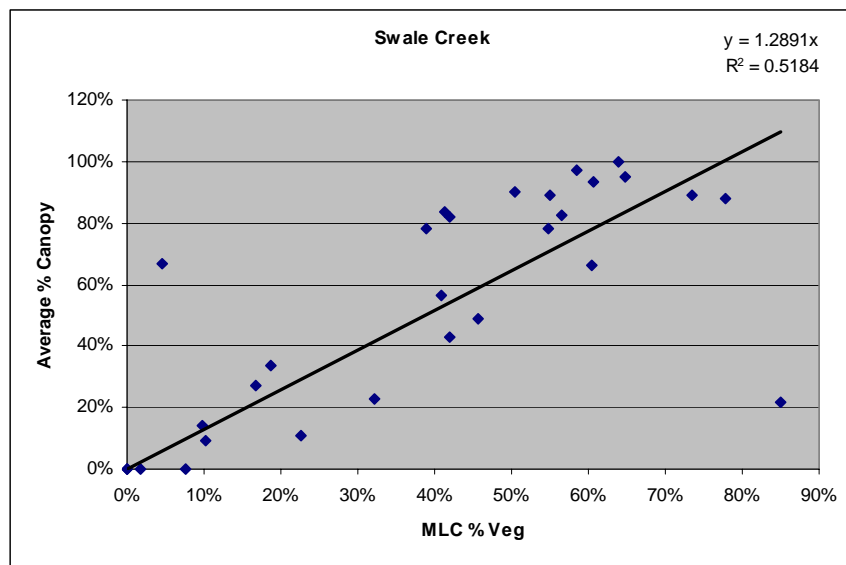
**Figure 5. Max Likelihood Classified Image (green shades are vegetation classes)**

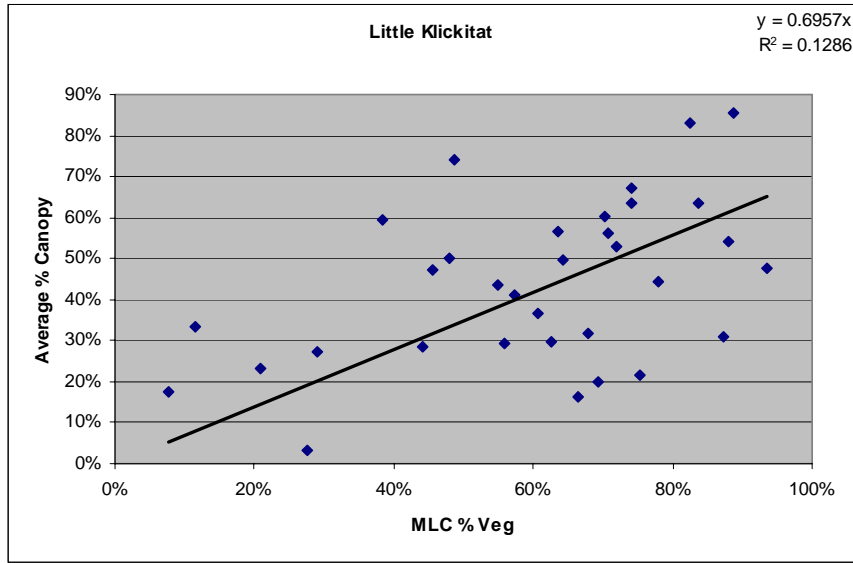
The MLC-classified raster output was then reclassified into a binary form where only relevant or successful vegetation classes for a given portion of an image were included. In some areas, the ability of the MLC method to delineate open water was limited – without tuning the classification scheme to overly-exclude dark trees. As such, a single classification of only the open water in the stream corridor was produced and subtracted from the binary classified output raster.



**Figure B6. Final Vegetation Coverage Estimate after Binary Reclassification from MLC Output and Open Water Class Subtraction**

The aforementioned field analysis segments were checked against this new classification scheme. The results showed an average absolute difference of 20% from field measurements for Swale Creek and 21% for Little Klickitat, some improvement from the initial analysis. The following scatter plot figures show the relationship between field and GIS measurements.

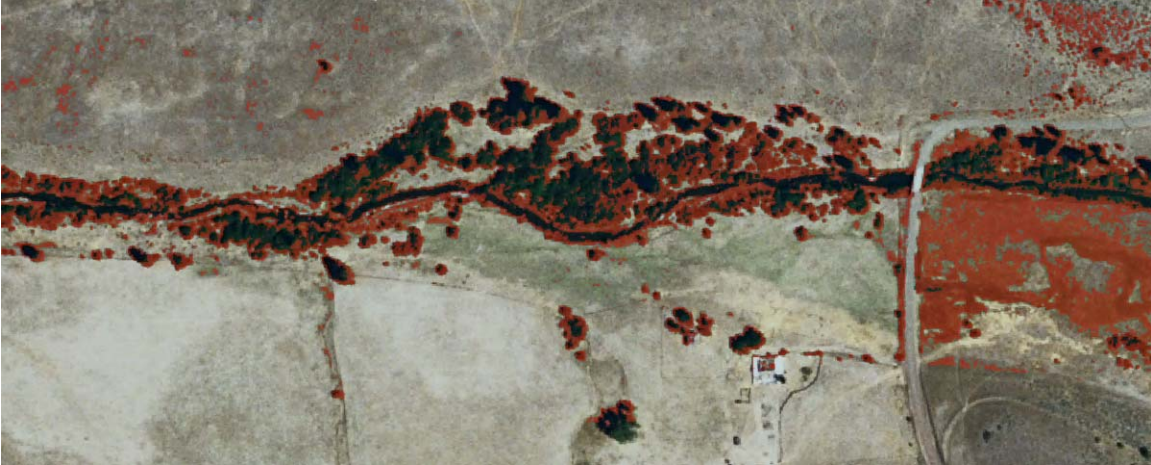




**Figure B7. Field-Measured Average Total Canopy against GIS-Estimated Vegetation Using MLC Method**

Though the relationship between the field data measurements and the GIS-estimated vegetation by MLC was still somewhat tenuous, there was notable improvement in both the linear relationships and the average discrepancy. Section 3.2 of the report text speaks to possible reasons for this discrepancy. Figures B9 and B10 show the field segments for Swale Creek and Little Klickitat River, respectively, that have the best and worst correlation between GIS estimates and field measurements. On the figures, areas estimated as vegetation by the GIS analysis are lightly hatched in yellow, and the field measurements and GIS numerical estimates of vegetative cover are listed with segment number below each map window.

Furthermore, visual inspection of the analysis results showed appreciable improvement. This improvement was particularly noticeable and beneficial in regards to the GIS’s ability to distinguish between open water and dark areas of trees. An example of this noticeable improvement is below:



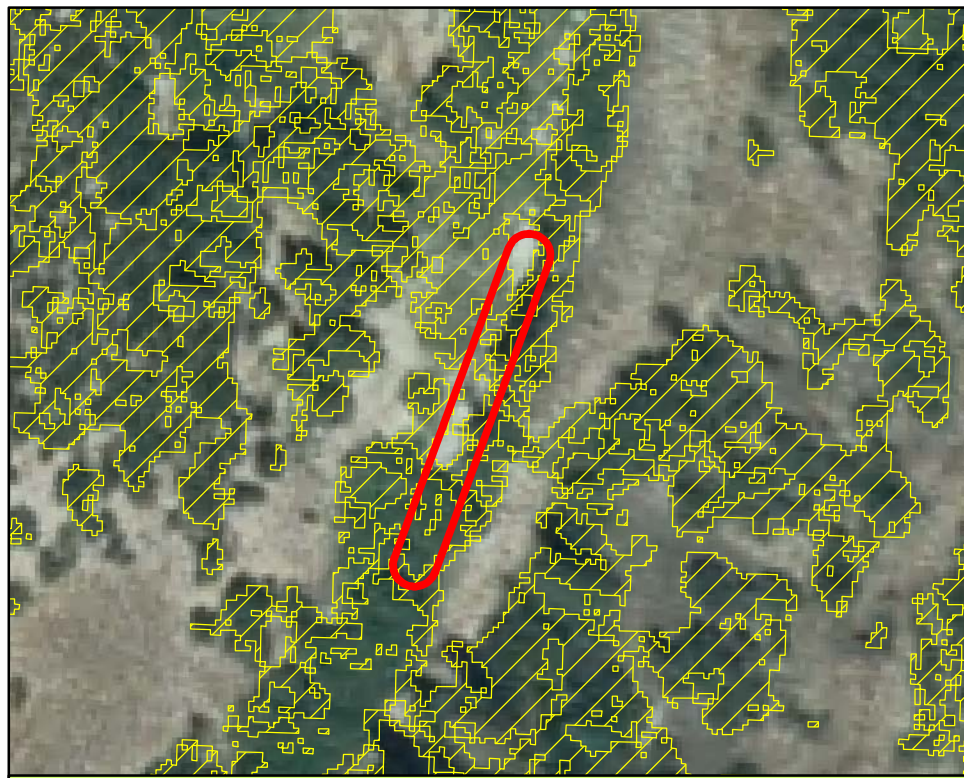
**Figure B8-A. Red Band (26-95) Classification Output. (shown in red)**



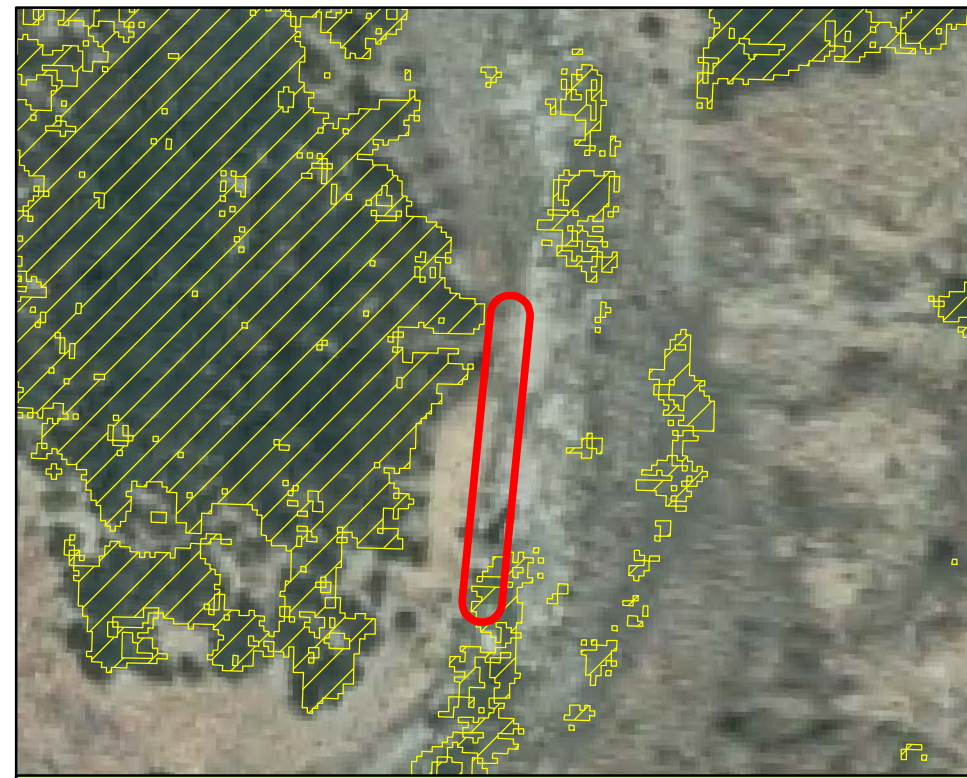
**Figure B8-B. MLC Classification Output. (shown in green)**

The only real exception to this improvement seemed to be in the upper 4.5 miles of the Little Klickitat where Ponderosa pine becomes a dominant vegetation type. This was possibly due to the sun angle as photographed on those particular tiles of the aerial photo that produced long shadows and harsh light or the nature of the spectral bands in that region. Regardless, from analysis segment 620 on, the MLC classification was superseded by the 26-95 classification for the purposes of both the historic comparison and current vegetation estimates.

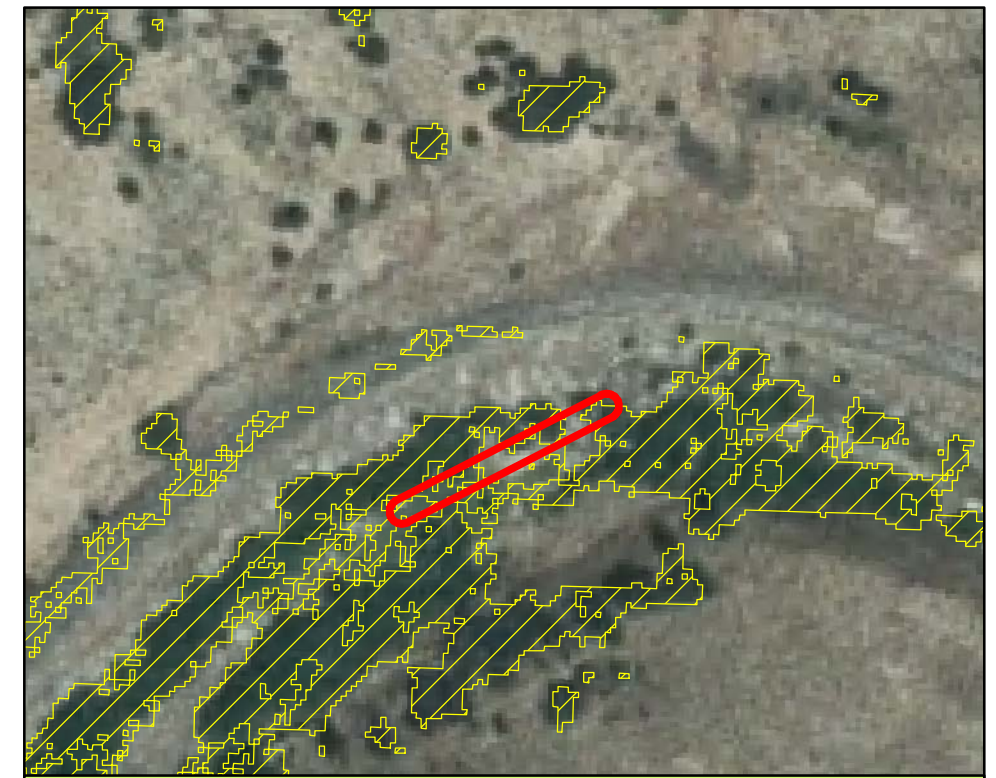
Historic aerial photo were also analyzed using the MLC classification method.



**Segment 96**  
 Field-measured average total canopy = 49%  
 GIS-estimated vegetation = 46%



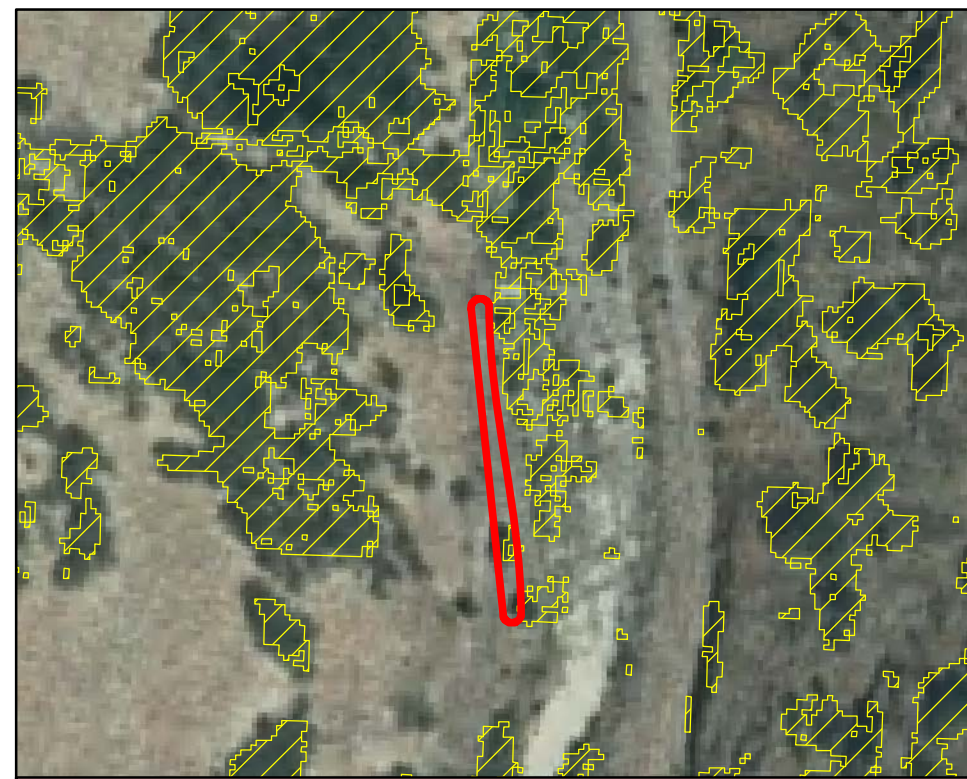
**Segment 181**  
 Field-measured average total canopy = 14%  
 GIS-estimated vegetation = 10%



**Segment 250**  
 Field-measured average total canopy = 43%  
 GIS-estimated vegetation = 42%





**Segment 119**  
 Field-measured average total canopy = 84%  
 GIS-estimated vegetation = 41%

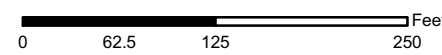


**Segment 190**  
 Field-measured average total canopy = 67%  
 GIS-estimated vegetation = 5%



**Segment 304**  
 Field-measured average total canopy = 22%  
 GIS-estimated vegetation = 85%

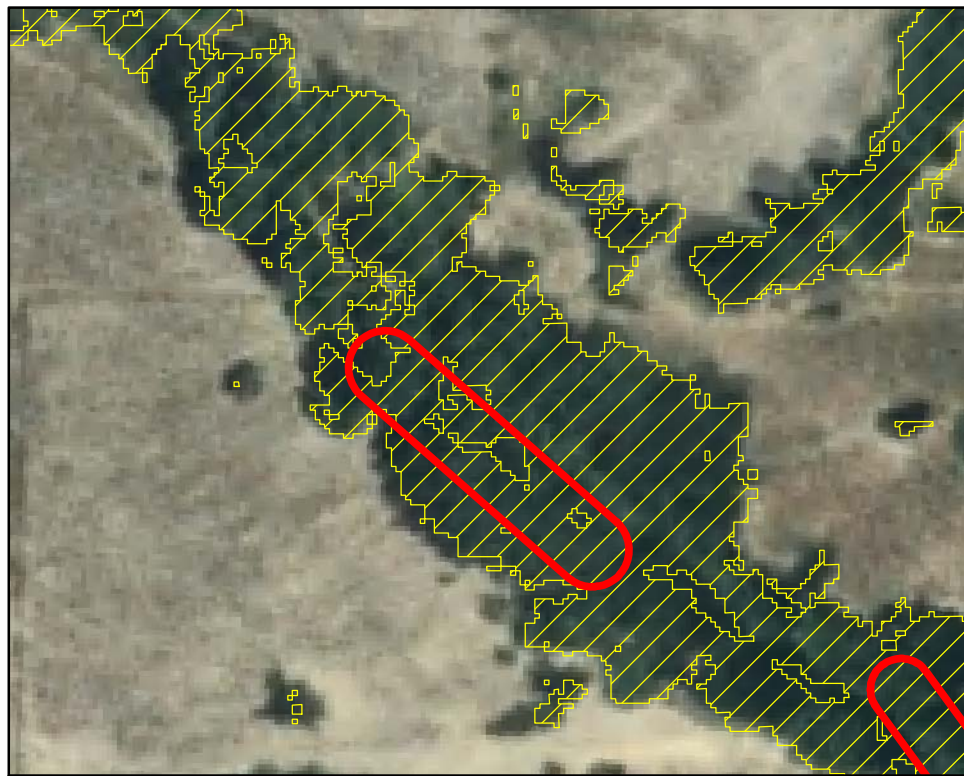
 Field Data Collection Segments  
 GIS-Classified Vegetation Coverage



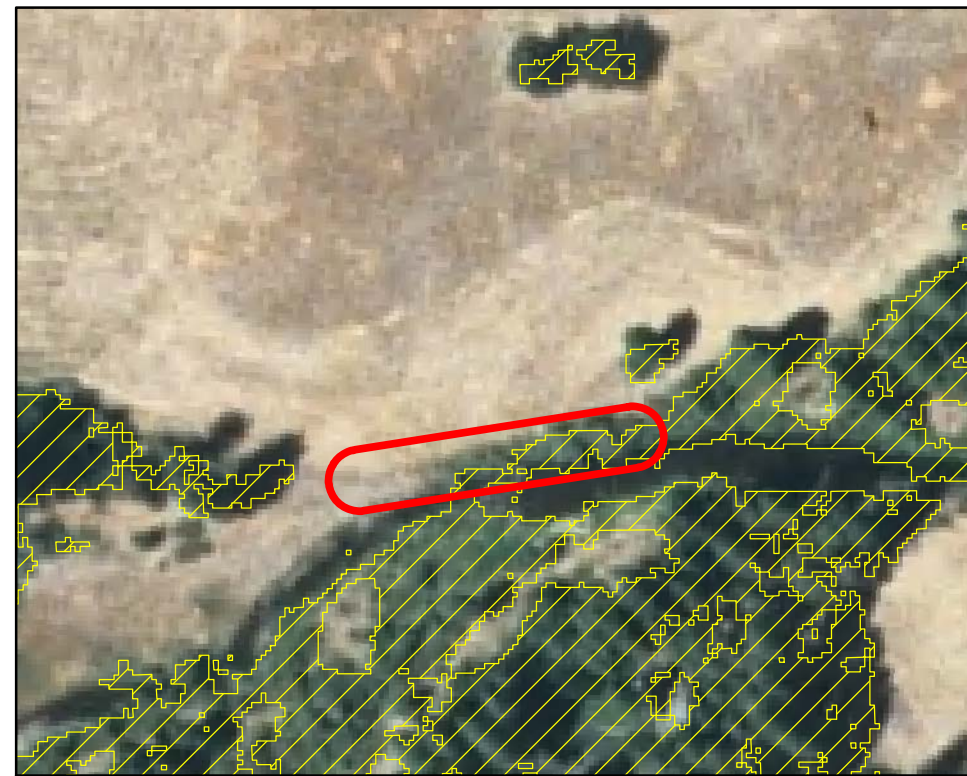
**Segments with Best and Worst GIS Calibration to Field Measurements, Swale Creek**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
 WRIA 30 - Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. B9
REVISED BY:	

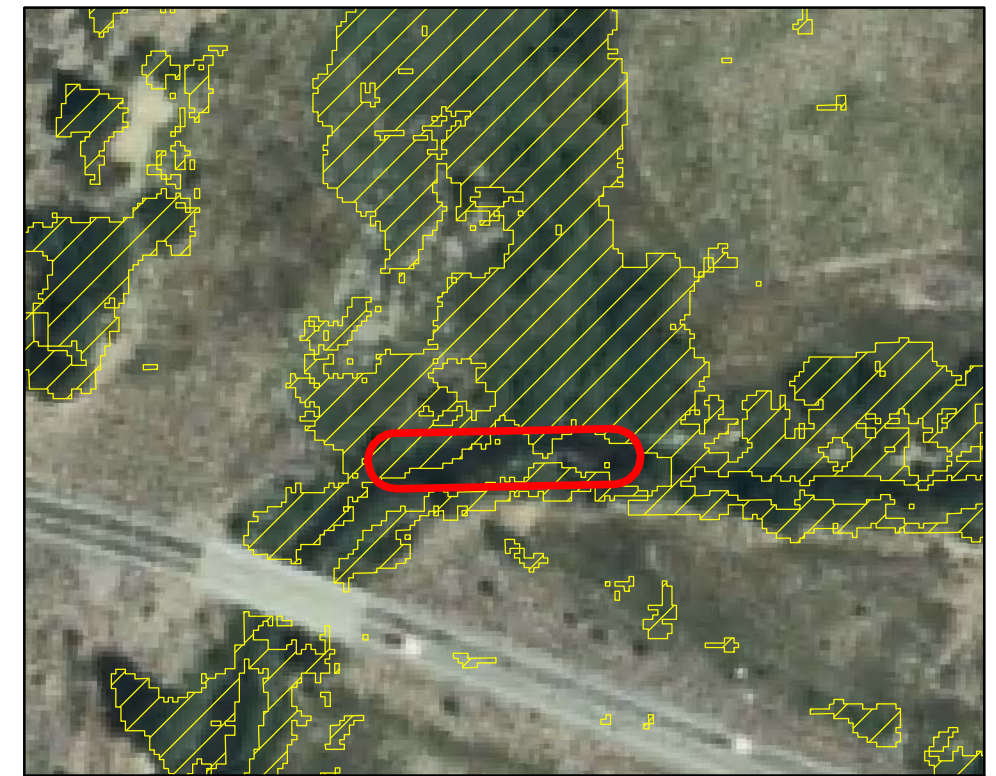
T:\projects\_8\WRIA30\Shade\_Study\_2008\Delivered\Final\GIS-Field-Calibration\_Swale.mxd



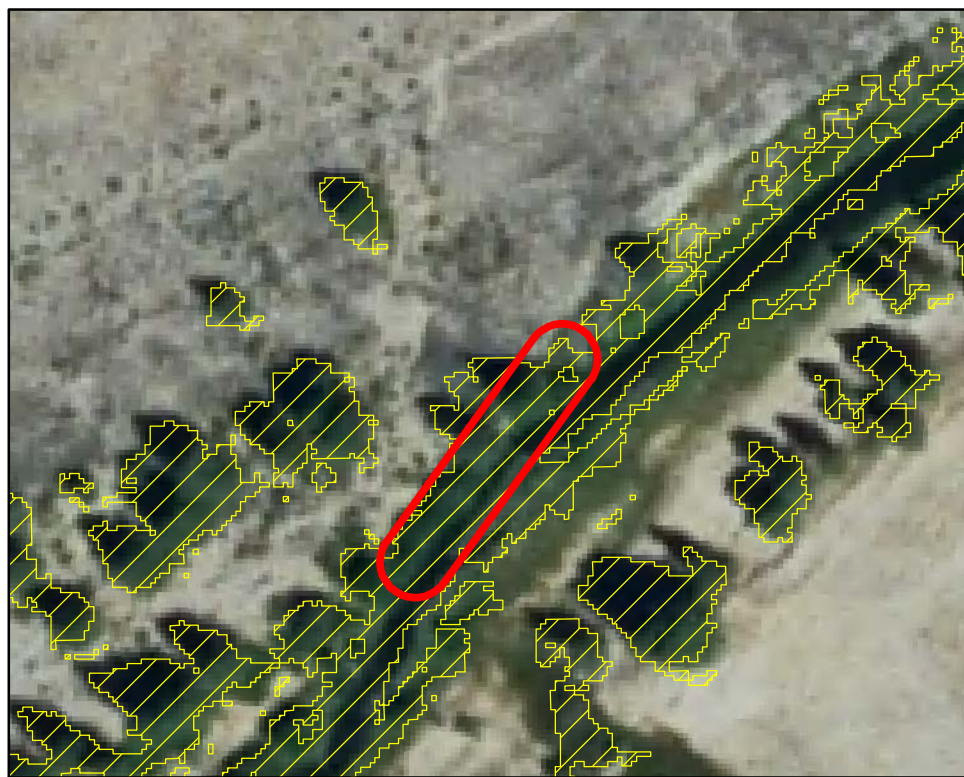
**Segment 442**  
 Field-measured average total canopy = 83%  
 GIS-estimated vegetation = 82%



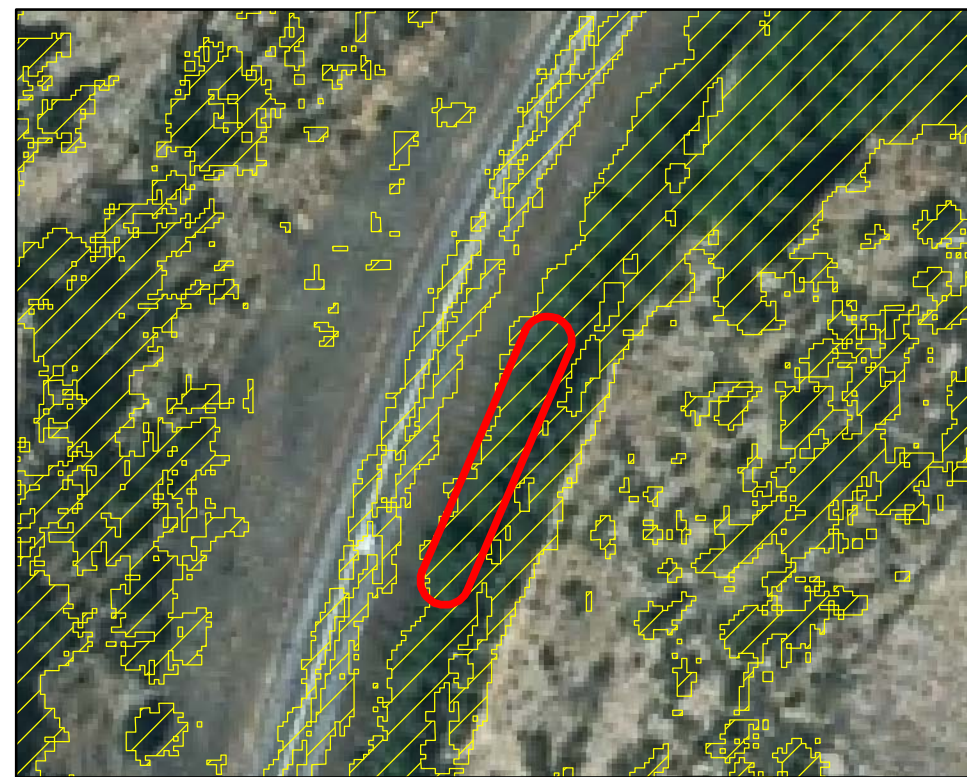
**Segment 571**  
 Field-measured average total canopy = 27%  
 GIS-estimated vegetation = 29%



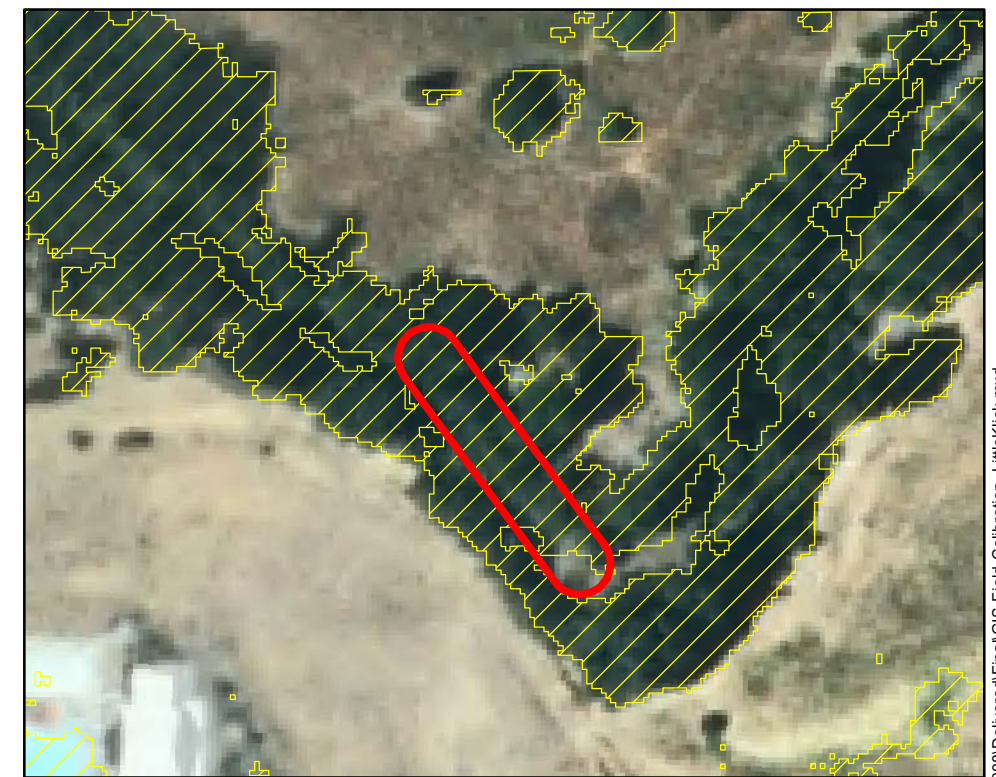
**Segment 411**  
 Field-measured average total canopy = 47%  
 GIS-estimated vegetation = 45%





**Segment 256**  
 Field-measured average total canopy = 31%  
 GIS-estimated vegetation = 87%

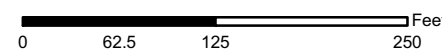


**Segment 502**  
 Field-measured average total canopy = 47%  
 GIS-estimated vegetation = 94%



**Segment 444**  
 Field-measured average total canopy = 54%  
 GIS-estimated vegetation = 88%

 Field Data Collection Segments  
 GIS-Classified Vegetation Coverage



**Segments with Best and Worst GIS Calibration to Field Measurements, Little Klickitat River**  
 Riparian Vegetation Assessment, Little Klickitat River and Swale Creek  
 WRIA 30 - Klickitat County, Washington

DATE: June 2009	PROJECT NO. 070024-009
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. B10
REVISED BY:	

T:\projects\_8\WRIA30\Shade\_study\_2008\Delivered\Final\GIS-Field-Calibration\_LittleKlick.mxd