3.10. UPPER GREEN RIVER AND SUNDAY CREEK WATERSHED ADMINISTRATIVE UNIT

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EXECUTIVE SUMMARY

SUBBASIN

The Green River, upstream of River Mile 64.5 has been divided in to five Watershed Administrative Units (WAUs). WAUs are drainage basins delineated by the Washington Department of Natural Resources (WDNR) for the purpose of conducting Watershed Analysis. The purpose of a Watershed Analysis is two fold and dependent on land ownership. For State and private lands the purpose is to address the cumulative effects of commercial timber harvest upon public resources such as the Northern Spotted Owl or salmonids. This is for the purpose of maintaining a manageable land unit size in order to meet the intended timelines as established by the Washington Forest Practices Board.

For federal lands which are managed under the provisions of the Northwest Forest Plan, the purpose is to meet the watershed analysis requirements established in the Record of Decision for Amendments to U.S. Forest Service and Bureau of Land Management Planning Documents within the range of the Northern Spotted Owl, April 13, 1994.

Both of these processes are not decision making processes, but are intended to be used in a manner to set the stage for subsequent decision making processes. Both characterize ecosystems, or portions of ecosystems, by highlighting problem areas and suggesting solutions on a watershed scale.

Within the State and Private lands, a Watershed Analysis in four of the five WAUs in the upper Green River Subbasin have been completed and three of these have been released. Forest management recommendations have been approved for the Lester WAU and drafts are currently being reviewed for the Howard Hanson, Smay Creek, Upper Green River and Sunday Creek WAUs. The North Fork Green River WAU report has not been started.

Under the federal process, the Green River Watershed Analysis (U.S. Forest Service 1996) has been completed and released.

For the purposes of this report we will attempt to summarize, by WAU, the current habitat conditions and document the potential for recovery of the impaired habitats.

WATERSHED ANALYSIS METHODS

Because the methodology used in watershed analysis is somewhat unique, it is useful to outline that methodology. Stream segments are selected to represent an array of geomorphic channel types of salmonid bearing streams. Gradient, confinement, and bankfull width, are the parameters in which to base the selection. Other features such as land-use, riparian conditions, aspect, and channel disturbance history provide additional considerations for representation. Because the objective of this analysis is to determine habitat features and factors that limit

natural salmon production in the respective WAUs, segment selection is targeted on known salmonid-bearing streams and those that met the physical criteria to qualify as fish-bearing as defined by the draft stream typing emergency rule (later adopted on November 14, 1996). Delineation of the segments is initially done using topographic maps and aerial photos, then field verified during the surveys. Also, old aerial photographs helped to visually assess channel character in an undisturbed state (prior to forest management) and hypothesize habitat potential [1942 (partial coverage) and 1958 (first complete stereo coverage)].

Surveyed stream segments are grouped into geomorphic channel classifications for sub-basins within the two WAUs. Based on the work of Montgomery and Buffington (1993), Pleus and Schuett-Hames (1998), O'Connor (1997), as well as considering the actual distribution of segments surveyed, groupings in the Green River and Sunday Creek WAUs were sorted into 3 classes of channel gradient, 3 classes of confinement, and 5 classes of bankfull width for a total of 45 possible combinations. These classes and their criteria for inclusion are provided in table Upper Green-1.

Table Upper Green-1. Matrix of Possible Channel Classifications Used to Group Segments for the Purpose of Establishing Geomorphic Units.

Geomorphic Feature	Criteria				
Gradient (%)	0-2		>2-8		>8-20*
Confinement	Unconfined (valley width > 4 channel widths)		Moderately confined (valley width 2-4 channel widths)		Confined (valley width < 2 channel widths)
Bankfull width (m)	0-5	>5-10	>10-15	>15-20	>20
*No streams were surveyed with gradients exceeding 20%.					

FIELD MEASUREMENTS AND OBSERVATIONS

Information sources to determine sampling sites include topographic maps (USGS), aerial photographs (1989), and fisheries distribution information (WARIS). Sampling sites are prioritized based on (in descending order of importance): a) the location of fish producing (or potentially producing) stream reaches; b) the need for verification of geomorphic character; and c) riparian diversity. Typically physical habitat sample reaches are 100 meters in length. The analyst surveyed one to three evenly distributed reaches within a segment.

In the Green River and Sunday Creek WAUs, stream surveys are conducted and completed during moderate to low flow conditions from July through September 1995. The sampled parameters were quantitatively assessed using methodologies for field habitat collection outlined in the State's Ambient Monitoring Manual (Schuett-Hames et al., 1994), the U.S. Forest Service Stream Handbook, and the Watershed Analysis Manual Version 3.0. Sediment samples were collected in riffle crests in accordance to the method of Schuett-Hames et al. (1994) using a McNeil core sampler, and analyzed by the gravimetric method. Temperature recordings were obtained by maximum thermometers, and thermographs recording at 1 hour intervals from July through September, also in accordance to the temperature monitoring methods of Schuett-Hames et al. (1994). Scour information was obtained using scour chains placed in suitable spawning area. Substrate data were categorized into six size classifications (based on the U.S. Forest Service Stream Handbook, 1991), and frequency of occurrence calculated. All visual

observations of juvenile and adult fish were also recorded during the surveys to verify DNR Water Type maps.

A synopsis of the definitions used in this methodology as described in Schuett-Hames (1994) is included in table Upper Green-2. Minimum area and depths for a unit to be considered a pool are shown below in table Upper Green-3.

Table Upper Green-2. Definitions of Units and Terms Used in this Report.	
Term	**Unit Description**
Log or large woody debris (LWD)	For Washington State Watershed Analysis, a log, not part of a live tree greater, than 0.10 m (0.33 ft) diameter and greater 2 m (6.5 ft) in length. To qualify, the piece of wood must lie within the vertical axes of the bankfull width, or at least protrude into these vertical axes. If ten or more pieces are touching, it is considered a jam (jams are explained below). The NMFS defines LWD as a minimum of 0.6 m diameter and 15 m length
Key Piece	A log or rootwad independently stable in the stream bankfull width (not functionally held by another factor – see stability factors) and retaining or having the potential to retain other pieces of wood. The NMFS has no comparable parameter.
Rootwad	A rootball greater than 51 cm (20 in) in diameter and with a stem less than 2 m (6.5 ft) length. A stem longer than 2 m in length is considered LWD. To qualify, the piece of wood must lie within the vertical axes of the bankfull width, or at least protrude into these vertical axes. If ten or more pieces are touching, the piece is considered part of a jam (jams are explained below).
Wood Zone	Zone 1- Protruding into the low flow wetted channel surface. Zone 2- Not protruding into the wetted channel surface, but protruding below the horizontal axis of the ordinary high water mark (OHWM). Zone 3- Not protruding into zone 1 or 2, but protruding to within the vertical boundaries of the bankfull width (i.e. bridged or suspended over the channel).
Bankfull Width (BFW)	Bankfull width is the width of the channel at bankfull flow. It includes the BFW of all side channels and braids along the measured cross-section.
Log or Debris Jam	A cluster of ten or more touching pieces of wood with at least part of the jam located within zones one or two. To qualify as piece to be counted, the wood must meet the size requirements of LWD or a rootwad.
Category 1	The dominant unit within the cross section of the main channel, occupying at least 50% of the wetted channel width. There is only one category 1 habitat unit per linear length of the main channel.
Category 2	Units within, or adjacent to category 1 units, occupying less than 50% of the wetted channel width. Category 2 units are included in the total sum of the length of habitat units surveyed. Therefore, the total length of habitat units can exceed the total stream distance surveyed.
Category 3	Isolated channels, smaller than the main channel, connected to the main channel both at the upstream and downstream ends. Category 3 units are included in the total sum of the length of habitat units surveyed. Therefore, the total length of habitat units can exceed the total stream distance surveyed.
Category 4	Off-channel areas. These units are not defined in the Ambient Monitoring Manual, but are assigned to habitat units that provide off-channel rearing in summer or winter, but do not fall into any of the above categories. These units are typically wetlands that are not defined as the main channel, but are connected to it, and channels that are connected to the stream at only one point (i.e. not a side channel). Category 4 units are not included in the sum of the length of habitat units surveyed.
Residual Depth	The maximum depth minus the tail crest depth. This depth does not change with flow and can be measured even if the stream channel is dry.
Maximum Depth	The maximum depth of the sampled habitat unit. Unlike, residual depth, this measurement is influenced by flow.
LWD Total length	Measured distance from one end to the other end of the wood piece, including attached rootball. Logs are measured to the point where it no longer meets the minimum required diameter.
LWD Diameter	Measured at the mid-point of the log.
LWD Stability Factor	Factor responsible for the stability of the wood in the channel. A piece is either is stabilized by (1) a root system; (2) burial exceeding 50% of the length of the wood; (3) pinned by other pieces of wood, trees or rocks, or (4) is unstable.
LWD Sediment Storage	Wood that retains significant quantities of fine or coarse sediment of any size by influencing bed form. Wood does not need to be directly touching the stored sediment. Generally, fine sediments are those less than 0.85 mm in size
Sources: Schuett-Hames *et al.* (1994), WPFB (1997), and NMFS (1995, 1998). Important differences between State and Federal definitions are noted.	

Table Upper Green-3. Habitat Units.								
Minimum Area Criteria for Pools by Channel BFW					Minimum Residual Depth Criteria for Pools by Channel BFW			
BFW	Min. Unit Size				BFW	Min. Residual Pool Depth		
Metric	Imperial	Metric	Imperial		Metric	Imperial	Metric	Imperial
0-2.5 m	0-8 ft	0.5 m^2	2 ft^2		0-2.5 m	0-8 ft	0.10 m	0.3 ft
2.51-5 m	8.1-16 ft	1.0 m^2	10 ft^2		2.51-5 m	8.1-16 ft	0.20 m	0.7 ft
5.01-10 m	16.1-32 ft	2.0 m^2	20 ft^2		5.01-10 m	16.1-32 ft	0.25 m	0.8 ft
10.01-15 m	32.1-49 ft	3.0 m^2	32 ft^2		10.01-1 5 m	32.1-49 ft	0.30 m	1.0 ft
15.01-20 m	49.1-65 ft	4.0 m^2	43 ft^2		15.01-20 m	49.1-60 ft	0.35 m	1.1 ft
>20 m	>65	5.0 m^2	54 ft^2		>20 m	>65 ft	0.40 m	1.3 ft
Note: Minimum area required to form pool, riffle, tailout, cascade, or wetland habitat units. A habitat feature must meet the minimum size to be split from another unit. Pools must meet a minimum residual depth to qualify as a pool. Wetland units also include off-channel areas associated with the main channel, but not part of the main channel.								

Any presence of salmonids was determined by surveys that were conducted utilizing methods outlined in the Washington DNR Forest Practices Handbook, (DNR 1994), the Timber/Fish/Wildlife Ambient Monitoring Program Manual (Schuett-Hames 1994), and the Water Type Emergency Rule (Forest Practices Board, 1996). Other physical information collected in the surveys included habitat data, potential salmonid passage barriers, and evidence of recent disturbance (<20 years). Streams classified as Type 4 and 5 by the DNR water type maps were selected with priority given to streams on the basis of physical features that indicated a strong likelihood of salmonid presence (e.g. drainage area >50 acres, gradients <20 percent , low basin elevation, or any combination of these), although several streams beyond these parameters may also be surveyed at the discretion of the survey team. The basin areas selected were prompted by Watershed Analysis in other similar stream basins. Surveys are concentrated on visiting as many streams as possible over the three month survey period of each year.

SURVEYS

Surveys are conducted during sampling seasons that are typically during July to October. Survey seasons were limited to this particular window of opportunity to allow for a better chance to observe salmonids due to local salmonid life history cycles. The elevation of stream reaches has a bearing on the ability to observe salmonids. In the Green River Sunday Creek WAUs, the elevation is relatively high (1500-4000 feet) and resident salmonids or juvenile anadromous salmonids can be lodged deeply within gravels and organic debris. Typically, during colder air and water temperatures food sources are not present for feeding, thus making any salmonid detection more difficult. Also, high flows often occurring outside the survey window likely contribute to difficult detection of salmonids because they are either displaced downstream, under cover in inaccessible interstitial space, or are difficult to see because of water turbidity.

The physical stream characteristics were determined from topographic maps and aerial photographs as had occurred during the original DNR water typing in 1979. These characteristics are verified in the field utilizing the methods from the TFW Ambient Monitoring protocols (NWIFC, 1994) for determining channel bankfull widths and wetted widths, as well as the DNR Forest Practices Handbook (DNR, 1994) for calculating gradient. Channel length and bankfull width are measured by a hip-chain and tape measure, respectively. Length and width are typically measured to the nearest 1/10th meter. Stream gradient is measured by a hand-held

clinometer at 25 meter stations and averaged, and pool depth is measured with a stadia rod from the deepest part of the pool to the water surface. Gradient is measured to the nearest 1 percent and pool depth to the nearest 1/10th meter. Flood plain connectivity is determined by measuring the lineal meters of road adjacent to one or both sides of a stream segment, and dividing by the length of the stream segment to generate a percent reduction in connectivity. Width-to-depth ratio is calculated by dividing the bankfull width by the channel depth. Road density is obtained by measuring road lengths per stream sub-basin using a desktop GIS software product.

METHODS OF ANALYSIS

Surveyed reaches are assessed to whether the habitat is potentially used by each of the four salmon species identified previously, using the methods of the US Army Corps of Engineers (USACE 1998) for determining species utilization in the upper Green River. The USACE delineated specific stream segments in the upper Green River that provide habitat for coho, steelhead, fall chinook, and spring chinook. Thus, the segments where habitat surveys are conducted were grouped in accordance to respective species in which they serve. To this end, the quality of habitat pertaining to each of these salmon species can be evaluated.

An analysis of the stream survey data, as categorized by respective salmon use, is conducted to determine habitat condition in the respective WAUs. Applicable, collected data are typically quantified using a Watershed Analysis Stream Survey Program spreadsheet (Fox 1996). Habitat metrics can then analyzed using two methods. The first compares the indices of resource conditions for interpretation of field survey results and habitat analysis in accordance with the methodology specified for Watershed Analysis in the State of Washington (Washington Forest Practices Board [WFPB] 1997). The second method of analysis compares these indices with the National Marine Fisheries Service's Matrix of Pathways and Indicators for habitat function (NMFS 1995; NMFS 1998). These methods provide quantitative or descriptive guides that link critical input variables to the habitat requirements of salmon. By accomplishing this, the factors that limit salmon habitat can be identified.

Both the NFMS "Matrix of Pathways and Indicators" and the Washington State Watershed Analysis "Indices of Resource Conditions" compare observed stream habitat conditions to a standard numerical or narrative descriptions. Both systems group the observed habitat quality or quantity into three broad categories. The WFPB uses "poor", "fair", and "good" while the NMFS uses "Not Properly Functioning", "At Risk", and "Properly Functioning". As both systems use three tiers of habitat condition, one can compare the narrative rating of equivalent or roughly equivalent habitat parameters. For the purposes of this report, "poor" was considered equivalent to "not Properly Functioning" and "good" comparable to "Properly Functioning". As several of the Washington State "Indices of Resource Conditions" metrics are similar to those of the NMFS "Matrix of Pathways and Indicators", both were listed for the purpose of comparing methods.

Several habitat parameters of the NMFS Matrix of Pathways do not contain threshold criteria in which to determine a habitat condition. For example, "Holding Pools" by the WFPB definition, synonymous with "Pool Quality" by the NMFS matrix, define respective ratings of "Good" and "Properly Functioning" as having "sufficient" pools >1m deep. Terms such as "sufficient", "few", and "most" do not have threshold criteria in which to base a determination of whether or not it serves as functional habitat. For this reason, criteria were developed for the parameters that

lack thresholds based on best professional judgement based on knowledge of life history requirements of salmonids utilizing these WAUs. Data, as available, were also used to support these determinations. The following criteria were developed for these habitat parameters:

RIPARIAN CONDITIONS

Riparian habitat conditions were used to assess potential sources of riparian wood recruitment, which is used in conjunction with the NMFS parameter of "LWD Quantity". The condition of riparian habitat is estimated using the methods described in the Washington Forest Practices Board Manual for Conducting Watershed Analysis (1994 [revised in 1997]). This method determines the age, species, and density of riparian forest stands. Potential wood recruitment into streams is based on tree height (McDade et al. 1989), and coniferous wood has greater longevity in the channel than deciduous wood (Robison and Beschta, 1990). Thus, riparian stands were considered to contain "properly functional" recruitment conditions if they were comprised of conifer trees in an "old" seral stage, "At Risk" if riparian trees were comprised of mature conifer or deciduous species, and "Not Properly Functioning" if riparian trees were young, (deciduous or conifer). Any stand that is classified as "sparse" in terms of density, is considered to be "Not Properly Functioning". Age classifications of "old" is defined as trees having a $\geq$20 inches diameter breast height (dbh), "mature" as trees having $\geq$12 and <20 inches dbh, and young as <12 inches dbh (WFPB 1997).

The frequency of deep (>1m) holding pools is likely intended for adult salmon during upstream migration and spawning. Thus, limits in the distance a salmon can swim prior to reaching the next "resting place" is a function of body size and adult salmonid metabolic requirements, or spawning density. Due to the variability in holding pool requirements and the paucity of studies that quantify this need, a threshold is determined through "best professional judgement" based on knowledge of salmon body-size and densities that use these WAUs. Thus in these watershed analyses, $\geq$4 pools >1m deep per 100 meters of stream length will constitute as "good" (WFPB) and "Properly Functioning"(NMFS), 2-4 pools per 100 meters as "fair" and "At Risk", and <2 per 100 meters as "poor" and "Not Properly Functioning".

Flood plain connectivity was assessed and ranked using the following criteria: 1) Severe reduction in connectivity: greater than 50 percent of the stream segment is confined by anthropogenically constructed features on at least one banks (e.g. roads, levees, railroad grades, etc.); 2) Reduced connectivity: between 10-50 percent of the stream segment is confined by anthropogenically constructed features on one or both banks; or 3) insignificant reduction in connectivity: less than 10 percent of the stream segment is confined by anthropogenically constructed features on one or both banks.

Off-channel habitats typically comprise the areas of slower water velocities, often associated with winter-rearing life histories. Lack of suitable off-channel habitats can adversely affect winter-rearing, and also summer-rearing salmonids. Studies that determine threshold quantities of off-channel habitat are unavailable, thus an estimate to these quantities was made based on best professional judgement and knowledge of life history requirements of salmonids utilizing these WAUs. Data, as available, were also used to support these determinations. The NMFS criteria has no specified quantities of off-channel habitat to meet "Properly Functioning condition", although it makes reference to "few", "some", and "present". To this end, off-

channel habitat greater than 10 percent of the total channel surface area within the survey reach will be considered as "Properly Functioning", 5-10 percent off-channel habitat will be considered as "At Risk", and less than 5 percent will be considered as "Not Properly Functioning".

SPAWNING GRAVEL

Salmonids require sufficient quantities of gravel of a size range for spawning and incubation. Such gravels are small enough to be readily excavated during redd construction, yet large enough to promote oxygenation and metabolic waste removal through flow permeability. The NMFS criteria specify that gravel or cobble must be dominant with clear interstitial spaces in order to qualify as "Properly Functioning". To this end, stream reaches having a frequency of occurrence of 50 percent or greater of gravel and cobble will be considered as "Properly Functioning", 25 to ≤50 percent cobble/gravel will be considered "At Risk", and <25 percent cobble/gravel "Not Properly Functioning". Size definitions for gravel and cobble are presented in table Upper Green-4.

Table Upper Green-4. Size criteria Used to Classify Substrate in the Habitat Surveys in the Upper Green River and Sunday Creek WAUs.

Substrates
1- Sand, silt, clay. [<0.25" or <0.8 cm (smaller than pea size)]
2- Small Gravel [0.25"-1" or >0.8-2.5 cm (pea to golf-ball size)]
3- Large Gravel [>1" - 3" or >2.5-7.5 cm (golf-ball to baseball size)]
4- Small Cobble [>3"-6" or >7.5-15 cm (baseball to cantaloupe size)]
5- Large Cobble [>6"-12" or >15-30 cm (cantaloupe to basketball size)]
6- Small Boulders [>12"-40" or >30cm-1.0 m (basketball to car-tire size)]
7- Large Boulders [>40" or >1.0 m (greater than car-tire size)]
8- Bedrock

Also in accordance to the NMFS criteria, suitable substrate must have less than a certain degree of embeddedness (see Table 4). Embeddedness data are typically not collected during the surveys; however, data regarding the quantity of spawning gravel are shown where they were obtained for each reach. These data indicate the percent of total substrate that meets the life-history requirements for spawning and incubation such as flow velocity, particle size, the ability to excavate, etc.. This parameter, when coupled with the percent frequency of habitat units containing gravel/cobble as substrate, indicates how much of this substrate is embedded or does not possess the qualities of suitable spawning gravels. To this end, gravel/cobble substrates meeting the required frequency percentage as discussed above also occupy a minimum of 10 percent of the reach area. This is a combined percent of both anadromous and resident spawning area. For example, if greater than 50 percent of the habitat units contain gravel/cobble, the total spawning area for anadromous and resident species must be greater than 10 percent to qualify as "Properly Functioning". If the area quantity is less than 10 percent, the gravel will be considered embedded or otherwise "non-spawnable", and will be considered "Not Properly Functioning" regardless of the percent frequency of habitat units containing gravel/cobble. The methods and definitions for determining anadromous and resident spawning gravel are provided immediately below:

Anadromous: Within the habitat unit, the surface area of suitable spawnable gravel for large bodied or anadromous fish (gravel sizes ranging from 0.76 inches to 1.5 inches) will be determined and quantified. The site must have favorable characteristics for successful spawning, and incubation to emergence (i.e.: loose gravel, non-embedded, little evidence of scour, and sufficient flow depth and velocity).

Resident: Within the habitat unit, the surface area of suitable spawnable gravel for small bodied or resident fish (gravel sizes ranging from 0.25 inches to 0.75 inches) will be determined and quantified. This site must have favorable characteristics for successful spawning, incubation, and emergence (i.e.: loose gravel, little evidence of scour, and sufficient flow depth and velocity).

Table Upper Green-4. Some of the Habitat Rating Parameters used by the NMFS (NMFS 1995; NMFS 1998) and the Washington State Forest Practices Board (WFPB 1997) to Assess the Quality of Salmonid Habitat.			
HABITAT PARAMETER	**HABITAT QUALITY RATING**		
WFPB (1997)	**Poor**	**Fair**	**Good**
Percent Pool	<30%	30 - 40%	>40%
Pool Frequency	> 4 channel widths/pool	2 - 4	< 2 channel widths/pool
LWD/BFW	< 1	1 – 2	>2
Key pieces/ BFW	<0.20	0.20 - 0.50	>0.50
Holding Pools	Few pools/km (> 1 m deep)		Sufficient pools/km (> 1 m deep)
% wood cover in pools	Most pools 0-5%	Most pools 6-20%	Most pools >20%
Fine Sediment in spawning gravels (<0.85mm)	>17% fines	12-17% fines	<12% fines
NMFS (1995, 1998)	**Not Properly Functioning**	**At Risk**	**Properly Functioning**
Temperature	>60°F (spawning) >64°F (migration & rearing)	57-60°F(Spawning) 57-64°F (migration & rearing)	50-57°F
Fine Sediment in spawning gravels (<0.85mm)	>17% fines	12-17% fines	<11% fines
Physical Barriers	Any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a normal range of flows	Any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a base/low flows or at normal high flow conditions	Any man-made barriers present in watershed allow upstream and/or downstream fish passage at all flows
Substrate	Bedrock, sand, silt or small gravel dominant, or if gravel and cobble dominant, embeddedness > 30%.	Gravel and cobble is subdominant, or if dominant, embeddedness 20-30%	Dominant substrate is gravel or cobble (interstitial spaces clear), or embeddedness < 20%
Large Woody Debris			
Quantity	Does not meet standards for Properly Functioning and lack potential recruitment	Meets standards for Properly Functioning, but lacks potential sources of woody debris to maintain that standard	>80 piece/mile > 24" diameter and >50 ft length and adequate sources of woody debris recruitment in the riparian areas
Frequency of LWD by channel width	Does not meet standards for Properly Functioning and lack potential recruitment	Meets standards for Properly Functioning, but lacks potential sources of woody debris to maintain that standard	2.44-2.04 pieces/bankfull channel width for streams 13-62 ft. wide, respectively.
Volume of LWD per piece by channel width	Does not meet standards for Properly Functioning and lack potential recruitment	Meets standards for Properly Functioning, but lacks potential sources of woody debris to maintain that standard	0.25-3.70 m^3/piece for streams 13 ft.-62 ft. wide

Stream Habitat Elements Pool Frequency Channel width Pools/mi. 5 (feet) 184 (pools) 10 96 15 70 20 56 25 47 50 26 75 23 100 18	Does not meet pool frequency standards	Meets pool frequency standards, but large woody debris recruitment inadequate to maintain over time	Meet pool frequency standards
Pool Quality	no deep pools (>1 meter) and inadequate cover/temperature, major reduction of pool volume by fine sediment	Few deeper pools (>1 meter) present or inadequate cover/temperature, moderate reduction of pool volume by fine sediment	Pools> meter deep (holding pools) with good cover and cool water, minor reduction of pool volume by fine sediment
Off-channel habitat	Few or no backwaters, no off-channel ponds	Some backwaters and high energy side channels	Backwater with cover, and low energy off-channel areas
Channel & Watershed Conditions: Width/Depth Ratio	>12	10-12	<10
Floodplain Connectivity	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced, riparian vegetation/succession altered significantly, and channel degradation apparent	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession
Road Density & location	< 2mi/mi^2, no valley bottom roads	2-3 mi/mi^2, some valley bottom roads	>3 mi/mi^2, many valley bottom roads

Table Upper Green-5 presents estimated specific area recommendations required for successful anadromous salmonid spawning.

Table Upper Green-5. Average Observed Redd Area and Recommended Area per Pair Including Defended Area.

Species	Area Recommended per Pair (m²)
Summer/fall chinook	19
Spring Chinook	13
Coho	11
Steelhead	11

Source: Bjorn and Reiser 1991.

After assessing the quality of salmon habitat for each of the four previously mentioned salmon species, the results are compared to the critical input variables for each life history stage to determine the habitat factors that potentially limit natural salmon production in the Sunday Creek and Upper Green River WAUs.

INFORMATION SOURCES

Information is collected from various sources: USFS stream surveys; Tacoma Public Utilities (TPU) stream flow data, water quality, and anecdotal information; the United States Geological Survey (USGS), the Washington Department of Natural Resources (DNR), the US Army Corps of Engineers (Corps), Washington Department of Fish and Wildlife (WDFW), aerial photos , and the U.S. Fish and Wildlife Service (USFW&S). Field surveys conducted by the fish, channel, and riparian module teams provide the required information not previously collected or available. Fish distribution data for salmonid species was provided by the WDFW Washington Rivers Information System (WARIS), WDFW Priority Habitat and Species list, Washington State Salmon and Steelhead Stock Index (SASSI) (WDFW and WWTIT 1994), and was supplemented by field observations by fisheries biologists.

UPPER GREEN RIVER AND SUNDAY CREEK WAUS

STREAM COURSE AND MORPHOLOGY

The Upper Green and Sunday Creek WAUs, are situated on the west side of the central Cascade Mountains divide, approximately 23 miles (34 km) east of Enumclaw, Washington and entirely within King County. The Green River is the largest water body within the two WAUs, followed by Sunday Creek. The Sunday Creek WAU can best be defined as beginning at its confluence with the Green River (at RM 84.2) and continues in a northeast direction for approximately 7.9 miles to the divide at Stampede Pass. The Sunday Creek WAU has numerous tributaries contribute an additional 29.5 linear miles of stream to the mainstem Sunday Creek (Williams 1975). The Green River WAU, can be defined as beginning at the confluence of the Green River (RM 84.2) with Sunday Creek, extending upstream to the headwaters of the Green River in the vicinity of Blowout Mountain (approximately 10 linear miles). Numerous tributaries contribute over 41 linear miles of stream to the drainage. The drainage basin of the combined Green River and Sunday Creek WAUs encompass 39,237 acres.

The base elevation of the Green River and Sunday Creek WAUs is approximately 1,700 feet (519 meters) at the confluence of Sunday Creek. The basins rise to the top of the Cascade divide with an average basin elevation of 5,400 ft (1,646m). Approximately 12 miles (19.5 kilometers (km)) downstream of the lower WAU boundary, the Green River discharges into Howard Hanson Reservoir, a flood control reservoir operated by the Army Corps of Engineers. Downstream of Howard Hanson Dam (HHD) (at RM 64.5) the Green River flows past the Tacoma Headworks Dam (at RM 61) and enters the Green River Gorge and flows west and eventually flows through the City of Auburn where it turns north and flows through the lower Green River valley and into Elliott Bay near West Seattle. The details of habitat downstream of HHD are contained elsewhere in this report.

SALMONID DISTRIBUTION

The known freshwater distribution of anadromous salmonids is depicted the report Appendix. There is no historical information concerning salmonid species distribution or abundance in the upper Green River and Sunday Creek WAUs. However, three is substantial anecdotal information that implies anadromous fish migrated upstream of the Tacoma Headworks Project prior to its completion in 1911. Anadromous access into the Upper Green River and Sunday Creek WAUs seem likely, since there are no natural or anthropogenic passage barriers located on the mainstem Green River downstream of the WAUs. Historically, adult salmonids were documented at the Tacoma Headworks Diversion Dam (Grette and Salo, 1986), and adults have been documented upstream of the diversion dam site (Riseland, 1913).

Currently, the salmonid species inhabiting the upper Green River and Sunday Creek WAUs include chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), resident and anadromous (steelhead) rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), and mountain whitefish (*Prosopium williamsonni*). Currently, only anadromous steelhead adults are passed upstream of the Tacoma Headworks Project and HHD. Spawning steelhead adults have been observed in the Green River as far upstream as RM 83.5 but they have not been observed in these WAUs. Juvenile steelhead, chinook and coho salmon have been released as hatchery plants

into numerous streams in these WAUs and are depicted in Appendix B. Mountain whitefish, cutthroat and resident rainbow trout are known to inhabit the primary tributaries. As of the date of this report there are no reported observations of bull trout (*Salvalinus confluentus*) within the Upper Green River or Sunday Creek WAUs (Plum Creek Timber Company, 1994).

There are known resident trout populations in the Upper Green River and Sunday Creek WAUs that include rainbow and cutthroat. These species have a wide distribution, but since no formal inventory has been done, an exact distribution and abundance estimate cannot be determined. Adfluvial trout populations have been observed throughout the lower portions of the Green River and Sunday Creek in the WAUs. Resident trout are found in most of the major Green River and Sunday Creek tributaries and extend into tributaries classified as "Type 3" waters. Type 4 waters are also likely to contain resident trout populations where the stream gradient is less than 14 percent.

The mainstem Green River and all the primary tributary channels support resident rainbow and/or cutthroat trout. While not demonstrated, it is likely that hybridization between the two species has occurred (T. Cropp, WDFW, pers. comm.). Trout in reaches of isolated high-gradient streams are often segregated from other strains by passage barriers, although dispersal by downstream migration frequently occurs. The mainstem Green River, support a population of cutthroat trout that attain lengths of 20 inches (T. Cropp, WDFW, pers. comm.). These large and mature fish may represent a stock of adfluvial cutthroat that have matured in the reservoir and ascend the streams to spawn. Spawning activity of the adfluvial strains of trout are believed to occur primarily in the mainstem Green River and in the lower reaches of the accessible tributaries (Wunderlich and Toal, 1992). The stream rearing habitat requirements for resident trout are similar to those of steelhead. As with all species of salmonids using the WAUs, relatively shallow, channel margin and pool habitat is important during the earliest stages of life soon after incubation.

HABITAT CONDITIONS

In the Upper Green River and Sunday Creek WAUs Watershed Analyses (WSA), a total of forty-seven segments were sampled and surveyed. Anecdotal evidence was noted between sample reaches to obtain inferences on channel character and habitat condition and whether or not the segment was representative of the surveyed. In those 47 segments, a total of 7,202 meters of channel were quantitatively surveyed. As a part of the WSA, an additional 5,800 meters of stream channel were walked, in which observations were made regarding the character of the segment and incorporated into descriptions for their respective channel classifications. This was conducted for the purpose to verify that the reaches surveyed are representative of the stream.

The classification of segments by salmon species for which it serves resulted in 24 segments for coho (3,652 meters of stream), 29 segments for steelhead (4,352 meters of stream), 6 segments for fall chinook (1,118 meters of stream), and 12 segments for spring chinook (1,742 meters of stream). The field metrics identified in the NMFS "Matrix of Pathways" were quantified for habitats utilized by each species.

The following discussion relates the existing quality of habitat in the upper Green and Sunday Creek WAUs for each species to their respective life history requirements. This is accomplished

by evaluating the effects associated with each respective critical input variable, which often dictates habitat quality.

FALL CHINOOK HABITAT CONDITIONS

Information was reviewed from six survey reaches that covered 1,118 meters of stream channel. These six survey reaches represent 18.3 percent of the presumed fall chinook habitat available in the Green River and Sunday Creek WAUs as identified by the Army Corps of Engineers (1998). Overall, the quality of fall chinook habitat is rated as "Not Properly Functioning". The key parameters examined are identified in table Upper Green-6.

Table Upper Green-6. Examined Key Habitat Parameters for Fall Chinook Reaches in the Green River and Sunday Creek WAUs.

Parameter	Minimum	Maximum	Mean	SD	N=
Survey Reach Length (m)	100	218	186	43.0	6
BFW (m)	5.3	20.9	11.2	5.3	6
Bankfull Depth (m)	0.40	0.6	0.5	0.1	6
Gradient (%)	1.5	3.0	2.4	0.7	6
Elevation (m)	558	607	588	18.7	6
Pools/mile	22.2	80.5	41.7	27.1	6
Holding Pools/mile	0	48.3	18.7	16.7	6
Percent of all pools that are holding/pools per mile	0%	67	43.6	26.5	6
Off-channel Habitat	0	45	11.7	16.9	6
Riparian Species 1=conifer, 2=deciduous	1	2	1.7	0.52	6
Riparian Age 1=old, 2=mature, 3=young	2	3	2.7	0.52	6
Riparian density: 1=dense, 2=sparse	1	2	1.2	0.41	6
Percent wood cover in pools	0-5%	5-10%	4.5%	2.7%	5
Width/depth ratio	13.3	37.3	21.2	8.4	6
Occurrence of sand, silt, clay (%)	0	25	4.17	10.21	6
Occurrence of gravel, cobble (%)	10	90	57.38	32.37	6
Occurrence of boulder/bedrock (%)	0	90	38.00	36.46	6
Anadromous Spawning Area (%)	0	2	0.67	0.82	6
Percent fines	16	16	16	0	1
Temperature (F)	62.24	62.24	62.24	0	1
Canopy Closure (%)	0%	78%	16.2%	30.9%	6
Min. shade requirement (%)*	47%	51%	48.5%	1.5%	6
NMFS wood pieces/mile	0	29.5	4.92	12.06	6

* Source: WFPB 1998.

RIPARIAN HABITAT

Watershed Analysis found that the bulk of the riparian habitats in the Green River and Sunday Creek WAUs are generally dense, but young deciduous trees. This condition is insufficient as a new LWD supply to the stream channel and hence maintain or improve the associated habitat forming processes. This situation will likely not ameliorate until the riparian stands reach a size and age that would allow for sufficient size and number to restore instream LWD loadings to a more natural level. The riparian condition is currently considered to be "Not Properly Functioning" for fall chinook in four of the six reaches surveyed and "At Risk" in the remaining

two. These ratings are due to: (1) the deciduous component of trees that dominate the assessed riparian reaches for fall chinook; and (2) the young age of the trees present in the riparian area.

The young tree age and large deciduous component are likely directly responsible for the scarcity of NMFS criteria LWD present in the stream channel. The quantity of LWD within the fall chinook reaches is insufficient to maintain many of the necessary habitat elements and habitat forming elements. Though pieces of wood are numerous, they are typically small. Only four pieces of wood were found that meet NMFS size criteria within the survey fall chinook reaches. This represents only 7.1 percent of the 56 pieces needed to be considered "Properly Functioning". None of the reaches surveyed met NMFS criteria for wood quantity, nor are the channel adjacent stands considered to be adequate to maintain LWD recruitment processes in the near term. Thus, for fall chinook this yields a "Not Properly Functioning" assessment.

SUBSTRATE

WSA indicates that spawning gravels are in short supply throughout the reaches examined. Surveys indicate that a mean of 0.76 percent of the total surveyed stream channel was observed to contain potential suitable spawning substrate. Three of the six reaches surveyed were dominated by boulder/bedrock and the remaining three reaches were dominated by gravel/cobble with very little gravel distributed in areas that were deemed useful for fall chinook spawning. Overall, the paucity of suitable spawning gravels in the reaches surveyed are a limiting factor for fall chinook production and were rated as "Not Properly Functioning."

Mass wasting and hillslope erosion was determined not to be a significant contributor to the overall levels of fine sediment produced in the Green River and Sunday Creek WAUs. Secondary sediment erosion from mass wasting scarps generally was below the 50 percent of the natural background sediment input cutoff point for a moderate hazard rating designation. There was one exception, the Pioneer Creek subbasin, where the estimated sediment yield is 57 percent of the background.

POOLS

Of the 24 reaches surveyed, the number of pools varied considerably. Using pool frequencies as calculated from the pool frequency regression curve, 16 of the 24 surveyed reaches do not meet NMFS criteria for "Properly Functioning" for pool frequency. When taken in the aggregate, the streams had roughly the required number of pools required to meet MNFS criteria as "Properly Functioning". Cumulatively, the surveyed reaches had 26 pools in fall chinook reaches where 28.4 were to be expected. Two of the six reaches surveyed had more pools than required and overly compensated for the other four reaches that had far fewer than the required number of pools. However, despite the number of pools present, all of the reaches, including those that met NMFS pool criteria to be considered "Properly Functioning" are assigned an "At Risk" factor because of the inadequacy of the riparian zone to recruit LWD into the stream channel to form pools.

Approximately 44 percent of the pools surveyed met minimum depth requirements (>1 meter). The ability of the pools to provide cover and holding areas is further reduced by the pool in-water and overwater cover, again because of the lack of LWD. Pool quality was deemed insufficient to provide suitable habitat for fall chinook as was assigned an "At Risk" rating.

CHANNEL CONDITIONS

Reach specific and cumulative observations suggest that the stream channel has become shallow and wide. This may also be an influencing factor in decreased pool quality and adversely impacts the ability of the available habitat to successfully hold adult and rear juvenile salmonids. The mean width:depth ratio was 21.22. This indicates increased proportion of riffles and glides that leads to reduced high flow refugia and available over-winter rearing habitats, an increased water surface area exposed to solar radiation that in turn could lead to increased stream water temperatures. Additionally, the high width to depth ratio may influence fall chinook spawning through decreases in wetted stream areas with acceptable depths for spawning fall chinook. A designation of "Not Properly Functioning" was assigned to stream channel conditions because of the high width:depth ratio.

There are a number of barriers, primarily culverts, that prevent adult and juvenile access to tributaries in this subbasin. A detailed listing of known anthropogenic barriers in this subbasin are contained in the Barriers Chapter of this report. However, a comprehensive survey has not been initiated that lists all known anthropogenic barriers.

OFF CHANNEL HABITAT

Six reaches were surveyed for the quantity of off-channel habitat. Only one of these six reaches was ranked as "Properly Functioning" with 45 percent of the off-channel habitat in this reach skewed the mean value to 11.7 percent. However, this single reach is not representative of the other five stream reaches as noted by the high variability, which is illustrated by a standard deviation of 16.9 percent. Three of the six reaches are rated as "Not Properly Functioning" while the others are rated as "At Risk". Overall, off-channel habitats are rated as "Not Properly Functioning" again due to the scarceness of LWD and the off-channel habitat forming processes associated with LWD.

WATER QUALITY

Water temperature was measured in one stream as 62.2 F, which would give a rating of "Not Properly Functioning". A probable cause of elevated stream temperatures is that the mean canopy closure is only 24.0 percent while 41.3 percent canopy coverage is required to meet shade standards (WFPB 1998) to avoid solar radiation and induced water temperature increases.

SPRING CHINOOK HABITAT

Information was reviewed from twelve (12) survey reaches that covered 1,742 meters of stream channel. These twelve survey reaches represent 16.6 percent of the presumed spring chinook habitat available in the Green River and Sunday Creek WAUs as identified by the Army Corps of Engineers (1998). The key parameters examined are identified in table Upper Green-7.

Table Upper Green-7. Examined Key Habitat Parameters for Spring Chinook Reaches in the Green River and Sunday Creek WAUs.					
Parameter	**Minimum**	**Maximum**	**Mean**	**SD**	**N=**
Survey Reach Length (m)	24	218	145	64.1	12
BFW (m)	4	21	10	438	12
Bankfull Depth (m)	0.4	1.5	1	0.4	12
Gradient (%)	1.5	5	2.5	0.4	12
Elevation (m)	558	723	635.4	58.4	12
Pools/mile	0	134.1	44.1	38.5	12
Holding Pools/mile	0	48.3	9.3	14.9	12
Percent of all pools that are holding/pools per mile	0%	67	26	30	10
Off-channel Habitat	0	45	1.3	16.2	9
Riparian Species 1=conifer, 2=deciduous	1	3	1.8	0.4	6
Riparian Age 1=old, 2=mature, 3=young	2	3	2.8	0.4	6
Riparian density: 1=dense, 2=sparse	1	2	1.2	0.4	6
Percent wood cover in pools	0.5%	5-10%	0-5%	---	9
Width/depth ratio	7.3	37.3	16.1	7.9	6
Occurrence of sand, silt, clay (%)	0	25	3.0	7.6	6
Occurrence of gravel, cobble (%)	10	100	69.1	30.4	6
Occurrence of boulder/bedrock (%)	0	90	27.80	32.4	6
Anadromous Spawning Area (%)	0	6	1.3	1.8	10
Percent fines	16	16	16	0	1
Temperature (F)	58.1	67.2	60.2	2.9	5
Canopy Closure (%)	0%	93%	20.7%	31.9%	12
Min. shade requirement (%)*	37%	51%	44.3%	5.1%	12
NMFS wood pieces/mile	0	257.6	27.3	73.8	12
* Source: WFPB 1998.					

RIPARIAN HABITAT

Watershed Analysis found that the bulk of the riparian habitats that could be utilized by spring chinook in the Green River and Sunday Creek WAUs are generally dense, but young deciduous trees. This condition is insufficient as a new LWD supply to the stream channel and hence maintain or improve the associated habitat forming processes. This situation will likely not ameliorate until the riparian stands reach a size and age that would allow for sufficient size and number to restore instream LWD loadings to a more natural level. The riparian condition is currently considered to be "Not Properly Functioning" for spring chinook in ten of the twelve reaches surveyed and "At Risk" in the remaining two. These ratings are due to: (1) the deciduous component of trees that dominate the assessed riparian reaches for fall chinook; and (2) the young age of the trees present in the riparian area.

The young tree age and large deciduous component are likely directly responsible for the scarcity of NMFS criteria LWD present in the stream channel. The quantity of LWD within the spring chinook reaches is insufficient to maintain many of the necessary habitat elements and habitat forming elements. None of the reaches surveyed met NMFS criteria for wood quantity, nor are the channel adjacent stands considered to be adequate to maintain LWD recruitment processes in the near term. Thus, for spring chinook this yields a "Not Properly Functioning" assessment.

SUBSTRATE

WSA indicates that spawning gravels are in short supply throughout the reaches examined. Surveys indicate that a mean of 1.3 percent of the total surveyed stream channel was observed to contain potential suitable spawning substrate. Individual reaches also reflected poor spawning gravel quality. Eleven of the twelve reaches were rated as "Not Properly Functioning" due to inadequate area of spawnable gravels. Boulder/bedrock was the dominant feature in four reaches while gravel/cobble dominated the remaining eight. The gravel/cobble reaches contained very little gravel distributed in areas that could be utilized by spawning spring chinook. Only one reach (mainstem Green River at RM 86.4) that contained 6 percent spawning gravel was considered "At Risk", the remaining reaches were all considered to be "Not Properly Functioning". Overall, the paucity of suitable spawning gravels in the reaches surveyed are a limiting factor for spring chinook production and were rated as "Not Properly Functioning".

Mass wasting and hillslope erosion was determined not to be a significant contributor to the overall levels of fine sediment produced in the Green River and Sunday Creek WAUs. Secondary sediment erosion from mass wasting scarps generally was below the 50 percent of the natural background sediment input cutoff point for a moderate hazard rating designation. There was one exception, the Pioneer Creek subbasin, where the estimated sediment yield is 57 percent of the background.

POOLS

Overall, the spring chinook reaches surveyed had 85 percent of the required number of pools to meet NMFS as "Properly Functioning". However, the poor quality of the pools and the inadequate stream adjacent riparian reserves strongly suggest that a lower habitat quality rating be assigned than consideration of pool frequency alone would suggest.

Of the twelve reaches surveyed, the number of pools varied considerably. Using pool frequencies as calculated from the pool frequency regression curve, nine of the twelve surveyed reaches do not meet NMFS criteria for "Properly Functioning" for pool frequency. When taken in the aggregate, the streams had roughly the required number of pools required to meet MNFS criteria as "Properly Functioning." Cumulatively, the surveyed reaches had 41 pools in spring chinook reaches where 48 were to be expected. Individually, nine of the twelve reaches had a pool deficit and are rated as "Not Properly Functioning". However, on a system wide basis, these numerical deficiencies were almost compensated by reaches containing more pools than required. However, despite the number of pools present, all of the reaches, including those that met NMFS pool criteria to be considered "Properly Functioning" are assigned an "At Risk" factor because of the inadequacy of the riparian zone to recruit LWD into the stream channel to form pools. Without LWD inputs into the stream channel it should be expected that there will be a net decrease over time of pool quality and pool numbers.

Approximately 26 percent of the pools surveyed met minimum depth requirements (>1 meter). The ability of the pools to provide cover and holding areas is further reduced by the pool in-water and overwater cover, again because of the lack of LWD. Cover in all pools was considered poor, with a mean coverage in the 0-5 percent range. Pool quality was deemed insufficient to provide suitable habitat for spring chinook as was assigned an "At Risk" rating.

CHANNEL CONDITIONS

Reach specific and cumulative observations suggest that the stream channel has become shallow and wide. This may also be an influencing factor in decreased pool quality and adversely impacts the ability of the available habitat to successfully hold adult and rear juvenile salmonids. The mean width:depth ratio was 16.1. This indicates increased proportion of riffles and glides that leads to reduced high flow refugia and available over-winter rearing habitats, an increased water surface area exposed to solar radiation that in turn could lead to increased stream water temperatures. Additionally, the high width to depth ratio may influence fall chinook spawning through decreases in wetted stream areas with acceptable depths for spawning fall chinook.

Individually, two of the twelve surveyed reaches met the NMFS criteria to be defined as "Properly Functioning" while two were "At Risk" and the remaining eight were "Not Properly Functioning".

A designation of "Not Properly Functioning" was assigned to stream channel conditions because of the high width:depth ratio.

OFF CHANNEL HABITAT

Nine reaches were surveyed for the quantity of off-channel habitat. Only two of these nine reaches was ranked as "Properly Functioning", three were ranked as "At Risk" and five at "Not Properly Functioning". Two reaches with exceptionally large percentages of off-channel rearing (45 percent and 32 percent) skewed the mean value to 11.3 percent. However, this single reach is not representative of the other five stream reaches as noted by the high variability, which is illustrated by a standard deviation of 16.2 percent. Overall, off-channel habitats are rated as "Not Properly Functioning" again due to the scarceness of LWD and the off-channel habitat forming processes associated with LWD.

WATER QUALITY

Water temperature was measured in one stream as 60.2 F, which would give a rating of "Not Properly Functioning". A probable cause of elevated stream temperatures is that the mean canopy closure is only 20.7 percent while 44 percent canopy coverage is required to meet shade standards (WFPB 1998) to avoid solar radiation and induced water temperature increases.

COHO

Information was reviewed from 24 reaches that were surveyed that were considered to support coho salmon. This represented an area covering 3,652 meters of stream channel and further represents approximately 17.8 percent of the presumed coho habitat in the Green River and Sunday Creek WAUs. Key parameters of the coho habitat survey are presented in table Upper Green-8 below.

Table Upper Green-8. Examined Key Habitat Parameters for Coho Reaches in the Green River and Sunday Creek WAUs.					
Parameter	**Minimum**	**Maximum**	**Mean**	**SD**	**N=**
Survey Reach Length (m)	24	300	152.0	77.0	24
BFW (m)	4	38	13.2	8.3	24
Bankfull Depth (m)	0.37	2.5	0.98	0.66	24
Gradient (%)	1.0	6.0	2.6	1.4	24
Elevation (m)	529	723	612	59.7	24
Pools/mile	0	134.1	37.0	32.6	24
Holding Pools/mile	0	48.3	9.2	11.8	24
Percent of all pools that are holding/pools per mile	0	100	35	35	21
Off-channel Habitat	0	49	10.2	16.6	16
Riparian Species 1=conifer, 2=deciduous	1	2	1.8	0.4	23
Riparian Age 1=old, 2=mature, 3=young	2	3	2.9	0.3	23
Riparian density: 1=dense, 2=sparse	1	2	1.2	0.4	23
Percent wood cover in pools	0-5%	5-10%	0-5%	2.7	16
Width/depth ratio	6.0	37.3	15.2	6.6	24
Occurrence of sand, silt, clay (%)	0	25	3.2	7.6	24
Occurrence of gravel, cobble (%)	0	100	66.7	32.4	24
Occurrence of boulder/bedrock (%)	0	100	24.3	32.0	24
Anadromous Spawning Area (%)	0	13.0	2.1	3.1	21
Percent fines	6	16	11.0	7.1	2
Temperature (F)	57.2	62.24	59.1	2.0	5
Canopy Closure (%)	0	93	21.3	25.7	24
Min. shade requirement (%)*	20%	54	42.8	9.6	24
NMFS wood pieces/mile	0	257	30.2	65.7	24
* Source: WFPB 1998.					

RIPARIAN HABITAT

Watershed Analysis found that the bulk of the riparian habitats that could be utilized by coho in the Green River and Sunday Creek WAUs are generally dense, but consist of young deciduous trees. This condition is insufficient as a new LWD supply to the stream channel and hence maintain or improve the associated habitat forming processes. This situation will likely not ameliorate until the riparian stands reach a size and age that would allow for sufficient size and number to restore instream LWD loadings to a more natural level. The riparian condition is currently considered to be "Not Properly Functioning" for coho in 20 of the 23 reaches surveyed and "At Risk" in the remaining three. These ratings are due to: (1) the deciduous component of trees that dominate the assessed riparian reaches for fall chinook; and (2) the young age of the trees present in the riparian area. The condition of the riparian habitat is currently not sufficient in the near term to provide suitable amounts and quality of LWD to the stream channel to maintain associated habitat and other ecological forming processes. Without large coniferous trees for recruitment and retention, the existing level of coho production should be expected to decline.

The mean pieces of WSA size wood (>10 centimeters diameter, >2 meters length) per channel width was 3.0. A rating of good is assigned to stream channels with at least 2.0 pieces per channel width (WFPB 1997). However, this good rating is strongly influenced by one reach in the mainstem Green River (RM85.8) where a segment long log jam contained an average of 34

pieces per channel width. In the absence of this log jam, the number of wood pieces per channel width over the surveyed habitat would be 1.7, yielding a rating of "Fair" under WSA standards. This patchy distribution of wood in the stream channel is indicated by the standard deviation of 7.1 pieces per channel width.

WSA key pieces are also below the desired target numbers, averaging only 0.02 pieces per channel width. This represents less than 10 percent of the target goal of 0.3 pieces per channel width.

When NMFS criteria are applied, only 56 pieces of wood were identified within the reaches surveyed for coho salmon. This represents only 31 percent of the target level of 181 pieces required to be considered "Properly Functioning" by NMFS. This yields an overall habitat rating as "Not Properly Functioning".

SUBSTRATE

WSA indicates that spawning gravels are in short supply and inadequate for adult coho salmon spawning throughout the reaches examined. Surveys indicate that a mean of 2.1 percent of the total surveyed stream channel was observed to contain potential suitable spawning substrate where the desired threshold is 10 percent. Individual reaches also reflected poor spawning gravel quality. Twenty of the twenty-one reaches were rated as "Not Properly Functioning" due to inadequate area of spawnable gravels. The gravel/cobble reaches category dominated (67 percent) the reaches but contained very little gravel distributed in areas that could be utilized by spawning coho. Only one reach (mainstem Green River at RM 86.4) that contained 13 percent spawning gravel was considered "Properly Functioning", while the remaining reaches were all considered to be "Not Properly Functioning". Overall, the paucity of suitable spawning gravels in the reaches surveyed are a limiting factor for coho production and were rated as "Not Properly Functioning".

Mass wasting and hillslope erosion was determined not to be a significant contributor to the overall levels of fine sediment produced in the Green River and Sunday Creek WAUs. Secondary sediment erosion from mass wasting scarps generally was below the 50 percent of the natural background sediment input cutoff point for a moderate hazard rating designation. There was one exception, the Pioneer Creek subbasin, where the estimated sediment yield is 57 percent of the background.

Fine sediment sampled in two reaches was measured at 6 percent and 16 percent. A mean of fines of 11.0 percent is considered to be "Properly Functioning" (NMFS).

POOLS

Overall, the coho reaches surveyed had 81 percent of the required number of pools to meet NMFS as "Properly Functioning". However, the poor quality of these pools and the inadequate stream adjacent riparian reserves strongly suggest that a lower habitat quality rating be assigned than consideration of pool frequency alone would suggest.

Of the 24 reaches surveyed, the number of pools varied considerably. Using pool frequencies as calculated from the pool frequency regression curve, 16 of the 24 surveyed reaches do not meet

NMFS criteria for “Properly Functioning” for pool frequency. When taken in the aggregate, the streams had roughly the required number of pools required to meet MNFS criteria as “Properly Functioning”. Cumulatively, the surveyed reaches had 75 pools in coho reaches where 91 were to be expected. However, on a system wide basis, these numerical deficiencies were almost compensated by reaches containing more pools than required. However, despite the number of pools present, all of the reaches, including those that met NMFS pool criteria to be considered “Properly Functioning” are assigned an “At Risk” factor because of the inadequacy of the riparian zone to recruit LWD into the stream channel to form pools. Without LWD inputs into the stream channel it should be expected that there will be a net decrease over time of pool quality and pool numbers.

Approximately 35 percent of the pools surveyed met minimum depth requirements (>1 meter). The ability of the pools to provide cover and holding areas is further reduced by the pool in-water and overwater cover, again because of the lack of LWD. Cover in all pools was considered poor, with a mean coverage in the 0-5 percent range. Pool quality was deemed insufficient to provide suitable habitat for spring chinook as was assigned an “At Risk” rating.

CHANNEL CONDITIONS

Reach specific and cumulative observations suggest that the stream channel has become shallow and wide. This may also be an influencing factor in decreased pool quality and adversely impacts the ability of the available habitat to successfully hold adult and rear juvenile salmonids. The mean width:depth ratio was 15.2. This indicates increased proportion of riffles and glides that leads to reduced high flow refugia and available over-winter rearing habitats, an increased water surface area exposed to solar radiation that in turn could lead to increased stream water temperatures. Additionally, the high width to depth ratio may influence coho spawning through decreases in wetted stream areas with acceptable depths for spawning coho.

Individually, three of the 24 surveyed reaches met the NMFS criteria to be defined as “Properly Functioning” while five were “At Risk” and the remaining 18 were “Not Properly Functioning”.

A designation of “Not Properly Functioning” was assigned to stream channel conditions because of the high width:depth ratio.

OFF CHANNEL HABITAT

The quantity of off-channel habitat is cumulatively 10.2 percent of the total wetted area and is considered to be “Properly Functioning”. However, on an individual basis, only four of the 16 reaches surveyed achieve a rating of “Properly Functioning”.

WATER QUALITY

Water temperature as measured in five streams averaged 59.1 F giving an overall rating of “At Risk”. A probable cause of elevated stream temperatures is that the mean canopy closure is only 20.5 percent while 42 percent canopy coverage is required to meet shade standards (WFPB 1998) to avoid solar radiation and induced water temperature increases.

STEELHEAD

Information was reviewed from 29 surveyed reaches that were considered to support steelhead. This represented an area covering 4,352 meters of stream channel and further represents approximately 20.3 percent of the presumed steelhead habitat in the Green River and Sunday Creek WAUs. Key parameters of the steelhead habitat survey are presented in table Upper Green-9 below.

Table Upper Green-9. Examined Key Habitat Parameters for Steelhead Reaches in the Green River and Sunday Creek WAUs.

Parameter	Minimum	Maximum	Mean	SD	N=
Survey Reach Length (m)	24	300	150.1	77.7	29
BFW (m)	4.0	38.0	13.0	7.8	29
Bankfull Depth (m)	0.4	2.5	1.1	0.7	29
Gradient (%)	1.0	11.0	3.0	2.0	29
Elevation (m)	529	838	635.7	78.1	29
Pools/mile	0	134.1	40	34.5	29
Holding Pools/mile	0	48.3	8.6	11.7	29
Percent of all pools that are holding/pools per mile	0	100	29	34	26
Off-channel Habitat	0	49	9.5	15.8	18
Riparian Species 1=conifer, 2=deciduous	1	2	1.8	0.4	28
Riparian Age 1=old, 2=mature, 3=young	2	3	2.9	0.3	28
Riparian density: 1=dense, 2=sparse	2	1	1.1	0.4	28
Percent wood cover in pools	0-5%	5-10%	0-5%	N/A	18
Width/depth ratio	6.0	37.3	14.3	6.4	29
Occurrence of sand, silt, clay (%)	0	25	2.9	7.1	28
Occurrence of gravel, cobble (%)	0	100	61.5	33.5	28
Occurrence of boulder/bedrock (%)	0	100	34.2	36.3	28
Anadromous Spawning Area (%)	0	13	2	2.9	25
Percent fines	6	16	11.0	7.1	2
Temperature (F)	57.2	62.2	59.6	2.2	5
Canopy Closure (%)	0	93.0	24.0	25.3	29
Min. shade requirement (%)*	20	54	41.3	9.4	29
NMFS wood pieces/mile	0	257.6	26.6	60.3	29

* Source: WFPB 1998.

RIPARIAN HABITAT

Watershed Analysis found that the bulk of the riparian habitats that could be utilized by steelhead in the Green River and Sunday Creek WAUs are generally dense, but consist of young deciduous trees. This condition is insufficient as a new LWD supply to the stream channel and hence maintain or improve the associated habitat forming processes. This situation will likely not ameliorate until the riparian stands reach a size and age that would allow for sufficient size and number to restore instream LWD loadings to a more natural level. The riparian condition is currently considered to be “Not Properly Functioning” for steelhead in 25 of the 28 reaches surveyed and “At Risk” in the remaining three. These ratings are due to: (1) the deciduous component of trees that dominate the assessed riparian reaches for steelhead; and (2) the young age of the trees present in the riparian area. The condition of the riparian habitat is currently not sufficient in the near term to provide suitable amounts and quality of LWD to the stream channel

to maintain associated habitat and other ecological forming processes. Without large coniferous trees for recruitment and retention, the existing level of steelhead production should be expected to decline.

The mean pieces of WSA size wood (>10 centimeters diameter, >2 meters length) per channel width was 2.8. A rating of good is assigned to stream channels with at least 2.0 pieces per channel width (WFPB 1997). However, this good rating is strongly influenced by one reach in the mainstem Green River (RM85.8) where a segment long log jam contained an average of 34 pieces per channel width. In the absence of this log jam, the number of wood pieces per channel width over the surveyed habitat would be 1.7, yielding a rating of "Fair" under WSA standards. This patchy distribution of wood in the stream channel is indicated by the standard deviation of 7.0 pieces per channel width.

WSA key pieces are also below the desired target numbers, averaging only 0.03 pieces per channel width. This represents less than 20 percent of the target goal of 0.15 pieces per channel width.

When NMFS criteria are applied, only 59 pieces of wood were identified within the reaches surveyed for steelhead. This represents only 27.3 percent of the target level of 216 pieces required to be considered "Properly Functioning" by NMFS. Individually, two of the 29 reaches met NMFS wood requirement criteria. However, due to the young deciduous conditions adjacent to the stream channel, potential wood recruitment sources will be unable to maintain or improve the necessary wood loadings. This yields an overall habitat rating as "Not Properly Functioning."

SUBSTRATE

WSA indicates that spawning gravels are in short supply and inadequate for adult steelhead spawning throughout the reaches examined. Surveys indicate that a mean of 2.0 percent of the total surveyed stream channel was observed to contain potential suitable spawning substrate where the desired threshold is 10 percent. Individual reaches also reflected poor spawning gravel quality. Twenty-four of the twenty-five reaches were rated as "Not Properly Functioning" due to inadequate area of spawnable gravels. The gravel/cobble reaches category dominated 17 of the 28 reaches (60.7 percent) but contained very little gravel distributed in areas that could be utilized by spawning steelhead. Only one reach (mainstem Green River at RM 86.4) that contained 13 percent spawning gravel was considered "Properly Functioning", while the remaining reaches were all considered to be "Not Properly Functioning". Overall, the paucity of suitable spawning gravels in the reaches surveyed are a limiting factor for steelhead production and were rated as "Not Properly Functioning".

Mass wasting and hillslope erosion was determined not to be a significant contributor to the overall levels of fine sediment produced in the Green River and Sunday Creek WAUs. Secondary sediment erosion from mass wasting scarps generally was below the 50 percent of the natural background sediment input cutoff point for a moderate hazard rating designation. There was one exception, the Pioneer Creek subbasin, where the estimated sediment yield is 57 percent of the background.

POOLS

Overall, the steelhead reaches surveyed had more than the required number of pools to meet NMFS as "Properly Functioning". However, the poor quality of these pools and the inadequate stream adjacent riparian reserves strongly suggest that a lower habitat quality rating be assigned than consideration of pool frequency alone would suggest.

Of the 29 reaches surveyed, the number of pools varied considerably. Cumulatively, using pool frequencies as calculated from the pool frequency regression curve, the reaches contained 98 pools and exceeded the NMFS requirement of 90 pools. However, on an individual basis, 18 of the 29 surveyed reaches do not meet NMFS criteria for "Properly Functioning" for pool frequency and in fact would be considered as "Not Properly Functioning". However, on a system wide basis, these numerical deficiencies were almost compensated by reaches containing more pools than required. Despite the number of pools present, all of the reaches, including those that met NMFS pool criteria to be considered "Properly Functioning" are assigned an "At Risk" factor because of the inadequacy of the riparian zone to recruit LWD into the stream channel to form pools. Without LWD inputs into the stream channel it should be expected that there will be a net decrease over time of pool quality and pool numbers.

Approximately 29 percent of the pools surveyed met minimum depth requirements (>1 meter). The ability of the pools to provide cover and holding areas is further reduced by the pool in-water and overwater cover, again because of the lack of LWD. Cover in all pools was considered poor, with a mean coverage in the 0-5 percent range. Pool quality was deemed insufficient to provide suitable habitat for spring chinook as was assigned an "At Risk" rating.

CHANNEL CONDITIONS

Of the 29 surveyed reaches for steelhead, only five met the NMFS criteria for "Properly Functioning", eight can be described as "At Risk" and the remaining sixteen as "Not Properly Functioning". Reach specific and cumulative observations suggest that the stream channel has become shallow and wide. This may also be an influencing factor in decreased pool quality and adversely impacts the ability of the available habitat to successfully hold adult and rear juvenile salmonids. The mean width:depth ratio was 14.3, where a target of less than 10 is required to meet favorable channel conditions. This indicates increased proportion of riffles and glides that leads to reduced high flow refugia and available over-winter rearing habitats, an increased water surface area exposed to solar radiation that in turn could lead to increased stream water temperatures. Additionally, the high width to depth ratio may influence steelhead spawning through decreases in wetted stream areas with acceptable depths for spawning steelhead.

A designation of "Not Properly Functioning" was assigned to stream channel conditions because of the high width:depth ratio.

OFF CHANNEL HABITAT

The quantity of off-channel habitat is cumulatively 9.5 percent of the total wetted area and is considered to be "At Risk". However, on an individual basis, only four of the 18 reaches surveyed achieve a rating of "Properly Functioning". Therefore, natural production of steelhead

is considered to be limited by the lack of off-channel rearing opportunities in the Green River and Sunday Creek WAUs.

WATER QUALITY

Water temperature as measured in five streams averaged 59.6 F giving an overall rating of "At Risk" for juvenile steelhead rearing and adult summer steelhead that might be migrating, holding or spawning in these reaches. A probable cause of elevated stream temperatures is that the mean canopy closure is only 24.0 percent while 41.3 percent canopy coverage is required to meet shade standards (WFPB 1998) to avoid solar radiation and induced water temperature increases.

SUBSTRATE

The quality of spawning habitat is dictated by the abundance of spawnable gravels, adjacent cover, and riparian shade. This is in turn affected by coarse and fine sediment, large wood, riparian vegetation, and flow. Spawning gravel is considered to be "Not Properly Functioning" for any of the salmon species present. A number of factors could be contributing to this alone or collectively. This could be a result influenced by the lack of LWD that serves to trap gravels, which is at levels considered to be "Not Properly Functioning" (NMFS) or poor (WFPB). Also, the cover component in pools, important for salmonid spawning may also be limiting due to is present rating of "poor" (WFPB). Furthermore, the stream temperatures for spawning is considered to be "At Risk" (NMFS) for all species except fall chinook, in which this condition is considered to be "Not Properly Functioning" (NMFS). The influence of the riparian area is likely to contribute to the lack of large wood, elevated stream temperatures, and lack of cover. The riparian condition is considered to be "Not Properly Functioning" (NMFS) for all the aforementioned salmon species.

Fine sediment is considered to be "At Risk" for coho and steelhead. Fine sediment can inhibit redd excavation and incubation, as noted previously. Fine sediment does not currently limit fall and spring chinook spawning, in which this metric is considered to be Properly Functioning (NMFS).

Mass wasting and hillslope erosion was determined not to be a significant contributor to the overall levels of fine sediment produced in the Green River and Sunday Creek WAUs. Secondary sediment erosion from mass wasting scarps generally was below the 50 percent of the natural background sediment input cutoff point for a moderate hazard rating designation. There was one exception, the Pioneer Creek subbasin, where the estimated sediment yield is 57 percent of the background.

SUMMARY

In summary, anadromous salmonid spawning habitat is limited by 1) the lack of suitable spawning gravels, 2) the lack of cover in pools, and 3) at times by elevated water temperatures. These components are influenced by the loss of LWD, which is lacking in the system, a poor riparian condition, which is also "Not Properly Functioning" condition, and fine sediment for coho and steelhead spawning habitat, which is considered to be "At Risk".

Summer rearing habitat requires the use of large deep pools and off-channel areas that provide adequate water flow, ample cover, cool water temperatures, optimal feeding opportunities, inter- and intra- species interaction, and opportunities, depending on needs, to hold in slow or fast moving water. The factors that influence summer-rearing habitat are channel form, gradient, small and large in-stream wood, canopy closure, and food input. Riparian vegetation and in-stream wood provide cover and channel complexity during this phase. Pool area and pool quality, large wood, cover in pools, and riparian vegetation are considered to be "Not Properly Functioning" for coho, steelhead, fall and spring chinook, and thus are likely to limit summer rearing opportunities and success.

Winter rearing areas provide stable and non-turbid stream flow during storm events. This habitat also must provide adequate flow, cover, and temperatures that facilitate metabolic conservation. The majority of the confined streams in the Upper Green River and Sunday Creek WAUs have only limited ability to form off-channel and wetland areas due to their confinement by road and railway grades. In the absence of side channels, salmonids typically are forced to over-winter in the substrate and under the protection of wood. Off-channel habitat is in short supply for coho and steelhead, and considered to be "At Risk"; however, this habitat is considered to be "Properly Functioning" for fall and spring chinook (NMFS).

The "At Risk" condition of winter-rearing habitat for coho and steelhead in the upper Green and Sunday Creek WAUs is likely caused by several factors. When LWD abundance is compared to NMFS criteria the large logs that contribute to off-channel habitat formation are in short supply and thus are likely to limit winter rearing. The riparian canopy, which helps to maintain ambient stream temperatures at night, is also in a "Not Properly Functioning" condition (NMFS). Interstitial substrate is adversely affected by overloading the stream with fine sediment, as indicated by the "At Risk" rating for fine sediment (NMFS), which reduces the available winter rearing habitat.

To summarize, winter-rearing habitat is limited for coho and steelhead in the Green and Sunday Creek WAUs. The lack of LWD is likely a limiting factor that contributes to the formation of these habitats. The quality of winter-rearing habitat is also reduced by the inadequate riparian condition, the elevated levels of fine sediment, and the lack of cover in pools.

Cover is an important component for juvenile salmonid migration, as is a normal temperature regime. LWD, which helps to provide cover to protect salmonids from predators, direct sunlight, and high water temperatures, is in short supply for all the species considered in this analysis (NMFS). The riparian vegetation, which provides shade and cover to the stream, is also considered to be lacking (NMFS). The elevated stream temperatures for migration, considered to be "At Risk", are an indication that the riparian canopy is insufficient to provide the necessary habitat for this life history.

To summarize, the paucity of LWD necessary for adequate cover, lack of suitable riparian areas to product shade, and the elevated stream temperatures may be factors that limit successful juvenile salmonid migration in the Upper Green and Sunday Creek WAUs.

KEY FINDINGS AND IDENTIFIED HABITAT-LIMITING FACTORS

- The Watershed Analysis indicates the riparian habitat is insufficient in the near term to meet the needs of habitat forming processes throughout the study area.

- LWD, low gravel sediment levels, canopy cover, the poor riparian habitat zone and pool quantity and quality are all considered limiting factors to natural salmonid production in the study area.

DATA GAPS

- Comprehensive barrier surveys need to be completed in this subbasin.

LIST OF TABLES