



Final

**Green River
Large Woody Debris Monitoring
2005 Data Report**

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EXECUTIVE SUMMARY

Tacoma Public Utilities is monitoring reach scale trends in both the number and distribution of large woody debris (LWD) in the middle mainstem Green River as part of the Green River Watershed Habitat Conservation Plan (HCP), and the Howard Hanson Dam, Additional Water Storage Project (AWSP). The mainstem Green River monitoring is intended to track long-term reach scale trends in habitat conditions. This report describes the results of the August 2005 survey of LWD in the mainstem Green River and compares those results to results of the baseline monitoring study completed in August and September 2001.

To ensure consistency between the 2001 and 2005 LWD surveys, LWD was surveyed using methods described in the August 2002 Green River Baseline Habitat Monitoring Report (R2 2002). Data from the 2005 survey was compared to baseline survey data to document changes in the quantity, type, channel location, and reach distribution of LWD in the middle mainstem Green River. The 2005 LWD survey encompassed the area from Tacoma Headworks at River Mile (RM) 61.0 to the Highway 18 Bridge crossing at approximately RM 33.8. This survey area is somewhat shorter than the 2001 survey in response to a request by Tacoma Public Utilities to eliminate Reach 1 (Howard Hanson Dam to Tacoma Headworks) from the survey. In addition, a channel-spanning log jam had formed just downstream of the Highway 18 Bridge crossing preventing access to the reach below RM 33.8. With the previously mentioned exceptions, the 2005 study reach breaks were the same as those established in 2001.

Reach 2: RM 61.5 (Tacoma Headworks) to RM 57 (Kanasket State Park)

Reach 3: RM 57 (Kanasket State Park) to RM 45 (Flaming Geyser State Park)

Reach 4: RM 45 (Flaming Geyser State Park) to RM 40.8 (Newaukum Creek)

Reach 5: RM 40.8 (Newaukum Creek) to RM 38 (Loans Levee)

Reach 6: RM 38 (Loans Levee) to RM 33.8 (Highway 18 Bridge) (previously RM 38 to RM 32).

To determine if LWD had been added to the middle mainstem Green River as part of restoration or enhancement activities since the 2001 LWD survey, resource managers and biologist at five regional agencies were contacted to obtain information on LWD placement within the middle mainstem Green River. The agencies contacted included: U.S. Army Corp of Engineers (USACE), U.S. Fish and Wildlife Service, National Marine Fisheries Service, King County, and

the Muckleshoot Indian Tribe. Only one of the five agencies contacted (USACE) reported placement of LWD within the middle mainstem Green River since the 2001 survey. These activities included the establishment of two engineered log jams, each containing 80-90 pieces of LWD, at RM 60 and the placement of three individual pieces within the same general area as part of mainstem Green River restoration efforts. A small number of LWD pieces associated with this effort have been transported downstream during high flow events. Special attention was given to identifying the location of these pieces during the survey.

The quantity of individual LWD pieces and jams increased substantially between the 2001 and 2005 surveys of LWD in the middle mainstem Green River. Even though the 2001 survey reach was 1.8 miles longer than the 2005 survey reach, the total number of LWD pieces (including medium and large logs, key-sized pieces, and rootwads) increased over sixty-five percent from 434 pieces in 2001 to 719 pieces in 2005. When converted to LWD pieces per mile, the density of LWD nearly doubled from 14.7 pieces per mile in 2001 to 26 pieces per mile in 2005. The total number of key-sized pieces also increased from the 2001 to 2005 surveys from 23 to 34 pieces, respectively. The number of rootwads also increased, from 42 in 2001 to 72 in 2005.

The total number of LWD jams increased from 24 jams counted in 2001 to 78 in 2005. The composition of small, medium, and large jams was also very different between the two surveys. Although there were significant increases in the number of jams within all three size categories, the largest increase occurred in the number of medium jams which increased from 1 in the 2001 survey to 13 in the 2005 survey. The number of jams per mile showed a corresponding increase from 0.8 jams per mile in 2001 to 2.8 jams per mile in 2005.

Although the number of LWD pieces has increased considerably since the 2001 survey, when converted to an annual recruitment rate, the increase is somewhat lower than expected. Assuming uniform recruitment of LWD to the middle mainstem Green River since the 2001 survey, the annual rate of recruitment for the entire study length (27.7 miles) was 2.6 pieces of LWD¹ per mile. When calculated on a reach scale, the annual recruitment rate ranged from a high of 3.9 pieces per mile in Reach 3 to a low of 1.2 pieces per mile in Reach 6. This rate of annual LWD recruitment is considerably less than the range of recruitment reported by Benda and Sias (1998). They estimated that the annual recruitment of LWD to streams from fires, mortality, bank erosion, landslides, and decay was approximately 16 LWD pieces per mile.

¹ Includes medium and large logs, key-sized pieces, and rootwads. Note: 2001 survey length was 1.8 miles longer than 2005 survey length.

There are several possible explanations for the increase in the number of LWD pieces and log jams in the middle mainstem Green River between the 2001 and 2005 surveys including restoration efforts, natural recruitment, and differences in survey methods. A brief discussion of each of these is presented below:

- Restoration and enhancement efforts in the middle mainstem Green River have been confined to Reach 2 (near RM 60) and have included the addition of two medium-sized log jams and three individual logs. These additions represent approximately four percent of the total increase in LWD jams and one percent of the increase in the number of LWD pieces.
- Although no effort was made to determine the number of LWD pieces recruited to the middle mainstem Green River by any specific natural recruitment mechanisms (e.g., mass wasting, windthrow, bank cutting, channel avulsion, downstream transport), anecdotal evidence suggest that LWD is recruited to the channel by each of these mechanisms. High flow events, associated with large storms, may increase LWD recruitment by as much as ten times over the annual input rate. Although large storm events have occurred since the 2001 survey, peak flow events have been similar or slightly lower than peak flows in the preceding ten years.
- The 2001 survey of middle mainstem Green River focused on assessment of baseline habitat conditions in the mainstem river and did not include side channel areas. Side channels were included as part of the 2005 LWD survey. Although the survey methods used during the 2005 LWD survey did not include a system for coding or identification of LWD pieces and/or log jams found within side channel areas, supplemental notes recorded for Reach 5 identified 30 individual LWD pieces and 4 jams in one large side channel. This represented 27 percent of the LWD and 18 percent of the LWD jams located in Reach 5.

1. INTRODUCTION

This report presents the results of the second in a series reach scale monitoring survey of large woody debris (LWD) in the middle mainstem Green River conducted by Tacoma Public Utilities as part of the Green River Watershed Habitat Conservation Plan (HCP), and the Howard Hanson Dam Additional Water Storage Project (AWSP). The monitoring program is being conducted to track reach scale trends in habitat conditions of which LWD is one component. Documenting the number and distribution of LWD over the entire study reach provides a means to evaluate whether restoration programs implemented as part of the HCP (RFM03A Monitoring Funding) and AWSP are achieving the desired goals.

Baseline monitoring of the middle mainstem Green River was initiated in August 2001. The results of the baseline monitoring are presented in the August 2002 report titled “Green River Baseline Habitat Monitoring: 2001 Data Report” (R2 2002). A follow up survey was conducted in 2005 to compare to baseline survey data and document changes in the quantity, type, channel location, and reach distribution of LWD in the middle mainstem Green River.

This report summarizes the results of the LWD monitoring in the middle mainstem Green River in August 2005. The report is organized into five sections, including this Introduction in Section 1. Section 2 provides a brief description of the study area and Section 3 presents field methods used to conduct the LWD surveys. The results of the 2005 survey and a comparison with data collected during the 2001 survey are presented in Section 4. Section 5 presents a summary of conclusions and Section 6 provides recommendations for future LWD monitoring activities. Appendices A-D contain Report of Contact forms, copies of field data sheets, data analysis, and quality assurance spreadsheets.

2. ENVIRONMENTAL SETTING

2.1 STUDY AREA

The 2005 LWD survey extended from Tacoma Headworks at RM 61.5 downstream to the Highway 18 Bridge crossing at approximately RM 33.8 (Figure 2-1). This survey length is somewhat shorter than the 2001 survey which encompassed the reach from Howard Hanson Dam at RM 64.5 to the Auburn Narrows at RM 32. The reach (Reach 1) from Howard Hanson Dam to the Tacoma Headworks was excluded from the 2005 survey at the request of Tacoma Public Utilities (Paul Hickey, Tacoma Public Utilities, July 21, 2005). The 2005 survey ended at the Highway 18 Bridge crossing due to limited river access points and the presence of a large debris jam that blocks river passage just downstream of the Highway 18 Bridge (RM 33).

The five reaches sampled as part of this effort included:

Reach 2: RM 61.5 (Tacoma Headworks) to RM 57 (Kanasket State Park)

Reach 3: RM 57 (Kanasket State Park) to RM 45 (Flaming Geyser State Park)

Reach 4: RM 45 (Flaming Geyser State Park) to RM 40.8 (Newaukum Creek)

Reach 5: RM 40.8 (Newaukum Creek) to RM 38 (Loans Levee)

Reach 6: RM 38 (Loans Levee) to RM 33.8 (Highway 18 Bridge) (previously RM 38 to RM 32 Auburn Narrows)

These reaches were delineated as part of the 2001 baseline habitat monitoring (R2, 2002). Each reach is defined as a length of channel with relatively consistent channel morphology (gradient, confinement, planform, flow, bedform, and substrate). With the noted exceptions, the reach designations developed as part of the 2001 monitoring survey were used in the 2005 survey to ensure consistent comparison of results between surveys.

2.2 PHYSICAL ENVIRONMENT

A detailed description of the environment setting and fisheries resources of the middle mainstem Green River was presented in the baseline monitoring report (R2, 2002) and will not be repeated here.

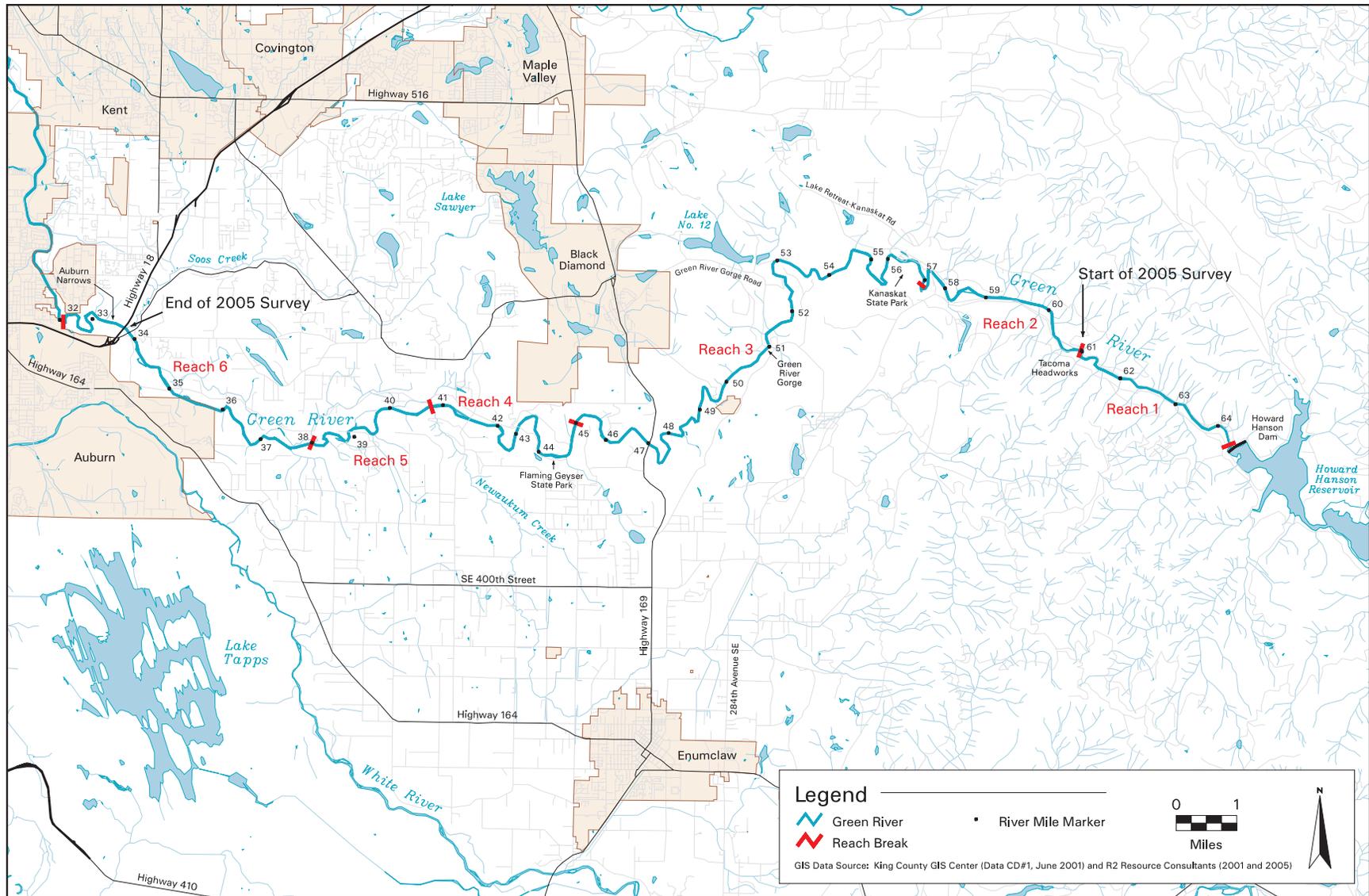


Figure 2-1. Middle Green River LWD monitoring area.

3. METHODS

3.1 MONITORING OVERVIEW

Stream system health can be monitored through the systematic collection of data on environmental parameters that are linked to beneficial uses and known to be sensitive to land management activities and natural events (Spence et al. 1996). Monitoring changes in habitat conditions that result from restoration is one of the primary goals of the Green River Habitat Restoration Evaluation Program. Reach scale monitoring is important for detecting the effects of programmatic mitigation and restoration measures (e.g., flow management, gravel nourishment, LWD placement). Reach scale monitoring is also needed to evaluate overall changes in habitat conditions resulting from integrated implementation of multiple projects. The specific objective of the LWD monitoring described in this report is to assess current conditions and evaluate the long term trend in LWD quantity and distribution within the middle mainstem Green River.

3.2 PROJECT APPROACH

3.2.1 Agency Contacts

To determine if LWD had been added to the middle mainstem Green River as part of restoration or enhancement activities since the 2001 LWD survey, resource specialist from tribal, state, federal, and local resource agencies were contacted via telephone and queried regarding past and potential future LWD placement. Information obtained during each telephone interview was summarized on Report of Contact forms (Appendix A).

3.2.2 LWD Monitoring

To ensure consistency between the 2001 and 2005 LWD surveys, large woody debris was surveyed using methods described in the August 2002 Green River Baseline Habitat Monitoring Report (R2 2002). The LWD survey methods described in the 2002 monitoring report were based on a modified version of the Level 1 protocol² outlined in the TFW Method Manual for LWD Survey (Schuett-Hames et al. 1999a). Only wood located wholly or partially within Zone 1 (wetted channel) or Zone 2 (bankfull channel) was counted (Figure 3-1). A piece of wood

² The TFW manual (Schuett-Hames et al. 1999) describes two levels of survey intensity. Level 1 surveys are appropriate for extensive reach-scale efforts. Intensive Level 2 surveys are most appropriate for short survey segments and best suited for site-specific monitoring.

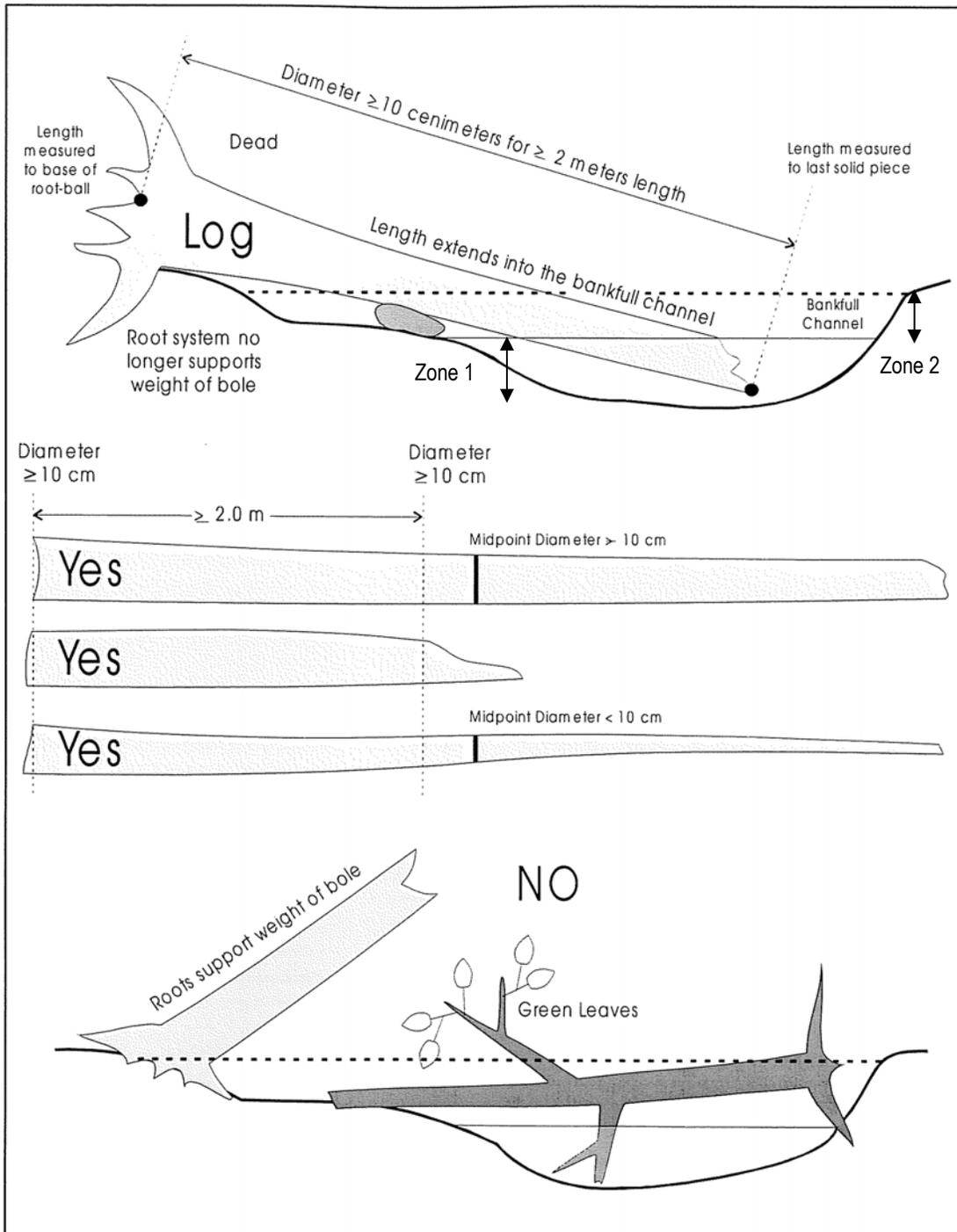


Figure 3-1. Criteria for identification of individual log utilized in 2001 and 2005 monitoring surveys of the mainstem middle Green River, King County, Washington (after Schuett-Hames et al. 1999a).

must be a least 4 inches (10 cm) in diameter and 12 feet (3.65 m) long to count as a piece of LWD, and a debris jam must contain 10 pieces of LWD to count as a debris jam. Debris jams were categorized by size as follows: 10 to 50 pieces, small; 50 to 100 pieces, medium; and greater than 100 pieces, large. The location of all large-sized LWD jams and most small and medium-sized jams were marked on aerial photographs.

Individual pieces of LWD with a diameter smaller than 12 inches (30.5 cm) and a length of less than 30 feet (9.1 m) were counted only when they occurred as part of a qualifying debris jam. Small individual pieces of wood that are not incorporated into a jam are unlikely to remain stable in the channel or influence channel morphology. Single pieces of LWD were tallied by size class as follows: diameter 12 inches (30.5 cm) to 20 inches (50 cm), medium log; diameter greater than or equal to 20 inches (50 cm) but less than 33.5 inches (85 cm), large log; diameter greater than or equal to 33.5 inches (85 cm), key piece.³ The count of wood further noted whether individual pieces of wood that are not part of a debris jam were cut and whether they had an attached rootball or not. To qualify as a rootball, the size of the rootmass must be a minimum of 4 feet (1.2 m) in diameter. Criteria used to identify qualifying individual pieces of LWD are depicted in Figure 3-1.

One significant difference between the 2001 and 2005 surveys methods was the decision to include side channel areas in the 2005 survey. The 2001 survey focused solely on mainstem habitat attributes and so side channels were not included. Side channels were included in the 2005 survey to ensure a thorough count of all LWD within the middle mainstem Green River and for long-term monitoring needs.

An initial attempt was made to identify the habitat unit that each individual piece of LWD was located within, but that effort was abandoned due to several factors including the number of LWD pieces encountered, changes in channel morphology, limitations in map and aerial photograph resolution, and difficulties in determining the exact start and end of individual habitat units. A tally of LWD by size class/type and channel zone location was recorded on field forms for each of the five surveyed reaches.

³ Perkins (1999) estimated that the minimum size of a key piece of LWD in the mainstem Green River is 85 cm in diameter and at least 10 meters long.

3.2.3 Quality Assurance/Quality Control

The quality assurance quality control (QA/QC) program is a critical part of a successful monitoring project. For the mainstem Green River Habitat Monitoring Program, QA/QC measures were implemented at a variety of levels.

Equipment Calibration and Gear

Field equipment used to measure LWD attributes was checked for damage and calibration at the beginning and end of field work. Measuring tapes and calipers were checked by comparing them to a new survey grade open reel tape.

LWD Calibration

To ensure consistent estimates of LWD size and channel location calls, team members estimated and then measured over 40 pieces of LWD. Estimated and measured LWD dimensions were recorded on field data forms.

Data Entry Check

All data forms, field books, and calculations were reviewed for errors and discrepancies following the end of field surveys. Questionable data points were corrected or eliminated from the analysis. Data was entered into MS EXCEL spreadsheets then cross-checked against the original field forms by a second person who had also been involved in the field work. The date and initials of the individual responsible for the original data entry and the data review were recorded both on the original field notes and in the electronic files.

3.3 DATA ANALYSIS

Data analyses were conducted using MS EXCEL and ArcInfo GIS tools. Simple statistics and charts describing 2005 LWD quantity and distribution and comparisons with 2001 survey results were generated for each reach. The GIS basemap constructed as part of the 2001 survey, was updated with new LWD jam locations and is available by request.

4. RESULTS

This section presents the results of agency contacts, reach specific LWD counts, and comparison of the 2001 and 2005 surveys. Comparison of results from the 2001 and 2005 LWD surveys should be made with caution as side channels were not included as part of the 2001 survey but were surveyed during the 2005 survey. No attempt was made to distinguish LWD located within side channel areas from LWD found within the main channel.⁴

4.1 AGENCY CONTACTS

Resource managers and biologist at five regional agencies were contacted to obtain information on LWD placement within the middle mainstem Green River. The agencies contacted were the USACE, U.S. Fish and Wildlife Service, King County, National Marine Fisheries Service, and the Muckleshoot Indian Tribe. Report of Contact forms were completed for each agency contact to document the specifics of each telephone interview (Appendix A). Of the agencies contacted, only the USACE (Scott Pozarycki, USACE) had participated in the placement of LWD within the middle mainstem Green River since the 2001 LWD survey. Section 4.2 of this report presents a detailed description of the location and quantity of LWD placed in the river as part of USACE activities.

4.2 REACH 2

Reach 2 was surveyed on August 2, 2005. The reach is approximately 4.5 miles long extending from Tacoma Headworks (RM 61) to Kanasket State Park (RM 57) (Figure 4-1). The flow at the time of the survey was 175 cubic feet per second (cfs) as measured at the Palmer, Washington stream gage.

Reach 2 was the only reach of the five surveyed that had experienced placement of LWD since the 2001 survey. In August of 2003, the U.S. Army Corp of Engineers (USACE) in cooperation with the City of Tacoma constructed two bar apex type engineered log jams (Zone 1 Project) at RM 60, about three miles upstream from Kanasket-Palmer State Park (USACE, 2003). Jam ELJ1 contained 81 pieces of LWD and jam ELJ2 contained 88 pieces. Individual pieces placed within the jam ranged from 50-60 feet long and had a diameter at breast height (dbh) ranging from 48 to less than 24 inches (Scott Pozarycki, USACE, personal communication to Mike

⁴ Individual LWD pieces and jams located within the large side channel at RM 40 were given a unique code when entered into the field notes.

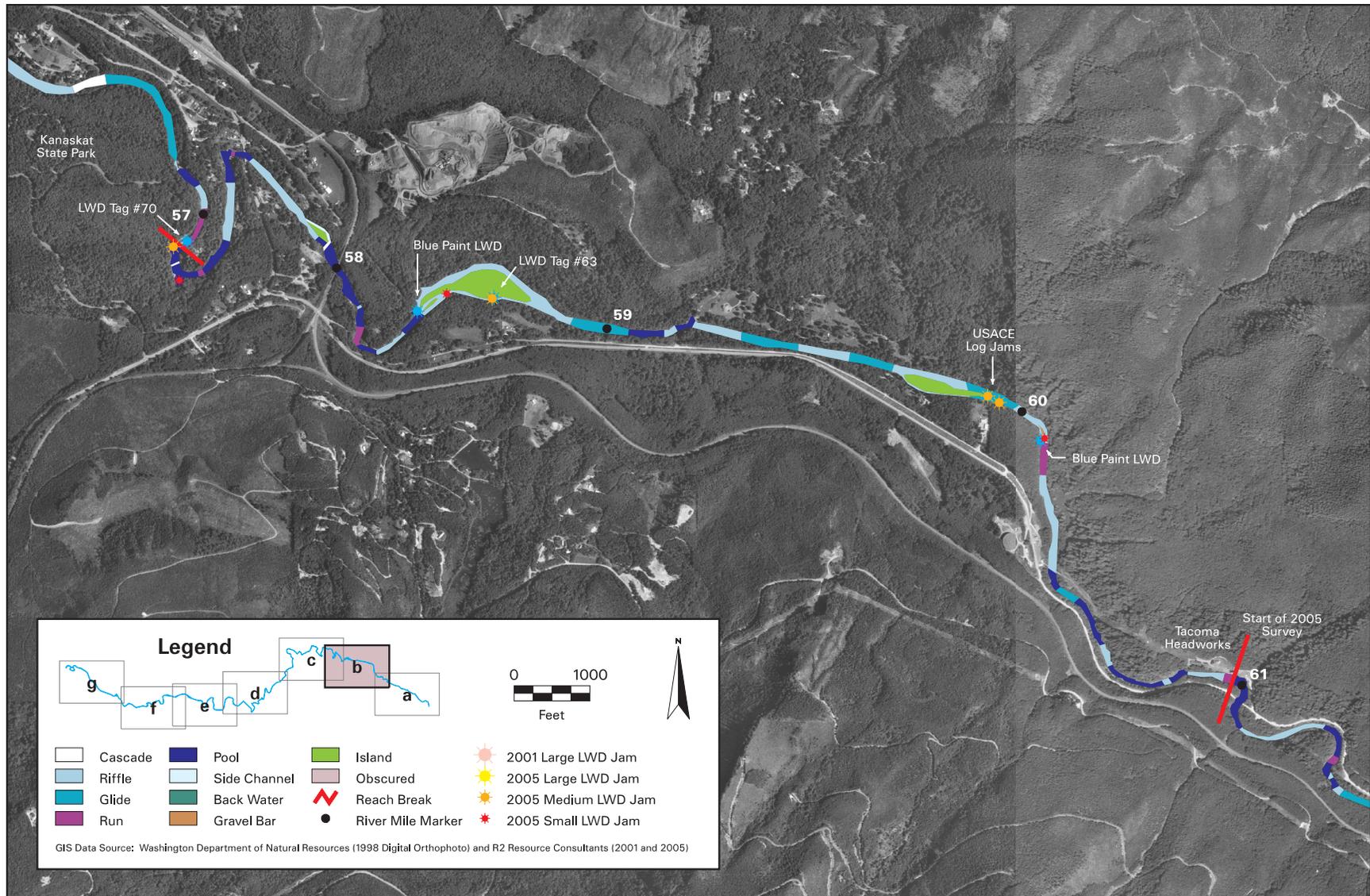


Figure 4-1. Middle Green River LWD Survey Reach 2 (Map b).

Gagner, R2, July 7, 2005). The USACE had numbered each individual piece of LWD included in the jams with a small metal tag attached near one end. Additionally, in late August 2004, the USACE placed three individual logs (20-24 in dbh & ~30 ft long) on a gravel nourishment site located at the same location (RM 60) as the engineered log jams (Scott Pozarycki, USACE, personal communication to Mike Gagner, R2, July 7, 2005). One end of each of these logs was painted blue at the time of placement to assist with future identification.

Eighty-three individual pieces of LWD and rootwads, including six key-sized pieces, were identified during the 2005 survey of Reach 2 (Table 4-1). Medium and large-sized logs comprised over 85 percent of the total LWD counted within Reach 2 and were nearly equally distributed between channel Zones 1 and 2. One medium sized piece with Tag # 63 was located at approximately RM 58.5 (Figure 4-1). Two medium size pieces marked with blue paint were identified during an August 2005 survey of the reach conducted by the USACE (Scott Pozarycki, USACE, personal communication to Mike Gagner, R2, October, 2005) (Figure 4-1). All but one of the key-sized piece logs were located within Zone 1, while only one of the six rootwads were located in Zone 1 (Table 4-1). All five of the LWD jams identified within the reach were located within Zone 1. Three of the five jams were classified as small and the remaining two were medium jams. Both of the medium jams had been constructed as part of the Green River Habitat Restoration Evaluation Program (Scott Pozarycki, USACE, personal communication to Mike Gagner, R2, July 7, 2005). Six of the 71 medium and large-sized logs appeared to have been cut (Table 4-1).

Comparison of summary statistics for the 2001 and 2005 LWD surveys of Reach 2 are presented in Table 4-2. Appendix C contains a comparison of LWD counts by channel zone for the 2001 and 2005 surveys. The total number of individual LWD pieces (including medium, large, key piece and rootwads) identified within Reach 2 more than doubled from the 2001 to 2005 surveys. The additional LWD pieces were nearly equally distributed between channel Zones 1 and 2 with 21 and 26 pieces, respectively. The percentage of total LWD pieces with cut ends went from zero in 2001 to just over seven percent in 2005. The number of key-size pieces of LWD increased three fold between the surveys from two pieces in 2001 to six in 2005. Five new LWD jams were identified during the 2005 survey. Sixty percent of the jams were classified as small and the remaining 40 percent were medium size.

Table 4-1. Large woody debris frequency by type and channel location in Reach 2, middle mainstem Green River, King County, Washington, 2005.

	Channel Zone		Total	Cut
	1	2		
Log-Medium	14	14	28	3
Log-Medium with Rootwad	13	13	26	1
Log-Large	5	6	11	1
Log-Large with Rootwad	4	2	6	1
Key Piece	4	1	5	
Key Piece with Rootwad	1	0	1	
Rootwad	1	5	6	
Total	42	41	83	6
Small Jam	3	0	3	
Medium Jam	2	0	2	
Large Jam	0	0	0	

Table 4-2. Comparison of summary statistics for the 2001 and 2005 middle mainstem Green River LWD surveys, Reach 2 (RM 61.5, Tacoma Headworks to RM 57, Kanasket State Park).

	Survey Year	
	2001	2005
Survey Length	4.5 miles	4.5 miles
Flow @ Palmer, WA	133 cfs	175 cfs
Flow @ Auburn, WA	405 cfs	296 cfs
Total LWD ¹	36	83
Number of LWD ¹ – Zone 1	21	42
Number of LWD ¹ – Zone 2	15	41
LWD ¹ per Mile	8.0	18.4
Percent Cut LWD	0%	7.2%
Total Number Key LWD	2	6
Key Pieces per Mile	0.44	1.3
Total Number of LWD Jams	0	5
Percent Small Jams	0%	60%
Percent Medium Jams	0%	40%
Percent Large Jams	0%	0%

¹Includes medium and large logs, key pieces, and rootwads.

4.3 REACH 3

Reach 3 was surveyed on August 1 and 2, 2005. The reach is approximately 12 miles long extending from Kanasket State Park (RM 57) to Flaming Geyser State Park (RM 45) (Figures 4-2 and 4-3). The average stream flow during the survey was 176 cfs as measured at the Palmer, Washington stream gage.

Three hundred and fifty-two individual pieces of LWD and rootwads, including 23 key-sized pieces, were identified during the 2005 survey of Reach 3 (Table 4-3). Medium and large-sized logs comprised over 86 percent of the total LWD counted within Reach 3 and were nearly equally distributed between channel Zones 1 and 2. One medium sized piece with Tag # 70 was located at approximately RM 57.1 (Figure 4-1). Twenty-three key-sized piece logs were located in the reach and were also nearly equally distributed between the two channel zones (Table 4-3). The distribution of the 24 rootwads found in the reach was somewhat different with approximately two-thirds of the pieces found in Zone 2. A total of 29 log jams were identified in the reach (Table 4-3). Twenty-five of the total number of jams were classified as small. There were no large jams observed in Reach 3. Nearly 70 percent of the identified jams were located in channel Zone 1.

Table 4-3. Large woody debris count by type and channel location in Reach 3, middle mainstem Green River, King County, Washington, 2005.

	Channel Zone		Total	Cut
	1	2		
Log-Medium	71	82	153	2
Log-Medium with Rootwad	39	42	81	3
Log-Large	20	16	36	
Log-Large with Rootwad	16	19	35	2
Key Piece	7	10	17	
Key Piece with Rootwad	5	1	6	
Rootwad	9	15	24	
Total	167	185	352	7
Small Jam	16	9	25	
Medium Jam	4	0	4	
Large Jam	0	0	0	

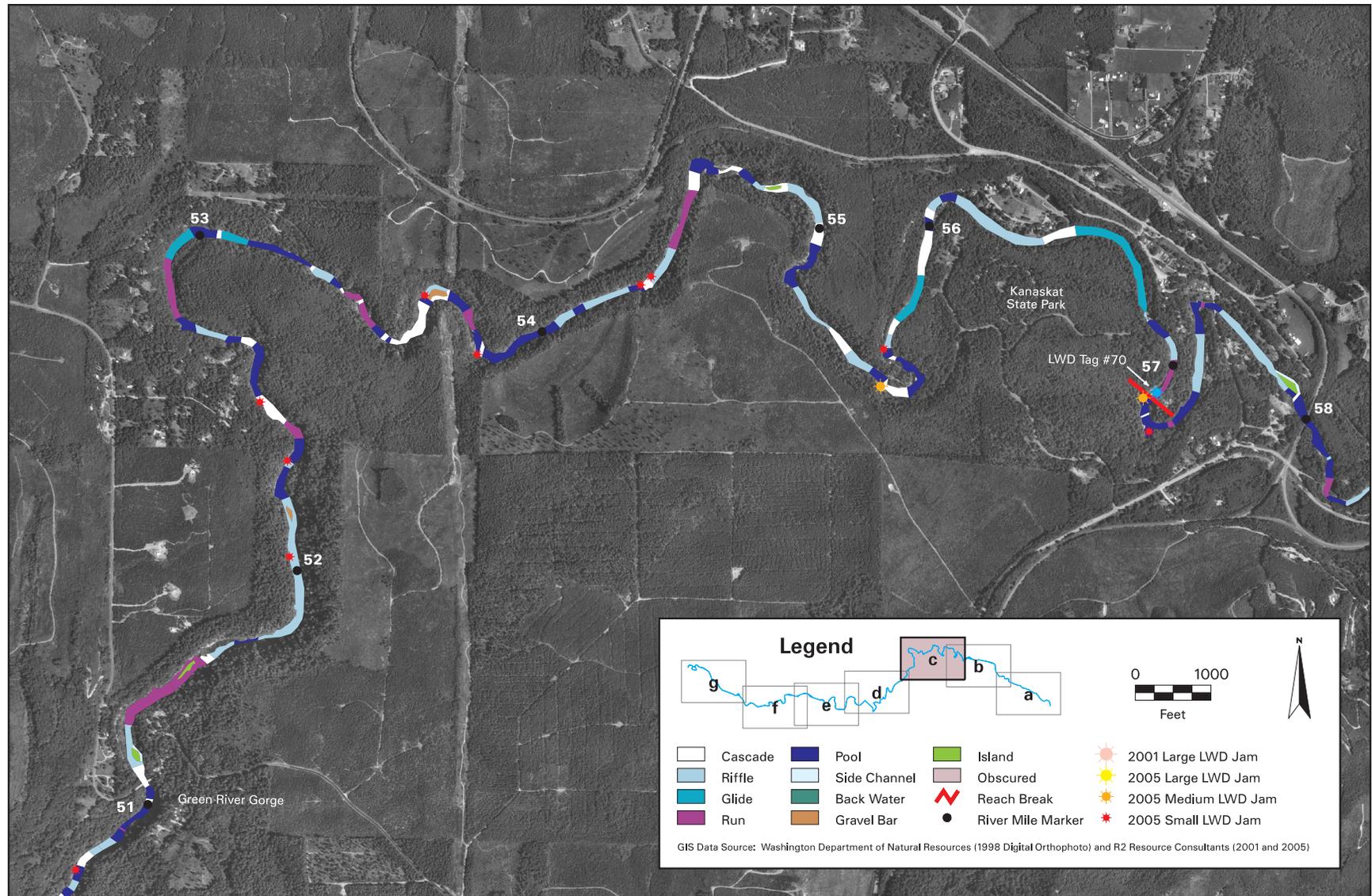


Figure 4-2. Middle Green River LWD Survey Reach 3 (Map c).

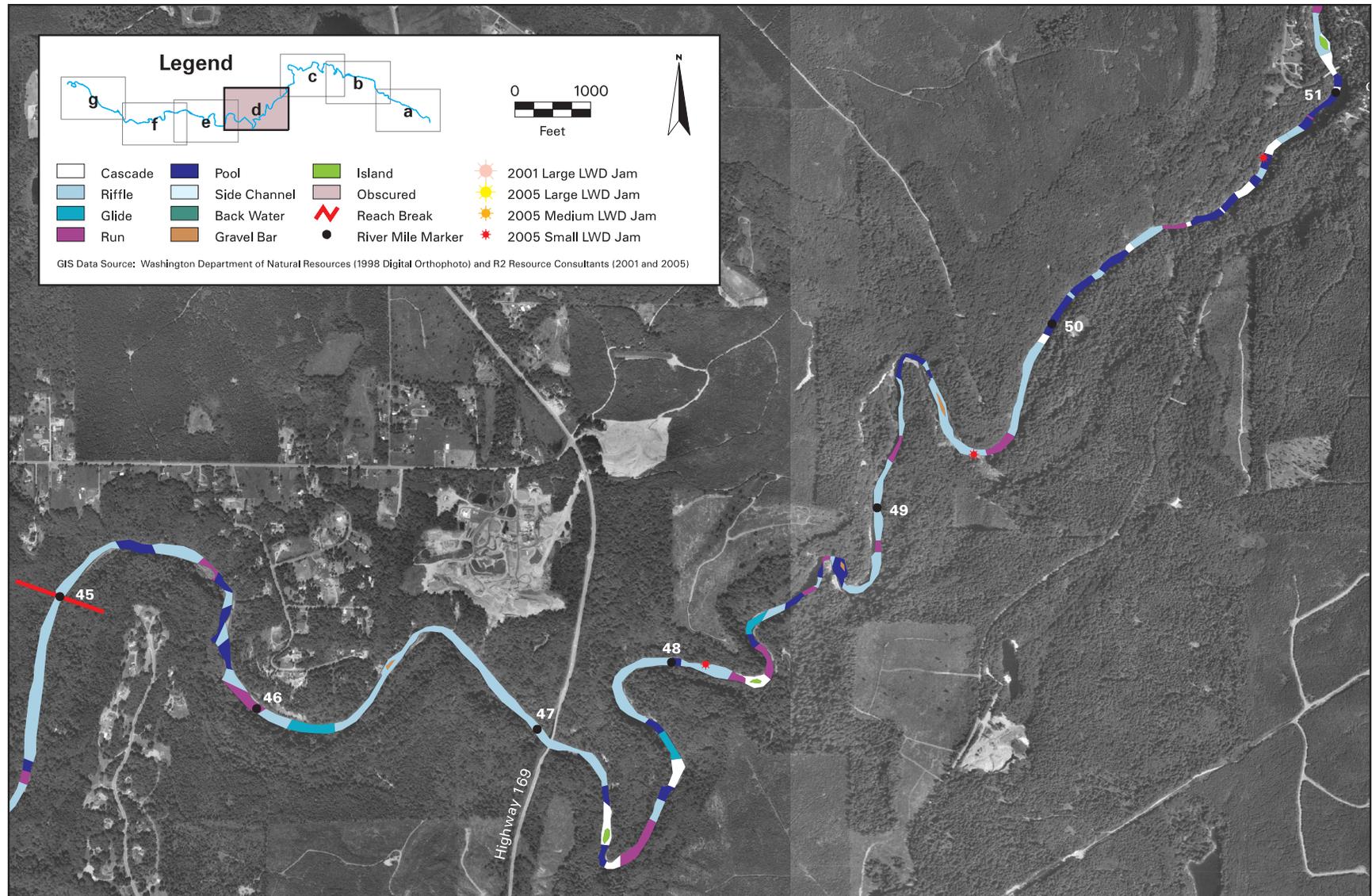


Figure 4-3. Middle Green River LWD Survey Reach 3 (Map d).

Reach 3 experienced the largest increase in both the number of LWD pieces and LWD jams between the 2001 and 2005 surveys. Comparison of summary statistics for the 2001 and 2005 LWD surveys of Reach 3 are presented in Table 4-4. Appendix C contains a comparison of LWD counts by channel zone for the 2001 and 2005 surveys. The total number of individual LWD pieces (including medium, large, key piece and rootwads) identified within Reach 3 more than doubled from 164 in 2001 to 352 in 2005. The distribution of LWD within the channel shifted slightly between the two surveys, with just over fifty-seven percent of the wood found in Zone 1 during the 2001 survey, dropping to 47 percent in Zone 1 for the 2005 survey. The number of LWD pieces with cut ends dropped from 10 in 2001 to 7 in 2005. The number of key-size pieces of LWD doubled between the surveys from 11 pieces in 2001 to 23 in 2005. The channel zone distribution of key-size pieces was relatively unchanged between the two surveys with approximately a fifty-fifty split in the number of pieces located in Zones 1 and 2. Twenty-one new LWD jams were identified during the 2005 survey. During the 2001 survey, small jams comprised 100 percent of the LWD jams present. For the 2005 survey, the percentage of changed slightly with 86 percent small jams and 14 percent medium jams.

Table 4-4. Comparison of summary statistics for the 2001 and 2005 middle mainstem Green River LWD surveys, Reach 3 (RM 57, Kanasket State Park to RM 45, Flaming Geyser State Park).

	Survey Year	
	2001	2005
Survey Length	12 miles	12 miles
Flow @ Palmer, WA	120 cfs	176 cfs
Flow @ Auburn, WA	259-360 cfs	304 cfs
Total LWD ¹	164	352
Number of LWD ¹ – Zone 1	94	167
Number of LWD ¹ – Zone 2	70	185
LWD ¹ per Mile	13.6	29.4
Percent Cut LWD	7%	2%
Total Number Key LWD	11	23
Key Pieces per Mile	0.9	1.9
Total Number of LWD Jams	8	29
Percent Small Jams	100%	86%
Percent Medium Jams	0%	14%
Percent Large Jams	0%	0%

¹Includes medium and large logs, key pieces, and rootwads.

4.4 REACH 4

Reach 4 was surveyed on August 3, 2005. The reach is approximately 4.2 miles long extending from Flaming Geyser State Park (RM 45) to Newaukum Creek (RM 40.8) (Figure 4-4). The average stream flow during the survey was 292 cfs as measured at the Auburn, Washington stream gage.

Reach 4 contained the fewest LWD pieces of the six survey reaches. Sixty-one individual pieces of LWD and rootwads, including one key-sized piece, were identified during the 2005 survey of Reach 4 (Table 4-5). Medium and large-sized logs comprised over 93 percent of the total LWD counted within Reach 4 with approximately 60 percent of the pieces located within channel Zone 1. Only one key-sized piece logs was located in the reach and it was located within channel Zones 1 (Table 4-5). The distribution of the four rootwads found in the reach was equally split between Zones 1 and 2. A total of ten log jams were identified in Reach 4 (Table 4-5). Seven of the ten jams were classified as small with the remaining three falling into the medium category. Sixty percent of the identified jams were located in channel Zone 2.

Table 4-5. Large woody debris count by type and channel location in Reach 4, middle mainstem Green River, King County, Washington, 2005.

	Channel Zone		Total	Cut
	1	2		
Log-Medium	16	15	31	
Log-Medium with Rootwad	12	8	20	
Log-Large	3	1	4	
Log-Large with Rootwad	1	0	1	
Key Piece	1	0	1	
Key Piece with Rootwad	0	0	0	
Rootwad	2	2	4	
Total	35	26	61	0
Small Jam	4	3	7	
Medium Jam	0	3	3	
Large Jam	0	0	0	

Comparison of summary statistics for the 2001 and 2005 LWD surveys of Reach 4 are presented in Table 4-6. Appendix C contains a comparison of LWD counts by channel zone for the 2001 and 2005 surveys. The total number of individual LWD pieces (including medium, large, key piece and rootwads) identified within Reach 4 nearly doubled from 33 in 2001 to 61 in 2005.

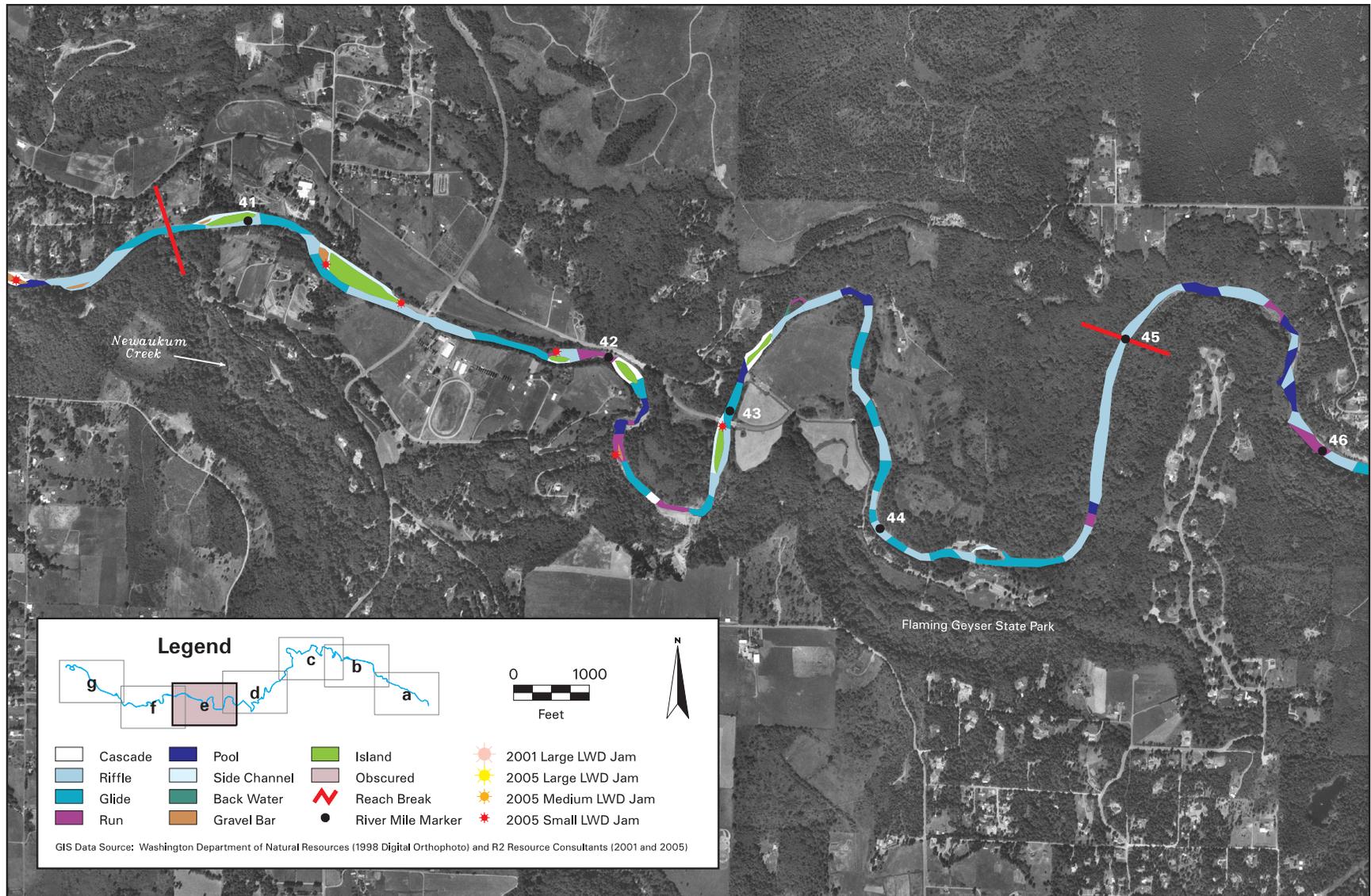


Figure 4-4. Middle Green River LWD Survey Reach 4 (Map e).

The distribution of LWD within the channel shifted dramatically between the two surveys, with over 80 percent of the wood found in Zone 1 during the 2001 survey, dropping to 57 percent in Zone 1 for the 2005 survey. None of the LWD pieces in either the 2001 or 2005 surveys appeared to have cut ends. The number of key-size pieces of LWD drop from four pieces in 2001 to only one piece in 2005. The channel zone distribution of key-size pieces was relatively unchanged between the two surveys with all of pieces located in Zones 1. The number of LWD jams found within the reach double from five in 2001 to ten in 2005. During the 2001 survey, only small jams were observed in Reach 4. For the 2005 survey, the number of small jams had increased to seven with three additional medium size jams.

Table 4-6. Comparison of summary statistics for the 2001 and 2005 middle mainstem Green River LWD surveys, Reach 4 (RM 45, Flaming Geyser State Park to RM 40.8 Newaukum Creek).

	Survey Year	
	2001	2005
Survey Length	4.2 miles	4.2 miles
Flow @ Palmer, WA	120 cfs	175 cfs
Flow @ Auburn, WA	252-256 cfs	292 cfs
Total LWD ¹	33	61
Number of LWD ¹ – Zone 1	27	35
Number of LWD ¹ – Zone 2	6	26
LWD ¹ per Mile	7.9	14.7
Percent Cut LWD	0	0
Total Number Key LWD	4	1
Key Pieces per Mile	0.95	0.24
Total Number of LWD Jams	5	10
Percent Small Jams	100%	70%
Percent Medium Jams	0%	30%
Percent Large Jams	0%	0%

¹Includes medium and large logs, key pieces, and rootwads.

4.5 REACH 5

Reach 5 was surveyed on August 3 and 4, 2005. The reach is approximately 4.2 miles long extending from Newaukum Creek (RM 40.8) to Loans Levee (RM 38) (Figure 4-5). The average stream flow during the survey was 292 cfs as measured at the Auburn, Washington

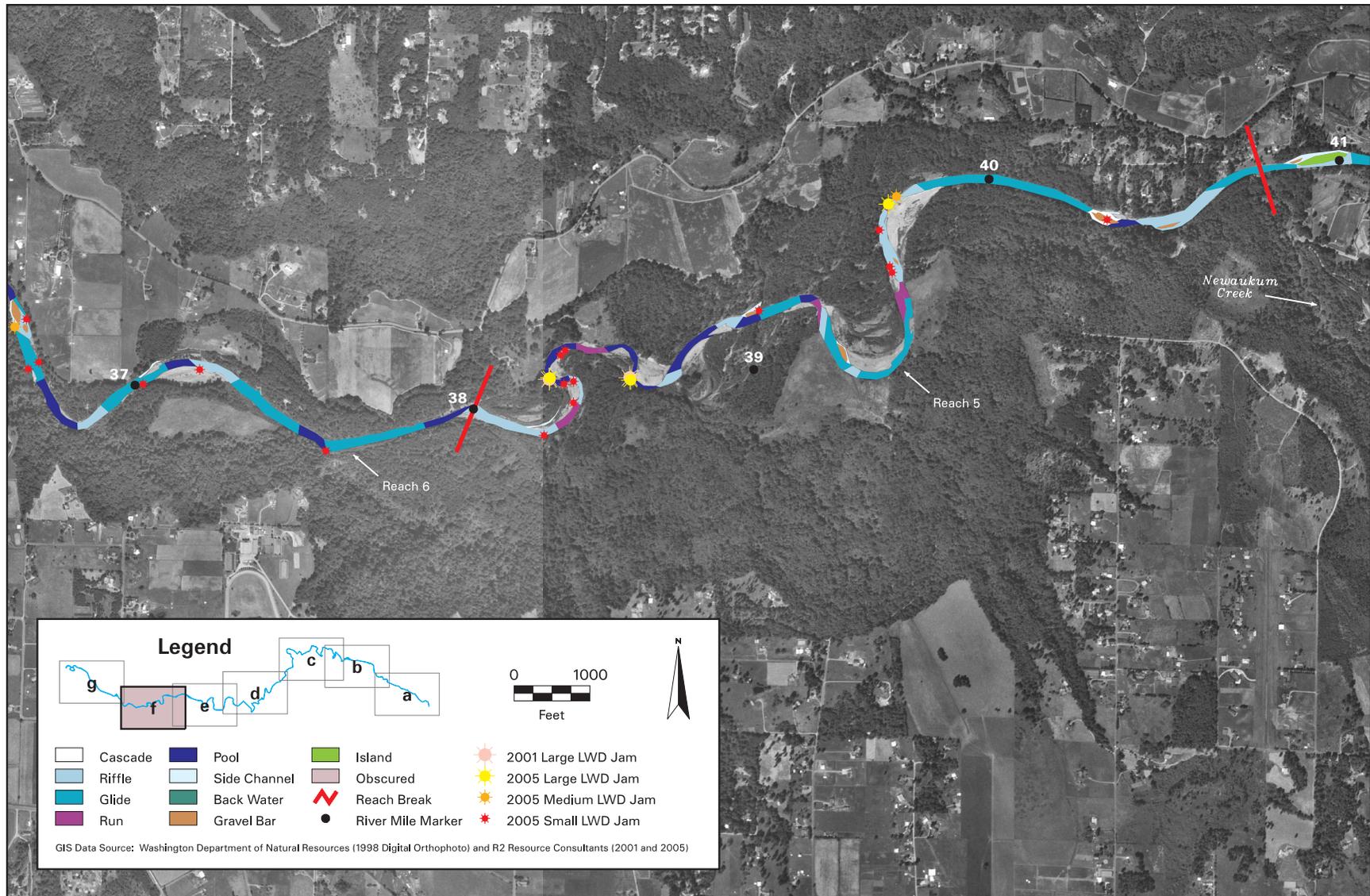


Figure 4-5. Middle Green River LWD Survey Reaches 5 and 6 (Map f).

stream gage. This reach of the middle mainstem Green River has experienced frequent channel shifts in the past ten to twenty years and contains numerous side channels that were not surveyed as part of the 2001 LWD survey. Since the winter of 1996-1997, almost half of the mainstem flow has been redirected into a large side channel near RM 40 (R2, 2002). This side channel was transmitting approximately forty to fifty percent of the flow at the time of the 2001 survey, but was not included as part of that survey (R2, 2002).

One hundred and eleven individual pieces of LWD and rootwads, including two key-sized pieces, were identified during the 2005 survey of Reach 5 (Table 4-7). Medium and large-sized logs comprised over 90 percent of the total LWD counted within Reach 5, with just over 50 percent of the pieces located within channel Zone 1. Only two key-sized piece logs were located in the reach and both pieces were located within channel Zones 1 (Table 4-7). The distribution of the five rootwads found in the reach was nearly equally split between Zones 1 and 2. A total of 22 log jams were identified in Reach 5 (Table 4-7). Sixteen of the jams were classified as small with the remaining six falling equally into the medium and large categories. Sixty-eight percent of the identified jams were located in channel Zone 1.

Table 4-7. Large woody debris count by type and channel location in Reach 5, mainstem Green River, King County, Washington, 2005.

	Channel Zone		Total	Cut
	1	2		
Log-Medium	26	16	42	1
Log-Medium with Rootwad	21	28	49	1
Log-Large	2	2	4	
Log-Large with Rootwad	8	1	9	
Key Piece	0	0	0	
Key Piece with Rootwad	2	0	2	
Rootwad	3	2	5	
Total	62	49	111	2
Small Jam	10	6	16	
Medium Jam	2	1	3	
Large Jam	3	0	3	

Summary statistics for the 2001 and 2005 LWD surveys of Reach 5 are presented in Table 4-8. Appendix C contains a comparison of LWD counts by channel zone for the 2001 and 2005 surveys. The total number of individual LWD pieces (including medium, large, key piece and

rootwads) identified within Reach 5 increased nearly 60 percent from 70 pieces in 2001 to 111 in 2005. Although the number of pieces of LWD increased significantly between the 2001 and 2005 surveys, 30 of the 41 new pieces of LWD identified during the 2005 survey were located within a large side channel near RM 40. This side channel was not surveyed in 2001, therefore, these pieces were not counted during the 2001 survey. The distribution of LWD within the channel was generally the same for both surveys with approximately 60 percent of all LWD found within Zone 1 (Appendix C). The number of key-size pieces of LWD dropped from three pieces in 2001 to two pieces in 2005. The number of LWD jams found within the reach nearly tripled from six in 2001 to 22 in 2005. Although four of the new jams were located in the large side channel at RM 40, new jams were distributed throughout the reach (Figure 4-5). During the 2001 survey, all of the jams were located within channel Zone 1 (Appendix C). In 2005, over thirty percent of the jams were now located in Zone 2. Although the percent composition of small, medium, and large jams was about the same for the two surveys, the number of small jams increased from four in 2001 to sixteen in 2005. Two additional large and medium jams were also present during the 2005 survey.

Table 4-8. Comparison of summary statistics for the 2001 and 2005 middle mainstem Green River LWD surveys, Reach 5 (RM 40.8, Newaukum Creek to RM 38, Loans Levee).

	Survey Year	
	2001	2005
Survey Length	2.8 miles	2.8 miles
Flow @ Palmer, WA	114-127 cfs	174 cfs
Flow @ Auburn, WA	256-356 cfs	292 cfs
Total LWD ¹	70	111
Number of LWD ¹ – Zone 1	41	62
Number of LWD ¹ – Zone 2	29	49
LWD ¹ per Mile	25.0	39.6
Percent Cut LWD	1	1.8
Total Number Key LWD	3	2
Key Pieces per Mile	1.1	0.7
Total Number of LWD Jams	6	22
Percent Small Jams	67%	73%
Percent Medium Jams	17%	14%
Percent Large Jams	16%	13%

¹Includes medium and large logs, key pieces, and rootwads.

4.6 REACH 6

Reach 6 was surveyed on August 4, 2005. The survey reach was approximately 4.2 miles long extending from Loans Levee (RM 38) to Highway 18 Bridge (RM 33.8) (Figures 4-5 and 4-6). A channel spanning log jam that had formed just downstream of the Highway 18 Bridge restricted access to the lower 1.8 miles of the reach that was included as part of the 2001 survey. The average stream flow during the survey was 287 cfs as measured at the Auburn, Washington stream gage.

One hundred and twelve individual pieces of LWD and rootwads, including two key-sized piece, were identified during the 2005 survey of Reach 6 (Table 4-9). Medium and large-sized logs comprised just over 23 percent of the total LWD counted within Reach 6 with approximately 74 percent of the pieces located within channel Zone 1. Only two key-sized piece logs were located in the reach and they were both located within channel Zones 1 (Table 4-9). Reach 6 had the largest number of rootwads of all the survey reaches with 28 (Table 4-9). Nearly 80 percent of all the rootwads found in the reach were located in channel Zone 1. A total of 12 log jams were identified in Reach 6. Nine of the 12 jams were classified as small with two of the remaining three falling into the large category. Eighty-three percent of the identified LWD jams were located in channel Zone 1.

Table 4-9. Large woody debris count by type and channel location in Reach 6, middle mainstem Green River, King County, Washington, 2005.

	Channel Zone		Total	Cut
	1	2		
Log-Medium	27	9	36	6
Log-Medium with Rootwad	27	10	37	2
Log-Large	5	1	6	
Log-Large with Rootwad	2	1	3	
Key Piece	2	0	2	
Key Piece with Rootwad	0	0	0	
Rootwad	22	6	28	
Total	85	27	112	8
Small Jam	7	2	9	
Medium Jam	1	0	1	
Large Jam	2	0	2	

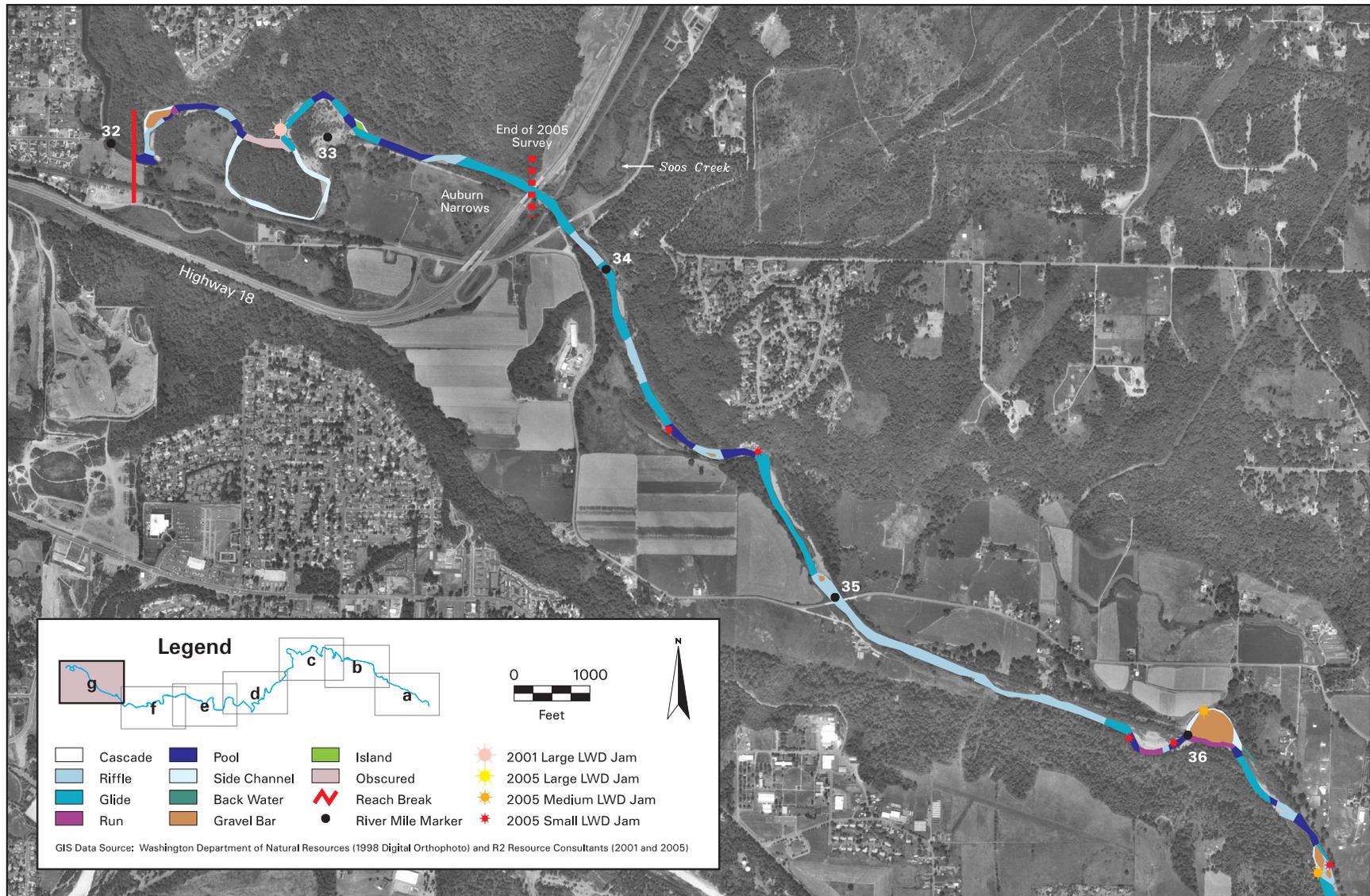


Figure 4-6. Middle Green River LWD Survey Reach 6 (Map g).

Comparison of summary statistics for the 2001 and 2005 LWD surveys of Reach 6 are presented in Table 4-10 as a point of reference for future survey efforts. Appendix C contains a comparison of LWD counts by channel zone for the 2001 and 2005 surveys. Although the length of the 2005 survey was 1.8 miles shorter than the 2001 survey, the number of LWD pieces per mile increased by nearly five pieces per mile (Table 4-9). The distribution of LWD within the channel zones was similar between the surveys with approximately 75 percent of all LWD pieces located in Zone 1. There were no LWD pieces with cut ends in 2001 and just over six percent in 2005. The number of key-size pieces of LWD drop from three in 2001 to only one piece in 2005. An even larger dropped occurred in the number of large logs with 22 fewer large logs in 2005 than in 2001. The number of LWD jams found within the reach more than doubled from five in 2001 to twelve in 2005. The largest gain came in the number of small jams which increased from four in 2001 to nine in 2005. One additional medium and large jam were present in the reach during the 2005 survey.

Table 4-10. Comparison of summary statistics for the 2001 and 2005 middle mainstem Green River LWD surveys, Reach 6 (RM 38, Loans Levee to RM 33.8, Highway 18 Bridge, Note that 2001 survey results reflect RM 38 to RM 32).

	Survey Year	
	2001	2005
Survey Length	6.0 miles	4.2 miles
Flow @ Palmer, WA	117-127 cfs	174 cfs
Flow @ Auburn, WA	266-326 cfs	287 cfs
Total LWD ¹	131	112
Number of LWD ¹ – Zone 1	93	85
Number of LWD ¹ – Zone 2	38	27
LWD ¹ per Mile	21.8	26.7
Percent Cut LWD	0	7%
Total Number Key LWD	3	2
Key Pieces per Mile	0.5	0.48
Total Number of LWD Jams	5	12
Percent Small Jams	80%	75%
Percent Medium Jams	0%	8%
Percent Large Jams	20%	17%

¹Includes medium and large logs, key pieces, and rootwads.

4.7 QUALITY ASSURANCE/QUALITY CONTROL

4.7.1 Equipment Calibration and Gear

Field equipment used to conduct the LWD survey was checked for damage and calibration at the beginning and end of the field effort. Table 4-11 list equipment used to conduct LWD surveys of the mainstem middle Green River in 2005.

Table 4-11. Equipment used to conduct habitat surveys for LWD surveys of the mainstem middle Green River in 2005.

Item	Size	Accuracy	Condition
Garmin GPS 76 Satellite Navigator	NA	±15 m	Good
LWD Calipers	24 inches	1/8 inch	Good
Open Reel Fiberglass tape	100 feet	¼ inch	Good
Spencer Logger's Tape	50 feet	1/8 inch	Good
Disposable Waterproof 35 mm Camera	Handheld	NA	Good

The upper half of Reach 3 was surveyed by two crews of two using inflatable kayaks. Weather conditions were warm and dry and crew members dressed in wading shoes and wetsuits. All crew members worked as a single unit for the first half of the initial field day to ensure crew cross training and consistent interpretation of field methods and equipment use.

Reaches 2, 4, 5, and 6 were surveyed by separate two person crews using inflatable kayaks. Crew members dressed in wading shoes and shorts or wetsuits, depending on personal preference.

LWD Calibration

Team members jointly estimated then measured the length and width of the first twenty-five pieces of LWD encountered. Additionally, five to ten pieces were estimated and then measured at the start of each subsequent field day. Appendix B contains copies of field notes with observer estimates and LWD piece measurements presented at the bottom of each page. Estimates and measurement of LWD length and width were made on a total of 44 individual pieces of LWD during the 2005 survey. Overall, the average error rate ranged from 7 to 14 percent for piece width, and 9 to 14 percent for piece length (Appendix D). This range of error was similar to those observed during the 2001 survey.

5. CONCLUSION

The frequency of individual LWD pieces and jams increased substantially between the 2001 and 2005 surveys of LWD in the middle mainstem Green River. A comparison of the 2001 and 2005 LWD survey results is presented in Table 5-1. A summary of the statistics generated from the 2001 and 2005 survey results is presented in Table 5-2. Even though the 2001 survey reach was 1.8 miles longer than the 2005 survey reach, the total number of LWD pieces (including medium and large logs, key-sized pieces, and rootwads) increased over sixty-five percent from 434 pieces in 2001 to 719 pieces in 2005. When converted to LWD pieces per mile, the density of LWD nearly doubles from 14.7 pieces per mile in 2001 to 26 pieces per mile in 2005. The total number of key-sized pieces also increased from the 2001 to 2005 surveys from 23 to 34 pieces, respectively. The number of rootwads also increased, from 42 in 2001 to 72 in 2005.

One of the most striking differences between the two surveys was the increase in both the number and channel distribution of LWD jams. The total number of LWD jams increased between the two surveys with only 24 jams counted in 2001 compared to 78 in 2005. In the 2001 survey, only one of the 24 jams was located in channel Zone 2. For the 2005 survey, 24 (31%) of the 78 jams were located within channel Zone 2.

There are several factors that could have influenced the dramatic increase in both the number and channel distribution of LWD between the 2001 and 2005 LWD surveys of the middle mainstem Green River. These would include restoration/enhancement efforts, differences in survey methods, and natural LWD recruitment. Each of these factors will be discussed in turn.

Since the 2001 LWD survey, restoration and enhancement efforts in the middle mainstem Green River have been confined to Reach 2 (near RM 60) and have included the addition of two medium-sized log jams and three individual logs. These additions represent approximately four percent of the total increase in LWD jams and one percent of the increase in the number of LWD pieces. Two LWD pieces (Tag #70 and #63) that had been part of the engineered jams were located during the 2005 survey. Pieces #63 was located approximately 1.3 miles downstream from the log jam structures and piece # 70 was located approximately 2.8 miles downstream of structures (Figure 4-1). Although an exact count of the number of LWD pieces remaining in each of the two engineered log jams is impractical, it does appear that both jams are intact and relatively unchanged since their construction in 2003.

Table 5-1. Comparison of total LWD counts for the 2001 and 2005 LWD surveys middle mainstem Green River, (RM 61.5, Tacoma Headworks to RM 33.8, Highway 18 Bridge).

	Survey Year ³		Total Increase
	2001	2005	
Total LWD ¹ Pieces	434	719	285
Medium Size Pieces	259	503	244
Large Size Pieces	110	115	5
Key Size Pieces	23	34	11
Rootwads	42	67	25
Total LWD Jams ²	24	78	54
Small Jams	21	60	39
Medium Jams	1	13	12
Large Jams	2	5	3

¹Includes medium and large logs, key pieces, and rootwads.

²Includes small, medium and large jams.

³2001 survey reach was 1.8 miles longer than 2005 survey length.

Table 5-2. Comparison of summary statistics for the 2001 and 2005 surveys of LWD within the middle mainstem Green River, Washington.

Reach ¹	Survey Year	Total LWD ²	Total Key Piece	LWD Per Mile	Key Piece Per Mile	Total # Jams ³	# of Jams Per Mile
2	2001	34	2	8.0	0.44	0	0.0
	2005	77	6	17.8	1.3	5	1.1
3	2001	164	11	13.7	0.92	8	0.7
	2005	329	23	27.4	1.9	29	2.4
4	2001	33	4	7.9	0.95	5	1.2
	2005	60	1	14.4	0.2	10	2.4
5	2001	70	3	25.0	1.1	6	2.1
	2005	109	2	39.0	0.7	22	4.9
6	2001	131	3	21.8	0.5	5	0.8
	2005	110	2	26.0	0.5	12	2.9

¹The surveyed length of Reach 6 was approximately 1.8 miles longer during the 2001 survey.

²Includes medium and large logs, and rootwads

³Includes small, medium, and large jams

Similar methods were used to count and determine channel location of LWD during the 2001 and 2005 surveys. To ensure consistent interpretation of sampling protocol between the surveys, one of the crew members from the 2001 survey was present during the 2005 survey. Members of each survey crew were cross trained to reduce crew bias. In addition to equipment calibration, team members estimated and then measured the width and length of over 40 pieces of LWD. The error rates associated with the crew estimates were similar between the two surveys. One significant difference between the 2001 and 2005 surveys was the inclusion of side channel areas in the 2005 survey. The 2001 survey focused only on mainstem habitat attributes and so side channels were not included. Including side channel areas effectively increased the area surveyed during the 2005 effort. A large number of both LWD pieces and LWD jams were located in side channel areas. As an example, one large side channel located in Reach 5 (approximately RM 39.8) contained 30 individual LWD pieces and 4 jams.⁵ This represented 27 percent of the LWD and 18 percent of the LWD jams located in Reach 5. Survey methods used during the 2005 LWD surveys did not include a system for coding or identification of LWD pieces and/or log jams found within side channel areas, making it impossible to quantify the number of pieces located within these areas.

Woody debris is naturally recruited to the stream system in a number of ways. On large, unconfined rivers, lateral migration of the channel undercuts banks, delivering whole trees with attached rootwads to the channel. Woody debris is also delivered from tributary rivers and streams, although transported LWD may consist primarily of fragments, particularly when it originates in smaller streams. Other major sources of LWD recruitment include landslides, windthrow, and downstream movement during high flow events. Although no effort has been made to determine the number of LWD pieces recruited to the middle mainstem Green River by any of the mechanisms listed above, anecdotal evidence suggest that LWD is recruited to the channel by each of these mechanisms.

High stream flow events, generally associated with severe storms, are believed to be one of the major LWD recruitment mechanisms. Relying on model estimates of wood recruitment from storm events, one study (Gyton, 2001) reported that LWD recruitment may increase by as much as ten times over the annual input rate. Howard Hanson Dam, located at RM 64.5, regulates flow in the middle mainstem Green River to reduce downstream flooding. Although large storm events have occurred since the 2001 survey, peak flow events have been similar or slightly lower

⁵ Due to its extreme length, a separate code was given to each LWD piece and jam located within this side channel. No other effort was made to distinguish between LWD found within the main channel and wood located within side channel areas.

than peak flows in the preceding ten years. For the period August 2001 to August 2005 the highest peak flow, as measured at Auburn Washington, was 8,590 cfs (www.nwis.waterdata.usgs.gov). Maximum peak flow during the period August 1991 to August 2001 was 12,400 cfs (www.nwis.waterdata.usgs.gov). Input of LWD to the reservoir behind Howard Hanson Dam has been relatively low over the past four years (Scott Pozarycki, USACE, personal communication to Mike Gagner, R2, December 6, 2005) indicating that storm related recruitment of LWD to the Green River basin has not been a significant factor.

If we assume uniform recruitment of LWD over the past four years, we can calculate the annual recruitment of LWD per mile ($LWD_{\text{per mile}}$) using the equation:

$$LWD_{\text{per mile}} = (Total_{2005} - Total_{2001}) \cdot Y^{-1} \cdot T_{\text{miles}}^{-1}$$

Where

Total₂₀₀₅ = total count of LWD during the 2005 survey;

Total₂₀₀₁ = total count of LWD during the 2001 survey

Y = years since last survey; and

T_{miles} = total number of miles surveyed.

Using this equation, the annual recruitment of LWD to the middle mainstem Green River since the 2001 survey has been 2.6 pieces per mile. A similar process can also be used to calculate the annual recruitment of LWD per survey reach, by using the equation:

$$LWD_{\text{per reach mile}} = (Reach_{2005} - Reach_{2001}) \cdot Y^{-1} \cdot T_{\text{miles}}^{-1}$$

Where

Reach₂₀₀₅ = total count of LWD within the reach during 2005 survey;

Reach₂₀₀₁ = total count of LWD within the reach during 2001 survey;

Y = years since last survey; and

T_{miles} = number of miles surveyed within each reach.

Using this equation, the annual per mile recruitment of LWD to each of the five reaches surveyed in middle mainstem Green River would be:

Reach Number	Total LWD Change* (2005 Total – 2001 Total)	Annual LWD Recruitment per Mile
2	47	2.6
3	188	3.9
4	28	1.7
5	41	3.6
6	29	1.2

*To compare 2001 and 2005 survey results for Reach 6, we assumed the density (number of LWD pieces per mile) of LWD found in the upper 4.2 miles surveyed would be similar to the density of LWD found in the adjacent (downstream) 1.8 miles.

6. RECOMMENDATIONS

Survey methods used to monitor the number and distribution of LWD in the middle mainstem Green River appear to adequately detect long-term changes in reach scale LWD quantity. Reach scale LWD data should not be used to track changes in the characteristics of individual habitat units that result from individual restoration projects. Recommendations for future LWD surveys would include:

- Note or code weather individual LWD pieces and jams are located within side channel areas. This change in survey protocol would be helpful in determining the contribution of LWD through channel avulsion (i.e., side channel formation).
- Measure all LWD pieces that are close in size (length and/or width) to the minimum criteria used for inclusion of LWD within the count. This change in survey protocol would help to ensure accurate classification of pieces that are close to size criteria breaks.
- Use wood calipers or diameter tapes when measuring LWD piece width. This change in survey protocol would increase the accuracy of measuring LWD width.
- Where possible, determine the mechanism (e.g., mass wasting, windthrow, channel avulsion, downstream transport) by which LWD was recruited to the channel. This change in survey protocol would help to determine the contribution of LWD by different recruitment mechanisms.
- Repeat LWD surveys at four to five year time intervals to determine long-term recruitment rate. Special emphasis should be made to complete surveys following large storm (sever wind and/or high flow) events. Woody debris input from storm events, may increase by as much as ten times over the annual input rate.
- Estimate the percent composition of woody debris within LWD jams by decay class. This change in survey protocol would help to answer questions such as; is new LWD material being added to existing jams, is newly recruited material forming jams, what is the anticipated lifespan of the existing jams.
- Obtain highest resolution aerial photographs (1 meter pixel or less) available for middle mainstem Green River and produce color copies of the survey reach in one-mile segments. These photographs would be used to map the location of LWD jams and areas of significant recruitment. They would also be helpful in mapping the exact location of individual tagged or painted LWD pieces that are of concern to private river users and the resource agencies.

7. REFERENCES

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APPENDIX A

Report of Contact Forms

Report of Contact

Contact Date: 07/07/05 Project Number: 1525Phone Number (206) 764-3316 Task Number: 01Person(s) Contacted: Scott PozaryckiContact's Affiliation/Location: USACEContacted By: Mike GagnerSubject LWD Placement Projects Middle Mainstem Green RiverTelephone Personal Other

The USACE has been somewhat active in the placement of LWD within the mainstem Green River. In August of 2003, the USACE in cooperation with the City of Tacoma constructed two bar apex type log jams (Zone 1 Project) at RM 60, about 3 miles upstream from Kanaskat-Palmer State Park. Jam ELJ1 contained 81 pieces of LWD and jam ELJ2 contained 88 pieces. Individual pieces ranged from 50-60 feet long and have a diameter at breast height of 48 to less than 24 inches. Each individual piece of LWD was numbered and a small metal tag was attached near one end. A few (two or three) of the logs from these jams have been washed downstream during high flow events. Scott requested that we attempt to locate the missing pieces during our survey.

In late August 2004, The USACE placed three painted (blue on ends) individual logs (20-24 inch dbh & ~30 ft long) on a gravel nourishment site located at the same location (RM 60) as the engineered log jams. The USACE has plans to place an additional 30 pieces of LWD at this site in October 2005.

Report of Contact

Contact Date: 07/08/05 Project Number: 1525Phone Number (253) 939-3311/(253) 876-3166 Task Number: 01Person(s) Contacted: Eric Warner/Karen WalterContact's Affiliation/Location: MITFDContacted By: Mike GagnerSubject LWD Placement Projects Middle Mainstem Green RiverTelephone Personal Other

Left a detailed voice message for Mr. Warner describing the general methods and timeframe for the LWD surveys and requested that he return my call if he had any information related to LWD placement in the middle mainstem Green River. Ms. Karen Walter of the MIT returned my call on 12 July 2005. According to Ms. Walter, the tribe has no LWD surveys planned for this year and have not been involved with LWD placement in the Green River. She did request that the LWD survey quantify the volume and function of each piece of LWD and that we extend the survey reach downstream past the Auburn Narrows. She also recommended that we contact Danny Eastman of King County.

Report of Contact

Contact Date: 07/19/05 Project Number: 1525Phone Number (360) 753-6041 Task Number: 01Person(s) Contacted: Tim RomanskiContact's Affiliation/Location: USFWSContacted By: Mike GagnerSubject LWD Placement Projects Middle Mainstem Green RiverTelephone Personal Other

Originally called for Gwill Ging, but was told that person retired and the new contact would be Craig Hanson. Mr. Hanson passed my call on to Mr. Romanski, who is the FWS contact for the Green River HCP. According to Mr. Romanski, the FWS has not been involved with the placement of LWD in the Green River and they have no current or future plans for surveys or monitoring of the Green River.

Report of Contact

Contact Date: 07/07/05 Project Number: 1525Phone Number (206) 296-8012 Task Number: 01Person(s) Contacted: Tom NelsonContact's Affiliation/Location: King CountyContacted By: Mike GagnerSubject LWD Placement Projects Middle Mainstem Green RiverTelephone Personal Other

Left a detailed voice message for Mr. Nelson describing the general methods and timeframe for the LWD surveys and requested that he return my call if he had any information related to LWD placement in the middle mainstem Green River. As of 10 October 2005 I had not received a return call from Mr. Nelson.

Report of Contact

Contact Date: 07/13/05 Project Number: 1525Phone Number (206) 860-3307 Task Number: 01Person(s) Contacted: Danny EastmanContact's Affiliation/Location: King CountyContacted By: Mike GagnerSubject LWD Placement Projects Middle Mainstem Green RiverTelephone Personal Other

Left a detailed voice message for Mr. Eastman describing the general methods and timeframe for the LWD surveys and requested that he return my call if he had any information related to LWD placement in the middle mainstem Green River. As of 10 October 2005 I had not received a return call from Mr. Eastman.

Report of Contact

Contact Date: 07/13/05 Project Number: 1525Phone Number (206) 860-3307 Task Number: 01Person(s) Contacted: Phil RoniContact's Affiliation/Location: NMFSContacted By: Mike GagnerSubject LWD Placement Projects Middle Mainstem Green RiverTelephone Personal Other

Mr. Roni appreciated the call and said that they (NMFS) had wanted to be more involved with monitoring on the Green River, but the CORP failed to provide them with funding. Mr. Roni confirmed that the NMFS has no plans for LWD surveys on the Green River and they have no current or future plans for involvement with LWD placement in the middle mainstem Green River.

APPENDIX B

2005 LWD Survey Field Data Forms

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 8/02/05
 Crew: MRG, Glen Anderson
 Reach: 2

• = intact
 + = cut end

Equipment:

Units:

Flow Auburn gage 296 cfs

Medium log (30-50mm)	Medium log w/Rootwad	Large Log (50-85mm)	Large Log w/ rootwad	Key Piece (>85 mm)	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam (50-100 pieces)	Large jam (>100 pieces)
Z1 Z2	Z1 Z2	Z1 Z2	Z1 Z2	Z1 Z2	Z1 Z2	Z1 Z2	Z1 Z2	Z1 Z2	Z1 Z2
14	13	5	4	4		5	3	2	
28	26	11	6	5	1	6			

Wood Calibration

	MRG (FH)		GA (FH)		Measured	Measured
	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Width	Length
1	1.2	45	1.2	38	1.1	42
2	1.3	35	1.3	30	1.4	33
3	1.3	13	1.3	14	1.3	14
4	1.4	40	1.5	52	1.6	51
5	1.2	60	1.1	100	1.1	80
6	1.0	35	1.0	35	1.0	40
7	0.5	40	0.6	33	0.5	36
8	1.2	40	1.3	42	1.1	36
9	1.2	45	1.3	52	1.4	51

* mid channel 20' exposed
 w 10' buried in channel

- 2 upper jam w 50-100 pieces visible
- 3 lower jam only an esti most wood buried.
- 4 w 25' long
- 5 top end of lower island
- 6 - potential boat hazard

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 08/02/05

Crew: M. Gagnier, G. Anderson

Reach: 3 upper (just below Reach 2)

Equipment:

Units:

Flow

Auburn gage 296 cfs

• = intact
+ = cut end

Medium log (30-50mm)	Medium log w/Rootwad	Large Log (50-85mm)	Large Log w/ rootwad	Key Piece (>85 mm)	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam (50-100 pieces)	Large jam (>100 pieces)
<i>Hand-drawn sketches of logs with dots and circled numbers 4 and 6.</i>	<i>Hand-drawn sketches of logs with dots and circled numbers 3 and 5.</i>	<i>Hand-drawn sketches of logs with dots and circled numbers 1 and 2.</i>	<i>Hand-drawn sketches of logs with dots and circled number 2.</i>	<i>Hand-drawn sketches of logs with dots and circled numbers 5, 1, and 1.</i>	<i>Hand-drawn sketches of logs with dots and circled numbers 1 and 1.</i>	<i>Hand-drawn sketches of logs with dots and circled number 2.</i>			

Wood Calibration

*1 tag # 70
2 blue paint*

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1						
2						
3						
4						
5						

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 8/1/05
 Crew: A. Weybright / J. Blanchard
 Reach: Upper 3

. = intact
 + = cut end

Equipment:

Units:

Flow Auburn Gage 304 cfs

Medium log (30-50mm)	Medium log w/Rootwad	Large Log (50-85mm)	Large Log w/ rootwad	Key Piece (>85 mm)	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam (50-100 pieces)	Large jam (>100 pieces)
IIII 6	IIII 3	II 2	0	0	0	0	2	0	0
IIII II 7	IIII II 7	I 1	IIII 3	I 1	0	2	1	0	0

71

32

13 10 3 3 1 2 3

Wood Calibration

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1	2.5/4.0	3.3/3.8	2.5/3.0		0.8	3.5
2	2.5/4.0	3.3/3.8	2.5/3.0		0.8	3.5
3						
4						
5						

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 8/2/05

Crew: A. Weighright / D. Blanchard

Reach: 3-1 lower Stay @ Gellum site

. = intact
+ = cut end

Equipment:

Units: feet

Flow: 296 cfs @ Auburn

Medium log (30-50mm)	Medium log w/Rootwad	Large Log (50-85mm)	Large Log w/ rootwad	Key Piece (>85 mm)	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam (50-100 pieces)	Large jam (>100 pieces)
 24	 8	 7	 5	 2	 2	 2	RB RM 52.4 52.5 island forming RB RM 52.0? RB SL RM RM (Copp Island) LB 1/2 pipe RM 48.4	6	
 34	 12	 6	 3	 3	 3	 3	LB RM 44.3	4	

Wood Calibration

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1	0.9'	35'	1.0'	40'	1.0'	32'
2	0.6'	24'	0.6'	18'	0.5'	21'
3	0.8'	40'	0.6'	35'	0.6'	48'
4	4.0'	30'	3.0'	25'	3.2'	28'
5	1.6'	47'	1.5'	45'	1.1'	42'

AW Camera

- #3 8/2 Jan #1 (Sun)
- #4 8/2 Jan #1 (Sun)
- 5 " Jan #2 RM 52.3
- 6 " #2

#8 420 Island of Jan #4 trees

RM 51.6

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 8/3/05

Crew: A. Wenbright G. Anderson

Reach: 3 lower part @ Jay Cr.

Equipment:

Units: ft.

Flow 292 cfs @ Auburn

• = intact

+ = cut end

Medium log (30-50mm) <small>cm</small>	Medium log w/Rootwad	Large Log (50-85mm) <small>cm</small>	Large Log w/ rootwad	Key Piece (>85 mm) <small>cm</small>	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam (50-100 pieces)	Large jam (>100 pieces)
 1	 						RM 48.2 RM 47.8?	RM 48.2 HWJ 169 RM 45.7	
(21)	(20)	(5)	(8)	(2)	(2)	(5)	(2)	(3)	
 	 						RM 47.4 RM 45.3 RM 45.3 no pic		
(17)	(13)	(6)	(3)	(2)		(3)	(3)		
38	33	11	11	4	2	8	5	3	

Wood Calibration

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1	1.0	50'	1.0'	50'	1.0'	53'
2	0.9	80'	0.8	70'	0.9	65'
3	1.2	45'	1.2	40'	1.4	42'
4	0.8	30'	1.0	35'	0.8	32'
5	0.9	90'	1.0	85'	0.8	80'
	1.4	80'	1.2	70'	1.4	80'
	1.2	47'	1.4	50'	1.3	50'
	1.6	28'	1.5	26'	1.8	24'

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 8/3/05

Crew: M. Gorman, C. Yoder

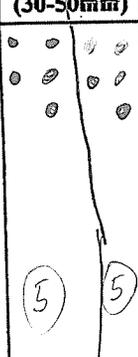
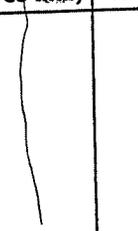
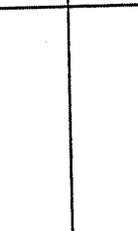
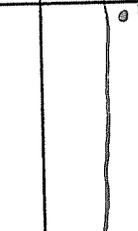
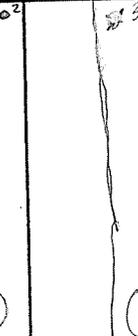
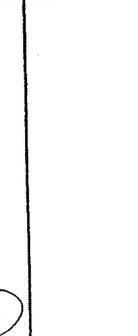
Reach: 4

Equipment:

Units:

Flow 292 cfs @ Auburn

• = intact
+ = cut end

Medium log z1 z2 (30-50mm)	Medium log z1 z2 w/Rootwad	Large Log z1 z2 (50-85mm)	Large Log z1 z2 w/ rootwad	Key Piece z1 z2 (>85 mm)	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam z1 z2 (50-100 pieces)	Large jam (>100 pieces)
									
10	0	2	0	0			2	1	

Wood Calibration

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1	0.7	21	0.6	18	0.4	20
2	0.9	22	0.8	20	0.8	21
3	2.4	55	2.8	55	2.2	60
4	3.5	40	0.6	35	0.65	42
5	2.5	42	2.8	45	2.5	41
6						
7						

1
2 - contains (1) large piece
3 - 476 17, 149 } does not appear
122° 03, 783 } to contain 2.00

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 8/3/05

Crew: F. Weinberger, G. Anderson

Reach: A

Equipment:

Units:

Flow 292 cfs @ Auburn

• = intact
+ = cut end

Medium log (30-50mm) <small>< 5M</small>	Medium log w/Rootwad	Large Log (50-85mm) <small>< 5M</small>	Large Log w/ rootwad	Key Piece (>85 mm) <small>< 5M</small>	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam (50-100 pieces)	Large jam (>100 pieces)
21 1 ⑪	 ⑫	 ②	 ①	 ①	∅	 ②	1 RM 44.8 PB 1 2M 44.3 LG Flan 60y 1 2M 42.3 island LG 1 2M 42.2 head of isl.		
22 ⑩	 ⑧		 1			 ②	1 RM 43.0 w/ end of island below bridge \$	1 RM 43.3 PB 1 head of bar PB RM 42.8	

Wood Calibration

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1						
2						
3						
4						
5						

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 08/03/05 continued 08/04/05

Crew: M. Gagner, C. Yoder & A. Waybright = intact
 + = cut end

Reach: 5

Equipment:

Units:

Flow 292 cfs @ Auburn

Medium log Z ₁ Z ₂ (30-50mm)		Medium log Z ₁ Z ₂ w/Rootwad		Large Log Z ₁ Z ₂ (50-85mm)		Large Log Z ₁ Z ₂ w/ rootwad		Key Piece Z ₁ Z ₂ (>85 mm)		Key Piece Z ₁ Z ₂ w/rootwad		Rootwad Z ₁ Z ₂		Small jam Z ₁ (10-50 pieces) Z ₂		Medium jam Z ₁ (50-100 pieces) Z ₂		Large jam Z ₁ (>100 pieces) Z ₂	
[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]	
(23) (16)		(21) (19)		(1) (2) (8) (1)		(2) (2)		(3) (1)		(8) (6)		(2) (1)		(3) (2)					

Wood Calibration

	C. Yoder		A. Waybright		Measured	
	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1						
2						
3						
4						
5						

7 - ~ 125' d/s of 6 10-photo 4
 8 - confirmed on map
 9 - 47 16.573
 122.06.242

1 - new small jam 47° 17.021
 122 04.555

2 - 47° 17.055
 122° 05.229

3 - 47° 17.053
 122° 05.244

4 = MDAS channels

5 = just d/s of moas
 47.16.798
 122.05.646

6 = 47° 16.648 photo 1 R2 camera
 122° 06.149

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 8/4/05

Crew: A. W. Wright / C. Yoder / M. Gagner

Reach: 5

• = intact

+ = cut end

Equipment:

Units:

Flow 287 cfs @ Auburn

	Medium log (30-50mm)	Medium log w/Rootwad	Large Log (50-85mm)	Large Log w/ rootwad	Key Piece (>85 mm)	Key Piece w/rootwad	Rootwad	Small jam (10-50 pieces)	Medium jam (50-100 pieces)	Large jam (>100 pieces)
Zone 1	Reach 5 							 by cut w/ debris at standing bank		
	Reach 5 ③	⊘	①	⊘	⊘	⊘	⊘	②	⊘	⊘
Zone 2	Reach 6 ⊘	⑤	①	①	①	⊘	⑫	⊘	⊘	⊘
	Reach 5 ⊘	⊘	⊘	⊘	⊘	⊘	①	⊘	⊘	⊘
Zone 2	Reach 5 ①		③	⊘	⊘	⊘		⊘	⊘	⊘
	Reach 6									

Wood Calibration

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1						
2						
3						
4						
5						

Mainstem Green River Habitat Monitoring

Large Woody Debris

Date: 08/04/05

Crew: M. Gagner, A. Waybright, C. Yoder

Reach: 6

Equipment:

Units:

Flow 287 cfs @ Auburn

• = intact
+ = cut end

Medium log Z ₁ Z ₂ (30-50mm)		Medium log Z ₁ Z ₂ w/Rootwad		Large Log Z ₁ Z ₂ (50-85mm)		Large Log w/ rootwad		Key Piece (>85 mm)		Key Piece w/rootwad		Rootwad Z ₁ Z ₂		Small jam (10-50 pieces)		Medium jam (50-100 pieces)		Large jam (>100 pieces)	
[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]		[Hand-drawn debris counts]	
(27)	(8)	(22)	(7)	(4)	(1)	(1)	(1)	(1)				(10)	(4)	(7)	(2)	(1)		(2)	

Wood Calibration

C. Yoder *A. Waybright*

	Estimated Width	Estimated Length	Estimated Width	Estimated Length	Measured Width	Measured Length
1	1.2	27.5	1.3	25	1.2	29
2	1.2	23	1.2	20	1.2	23
3	0.80	35	0.70	35	0.6	36
4	2.0	68	2.2	95	2.1	100
5	1.2	35	1.1	45	1.1	38

12- 47° 16.673 surjam
122.07.522

18- 47' 17.017 } possible medium?
122° 08.278

19- 47° 17.080
122.08.359

20- A. way on top
47.17.006
122.08.565

21- 47.17.022
122.08.671

APPENDIX C

2005 LWD Survey Results – Data Tables

Middle Mainstem Green River 2005 LWD Survey

Entered by: Mike Gagner 5 September 2005

Reach	Medium Log (30-50 cm)		Medium Log w/ Rootwad		Large Log (50-85 cm)		Large Log w/ Rootwad		Key Piece (>85 cm)		Key Piece w/ Rootwad		Rootwad		Small Jam (10-50 pieces)		Medium Jam (50-100 pieces)		Large Jam (>100 pieces)	
	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2
2	14	14	13	13	5	6	4	2	4	1	1	0	1	5	3	0	2	0	0	0
3	4	6	3	5	1	2	0	2	0	2	1	1	0	2	0	0	0	0	0	0
3	16	18	5	5	5	1	3	8	3	2	0	0	2	5	6	1	1	0	0	0
3	6	7	3	7	2	1	0	3	0	1	0	0	0	2	2	1	0	0	0	0
3	24	34	8	12	7	6	5	3	2	3	2	0	2	3	6	4	0	0	0	0
3	21	17	20	13	5	6	8	3	2	2	2	0	5	3	2	3	3	0	0	0
Total	71	82	39	42	20	16	16	19	7	10	5	1	9	15	16	9	4	0	0	0
4	5	5	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0	1	0	0
4	11	10	12	8	2	0	1	0	1	0	0	0	2	2	4	1	0	2	0	0
Total	16	15	12	8	3	1	1	0	1	0	0	0	2	2	4	3	0	3	0	0
5	23	16	21	19	1	2	8	1	0	0	2	0	3	1	8	6	2	1	3	0
5	3	0	0	9	1	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
Total	26	16	21	28	2	2	8	1	0	0	2	0	3	2	10	6	2	1	3	0
6	0	1	5	3	1	0	1	0	1	0	0	0	12	2	0	0	0	0	0	0
6	27	8	22	7	4	1	1	1	1	0	0	0	10	4	7	2	1	0	2	0
Total	27	9	27	10	5	1	2	1	2	0	0	0	22	6	7	2	1	0	2	0
SubTot	154	136	112	101	35	26	31	23	14	11	8	1	37	30	40	20	9	4	5	0
Total	503		115		34		67		13		60		5							

MIDDLE MAINSTEM GREEN RIVER 2005 LWD SURVEY RESULTS

Table 1-1. Large woody debris count by type and channel location in Reach 2, mainstem Green River, King County, Washington, 2005.

	Zone		Total	Cut
	1	2		
Log-Medium	14	14	28	3
Log-Medium with Rootwad	13	13	26	1
Log-Large	5	6	11	1
Log-Large with Rootwad	4	2	6	1
Key Piece	4	1	5	
Key Piece with Rootwad	1	0	1	
Rootwad	1	5	6	
Small Jam	3	0	3	
Medium Jam	2	0	2	
Large Jam	0	0	0	

Table 1-2. Large woody debris count by type and channel location in Reach 3, mainstem Green River, King County, Washington, 2005.

	Zone		Total	Cut
	1	2		
Log-Medium	71	82	153	2
Log-Medium with Rootwad	39	42	81	3
Log-Large	20	16	36	
Log-Large with Rootwad	16	19	35	2
Key Piece	7	10	17	
Key Piece with Rootwad	5	1	6	
Rootwad	9	15	24	
Small Jam	16	9	25	
Medium Jam	4	0	4	
Large Jam	0	0	0	

Table 1-3. Large woody debris count by type and channel location in Reach 4, mainstem Green River, King County, Washington, 2005.

	Zone		Total	Cut
	1	2		
Log-Medium	16	15	31	1
Log-Medium with Rootwad	12	8	20	1
Log-Large	3	1	4	
Log-Large with Rootwad	1	0	1	
Key Piece	1	0	1	
Key Piece with Rootwad	0	0	0	
Rootwad	2	2	4	
Small Jam	4	3	7	
Medium Jam	0	3	3	
Large Jam	0	0	0	

MIDDLE MAINSTEM GREEN RIVER 2005 LWD SURVEY RESULTS

Table 1-4. Large woody debris count by type and channel location in Reach 5, mainstem Green River, King County, Washington, 2005.

	Zone		Total	Cut
	1	2		
Log-Medium	26	16	42	
Log-Medium with Rootwad	21	28	49	
Log-Large	2	2	4	
Log-Large with Rootwad	8	1	9	
Key Piece	0	0	0	
Key Piece with Rootwad	2	0	2	
Rootwad	3	2	5	
Small Jam	10	6	16	
Medium Jam	2	1	3	
Large Jam	3	0	3	

Table 1-5. Large woody debris count by type and channel location in Reach 6, mainstem Green River, King County, Washington, 2005.

	Zone		Total	Cut
	1	2		
Log-Medium	27	9	36	6
Log-Medium with Rootwad	27	10	37	2
Log-Large	5	1	6	
Log-Large with Rootwad	2	1	3	
Key Piece	2	0	2	
Key Piece with Rootwad	0	0	0	
Rootwad	22	6	28	
Small Jam	7	2	9	
Medium Jam	1	0	1	
Large Jam	2	0	2	

COMPARISON OF 2001 AND 2005 LWD SURVEY RESULTS
MIDDLE MAINSTEM GREEN RIVER

Table 1-1. Comparison of large woody debris located in Zone 1 of Reach 2 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	7	14	7
Log-Medium with Rootwad	3	13	10
Log-Large	8	5	-3
Log-Large with Rootwad	2	4	2
Key Piece	0	5	5
Rootwad	1	1	0
Small Jam	0	3	3
Medium Jam	0	2	2
Large Jam	0	0	0

Table 1-2. Comparison of large woody debris located in Zone 2 of Reach 2 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	6	14	8
Log-Medium with Rootwad	0	13	13
Log-Large	4	6	2
Log-Large with Rootwad	2	2	0
Key Piece	2	1	-1
Rootwad	1	5	4
Small Jam	0	0	0
Medium Jam	0	0	0
Large Jam	0	0	0

Table 1-3. Comparison of large woody debris located in Zone 1 of Reach 3 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	35	71	36
Log-Medium with Rootwad	20	39	19
Log-Large	13	20	7
Log-Large with Rootwad	18	16	-2
Key Piece	6	13	7
Rootwad	2	9	7
Small Jam	7	16	9
Medium Jam	0	4	4
Large Jam	0	0	0

COMPARISON OF 2001 AND 2005 LWD SURVEY RESULTS
MIDDLE MAINSTEM GREEN RIVER

Table 1-4. Comparison of large woody debris located in Zone 2 of Reach 3 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	30	82	52
Log-Medium with Rootwad	11	42	31
Log-Large	15	16	1
Log-Large with Rootwad	6	19	13
Key Piece	5	11	6
Rootwad	3	15	12
Small Jam	1	9	8
Medium Jam	0	0	0
Large Jam	0	0	0

Table 1-5. Comparison of large woody debris located in Zone 1 of Reach 4 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	13	16	3
Log-Medium with Rootwad	7	12	5
Log-Large	0	3	3
Log-Large with Rootwad	2	1	-1
Key Piece	4	1	-3
Rootwad	1	2	1
Small Jam	5	4	-1
Medium Jam	0	0	0
Large Jam	0	0	0

Table 1-6. Comparison of large woody debris located in Zone 2 of Reach 4 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	2	15	13
Log-Medium with Rootwad	2	8	6
Log-Large	1	1	0
Log-Large with Rootwad	1	0	-1
Key Piece	0	0	0
Rootwad	0	2	2
Small Jam	0	3	3
Medium Jam	0	3	3
Large Jam	0	0	0

COMPARISON OF 2001 AND 2005 LWD SURVEY RESULTS
MIDDLE MAINSTEM GREEN RIVER

Table 1-7. Comparison of large woody debris located in Zone 1 of Reach 5 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	18	26	8
Log-Medium with Rootwad	12	21	9
Log-Large	0	2	2
Log-Large with Rootwad	4	8	4
Key Piece	2	2	0
Rootwad	5	3	-2
Small Jam	4	10	6
Medium Jam	1	2	1
Large Jam	1	3	2

Table 1-8. Comparison of large woody debris located in Zone 2 of Reach 5 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	13	16	3
Log-Medium with Rootwad	9	28	19
Log-Large	2	2	0
Log-Large with Rootwad	1	1	0
Key Piece	1	0	-1
Rootwad	3	2	-1
Small Jam	0	6	6
Medium Jam	0	1	1
Large Jam	0	0	0

Table 1-9. Comparison of large woody debris located in Zone 1 of Reach 6 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	23	27	4
Log-Medium with Rootwad	29	27	-2
Log-Large	2	5	3
Log-Large with Rootwad	17	2	-15
Key Piece	1	2	1
Rootwad	21	22	1
Small Jam	4	7	3
Medium Jam	0	1	1
Large Jam	1	2	1

COMPARISON OF 2001 AND 2005 LWD SURVEY RESULTS
MIDDLE MAINSTEM GREEN RIVER

Table 1-10. Comparison of large woody debris located in Zone 2 of Reach 6 by type and survey date, mainstem Green River, King County, Washington, 2005.

Type/Size Class	Survey Date		Total Change (+/-)
	2001	2005	
Log-Medium	9	9	0
Log-Medium with Rootwad	10	10	0
Log-Large	5	1	-4
Log-Large with Rootwad	7	1	-6
Key Piece	2	0	-2
Rootwad	5	6	1
Small Jam	0	2	2
Medium Jam	0	0	0
Large Jam	0	0	0

APPENDIX D

Quality Assurance and Control Checks

Crew Calibration August 1, 2005 Middle Mainstem Green River, Washington.

Piece #	Est.		Measured		% Error		Absolute % Error	
	Width (ft in 10ths)	Length (ft)	Width (ft in 10ths)	Length (ft)	Width	Length	Width	Length
1	0.80	55	0.7	60	-14.3	8.3	14.3	8.3
	0.90	40	0.7	60	-28.6	33.3	28.6	33.3
	0.80	45	0.7	60	-14.3	25.0	14.3	25.0
2	0.90	65	0.8	93	-12.5	30.1	12.5	30.1
	0.90	80	0.8	93	-12.5	14.0	12.5	14.0
	0.60	100	0.8	93	25.0	-7.5	25.0	7.5
3	0.90	20	0.75	25	-20.0	20.0	20.0	20.0
	0.80	24	0.75	25	-6.7	4.0	6.7	4.0
	0.90	25	0.75	25	-20.0	0.0	20.0	0.0
4	1.20	25	1.0	26	-20.0	3.8	20.0	3.8
	1.20	25	1.0	26	-20.0	3.8	20.0	3.8
	1.00	26	1.0	26	0.0	0.0	0.0	0.0
5	0.70	40	0.8	40	12.5	0.0	12.5	0.0
	0.60	35	0.8	40	25.0	12.5	25.0	12.5
	0.70	40	0.8	40	12.5	0.0	12.5	0.0
6	0.90	60	1.0	57	10.0	-5.3	10.0	5.3
	1.00	70	1.0	57	0.0	-22.8	0.0	22.8
	1.00	60	1.0	57	0.0	-5.3	0.0	5.3
7	0.70	35	0.7	42	0.0	16.7	0.0	16.7
	0.80	42	0.7	42	-14.3	0.0	14.3	0.0
	0.80	45	0.7	42	-14.3	-7.1	14.3	7.1
8	1.10	28	1.1	28	0.0	0.0	0.0	0.0
	1.10	26	1.1	28	0.0	7.1	0.0	7.1
	1.10	25	1.1	28	0.0	10.7	0.0	10.7
9	0.80	50	0.7	40	-14.3	-25.0	14.3	25.0
	0.90	49	0.7	40	-28.6	-22.5	28.6	22.5
	0.70	47	0.7	40	0.0	-17.5	0.0	17.5
10	0.90	35	0.8	35	-12.5	0.0	12.5	0.0
	0.70	30	0.8	35	12.5	14.3	12.5	14.3
	0.80	35	0.8	35	0.0	0.0	0.0	0.0
11	1.10	25	1.2	28	8.3	10.7	8.3	10.7
	1.25	25	1.2	28	-4.2	10.7	4.2	10.7
	1.20	27	1.2	28	0.0	3.6	0.0	3.6
12	1.10	55	0.9	52	-22.2	-5.8	22.2	5.8
	0.90	45	0.9	52	0.0	13.5	0.0	13.5
	0.90	35	0.9	52	0.0	32.7	0.0	32.7
13	1.20	24	1.3	26	7.7	7.7	7.7	7.7
	1.30	25	1.3	26	0.0	3.8	0.0	3.8
	1.20	26	1.3	26	7.7	0.0	7.7	0.0
14	2.10	55	1.9	66	-10.5	16.7	10.5	16.7
	1.80	60	1.9	66	5.3	9.1	5.3	9.1
	2.50	70	1.9	66	-31.6	-6.1	31.6	6.1
15	0.80	35	1.0	32	20.0	-9.4	20.0	9.4
	1.20	30	1.0	32	-20.0	6.3	20.0	6.3
	1.50	29	1.0	32	-50.0	9.4	50.0	9.4

Crew Calibration August 1, 2005 Middle Mainstem Green River.

Piece #	Est.		Measured		% Error		Absolute	
	Width (ft in 10ths)	Length (ft)	Width (ft in 10ths)	Length (ft)	Width	Length	Width	Length
16	0.75	50	0.6	48	-25.0	-4.2	25.0	4.2
	0.50	45	0.6	48	16.7	6.3	16.7	6.3
	0.80	47	0.6	48	-33.3	2.1	33.3	2.1
17	1.20	40	1.0	42	-20.0	4.8	20.0	4.8
	0.80	35	1.0	42	20.0	16.7	20.0	16.7
	1.00	45	1.0	42	0.0	-7.1	0.0	7.1
18	1.30	55	1.5	65	13.3	15.4	13.3	15.4
	1.50	60	1.5	65	0.0	7.7	0.0	7.7
	1.20	60	1.5	65	20.0	7.7	20.0	7.7
19	1.50	30	1.1	35	-36.4	14.3	36.4	14.3
	1.00	32	1.1	35	9.1	8.6	9.1	8.6
	1.30	37	1.1	35	-18.2	-5.7	18.2	5.7
20	2.00	60	1.8	65	-11.1	7.7	11.1	7.7
	1.50	70	1.8	65	16.7	-7.7	16.7	7.7
	1.70	67	1.8	65	5.6	-3.1	5.6	3.1
21	1.00	40	1.1	42	9.1	4.8	9.1	4.8
	1.30	38	1.1	42	-18.2	9.5	18.2	9.5
	0.90	45	1.1	42	18.2	-7.1	18.2	7.1
22	0.60	23	0.5	21	-20.0	-9.5	20.0	9.5
	0.50	18	0.5	21	0.0	14.3	0.0	14.3
	0.40	20	0.5	21	20.0	4.8	20.0	4.8
23	3.00	30	3.2	28	6.3	-7.1	6.3	7.1
	2.80	25	3.2	28	12.5	10.7	12.5	10.7
	3.50	24	3.2	28	-9.4	14.3	9.4	14.3
24	0.50	30	0.7	32	28.6	6.3	28.6	6.3
	0.60	35	0.7	32	14.3	-9.4	14.3	9.4
	0.90	28	0.7	32	-28.6	12.5	28.6	12.5
25	1.50	40	1.5	45	0.0	11.1	0.0	11.1
	1.30	42	1.5	45	13.3	6.7	13.3	6.7
	1.60	45	1.5	45	-6.7	0.0	6.7	0.0
					-3.3	4.2	13.2	9.5

Crew Calibration August 2, 2005 Middle Mainstem Green River, Washington.

Piece #	Est.		Measured		% Error		Absolute	
	Width (ft in 10ths)	Length (ft)	Width (ft in 10ths)	Length (ft)	Width	Length	Width	Length
1	1.2	40	1.1	42	-9.1	4.8	9.1	4.8
	1.2	38	1.1	42	-9.1	9.5	9.1	9.5
2	1.3	35	1.4	33	7.1	-6.1	7.1	6.1
	1.3	30	1.4	33	7.1	9.1	7.1	9.1
3	1.3	13	1.3	14	0.0	7.1	0.0	7.1
	1.3	14	1.3	14	0.0	0.0	0.0	0.0
4	1.4	40	1.6	51	12.5	21.6	12.5	21.6
	1.5	52	1.6	51	6.3	-2.0	6.3	2.0
5	1.2	60	1.1	80	-9.1	25.0	9.1	25.0
	1.1	100	1.1	80	0.0	-25.0	0.0	25.0
6	1.0	35	1.0	40	0.0	12.5	0.0	12.5
	1.0	35	1.0	40	0.0	12.5	0.0	12.5
7	0.5	40	0.5	36	0.0	-11.1	0.0	11.1
	0.6	33	0.5	36	-20.0	8.3	20.0	8.3
8	1.2	40	1.1	36	-9.1	-11.1	9.1	11.1
	1.3	42	1.1	36	-18.2	-16.7	18.2	16.7
9	1.2	45	1.4	51	14.3	11.8	14.3	11.8
	1.3	52	1.4	51	7.1	-2.0	7.1	2.0
					-1.1	2.7	7.2	10.9

Crew 2 Calibration August 2, 2005 Middle Mainstem Green River, Washington.

Piece #	Est.		Measured		% Error		Absolute	
	Width (ft in 10ths)	Length (ft)	Width (ft in 10ths)	Length (ft)	Width	Length	Width	Length
1	0.9	35	1.0	32	10.0	-9.4	10.0	9.4
	1.0	40	1.0	32	0.0	-25.0	0.0	25.0
2	0.6	24	0.5	21	-20.0	-14.3	20.0	14.3
	0.6	18	0.5	21	-20.0	14.3	20.0	14.3
3	0.8	40	0.6	48	-33.3	16.7	33.3	16.7
	0.6	50	0.6	48	0.0	-4.2	0.0	4.2
4	4	30	3.2	28	-25.0	-7.1	25.0	7.1
	3	25	3.2	28	6.3	10.7	6.3	10.7
5	1.6	42	1.1	42	-45.5	0.0	45.5	0.0
	1.5	45	1.1	42	-36.4	-7.1	36.4	7.1
6	0.9	40	0.7	32	-28.6	-25.0	28.6	25.0
	0.7	40	0.7	32	0.0	-25.0	0.0	25.0
7	1.6	60	1.5	65	-6.7	7.7	6.7	7.7
	1.4	55	1.5	65	6.7	15.4	6.7	15.4
8	1.6	35	1.6	45	0.0	22.2	0.0	22.2
	1.5	35	1.6	45	6.3	22.2	6.3	22.2
9	1.8	80	1.8	65	0.0	-23.1	0.0	23.1
	1.8	60	1.8	65	0.0	7.7	0.0	7.7
10	1	30	1.1	35	9.1	14.3	9.1	14.3
	1.2	35	1.0	35	-20.0	0.0	20.0	0.0
					-9.9	-0.5	13.7	13.6