

FINAL
**Middle Green River
Large Woody Debris Monitoring**
- 2006 Data Report -

Prepared for:
U.S. Army Corps of Engineers
Seattle District

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July 2007

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Prepared for:

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CONTENTS

EXECUTIVE SUMMARY	VIII
1. INTRODUCTION	1-1
2. ENVIRONMENTAL SETTING	2-1
2.1 STUDY AREA.....	2-1
2.2 PHYSICAL ENVIRONMENT	2-1
3. METHODS	3-1
3.1 MONITORING OVERVIEW.....	3-1
3.2 PROJECT APPROACH.....	3-1
3.2.1 LWD Monitoring.....	3-1
3.2.2 Quality Assurance/Quality Control	3-3
3.3 DATA ANALYSIS	3-5
4. RESULTS	4-1
4.1 REACH 1	4-1
4.2 REACH 2.....	4-3
4.3 REACH 3.....	4-6
4.4 REACH 4.....	4-10
4.5 REACH 5	4-13
4.6 REACH 6.....	4-16
5. ANALYSIS AND SUMMARY	5-1
6. RECOMMENDATIONS.....	6-1
7. REFERENCES	7-1

APPENDIX A: 2006 LWD Survey Field Data Forms

APPENDIX B: 2006 Quality Assurance and Control Checks

APPENDIX C: LWD Data Comparison Tables

FIGURES

Figure 2-1.	Middle Green River LWD monitoring area.....	2-2
Figure 3-1.	Size criteria for identification of individual log utilized in 2001, 2005 and 2006 monitoring surveys of the mainstem middle Green River, King County, Washington (after Schuett-Hames et al. 1999a).	3-2
Figure 3-2.	Example surveyor estimating the size of a rootmass for LWD survey, Green River, Washington 2006.	3-4
Figure 4-1.	Middle Green River LWD Survey Reach 1 (Map a).....	4-2
Figure 4-2.	Middle Green River LWD Survey Reach 2 (Map b).....	4-4
Figure 4-3.	Middle Green River LWD Survey Reach 3, upstream half (Map c).	4-7
Figure 4-4.	Middle Green River LWD Survey Reach 3, downstream half (Map d).	4-8
Figure 4-5.	Middle Green River LWD Survey Reach 4 (Map e).....	4-11
Figure 4-6.	Middle Green River LWD Survey Reach 5 (Map f).	4-14
Figure 4-7.	Middle Green River LWD Survey Reach 6 upstream half (Map g).	4-17
Figure 4-8.	Middle Green River LWD Survey Reach 6 downstream half (Map h).	4-18

TABLES

Table 3-1.	Equipment used to conduct habitat surveys for LWD surveys of the mainstem middle Green River in 2006.....	3-4
Table 4-1.	Large woody debris count by type and channel location in Reach 1, middle Green River, King County, Washington, August 2006.....	4-1
Table 4-2.	Comparison of summary statistics for the 2001 and 2006 middle Green River LWD surveys, Reach 1 (RM 64.5, Howard Hanson Dam to RM 61.0, Tacoma Headworks).....	4-3
Table 4-3.	Large woody debris count by type and channel location in Reach 2, middle Green River, King County, Washington, August 2006.....	4-5
Table 4-4.	Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Reach 2 (RM 61.0, Tacoma Headworks to RM 57.0, Kanasket State Park).	4-6
Table 4-5.	Large woody debris count by type and channel location in Reach 3, middle Green River, King County, Washington, August 2006.....	4-9
Table 4-6.	Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Reach 3 (RM 57, Kanasket State Park to RM 45, Flaming Geyser State Park).....	4-10
Table 4-7.	Large woody debris count by type and channel location in Reach 4, (RM 45, Flaming Geyser State Park to RM 40.8 Newaukum Creek), middle Green River, King County, Washington, August 2006.....	4-12
Table 4-8.	Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Reach 4 (RM 45, Flaming Geyser State Park to RM 40.8 Newaukum Creek).	4-13
Table 4-9.	Large woody debris count by type and channel location in Reach 5, (RM 40.8, Newaukum Creek to RM 38, Loans Levee), of the middle Green River, King County, Washington, August 2006.....	4-15
Table 4-10.	Comparison of summary statistics for the 2001, 2005, and 2006 LWD surveys of the middle Green River, Reach 5 (RM 40.8, Newaukum Creek to RM 38, Loans Levee).	4-16
Table 4-11.	Large woody debris count by type and channel location in Reach 5, (RM 40.8, Newaukum Creek to RM 38, Loans Levee), of the middle Green River, King County, Washington, August 2006.....	4-19

Table 4-12. Comparison of summary statistics for the 2001, 2005, and 2006 LWD surveys of the middle Green River, Reach 6 (RM 38, Loans Levee to RM 32, Auburn Narrows)..... 4-19

Table 5-1. Comparison of total LWD counts for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Washington (RM 61.0, Howard Hanson Dam to RM 32, Auburn Narrows)..... 5-2

Table 5-2. Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Washington (RM 64.5, Howard Hanson Dam to RM 32, Auburn Narrows)..... 5-3

Table 5-3. Comparison of average annual LWD recruitment rates for the Green River, Washington (RM 61.0, Howard Hanson Dam to RM 32, Auburn Narrows)..... 5-5

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (Corps) and Tacoma Public Utilities (TPU) are 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 Howard Hanson Dam Additional Water Storage Project (AWSP) and the Tacoma Water Habitat Conservation Plan (HCP). The middle Green River monitoring is intended to track long-term reach scale trends in habitat conditions. This report describes results of the August 2006 LWD survey of the middle Green River and compares those results to the August 2005 study and the baseline monitoring study completed in August/September 2001.

The quantity of individual LWD pieces and jams increased substantially between each of the 2001, 2005 and 2006 surveys of LWD in the middle mainstem Green River (see Section 5.0 for complete data tables). However, side channels were not surveyed in 2001; and while they were surveyed in 2005 the wood totals in the side channels were not kept in a separate tally from the mainstem wood. Side channels were again surveyed in 2006, but the side channel wood and mainstem wood counts were kept separate during that survey. Even though the 2001 survey reach was 5.3 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 724 pieces in 2005. This total increased again to 1,140 pieces (not including side channel data) and 1,297 pieces (including side channel data) in 2006, an increase of fifty-nine and eighty percent respectively. When converted to LWD pieces per mile, the density of LWD doubled from 13 pieces per mile in 2001 to 26.6 pieces per mile in 2005 and increased again in 2006 to 35 pieces (not including side channel data) and 40 pieces (including side channel data). The total number of key-sized pieces also increased from the 2001 to 2005 surveys from 23 to 34 pieces, respectively and again to 46 and 51 without and with side channel data respectively in 2006. The number of rootwads also increased, from 42 in 2001 to 72 in 2005 and 183 (without side channel data) and 207 (with side channel data) in 2006.

The total number of LWD jams increased from 24 jams counted in 2001 to 78 in 2005. Total LWD jams measured in 2006 were 66 (not including side channel data) and 84 (including side channel data). The number of jams per mile showed a corresponding increase from 0.7 jams per mile in 2001 to 2.9 jams per mile in 2005. 2006 jams per mile measured 2.0 and 2.6 (without and with side channel data respectively).

1. INTRODUCTION

This report presents the results of the third survey effort in a series of reach scale monitoring surveys of large woody debris (LWD) in the middle mainstem Green River conducted by the U.S Army Corps of Engineers (Corps) and Tacoma Public Utilities as part of the Howard Hanson Dam Additional Water Storage Project (AWSP) and the Tacoma Water Habitat Conservation Plan (HCP). 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 AWSP and HCP are achieving the desired goals.

A principle component of the habitat restoration is collection of wood debris from Eagle Gorge Reservoir behind Howard Hanson Dam and placement of that wood into the Green River downstream of the dam at RM 60. This includes both large wood debris (LWD) and small wood debris as defined in the AWSP biological opinions and the HCP. The project was initiated in 2004 with the placement of three pieces of LWD. In 2005, 35 pieces of LWD and 5 trash trucks of small debris were placed at RM 60. This debris was at least 12 inches diameter at breast height and 12 feet long. All 2004 LWD was marked with blue spray paint. 2005 LWD was marked with orange spray point. Special attention was given to identifying the location of these pieces during the survey; however, the majority of the restoration wood was under the minimum length (30 ft) to be considered individual LWD during the survey. These logs would however, contribute to forming jams and would count as logs as part of a jam (12 ft minimum length).

Restoration activities also included construction of two engineered log jams at RM 60 in 2003 and annual gravel nourishment. More detail about these projects can be found in applicable monitoring reports (R2 Resource Consultants 2004 and Corps 2005).

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 (R2 2006).

This report summarizes the results of the third LWD monitoring event in the middle mainstem Green River in August 2006. 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 2006 survey and a comparison with data collected during the 2001 and 2005 surveys are presented in Section 4. Section 5 presents a summary of conclusions and Section 6 provides recommendations for future LWD monitoring activities. Appendices A-C contain copies of field data sheets, quality assurance spreadsheets, and LWD summary data tables.

2. ENVIRONMENTAL SETTING

2.1 STUDY AREA

The 2006 LWD survey extended from Howard Hansen Dam at RM 64.5 downstream to the Auburn Narrows at approximately RM 32.0 (Figure 2-1). This survey length is somewhat longer than the 2005 survey, but identical to the 2001 survey. The 2005 survey encompassed only Reaches 2 through 6 extending from the Tacoma Headworks at RM 61.0 to the Hwy 18 bridge at RM 33.8. 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. This reach was added back in to the survey range for the 2006 survey effort.

The six reaches sampled as part of the 2006 survey effort included:

Reach 1: RM 64.5 (Howard Hanson Dam) to RM 61.0 (Tacoma Headworks)

Reach 2: RM 61.0 (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 32 (Auburn Narrows) (in 2005 RM 38 to RM 33.8 (Highway 18 Bridge))

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, flow, bedform, and substrate). With the noted exceptions, the reach designations developed as part of the 2001 monitoring survey were used in the 2006 survey to ensure consistent comparison of results between surveys.

2.2 PHYSICAL ENVIRONMENT

A detailed description of the environmental 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.

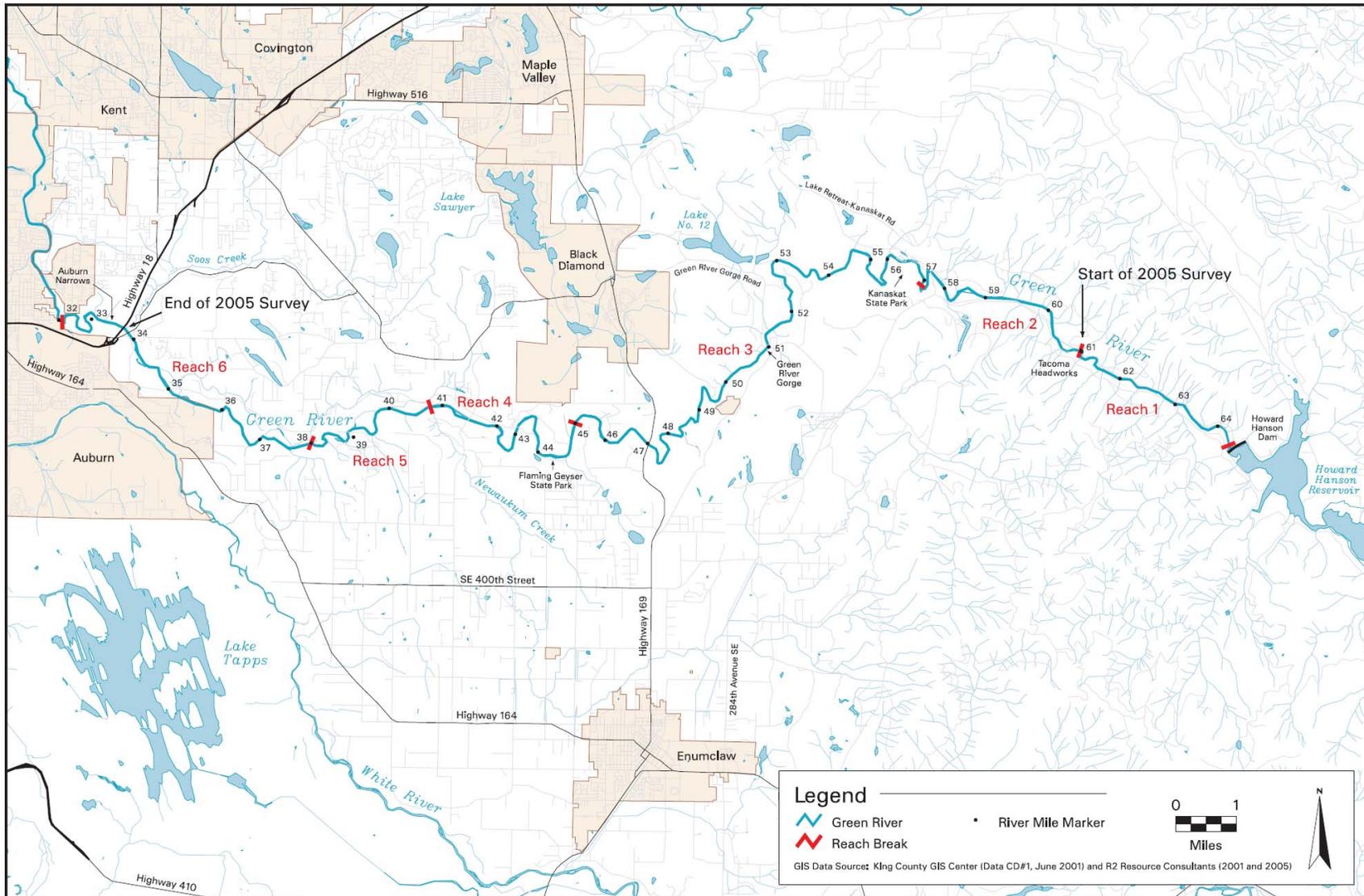


Figure 2-1. Middle Green River LWD monitoring area.

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 LWD Monitoring

To ensure consistency between the 2001 and later 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 protocol¹ 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). Zone 1 was defined as the portion of the bankfull channel that was wetted at the time of survey, regardless of whether the water was flowing or stagnant. Zone 2 was defined as the area between the bankfull channel edge on both banks, below an imaginary line that connects these points, above the wetted channel surface. A piece was assigned to Zone 1 if a minimum of 3.9 inches (0.1 meter) of its length was within the water. Similarly, a piece was assigned to Zone 2 if a minimum of 3.9 inches (0.1 meter) was within the bankfull channel, but did not extend the minimum length into the water. A piece of wood 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

¹ 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.

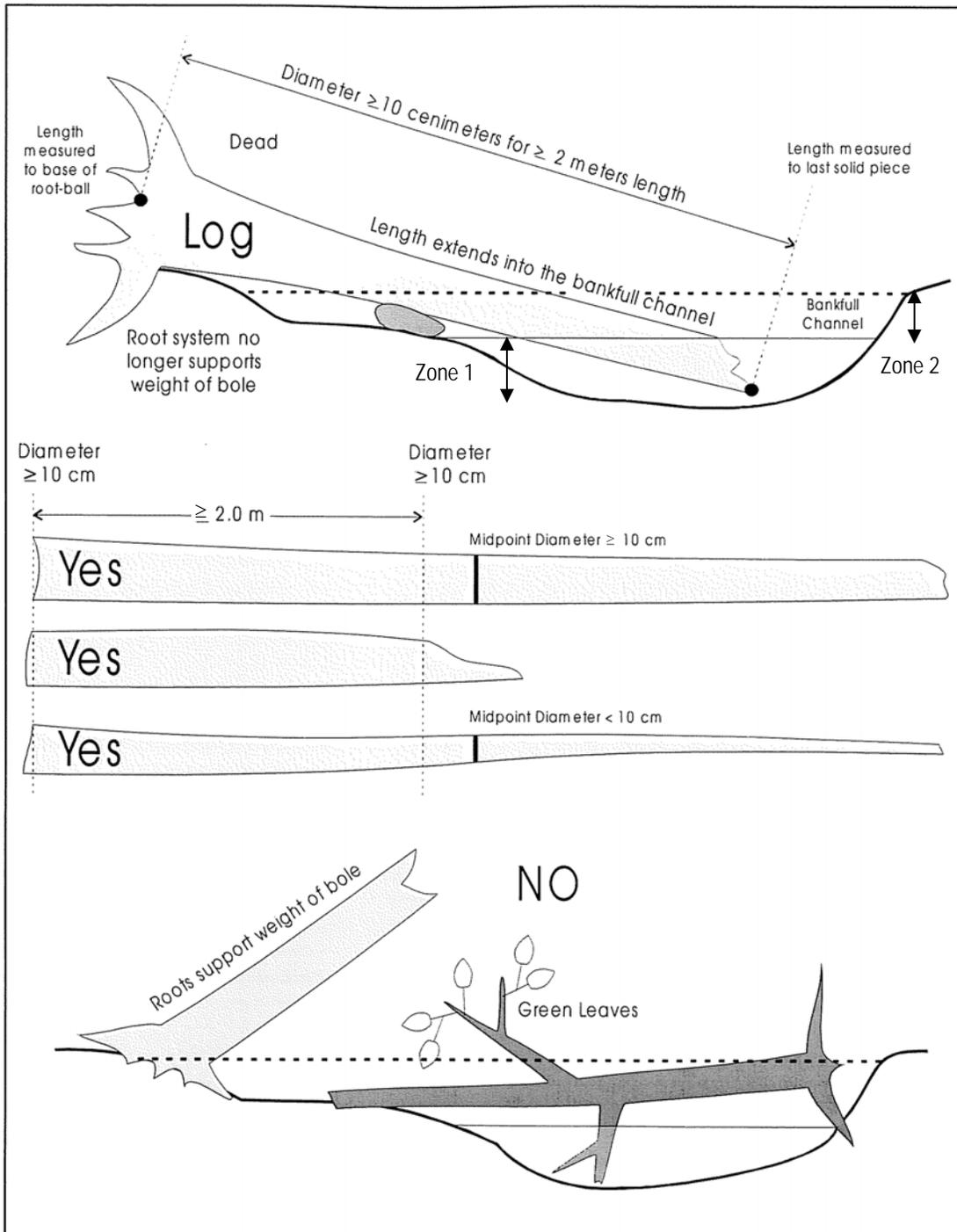


Figure 3-1. Size criteria for identification of individual log utilized in 2001, 2005 and 2006 monitoring surveys of the mainstem middle Green River, King County, Washington (after Schuett-Hames et al. 1999a).

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.² 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 (Figure 3-2).

One significant difference between the 2001 and later surveys methods was the decision to include side channel areas. The 2001 survey focused solely on mainstem habitat attributes and so side channels were not included. Side channels were included in the 2005 and 2006 surveys to ensure a thorough count of all LWD within the middle mainstem Green River and for long-term monitoring needs. All side channels with noticeable inlet flow at the time of the survey were surveyed. Thirty side channels were surveyed in 2006, measuring a total of approximately 5 miles. These side channels are noted on the maps in Section 4.

3.2.2 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. Table 3-1 lists equipment used to conduct LWD surveys of the mainstem middle Green River in 2006.

² 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.



Figure 3-2. Example surveyor estimating the size of a rootmass for LWD survey, Green River, Washington 2006.

Table 3-1. Equipment used to conduct habitat surveys for LWD surveys of the mainstem middle Green River in 2006.

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

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 A contains copies of field notes with observer estimates and LWD piece measurements presented at the bottom of each page. Appendix B has a complete list of the error estimations.

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. Tables describing 2006 LWD quantity and distribution and comparisons with 2001 and 2005 survey results were generated for each reach. New high resolution aerial photographic coverage was supplied by the Corps in 2007. The GIS basemap constructed as part of the 2005 survey was updated with the new aerial photo coverage and 2006 LWD information was added.

4. RESULTS

This section presents the results of reach specific LWD counts, and comparison of the 2001, 2005 and 2006 surveys. Comparison of results from the 2001 and 2005/2006 LWD surveys should be made with caution as side channels were not included as part of the 2001 survey but were surveyed during the later surveys (2005 and 2006). No attempt was made to distinguish LWD located within side channel areas from LWD found within the main channel during the 2005 survey³. Side channel wood counts were kept separate from mainstem counts starting in 2006.

4.1 REACH 1

Reach 1 was surveyed on 17 August 2006. The reach is approximately 3.5 miles long extending from Howard Hanson Dam (RM 64.5) to Tacoma Headworks (RM 61.0) (Figure 4-1). The average stream flow during the survey was 236 cfs as measured below Howard Hanson Dam (USGS #12105900). This reach was not surveyed in 2005. Results of the large woody debris count and summary statistics for Reach 1 are provided in Tables 4-1 and 4-2.

Table 4-1. Large woody debris count by type and channel location in Reach 1, middle Green River, King County, Washington, August 2006.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	14	38	0	52	52
Log-Medium with Rootwad	7	2	0	9	9
Log-Large	10	10	0	20	20
Log-Large with Rootwad	4	2	0	6	6
Key Piece	0	2	0	2	2
Key Piece with Rootwad	0	0	0	0	0
Rootwad	2	3	0	5	5
Total	37	57	0	94	94
Small Jam	2	1	0	3	3
Medium Jam	0	0	0	0	0
Large Jam	0	0	0	0	0

³ 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.

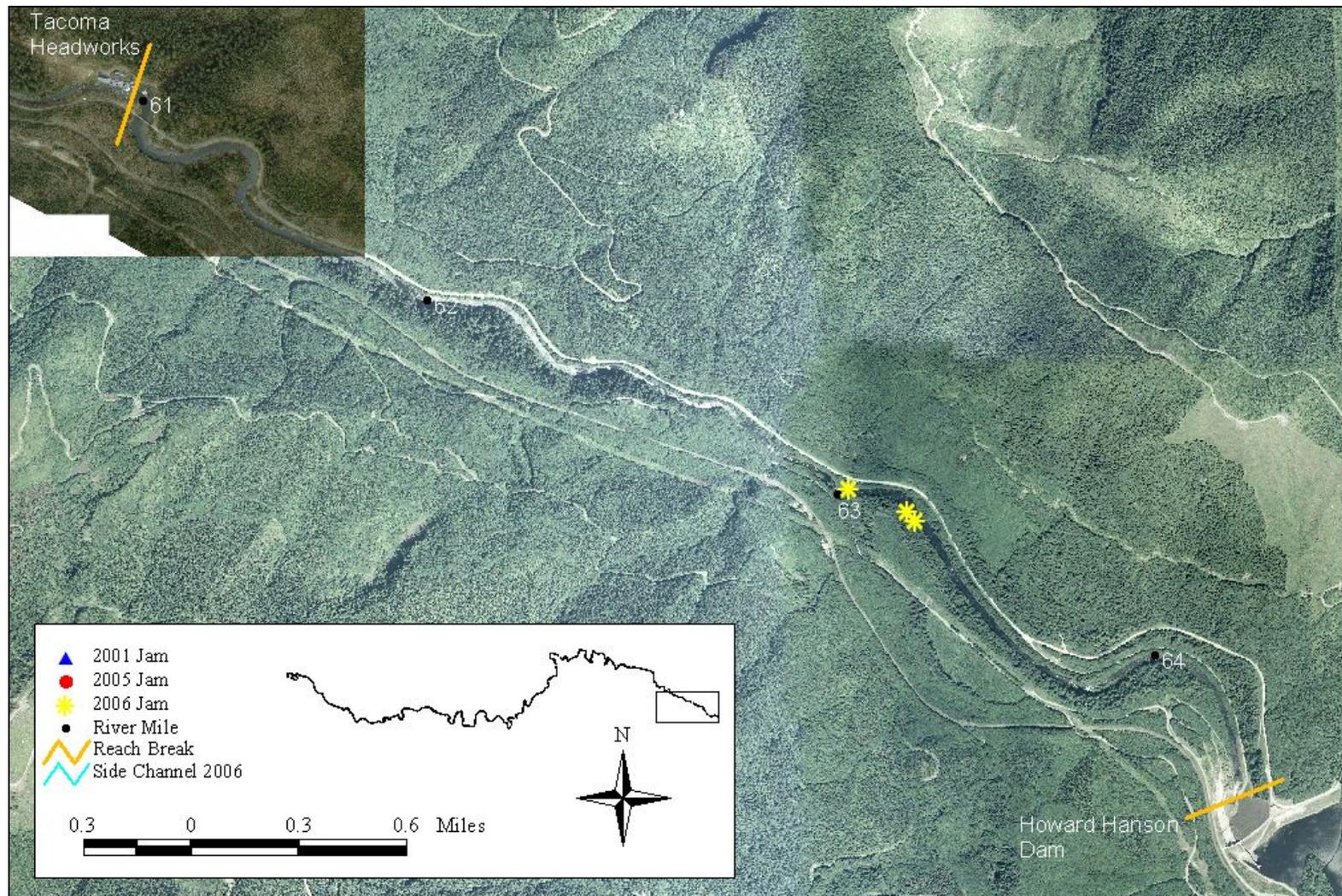


Figure 4-1. Middle Green River LWD Survey Reach 1 (Map a).

Table 4-2. Comparison of summary statistics for the 2001 and 2006 middle Green River LWD surveys, Reach 1 (RM 64.5, Howard Hanson Dam to RM 61.0, Tacoma Headworks).

	Survey Year		
	2001 Not Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Survey Length	3.5 miles	3.5 miles	3.5 miles
Flow @ Howard Hanson Dam	223-231 cfs	236 cfs	236 cfs
Total LWD ¹	18	94	94
Number of LWD ¹ – Zone 1	9	37	37
Number of LWD ¹ – Zone 2	9	57	57
Number of LWD – Side channel	n/a ²	0	0
LWD ¹ per Mile	5.1	26.9	26.9
Percent Cut LWD	6%	6%	6%
Total Number Key LWD	1	2	2
Key Pieces per Mile	0.3	0.6	0.6
Total Number of LWD Jams	0	3	3
Percent Small Jams	0%	100%	100%
Percent Medium Jams	0%	0%	0%
Percent Large Jams	0%	0%	0%

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

²2001 survey did not include side channels.

4.2 REACH 2

Reach 2 was surveyed on August 15, 2006. The reach is approximately 4.0 miles long extending from the Tacoma Headworks (RM 61.0) to Kanasket State Park (RM 57.0) (Figure 4-2). The flow at the time of the survey was 129 cubic feet per second (cfs) as measured at the Palmer, Washington stream gage (USGS #12106700). Summary statistics for Reach 2 are provided in Tables 4-3 and 4-4.

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 Corps of Engineers (Corps) 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 (Corps 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, Corps, personal communication to Mike Gagner, R2, July 7, 2005). The Corps had numbered each individual piece of LWD included in the jams with a

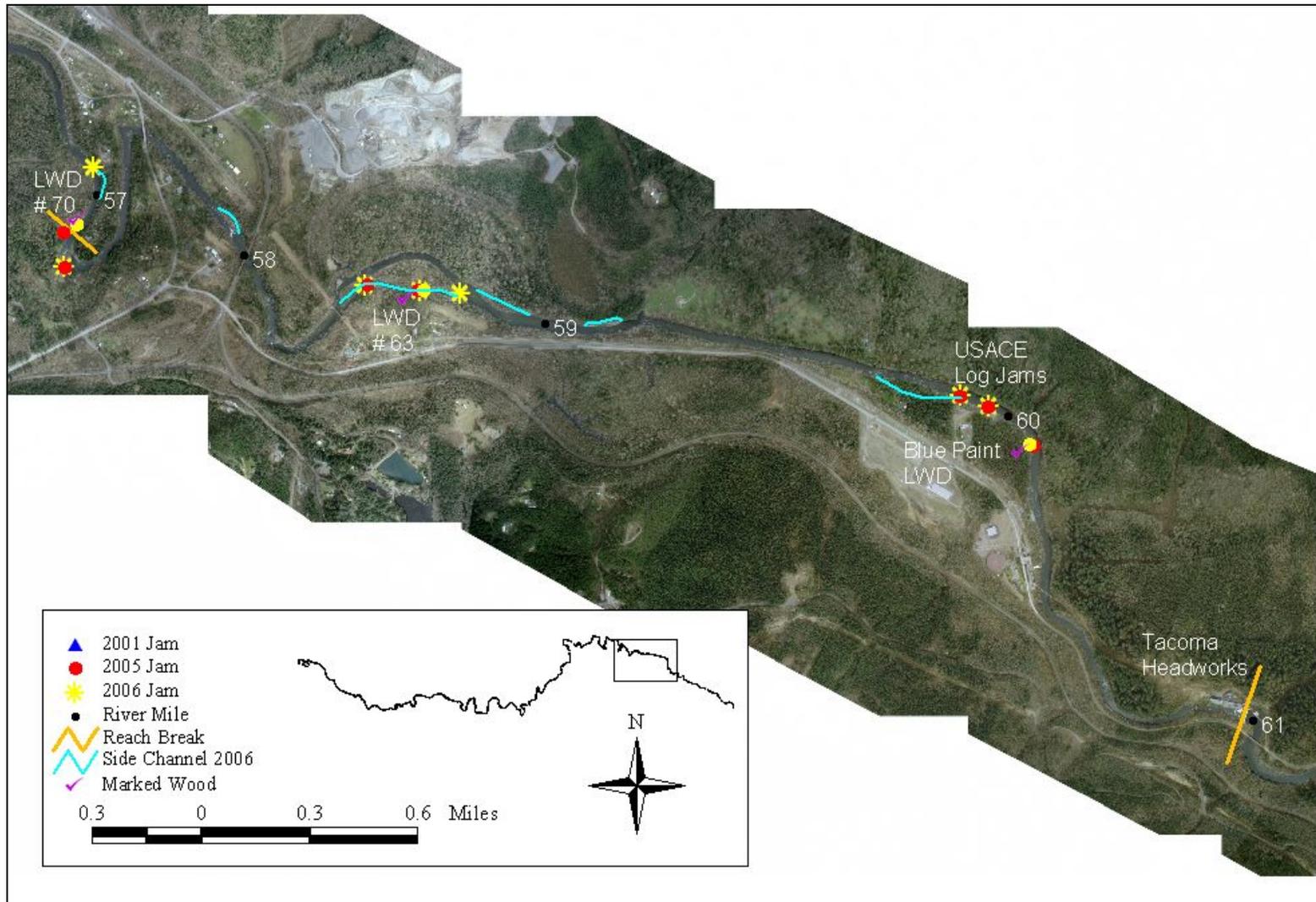


Figure 4-2. Middle Green River LWD Survey Reach 2 (Map b).

small metal tag attached near one end. Additionally, in late August 2004, the Corps placed three individual logs (20-24 in dbh and ~30 ft long) on a gravel nourishment site located at the same location (RM 60) as the engineered log jams (Scott Pozarycki, Corps, 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. One blue log (large log with rootwad) was identified in Zone 2 of Reach 2 during 2006 surveys.

In October 2005 the Corps placed 35 pieces of LWD and 5 trash trucks of small debris at the upstream and downstream gravel berms in Zone 1. This debris was at least 12 inches diameter at breast height and 12 feet long, and included 6 large rootwads. All LWD was marked with orange spray paint.

Table 4-3. Large woody debris count by type and channel location in Reach 2, middle Green River, King County, Washington, August 2006.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	25	32	13	70	57
Log-Medium with Rootwad	4	1	2	7	5
Log-Large	11	5	3	19	16
Log-Large with Rootwad	4	3	3	10	7
Key Piece	4	3	0	7	7
Key Piece with Rootwad	0	1	0	1	1
Rootwad	4	6	2	12	10
Total	52	51	23	126	103
Small Jam	2	0	2	4	2
Medium Jam	2	0	0	2	2
Large Jam	0	0	0	0	0

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

Table 4-4. Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Reach 2 (RM 61.0, Tacoma Headworks to RM 57.0, Kanasket State Park).

	Survey Year			
	2001 Not Including Side Channel Data	2005 Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Survey Length	4.0 miles	4.0 miles	4.0 miles	4.0 miles
Flow @ Palmer, WA	133 cfs	175 cfs	129 cfs	129 cfs
Flow @ Auburn, WA	257 cfs	296 cfs	248 cfs	248 cfs
Total LWD ¹	36	88	126	103
Number of LWD ¹ – Zone 1	21	47	57	52
Number of LWD ¹ – Zone 2	15	41	69	51
LWD ¹ per Mile	9.0	22.0	31.5	25.8
Percent Cut LWD	0%	7.2%	2%	3%
Total Number Key LWD	2	6	8	8
Key Pieces per Mile	0.5	1.5	2.0	2.0
Total Number of LWD Jams	0	5	6	4
Percent Small Jams	0%	60%	67%	50%
Percent Medium Jams	0%	40%	33%	50%
Percent Large Jams	0%	0%	0%	0%

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

4.3 REACH 3

The survey of Reach 3 took place over August 14, 15, and 16, 2006. The reach is approximately 12 miles long extending from Kanasket State Park (RM 57) to Flaming Geyser State Park (RM 45) (Figures 4-3 and 4-4). The average stream flow during the survey was 127 cfs as measured at the Palmer, Washington stream gage (USGS # 12106700). Summary statistics for Reach 3 are provided in Tables 4-5 and 4-6.

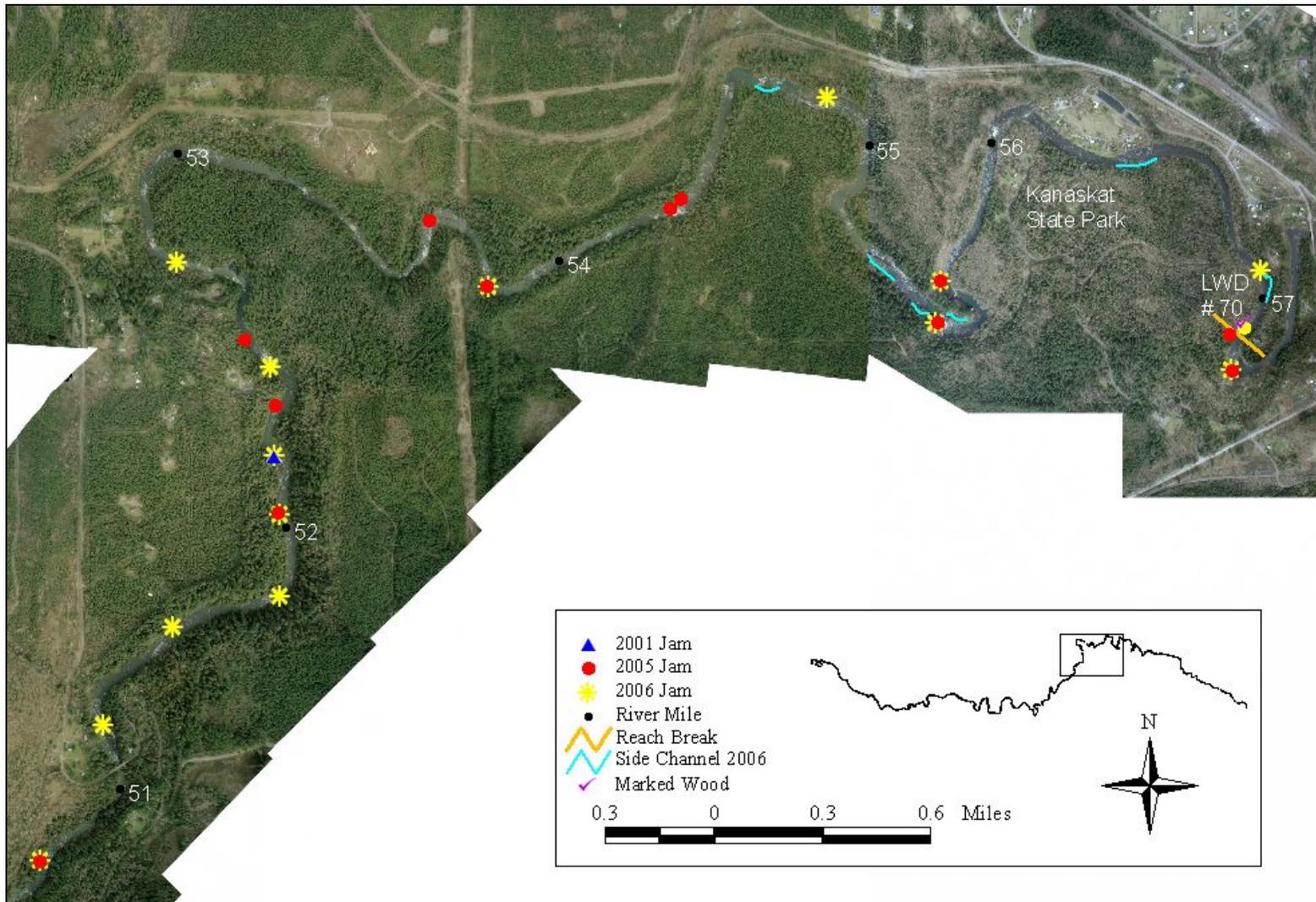


Figure 4-3. Middle Green River LWD Survey Reach 3, upstream half (Map c).

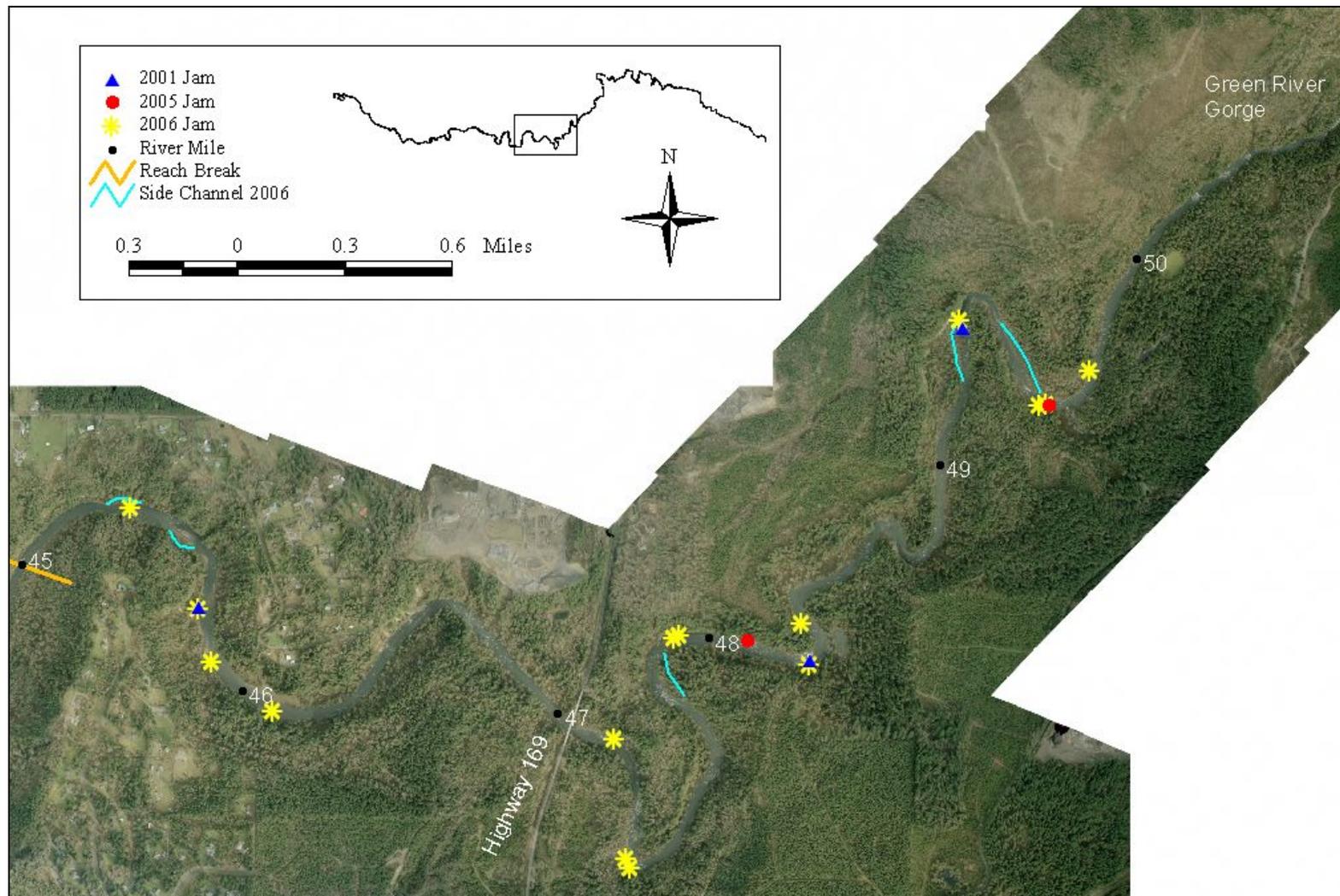


Figure 4-4. Middle Green River LWD Survey Reach 3, downstream half (Map d).

Table 4-5. Large woody debris count by type and channel location in Reach 3, middle Green River, King County, Washington, August 2006.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	72	128	12	212	200
Log-Medium with Rootwad	64	79	2	145	143
Log-Large	29	47	2	78	76
Log-Large with Rootwad	23	23	2	48	46
Key Piece	8	10	0	18	18
Key Piece with Rootwad	8	4	0	12	12
Rootwad	12	55	4	71	67
Total	216	346	22	584	562
Small Jam	14	11	0	25	25
Medium Jam	1	1	0	2	2
Large Jam	0	0	0	0	0

Table 4-6. Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Reach 3 (RM 57, Kanasket State Park to RM 45, Flaming Geyser State Park).

	Survey Year			
	2001 Not Including Side Channel Data	2005 Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Survey Length	12 miles	12 miles	12 miles	12 miles
Flow @ Palmer, WA	120 cfs	176 cfs	127 cfs	127 cfs
Flow @ Auburn, WA	259-360 cfs	304 cfs	249 cfs	249 cfs
Total LWD ¹	164	352	584	562
Number of LWD ¹ – Zone 1	94	167	222	216
Number of LWD ¹ – Zone 2	70	185	362	346
LWD ¹ per Mile	13.6	29.4	48.7	46.8
Percent Cut LWD	7%	2%	1	1
Total Number Key LWD	11	23	30	30
Key Pieces per Mile	0.9	1.9	2.5	2.5
Total Number of LWD Jams	8	29	27	27
Percent Small Jams	100%	86%	93%	93%
Percent Medium Jams	0%	14%	7%	7%
Percent Large Jams	0%	0%	0%	0%

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

4.4 REACH 4

Reach 4 was surveyed on the 16th and 17th of August 2006. The reach is approximately 4.2 miles long extending from Flaming Geyser State Park (RM 45) to Newaukum Creek (RM 40.8) (Figure 4-5). The average stream flow during the survey was 250 cfs as measured at the Auburn, Washington stream gage (USGS #12113000). Comparison of summary statistics for the 2001, 2005 and 2006 LWD surveys of Reach 4 are presented in Tables 4-7 and 4-8.

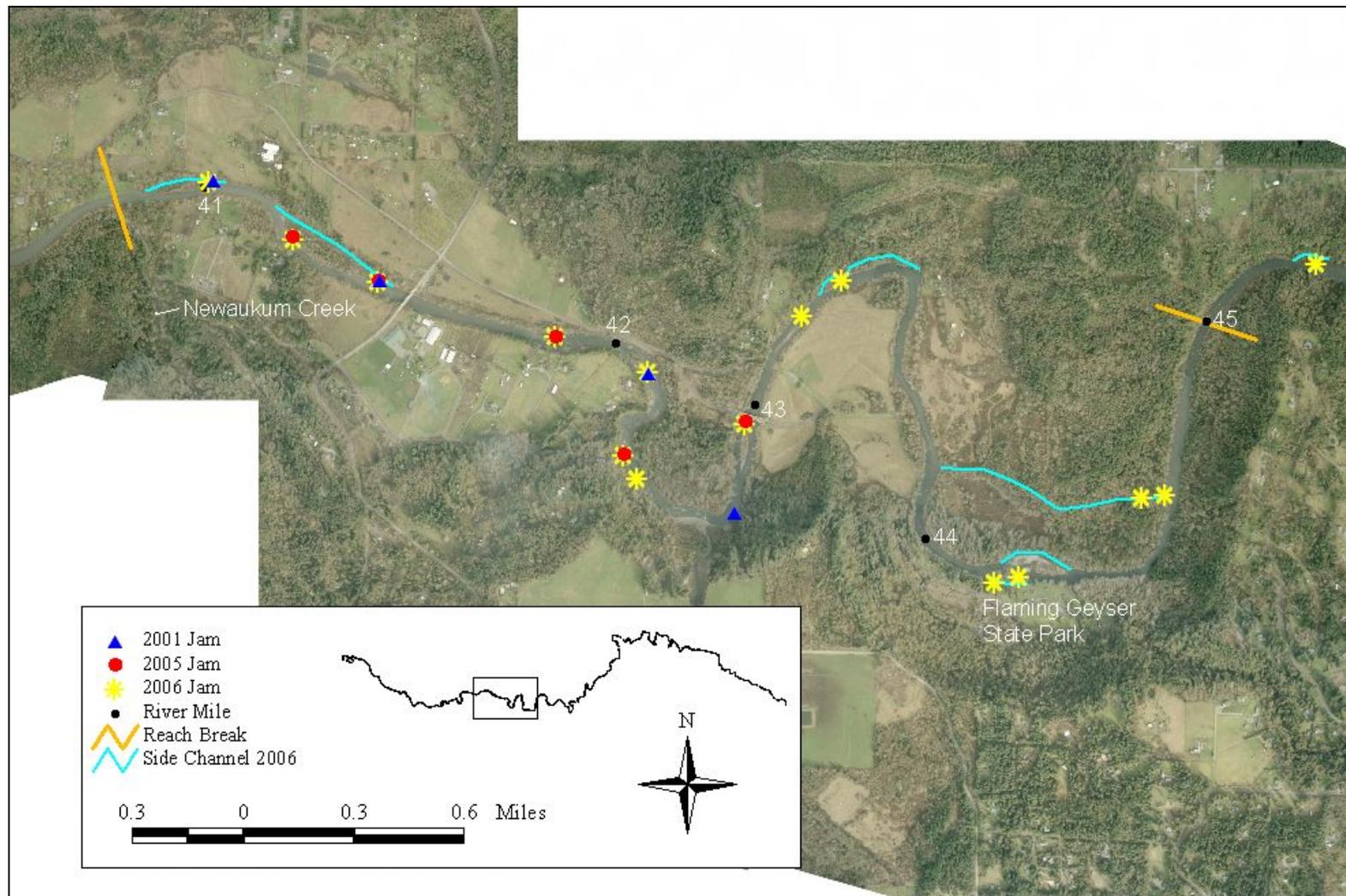


Figure 4-5. Middle Green River LWD Survey Reach 4 (Map e).

Table 4-7. Large woody debris count by type and channel location in Reach 4, (RM 45, Flaming Geyser State Park to RM 40.8 Newaukum Creek), middle Green River, King County, Washington, August 2006.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	21	9	21	51	30
Log-Medium with Rootwad	8	14	2	24	22
Log-Large	5	4	7	16	9
Log-Large with Rootwad	7	2	7	16	9
Key Piece	0	4	2	6	4
Key Piece with Rootwad	0	0	3	3	0
Rootwad	15	7	7	29	22
Total	56	40	50	145	96
Small Jam	5	4	4	13	9
Medium Jam	0	0	0	0	0
Large Jam	1	0	0	1	1

Table 4-8. Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Reach 4 (RM 45, Flaming Geyser State Park to RM 40.8 Newaukum Creek).

	Survey Year			
	2001 Not Including Side Channel Data	2005 Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Survey Length	4.2 miles	4.2 miles	4.2 miles	4.2 miles
Flow @ Palmer, WA	120 cfs	175 cfs	129 cfs	129 cfs
Flow @ Auburn, WA	252-256 cfs	292 cfs	250 cfs	250 cfs
Total LWD ¹	33	61	145	96
Number of LWD ¹ – Zone 1	27	35	68	56
Number of LWD ¹ – Zone 2	6	26	77	40
LWD ¹ per Mile	7.9	14.7	34.8	22.9
Percent Cut LWD	0%	0%	5%	2%
Total Number Key LWD	4	1	9	4
Key Pieces per Mile	1.0	0.2	2.1	1.0
Total Number of LWD Jams	5	10	14	10
Percent Small Jams	100%	70%	93%	90%
Percent Medium Jams	0%	30%	0%	0%
Percent Large Jams	0%	0%	7%	10%

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

4.5 REACH 5

Reach 5 was surveyed on 17 August 2006. The reach is approximately 2.8 miles long extending from Newaukum Creek (RM 40.8) to Loans Levee (RM 38.0) (Figure 4-6). The average stream flow during the survey was 250 cfs as measured at the Auburn, Washington stream gage (USGS #12113000). 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). Summary statistics for the 2001, 2005, and 2006 LWD surveys of Reach 5 are presented in Tables 4-9 and 4-10.

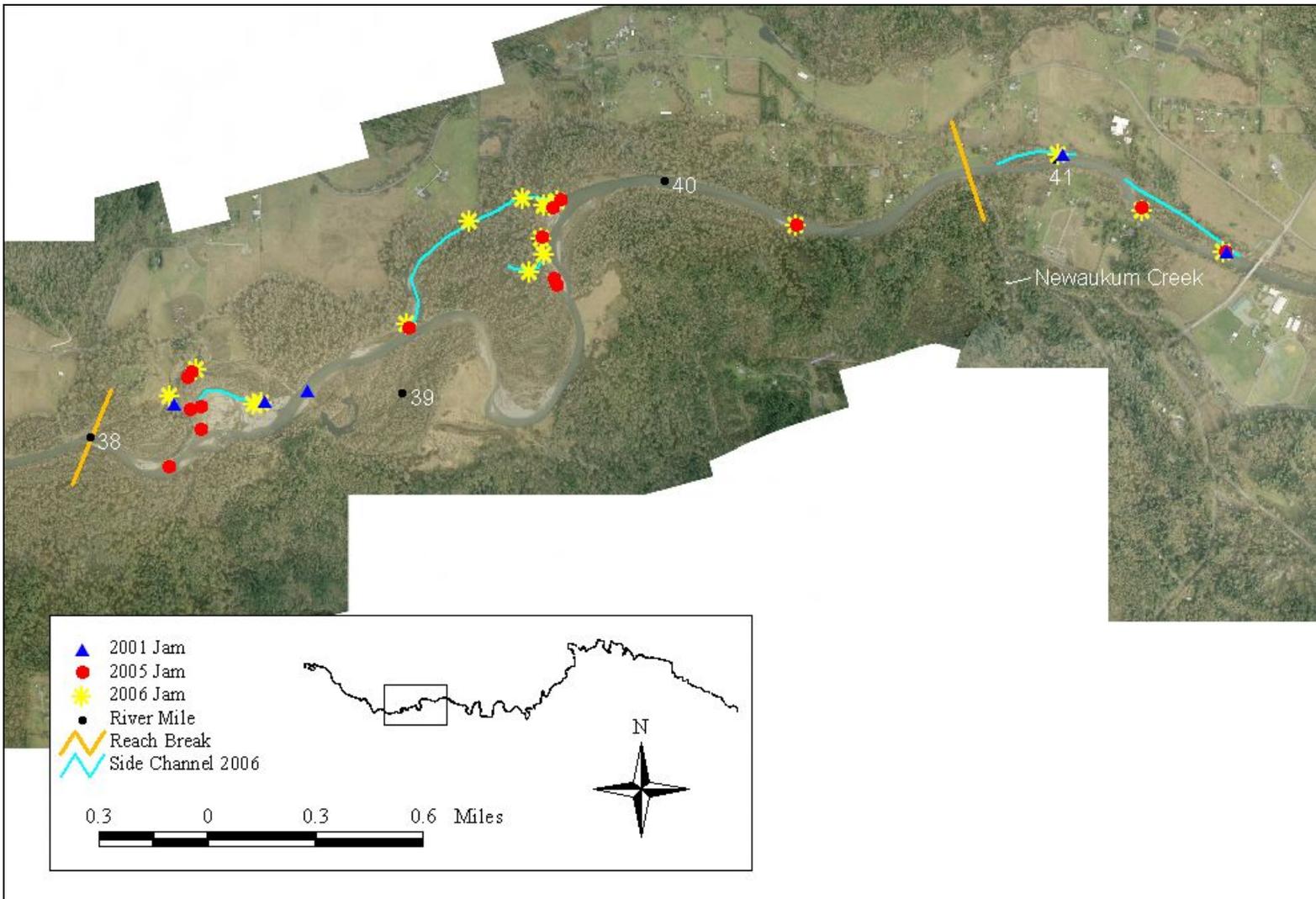


Figure 4-6. Middle Green River LWD Survey Reach 5 (Map f).

Table 4-9. Large woody debris count by type and channel location in Reach 5, (RM 40.8, Newaukum Creek to RM 38, Loans Levee), of the middle Green River, King County, Washington, August 2006.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	6	9	21	36	15
Log-Medium with Rootwad	19	19	10	48	38
Log-Large	1	1	1	3	2
Log-Large with Rootwad	4	2	6	12	6
Key Piece	0	0	0	0	0
Key Piece with Rootwad	0	0	0	0	0
Rootwad	9	16	8	33	25
Total	39	47	46	132	86
Small Jam	3	1	7	11	4
Medium Jam	0	0	2	2	0
Large Jam	0	0	1	1	0

Table 4-10. Comparison of summary statistics for the 2001, 2005, and 2006 LWD surveys of the middle Green River, Reach 5 (RM 40.8, Newaukum Creek to RM 38, Loans Levee).

	Survey Year			
	2001 Not Including Side Channel Data	2005 Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Survey Length	2.8 miles	2.8 miles	2.8 miles	2.8 miles
Flow @ Palmer, WA	114-127 cfs	174 cfs	130 cfs	130 cfs
Flow @ Auburn, WA	256-356 cfs	292 cfs	250 cfs	250 cfs
Total LWD ¹	70	111	132	86
Number of LWD ¹ – Zone 1	41	62	77	39
Number of LWD ¹ – Zone 2	29	49	55	47
LWD ¹ per Mile	25.0	39.6	47.2	30.7
Percent Cut LWD	1%	1.8%	0%	0%
Total Number Key LWD	3	2	0	0
Key Pieces per Mile	1.1	0.7	0	0
Total Number of LWD Jams	6	22	14	4
Percent Small Jams	67%	73%	79%	100%
Percent Medium Jams	17%	14%	14%	0%
Percent Large Jams	16%	13%	7%	0%

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

4.6 REACH 6

Reach 6 was surveyed on August 17, 18 and 22, 2006. The survey reach was approximately 6.0 miles long extending from Loans Levee (RM 38.0) to the Auburn Narrows (RM 32.0) (Figure 4-7 and 4-8). The average stream flow during the survey was 250 cfs as measured at the Auburn, Washington stream gage (USGS # 12113000). Summary statistics for Reach 6 are presented in Tables 4-11 and 4-12.

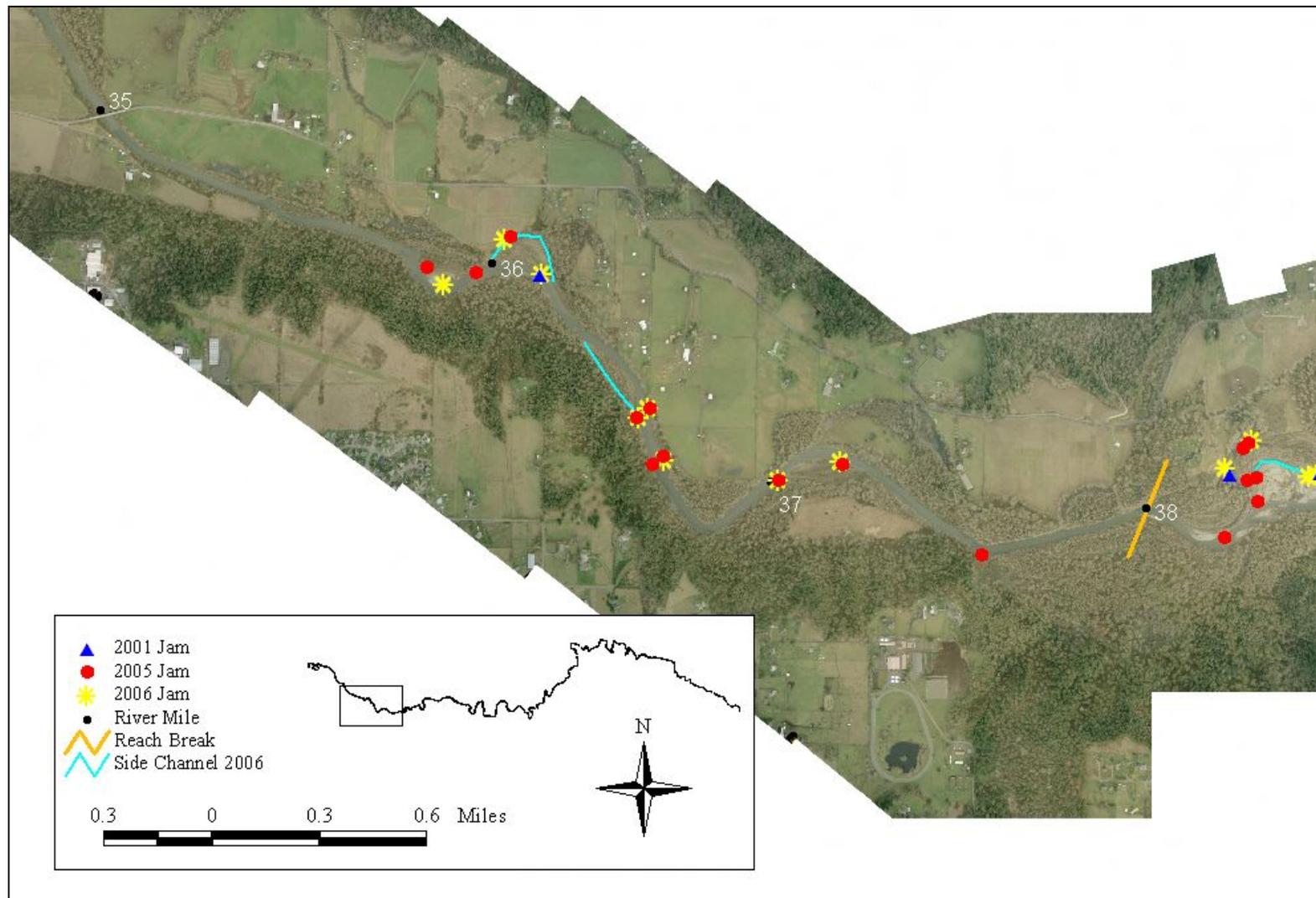


Figure 4-7. Middle Green River LWD Survey Reach 6 upstream half (Map g).

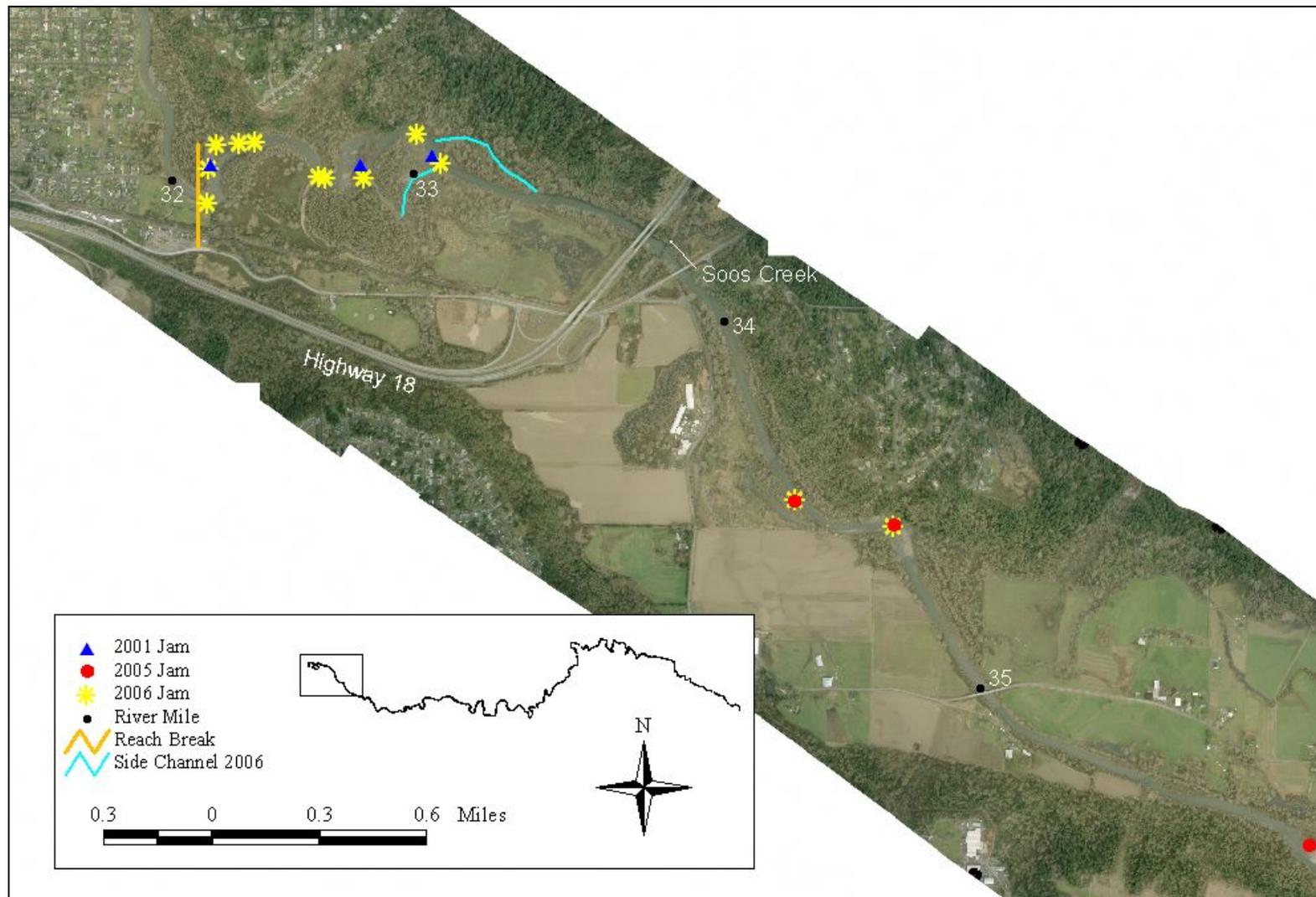


Figure 4-8. Middle Green River LWD Survey Reach 6 downstream half (Map h).

Table 4-11. Large woody debris count by type and channel location in Reach 5, (RM 40.8, Newaukum Creek to RM 38, Loans Levee), of the middle Green River, King County, Washington, August 2006.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	24	16	8	48	40
Log-Medium with Rootwad	54	17	4	75	71
Log-Large	8	1	2	11	9
Log-Large with Rootwad	18	5	0	23	23
Key Piece	1	0	0	1	1
Key Piece with Rootwad	1	0	0	1	1
Rootwad	42	12	3	57	54
Total	148	51	17	216	199
Small Jam	11	3	1	15	14
Medium Jam	3	0	1	4	3
Large Jam	1	0	0	1	1

Table 4-12. Comparison of summary statistics for the 2001, 2005, and 2006 LWD surveys of the middle Green River, Reach 6 (RM 38, Loans Levee to RM 32, Auburn Narrows).

	Survey Year			
	2001 Not Including Side Channel Data	2005 Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Survey Length	6.0 miles	4.2 miles	6.0 miles	6.0 miles
Flow @ Palmer, WA	117-127 cfs	174 cfs	134 cfs	134 cfs
Flow @ Auburn, WA	266-326 cfs	287 cfs	250 cfs	250 cfs
Total LWD ¹	131	112	216	199
Number of LWD ¹ – Zone 1	93	85	158	148
Number of LWD ¹ – Zone 2	38	27	58	51
LWD ¹ per Mile	21.8	26.7	36.0	33.2
Percent Cut LWD	0%	7%	2%	2%
Total Number Key LWD	3	2	2	2
Key Pieces per Mile	0.5	0.5	0.3	0.3
Total Number of LWD Jams	5	12	20	18
Percent Small Jams	80%	75%	75%	77.8%
Percent Medium Jams	0%	8%	20%	16.7%
Percent Large Jams	20%	17%	5%	5.5%

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

5. ANALYSIS AND SUMMARY

Similar methods were used to count and determine channel location of LWD during the 2001, 2005 and 2006 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 and 2006 surveys. 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 the later surveys was the inclusion of side channel areas. The 2001 survey focused only on mainstem habitat attributes and so side channels were not included. However, side channel woody debris tallies were kept separate from mainstem numbers in 2005. 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, in 2005 one large side channel located in Reach 5 (approximately RM 39.8) contained 30 individual LWD pieces and 4 jams.⁴ 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. The side channel data were kept separate from the mainstem data in the 2006 surveys. In 2006 side channels accounted for approximately 12 percent of the total LWD counted in the river. Comparison of woody debris totals over the three survey periods is provided in Tables 5-1 and 5-2.

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.

⁴ 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.

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 than peak flows in the preceding ten years. For the period August 2001 to August 2006 the highest peak flow, as measured at Auburn Washington, was 10,200 cfs (USGS #12113000). Maximum peak flow during the period August 1991 to August 2001 was 12,400 cfs (USGS #12113000). Input of LWD to the reservoir behind Howard Hanson Dam has been relatively low over the past four years (Scott Pozarycki, Corps, personal communication to Mike Gagner, R2, December 6, 2005) indicating that storm related recruitment of LWD to the Green River basin had not been a significant factor at least through summer of 2006.

Table 5-1. Comparison of total LWD counts for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Washington (RM 61.0, Howard Hanson Dam to RM 32, Auburn Narrows).

	Survey Year ³			
	2001 Not Including Side Channel Data	2005 Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Total LWD ¹ Pieces	434	724	1,297	1,140
Medium Size Pieces	259	503	777	682
Large Size Pieces	110	115	262	229
Key Size Pieces	23	34	51	46
Rootwads	42	72	207	183
Total LWD Jams ²	24	78	84	66
Small Jams	21	60	71	57
Medium Jams	1	13	10	7
Large Jams	2	5	3	2

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

²Includes small, medium and large jams.

³2005 survey length was 5.3 miles shorter than the 2001 and 2006 survey length.

Table 5-2. Comparison of summary statistics for the 2001, 2005, and 2006 surveys of LWD in the middle Green River, Washington (RM 64.5, Howard Hanson Dam to RM 32, Auburn Narrows).

Reach ¹	Survey Year	Includes Side Channel Data?	Total LWD ²	Total Key Piece	LWD Per Mile	Key Piece Per Mile	Total # Jams ³	# of Jams Per Mile
1	2001	No	18	1	5.1	0.3	0	0.0
	2005		<i>Reach 1 was not included in 2005 LWD survey</i>					
	2006	Yes	94	2	26.9	0.6	3	0.9
	2006	No	94	2	26.9	0.6	3	0.9
2	2001	No	36	2	9.0	0.5	0	0.0
	2005	Yes	88	6	22.0	1.5	5	1.3
	2006	Yes	126	8	31.5	2.0	6	1.5
	2006	No	103	8	25.8	2.0	4	1.0
3	2001	No	164	11	13.6	0.9	8	0.7
	2005	Yes	352	23	29.3	1.9	29	2.4
	2006	Yes	584	30	48.7	2.5	27	2.3
	2006	No	562	30	46.8	2.5	27	2.3
4	2001	No	33	4	7.9	1.0	5	1.2
	2005	Yes	61	1	14.5	0.2	10	2.4
	2006	Yes	145	9	34.8	2.1	14	3.4
	2006	No	96	4	22.9	1.0	10	2.4
5	2001	No	70	3	25.0	1.1	6	2.1
	2005	Yes	111	2	39.6	0.7	22	7.9
	2006	Yes	132	0	47.2	0.0	14	5.0
	2006	No	86	0	30.7	0.0	4	1.4
6	2001	No	131	3	21.8	0.5	5	0.8
	2005	Yes	112	2	26.7	0.5	12	2.9
	2006	Yes	216	2	36.0	0.3	20	3.3
	2006	No	199	2	33.2	0.3	18	3.0

¹The surveyed length of Reach 6 was approximately 1.8 miles shorter during the 2005 survey.

²Includes medium and large logs, key-sized pieces and rootwads.

³Includes small, medium, and large jams.

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

$Total_{2005}$ = total count of LWD during the 2005 survey;

$Total_{2001}$ = 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

$Reach_{2005}$ = total count of LWD within the reach during 2005 survey;

$Reach_{2001}$ = 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:

Although the 2005 number of LWD pieces increased considerably since the 2001 survey, when converted to an annual recruitment rate, the increase is somewhat lower than expected (Table 5-3). 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 (27.2 miles) was 2.8 pieces of LWD⁵ per mile. When calculated on a reach scale, the annual recruitment rate ranged from a high of 3.7 pieces per mile in Reach 5 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. Recruitment is the amount of wood added to the stream system, the input level. The average annual recruitment rate in the Green River from 2005 to 2006 measured 13.1 pieces per year. This total is much closer to that reported in literature. The 2006 values ranged from a high of 19.3 in Reach 3 to a low of 7.5 in Reach 5.

Table 5-3. Comparison of average annual LWD recruitment rates for the Green River, Washington (RM 61.0, Howard Hanson Dam to RM 32, Auburn Narrows).

Reach Number	Total LWD Change ¹ (2005 Total – 2001 Total)	Total LWD Change ² (2006 Total – 2005 Total)	Annual LWD Recruitment per Mile 2005- 2001	Annual LWD Recruitment per Mile 2006- 2005
2	52	38	3.25	9.5
3	188	232	3.9	19.3
4	28	84	1.7	20.0
5	41	21	3.7	7.5
6	29	56	1.2	9.3

¹To compare 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.

²2006 data includes side channel LWD

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 surveys including restoration efforts, natural recruitment, and differences in survey methods. A brief discussion of each of these is presented below:

⁵ Includes medium and large logs, key-sized pieces, and rootwads. Note: 2001 survey length was 5.3 miles longer than 2005 survey length.

- 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 several 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. In an effort to address this issue side channel LWD tallies were kept separate in 2006. Overall, in 2006 side channels provided 12 percent of the total LWD pieces in the survey area. 2006 average annual recruitment was calculated with side channel data included to match that of the 2005 data.

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:

- 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.

7. REFERENCES

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APPENDIX A

2006 LWD Survey Field Data Forms

Middle Mainstem Green River LWD Survey

Survey Date: Aug 17, 2006

9:40

Crew: M. Gagnier, Devos

Reach: 1 / HAD → Tacoma Headwards

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootball	Large Log (20-33.5in)	Large Log w/rootball	Key Piece (>33.5in)	Key Piece w/rootball	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
(11)	(7)	(4)	(4)			(2)	(2)		
				Restored wood (>30' long)					
(3)	(6)						1		
(35)	(2)	(9)	(2)	(2)			(1)		
				Restored wood (>30' long)					
(3)	(1)								

Zone 1

Zone 2

Wood Estimate Calibration

Estimated Width"	Estimated Length'	Measured Width"	Measured Length'
7"	35'	7.5"	38'
5"	25.5'	5.5"	30'
12"	30'	12"	36'
18"	35'	18"	37'
18"	32'	21"	35'

Estimated Width"	Estimated Length'	Measured Width"	Measured Length'
4"	20'	4"	18'
20"	33'	16"	30'
26"	40'	26"	50'
11"	47'	12"	50'
16"	38'	17"	37'

Zone 1 - Within Current Wetted Channel Area

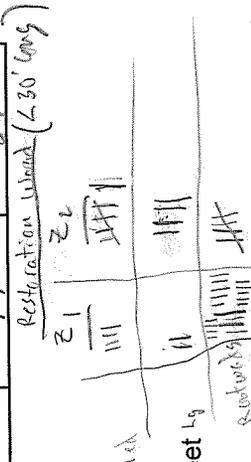
Zone 2 - Within Bankfull Channel & Above Current Wetted Surface

Minimum length for medium, large, and key piece logs is 30 feet.

Minimum size for pieces within jams is 4 inch diameter and 12 feet long ;

Rootwads have minimum log diameter of 8 inches, a minimum rootball diameter of 4 feet, and a maximum length of 6.5 feet

+ = cut end



8/15/06 Green R LWD EQ

Side channel below ELJ's "A"
Left bank / small zone / 20' long ✓
/ small zone / 100' long ✓
/ small zone / 60' long ✓
with RW - / med zone / 85' long ✓

RT bank / rootwad 6' ✓
END Side Ch A
Add to main channel data from just w/s
of side ch D: / rootwad zone 1 ✓
/ small log zone 2 ✓

Side ch D
/ small jam at left bank ✓
/ med log zone 2 rt bank ✓
2 small logs zone 2 left bank ✓
/ small jam zone 2 rt bk ✓
Last includes log # 63

1 med log w rootwad zone 2 left bk ✓
/ small log zone 1 left bk ✓
/ small log w rtwad zone 2 left bk ✓
/ med log zone 2 w rtwad right bk ✓
/ small log w rtwad zone 2 right bk ✓
ID main side channel D

lower side channel of side ch D
2 small logs zone 2 left bk ✓
2 small logs zone 2 left bk ✓
END ALL OF SIDE CH D
253-381-0333 Dong call

Boulder/cascade/Riffle
just w/s of Kamsket haul-out
Left channel data:
/ med log w rtwad zone 1 left
/ med log w rtwad zone 2 left
/ small log zone 2 left
/ small log zone 1 left
2 med zone 2 logs left
/ small zone 1 log left
/ medly zone 1 log left
2 small logs zone 2 left
/ medly zone 2 log left
END DATA 8/15/06

Middle Mainstem Green River LWD Survey

Survey Date: 8/15/06

Crew: AW, M, B, D, J, K, L, N, O, P, Q, R, S, T, U, V, W, X, Y, Z

Reach: 3 (Juluha to Dry Cr Hatchery)

Side Channel Code:

Medium Log (30-50cm)	Medium Log w/rootwad	Large Log (50-85cm)	Large Log w/rootwad	Key Piece (>85cm)	Key Piece w/rootwad	Rootwads (>20cm)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
(18)	(29)	(10)	(8)	(3)	(4)	(5)	(3)		
(13f)									
(44)	(43)	(18)	(14)	(3)	(2)	(24)	(8)		

Wood Estimate Calibration

Estimated Width	Estimated Length	Measured Width	Measured Length
24,20	55,50	21	59
13,14	30,40	12	32
6,7	4,5,8,8	6.5	9.2
10,11	42,46	10	47
9,10	32,38	9	39

Estimated Width	Estimated Length	Measured Width	Measured Length
17,13	30,38	13	35
28,26	22,20	37	30
13,14	50,55	13	50
13,14	20,22	18,13.5	18
12,13	75,60	12	65

- 1 - Jam
- 2 - 3' side
- 3 - 5' side
- 4 - 10' side
- 5 - 1/3
- 6 - 1/3

Zone 1 - Within Current Wetted Channel Area
 Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
 Medium Log (12"-20" diameter & >30 ft long) ; Large Log (20"-33.5" diameter & >30 ft long) ; + = cut end
 Key Piece (>33.5" diameter & >30 ft long) ; Rootwad (>8" diameter, <6.5' long) ; Jam Piece (>4" diameter & >12' long)

Middle Mainstem Green River LWD Survey

Survey Date: 8/14/06

Crew: A. W. [unclear], B. [unclear], G. [unclear], J. [unclear], K. [unclear]

Reach: 3 (Bankcut - Gelton)

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootwad	Large Log (20-33.5in)	Large Log w/rootwad	Key Piece (>33.5in)	Key Piece w/rootwad	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
III	III 16								
(4)	(8)								
3d-10									
(1)									
III	III III III	III	III			III III III			
(19)	(19)	(9)	(2)			(9)			
(25)	(11)					SC-10			
(7)	(2)								

Zone 1

Zone 2

Wood Estimate Calibration

Estimated Width	Estimated Length	Measured Width	Measured Length
1 14, 18	24, 24, 30	17.5	26
2 21, 26	24	28.25	24
3			
4			
5			

Estimated Width	Estimated Length	Measured Width	Measured Length
6			
7			
8			
9			
10			

- Zone 1 - Within Current Wetted Channel Area
- Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Minimum length for medium, large, and key piece logs is 30 feet.
- Minimum size for pieces within jams is 4 inch diameter and 12 feet long ;
- Rootwads have minimum diameter of 8 inches and a maximum length of 6.5 feet

+ = cut end

Middle Mainstem Green River LWD Survey

Survey Date: 8/14/06

Crew: A. Weisbrich, M. Gessner, G. Anderson, R. Jank

Reach: Kandahar → Gallum

Crew 1 - right side looking up

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootwad	Large Log (20-33.5in)	Large Log w/rootwad	Key Piece (>33.5in)	Key Piece w/rootwad	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
III	II	III I	III	I		I			
(5)	(2)	(6)	(4)	(1)		(1)	(1)		
III III III III III I	III III III III III	III III III III III	III III III III III	II		III III III III III			
(21)	(5)	(13)	(3)	(2)		(5)	(1)		
		(10)				(10)			

Zone 1

Zone 2

Wood Estimate Calibration

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

Estimated Width	Estimated Length	Measured Width	Measured Length
6			
7			
8			
9			
10			

* = side channel = B
I = > 6.6' log

- Zone 1 - Within Current Wetted Channel Area
 - Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Minimum length for medium, large, and key piece logs is 30 feet.
Minimum size for pieces within jams is 4 inch diameter and 12 feet long;
Rootwads have minimum diameter of 8 inches and a maximum length of 6.5 feet

+ = cut end

Middle Mainstem Green River LWD Survey

Survey Date: 8/16/06

Crew: A Wengrich, G Anderson

Reach: 3 (Dry Cr. Hedberg to RMA 45)

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootball	Large Log (20-33.5in)	Large Log w/rootball	Key Piece (>33.5in)	Key Piece w/rootball	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
							9		
							39-T		
3j-1	3j-1	3j-1	3j-11	4	4	6			
							2		
							14		
27	10	7	3	1	2	3i-1			
34-11	3j-11								

Zone 1

Zone 2

Wood Estimate Calibration

Estimated Width	Estimated Length	Measured Width	Measured Length
11, 11	26, 26	10	28
10, 10	45, 40	10	28
18, 18	30, 30	18	30.5
11, 10	26, 24	11	25
18, 20	65, 70	19	77

Estimated Width	Estimated Length	Measured Width	Measured Length
13, 16	34, 36	16	35
20, 18	45, 50	19	53
14, 17	50, 55	12	57
17, 18	48, 50	17	50
21, 22	25, 26	24	25

- Zone 1 - Within Current Wetted Channel Area
- Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Minimum length for medium, large, and key piece logs is 30 feet.
- Minimum size for pieces within jams is 4 inch diameter and 12 feet long ;
- Rootwads have minimum log diameter of 8 inches, a minimum rootball diameter of 4 feet, and a maximum length of 6.5 feet

+ = cut end

Middle Mainstem Green River LWD Survey

Survey Date: 08/15/06
 Crew: M. Gagner, Randy Jenic
 Reach: #3 upper section

Side Channel Code:

Medium Log (30-50cm)	Medium Log w/rootwad	Large Log (50-85cm)	Large Log w/rootwad	Key Piece (>85cm)	Key Piece w/rootwad	Rootwads (>20cm)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
	1		1						
(5)	(1)	(6)	(1)						
			1						
	1								
(10)	(2)	(5)	(1)	(4)		(3)	(0)		

Wood Estimate Calibration

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

Estimated Width	Estimated Length	Measured Width	Measured Length
6			
7			
8			
9			
10			

Entered on 09/08/06
 by M. Gagner

- Zone 1 - Within Current Wetted Channel Area
- Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Medium Log (12"-20" diameter & >30 ft long) ; Large Log (20"-33.5" diameter & >30 ft long) ; + = cut end
- Key Piece (>33.5" diameter & >30 ft long) ; Rootwad (>8" diameter, <6.5' long) ; Jam Piece (>4" diameter & >12' long)

Middle Mainstem Green River LWD Survey

Survey Date: 8/17/06

Crew: Aulenbriant R Jenrick

Reach: 4 (Whitish bridge to end Reach 4 @ RM 40.8) → Newmarket Cr.

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootball	Large Log (20-33.5in)	Large Log w/rootball	Key Piece (>33.5in)	Key Piece w/rootball	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
VI	I	I				I			
③	①	①				①			
46-1						46-1			
	II					II	II		
48-1 49-1 49-11	②		48-1			②	③		

Wood Estimate Calibration

Estimated Width	Estimated Length	Measured Width	Measured Length
16.16	20.32	17	24
18.18	32.28	18	27
15.16	32.30	16	29
14.15	36.48	14	34
35.33	35.59	30	57

Estimated Width	Estimated Length	Measured Width	Measured Length
21.21	45.47	21	37
18.16	27.32	19	33
14.15	26.28	14	22
14.16	34.45	17	46
4.12	34.21	10	34

Zone 1 - Within Current Wetted Channel Area

Zone 2 - Within Bankfull Channel & Above Current Wetted Surface

Minimum length for medium, large, and key piece logs is 30 feet.

Minimum size for pieces within jams is 4 inch diameter and 12 feet long ;

Rootwads have minimum log diameter of 8 inches, a minimum rootball diameter of 4 feet, and a maximum length of 6.5 feet

+ = cut end

Entrod 9/19/06
MRR

Middle Mainstem Green River LWD Survey

Survey Date: 8/16/06

Crew: A. W. Anderson, G. Anderson

Reach: 4 (20' - 43' - Fleming Green)

Side Channel Code: _____

Medium Log (30-50cm)	Medium Log w/rootwad	Large Log (50-85cm)	Large Log w/rootwad	Key Piece (>85cm)	Key Piece w/rootwad	Rootwads (>20cm)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
III	III	II	II						
(8)	(3)	(2)	(2)			(1)		Entered 09/19/06 MRG	
III	III	I	I			III			
(1)	(10)	(1)	(1)			(4)	4a-1 ✓ (2)		

Wood Estimate Calibration

Estimated Width	Estimated Length	Measured Width	Measured Length
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

one @ north
one @ 200' d/s
walked ~ 600' d/s

- Zone 1 - Within Current Wetted Channel Area
- Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Medium Log (12"-20" diameter & >30 ft long) ; Large Log (20"-33.5" diameter & >30 ft long) ; + = cut end
- Key Piece (>33.5" diameter & >30 ft long) ; Rootwad (>8" diameter, <6.5' long) ; Jam Piece (>4" diameter & >12' long)

Middle Mainstem Green River LWD Survey

Survey Date: 8/7/06

Crew: Awebright R Terick

Side Channel Code: _____

Reach: 5 (RM 40.8 - end R5 + RM 38.0)
SAWDOCKSV

Medium Log (12-20in)	Medium Log w/rootball	Large Log (20-33.5in)	Large Log w/rootball	Key Piece (>33.5in)	Key Piece w/rootball	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
		1							1
(6)	(19)	(1)	(4)	-	-	(9)	(3)	-	(10)
5b-11 5a-12	5b-11 5a-3 5c-1	5a-1	5a-5			5b-11 5a-2 5a-1	5b-2 5a-4 5c-1	5c-1 5a-1 @ north	
		1					1		
(9)	(19)	(1)	(2)			(16)	(1)		
5a-10 5c-1	5a-10 5c-1	5a	5a-1						

Wood Estimate Calibration

	Estimated Width	Estimated Length	Measured Width	Measured Length
1				
2	5a	Large	1	for calibration
3		for	calibration	data
4				
5				

	Estimated Width	Estimated Length	Measured Width	Measured Length
6				
7				
8				
9				
10				

Entered by
MARG on
9/21/06

- Zone 1 - Within Current Wetted Channel Area
 - Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Minimum length for medium, large, and key piece logs is 30 feet.
Minimum size for pieces within jams is 4 inch diameter and 12 feet long ;
Rootwads have minimum log diameter of 8 inches, a minimum rootball diameter of 4 feet, and a maximum length of 6.5 feet

+ = cut end

Middle Mainstem Green River LWD Survey

Survey Date: 8/18/06

Crew: Ansbrecht (Jewick DB Leachard (all))

Reach: 6 (JW 35, B - Hwy 18 bridge)

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootwad	Large Log (20-33.5in)	Large Log w/rootwad	Key Piece (>33.5in)	Key Piece w/rootwad	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
(13)	(34)	(5)	(11)	(1)	(1)	(18)	(5)	(2)	
bb-1	bb-1					64-1 + 30 @ d/s and * (45 = 2)		bb-ft	
(8)	(9)	(4)				(8)	(1)		
bb-11									

Wood Estimate Calibration

Estimated Width	Estimated Length	Measured Width	Measured Length
32, 34, 33	29, 30, 31	33	30
14, 13, 14	65, 65, 70	13.5	85
10, 9, 9	34, 47, 42	58, 10	38
12, 11, 11, 11, 11	30, 31, 36	12	31
23, 19, 19	48, 53, 50	20	50

Estimated Width	Estimated Length	Measured Width	Measured Length
17, 15, 15	59, 57, 56	15	55
7, 8, 9	22, 48, 50	9	48
11, 12, 11	30, 34, 31	12	31
10, 11	32, 33	10.5	35
14, 16, 17	38, 35, 40	15	36

* RW's in lower end of
32, 66 placed in bank
After estimation effort
+ = cut end

Zone 1 - Within Current Wetted Channel Area

Zone 2 - Within Bankfull Channel & Above Current Wetted Surface

Minimum length for medium, large, and key piece logs is 30 feet.

Minimum size for pieces within jams is 4 inch diameter and 12 feet long ;

Rootwads have minimum diameter of 8 inches and a maximum length of 6.5 feet

Middle Mainstem Green River LWD Survey

Survey Date: Aug. 22, 2006

Crew: M. Beggs, A. Weighright

Reach: Highway 18 crossing L End Reach 6

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootwad	Large Log (20-33.5in)	Large Log w/rootwad	Key Piece (>33.5in)	Key Piece w/rootwad	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
						(4)	(2)		(1)
(7)	(7)	(5)							
	(5)	(1)	(1)			(1)			
(4)	(1 ^a)								
(1 ^b)									

Zone 1

Zone 2

Wood Estimate Calibration

Estimated Width	Estimated Length	Measured Width	Measured Length
20, 21	8	22	8
34, 16	35, 34	15	40
23, 21	9	22	10
9, 10	28, 30	9	31
26, 24	30	25	30

Estimated Width	Estimated Length	Measured Width	Measured Length
10	20	11	23
13	55	12.5	60
15	40	13	50
12	31	13	33

- Zone 1 - Within Current Wetted Channel Area
 - Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Minimum length for medium, large, and key piece logs is 30 feet.
 Minimum size for pieces within jams is 4 inch diameter and 12 feet long;
 Rootwads have minimum diameter of 8 inches and a maximum length of 6.5 feet

+ = cut end

Middle Mainstem Green River LWD Survey

Survey Date: 8/22/06

Crew: A Newbright, ~~Robert~~ M. Gagner

Reach: 6 (Hwy 10 - Endpoint of impoundment)

Side Channel Code: _____

Zone	Medium Log (12-20in)	Medium Log w/rootwad	Large Log (20-33.5in)	Large Log w/rootwad	Key Piece (>33.5in)	Key Piece w/rootwad	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
Zone 1										
	(3)	(10)	(3)	(2)			(12)	(4)	(1)	
Zone 2	ba-1	ba-1					ba-1	ba-1		
	(1)	(1)					(1)	(1)		

Wood Estimate Calibration

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

Estimated Width	Estimated Length	Measured Width	Measured Length
6			
7			
8			
9			
10			

ba - pb Side Chan not actively forming @
 + = cut end
 to seepage or ~~small~~ small jams

- Zone 1 - Within Current Wetted Channel Area
 - Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Minimum length for medium, large, and key piece logs is 30 feet.
 Minimum size for pieces within jams is 4 inch diameter and 12 feet long;
 Rootwads have minimum diameter of 8 inches and a maximum length of 6.5 feet

Middle Mainstem Green River LWD Survey

Survey Date: 8/17/06
 Crew: Anley, ... R. J. ...
 Reach: 6 (RM 28.0 - 28.8)

Side Channel Code:

Medium Log (12-20in)	Medium Log w/rootball	Large Log (20-33.5in)	Large Log w/rootball	Key Piece (>33.5in)	Key Piece w/rootball	Rootwads (>8in)	Small Jam (10-50)	Medium Jam (50-100)	Large Jam (>100)
						HTT	①		
①	③					⑧	①		
							1		
③	②					②	①		

Zone 1

Zone 2

Wood Estimate Calibration

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

	Estimated Width	Estimated Length	Measured Width	Measured Length
6				
7				
8				
9				
10				

* - King cedar 30'?

+ = cut end

- Zone 1 - Within Current Wetted Channel Area
- Zone 2 - Within Bankfull Channel & Above Current Wetted Surface
- Minimum length for medium, large, and key piece logs is 30 feet.
- Minimum size for pieces within jams is 4 inch diameter and 12 feet long ;
- Rootwads have minimum log diameter of 8 inches, a minimum rootball diameter of 4 feet, and a maximum length of 6.5 feet

APPENDIX B

2006 Quality Assurance and Control Checks

Table B-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Est. Width (inches)	Est. Length (ft)	Measured Width (inches)	Measured Length (ft)	% Error Width	% Error Length	Absolute % Error Width	% Error Length
1	7	35	7.0	38	0.0	7.9	0.0	7.9
2	5	25.5	5.5	30	9.1	15.0	9.1	15.0
3	12	30	12.0	36	0.0	16.7	0.0	16.7
4	15	35	18.0	37	16.7	5.4	16.7	5.4
5	18	32	21.0	35	14.3	8.6	14.3	8.6
6	4	20	4.0	18	0.0	-11.1	0.0	11.1
7	20	33	16.0	30	-25.0	-10.0	25.0	10.0
8	26	40	26.0	50	0.0	20.0	0.0	20.0
9	11	47	12.0	50	8.3	6.0	8.3	6.0
10	16	38	17.0	37	5.9	-2.7	5.9	2.7
11	10	40	n/a	n/a	n/a	n/a	n/a	n/a
12	13	50	12.0	50	-8.3	0.0	8.3	0.0
13	15	32	14.0	33	-7.1	3.0	7.1	3.0
14	20	40	22.0	45	9.1	11.1	9.1	11.1
15	21	48	22.2	50	5.4	4.0	5.4	4.0
16	13	90	12.0	80	-4.2	-12.5	4.2	12.5
17	14	30	12.0	32	-16.7	6.3	16.7	6.3
18	37	30	40.0	31	7.5	3.2	7.5	3.2
19	16	22	18.0	20	11.1	-10.0	11.1	10.0
20	12	33	12.1	35	0.8	5.7	0.8	5.7
21	24	55	21.0	59	-14.3	6.8	14.3	6.8
	20	50	21.0	59	4.8	15.3	4.8	15.3
22	13	38	12.0	32	-8.3	-18.8	8.3	18.8
	14	40	12.0	32	-16.7	-25.0	16.7	25.0
23	6	32	6.5	32	7.7	0.0	7.7	0.0
	7	38	6.5	32	-7.7	-18.8	7.7	18.8
24	10	42	10.0	44	0.0	4.5	0.0	4.5
	11	46	10.0	44	-10.0	-4.5	10.0	4.5
25	9	32	9.0	39	0.0	17.9	0.0	17.9
	10	38	9.0	39	-11.1	2.6	11.1	2.6
26	14	36	13.0	35	-7.7	-2.9	7.7	2.9
	13	38	13.0	35	0.0	-8.6	0.0	8.6
27	28	22	37.0	30	24.3	26.7	24.3	26.7
	26	28	37.0	30	29.7	6.7	29.7	6.7

Table B-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Est. Width (inches)	Est. Length (ft)	Measured Width (inches)	Measured Length (ft)	% Error Width	% Error Length	Absolute % Error Width	% Error Length
28	13	50	13.0	50	0.0	0.0	0.0	0.0
	14	55	13.0	50	-7.7	-10.0	7.7	10.0
29	13	20	13.5	18	3.7	-11.1	3.7	11.1
	14	22	13.5	18	-3.7	-22.2	3.7	22.2
30	12	75	12.0	65	0.0	-15.4	0.0	15.4
	13	60	12.0	65	-8.3	7.7	8.3	7.7
31	14	24	17.5	26	20.0	7.7	20.0	7.7
	14	24	17.5	26	20.0	7.7	20.0	7.7
	18	30	17.5	26	-2.9	-15.4	2.9	15.4
32	24	28	24.0	26	0.0	-7.7	0.0	7.7
	26	24	24.0	26	-8.3	7.7	8.3	7.7
33	11	26	10.0	28	-10.0	7.1	10.0	7.1
	11	28	10.0	28	-10.0	0.0	10.0	0.0
34	10	45	10.0	38	0.0	-18.4	0.0	18.4
	10	40	10.0	38	0.0	-5.3	0.0	5.3
35	18	30	18.0	30.5	0.0	1.6	0.0	1.6
	18	30	18.0	30.5	0.0	1.6	0.0	1.6
36	11	26	11.0	25	0.0	-4.0	0.0	4.0
	10	24	11.0	25	9.1	4.0	9.1	4.0
37	18	65	19.0	77	5.3	15.6	5.3	15.6
	20	70	19.0	77	-5.3	9.1	5.3	9.1
38	13	34	16.0	35	18.8	2.9	18.8	2.9
	16	36	16.0	35	0.0	-2.9	0.0	2.9
39	20	45	19.0	53	-5.3	15.1	5.3	15.1
	18	50	19.0	53	5.3	5.7	5.3	5.7
40	14	50	12.0	57	-16.7	12.3	16.7	12.3
	12	55	12.0	57	0.0	3.5	0.0	3.5
41	17	48	17.0	50	0.0	4.0	0.0	4.0
	18	50	17.0	50	-5.9	0.0	5.9	0.0
42	21	25	24.0	25	12.5	0.0	12.5	0.0
	22	26	24.0	25	8.3	-4.0	8.3	4.0
43	16	26	17.0	24	5.9	-8.3	5.9	8.3
	16	32	17.0	24	5.9	-33.3	5.9	33.3
44	18	32	18.0	27	0.0	-18.5	0.0	18.5
	18	28	18.0	27	0.0	-3.7	0.0	3.7

Table B-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Est. Width (inches)	Est. Length (ft)	Measured Width (inches)	Measured Length (ft)	% Error Width	% Error Length	Absolute % Error Width	% Error Length
45	15	32	16.0	29	6.3	-10.3	6.3	10.3
	16	30	16.0	29	0.0	-3.4	0.0	3.4
46	14	36	14.0	34	0.0	-5.9	0.0	5.9
	15	40	14.0	34	-7.1	-17.6	7.1	17.6
47	35	50	30.0	57	-16.7	12.3	16.7	12.3
	33	55	30.0	57	-10.0	3.5	10.0	3.5
48	21	45	21.0	37	0.0	-21.6	0.0	21.6
	21	47	21.0	37	0.0	-27.0	0.0	27.0
49	18	27	19.0	33	5.3	18.2	5.3	18.2
	16	32	19.0	33	15.8	3.0	15.8	3.0
50	14	36	14.0	22	0.0	-63.6	0.0	63.6
	15	28	14.0	22	-7.1	-27.3	7.1	27.3
51	19	34	17.0	46	-11.8	26.1	11.8	26.1
	16	45	17.0	46	5.9	2.2	5.9	2.2
52	11	34	10.0	31	-10.0	-9.7	10.0	9.7
	12	29	10.0	31	-20.0	6.5	20.0	6.5
53	9	25	10.0	24	10.0	-4.2	10.0	4.2
54	11	19	12.0	22	8.3	13.6	8.3	13.6
55	10	17	8.0	16	-25.0	-6.3	25.0	6.3
56	9	13	10.0	13.5	10.0	3.7	10.0	3.7
57	9	12	9.0	12	0.0	0.0	0.0	0.0
58	18	50	21.0	48	14.3	-4.2	14.3	4.2
59	8	23	9.0	19.5	11.1	-17.9	11.1	17.9
60	19	25	17.5	26	-8.6	3.8	8.6	3.8
61	17	55	18.5	65	8.1	15.4	8.1	15.4
62	42	50	46.0	45	8.7	-11.1	8.7	11.1
63	37	29	33.0	30	-12.1	3.3	12.1	3.3
	34	30	33.0	30	-3.0	0.0	3.0	0.0
	33	31	33.0	30	0.0	-3.3	0.0	3.3
64	14	65	13.5	85	-3.7	23.5	3.7	23.5
	13	65	13.5	85	3.7	23.5	3.7	23.5
	14	70	13.5	85	-3.7	17.6	3.7	17.6
65	10	34	10.0	38	0.0	10.5	0.0	10.5
	9	42	10.0	38	10.0	-10.5	10.0	10.5
	9	42	10.0	38	10.0	-10.5	10.0	10.5

Table B-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Est. Width (inches)	Est. Length (ft)	Measured Width (inches)	Measured Length (ft)	% Error Width	% Error Length	Absolute % Error Width	% Error Length
66	12	30	12.0	31	0.0	3.2	0.0	3.2
	13	31	12.0	31	-8.3	0.0	8.3	0.0
	12	36	12.0	31	0.0	-16.1	0.0	16.1
67	23	48	20.0	50	-15.0	4.0	15.0	4.0
	19	53	20.0	50	5.0	-6.0	5.0	6.0
	19	50	20.0	50	5.0	0.0	5.0	0.0
68	14	59	15.0	55	6.7	-7.3	6.7	7.3
	15	54	15.0	55	0.0	1.8	0.0	1.8
	15	56	15.0	55	0.0	-1.8	0.0	1.8
69	37	29	33.0	30	-12.1	3.3	12.1	3.3
	34	30	33.0	30	-3.0	0.0	3.0	0.0
	33	31	33.0	30	0.0	-3.3	0.0	3.3
70	14	65	13.5	85	-3.7	23.5	3.7	23.5
	13	65	13.5	85	3.7	23.5	3.7	23.5
	14	70	13.5	85	-3.7	17.6	3.7	17.6
71	10	34	10.0	38	0.0	10.5	0.0	10.5
	9	42	10.0	38	10.0	-10.5	10.0	10.5
	9	42	10.0	38	10.0	-10.5	10.0	10.5
72	12	30	12.0	31	0.0	3.2	0.0	3.2
	13	31	12.0	31	-8.3	0.0	8.3	0.0
	12	36	12.0	31	0.0	-16.1	0.0	16.1
73	23	48	20.0	50	-15.0	4.0	15.0	4.0
	19	53	20.0	50	5.0	-6.0	5.0	6.0
	19	50	20.0	50	5.0	0.0	5.0	0.0
74	14	54	15.0	55	6.7	1.8	6.7	1.8
	15	54	15.0	55	0.0	1.8	0.0	1.8
	15	56	15.0	55	0.0	-1.8	0.0	1.8
75	7	42	9.0	48	22.2	12.5	22.2	12.5
	8	48	9.0	48	11.1	0.0	11.1	0.0
	9	50	9.0	48	0.0	-4.2	0.0	4.2
76	11	30	12.0	31	8.3	3.2	8.3	3.2
	16	34	12.0	31	-33.3	-9.7	33.3	9.7
	14	31	12.0	31	-16.7	0.0	16.7	0.0
77	10	32	10.5	35	4.8	8.6	4.8	8.6
	11	33	10.5	35	-4.8	5.7	4.8	5.7

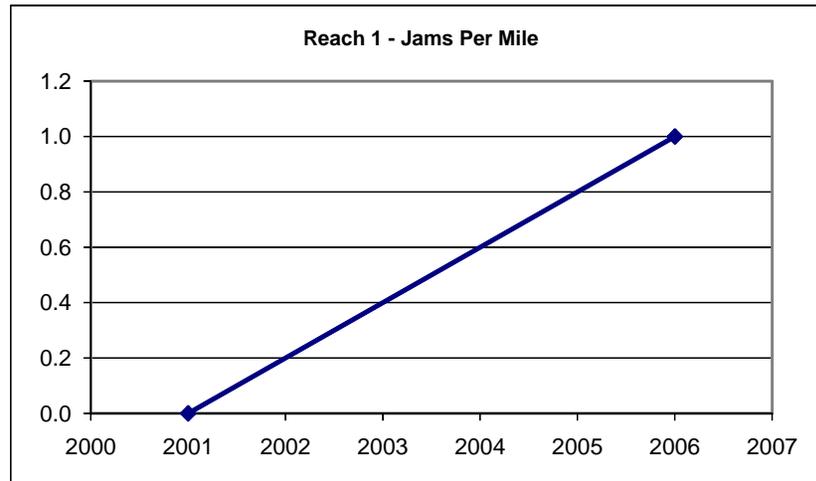
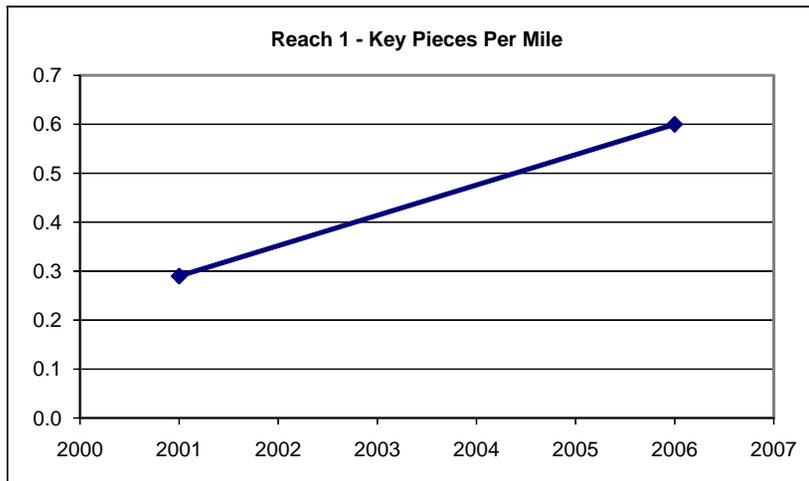
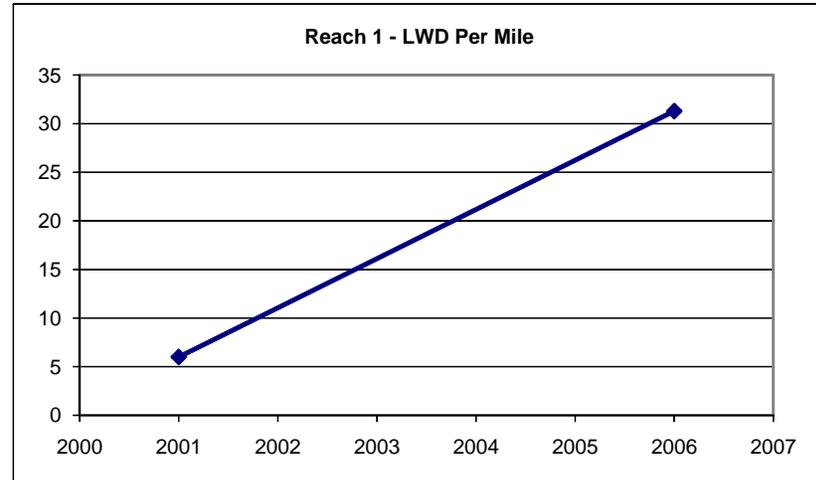
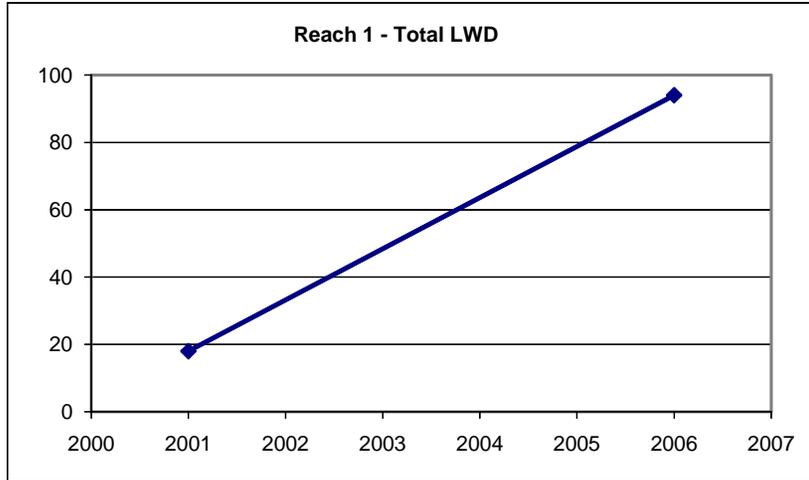
Table B-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Est. Width (inches)	Est. Length (ft)	Measured Width (inches)	Measured Length (ft)	% Error Width	% Error Length	Absolute % Error Width	% Error Length
78	14	38	15.0	36	6.7	-5.6	6.7	5.6
	16	35	15.0	36	-6.7	2.8	6.7	2.8
	17	40	15.0	36	-13.3	-11.1	13.3	11.1
79	20	8	22.0	8	9.1	0.0	9.1	0.0
	21	8	22.0	8	4.5	0.0	4.5	0.0
80	14	35	15.0	40	6.7	12.5	6.7	12.5
	16	34	15.0	40	-6.7	15.0	6.7	15.0
81	23	9	22.0	10	-4.5	10.0	4.5	10.0
	21	9	22.0	10	4.5	10.0	4.5	10.0
82	9	28	9.0	31	0.0	9.7	0.0	9.7
	10	30	9.0	31	-11.1	3.2	11.1	3.2
83	26	30	25.0	30	-4.0	0.0	4.0	0.0
	24	30	25.0	30	4.0	0.0	4.0	0.0
84	10	20	11.0	23	9.1	13.0	9.1	13.0
85	13	55	12.5	60	-4.0	8.3	4.0	8.3
86	15	40	13.0	50	-15.4	20.0	15.4	20.0
87	12	31	13.0	33	7.7	6.1	7.7	6.1

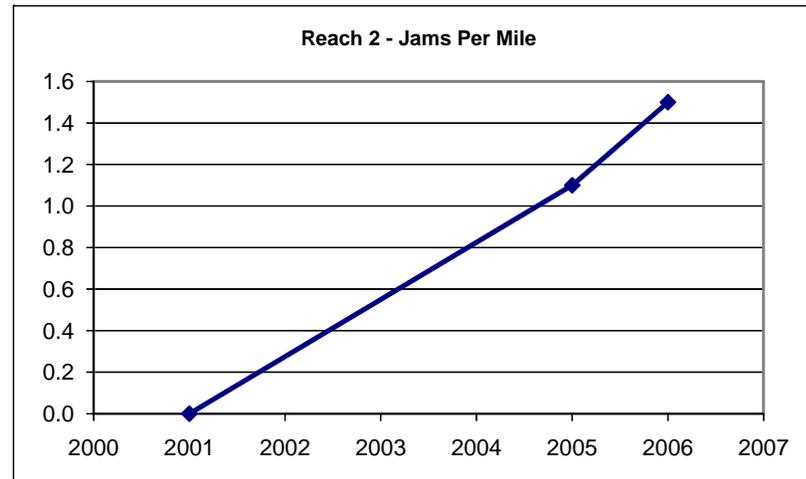
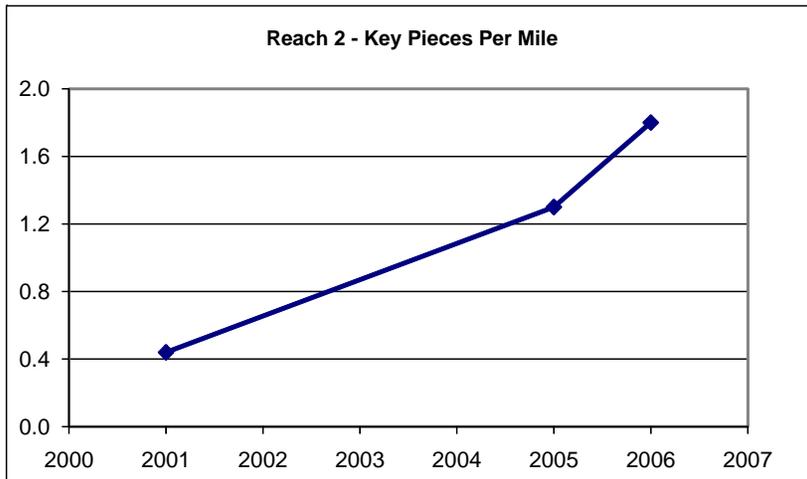
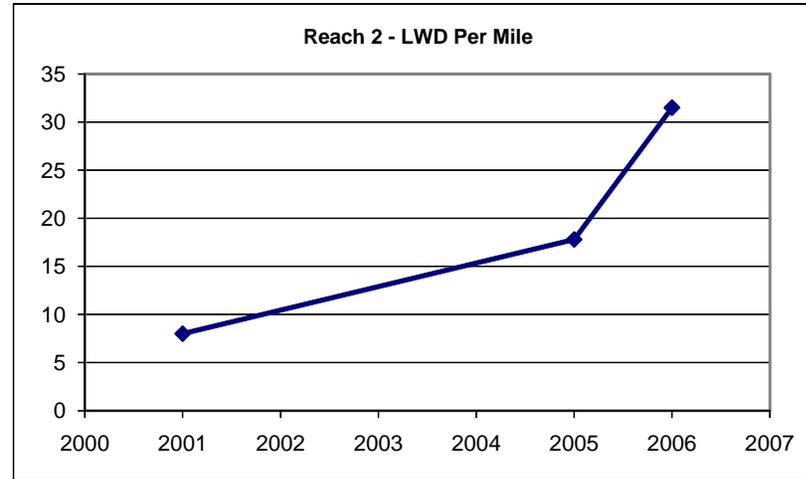
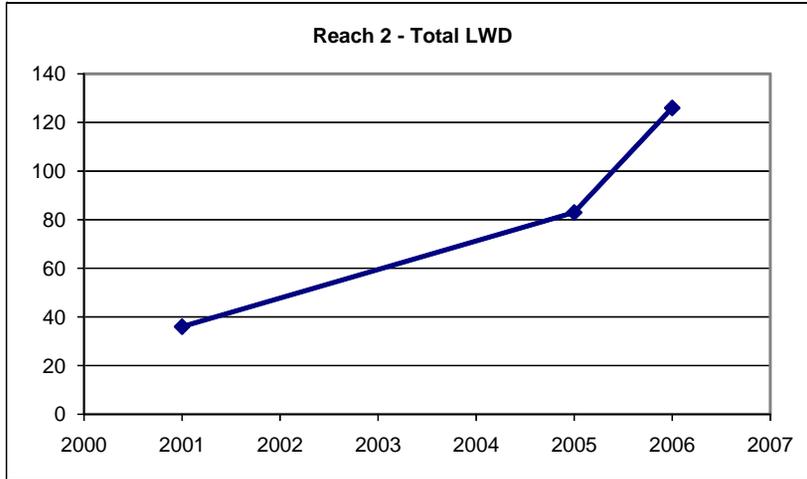
APPENDIX C

LWD Data Comparison Tables

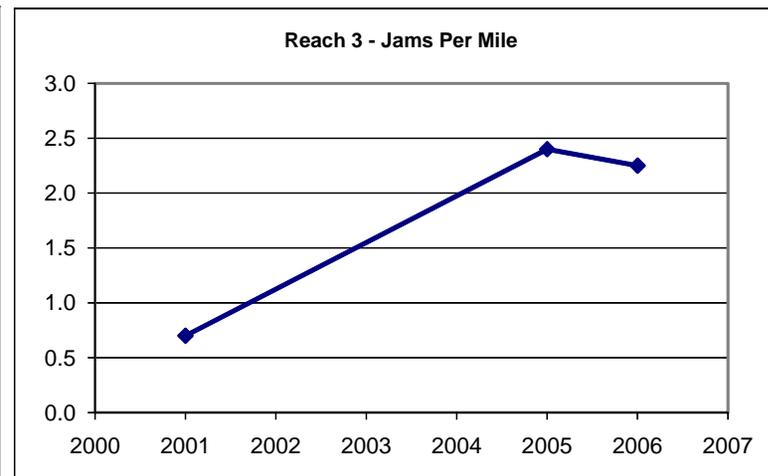
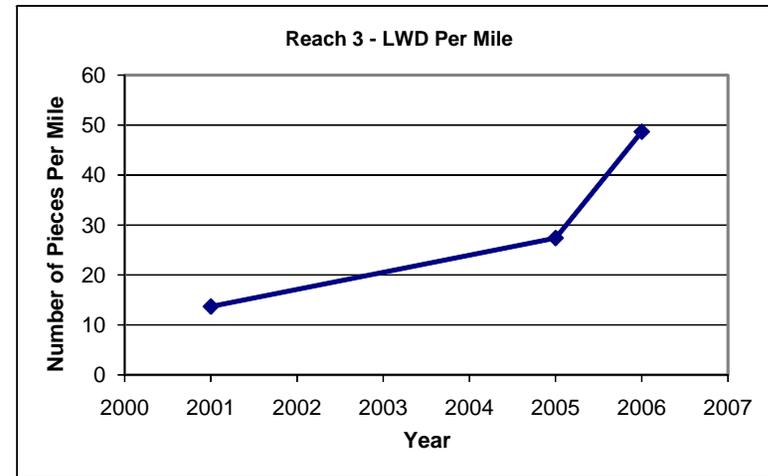
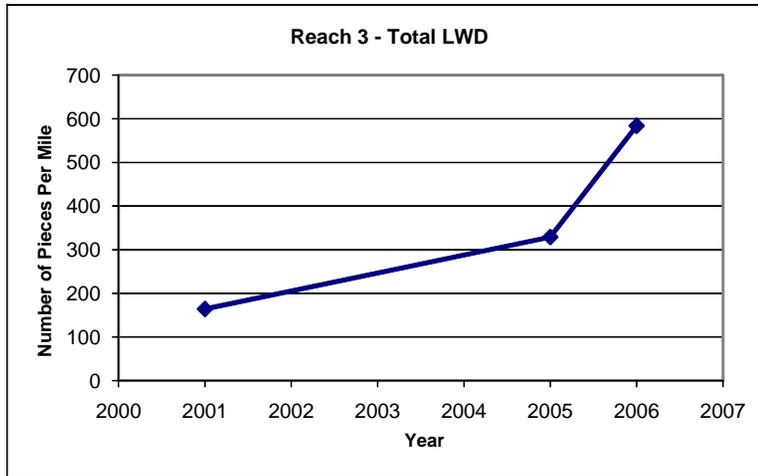
Reach 1	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	18	6	0.29	0
	2006	94	31.3	0.6	1



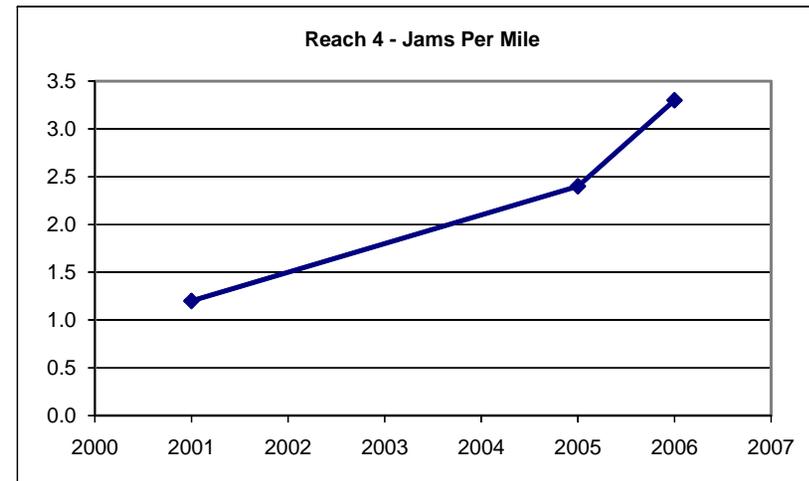
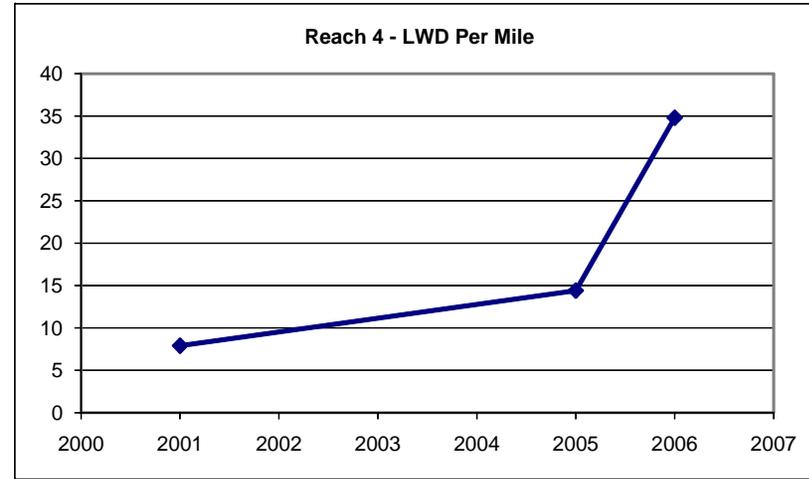
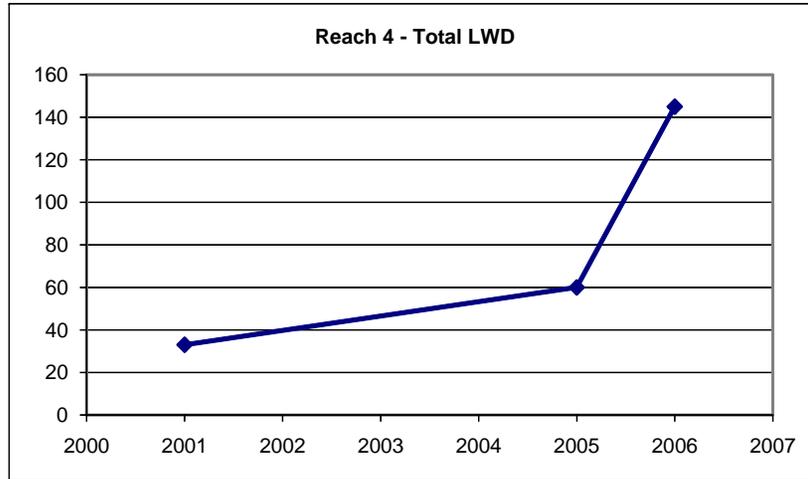
Reach 2	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	36	8	0.44	0
	2005	83	17.8	1.3	1.1
	2006	126	31.5	1.8	1.5



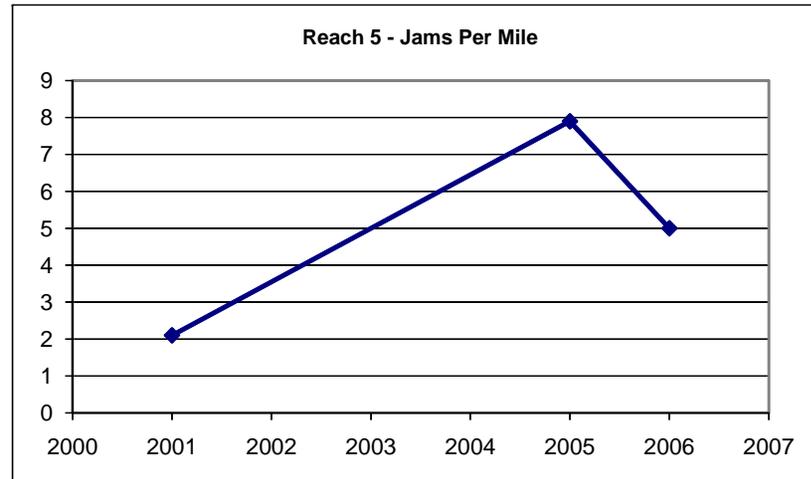
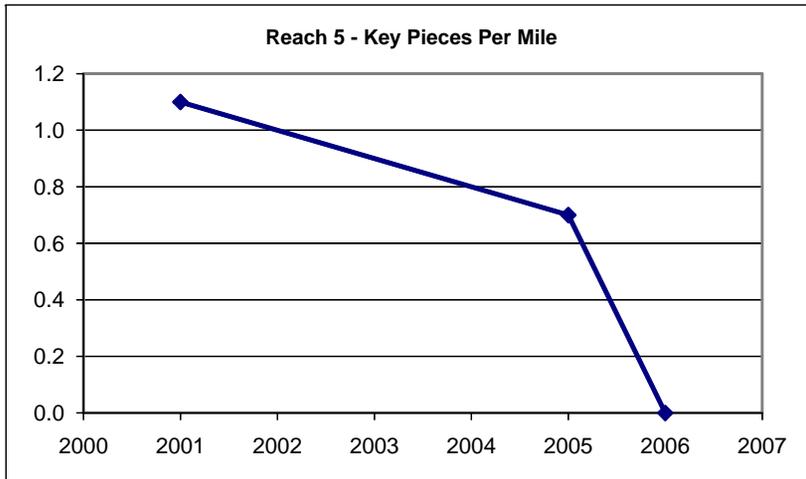
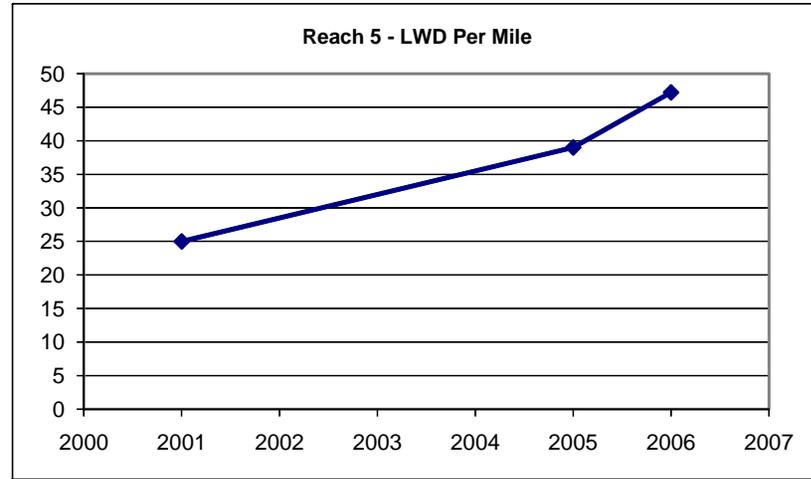
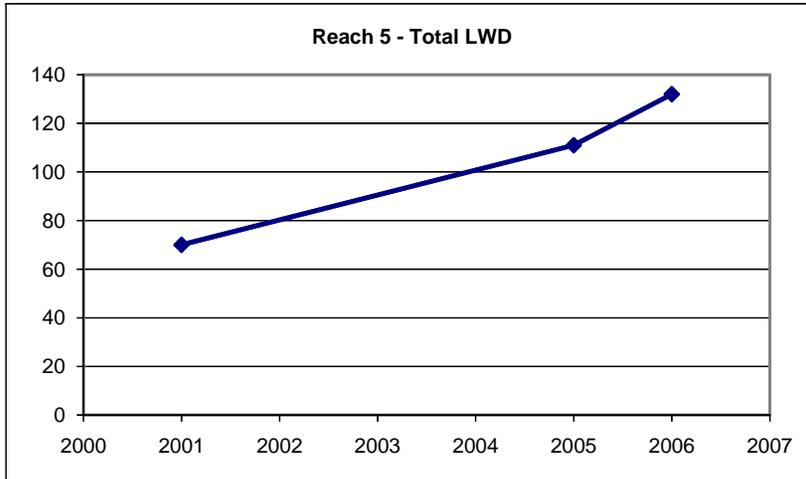
Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
2001	164	13.7	0.92	0.7
2005	329	27.4	1.9	2.4
2006	584	48.7	2.5	2.25



Reach 4	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	33	7.9	0.95	1.2
	2005	60	14.4	0.2	2.4
	2006	145	34.8	2.1	3.3



Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
2001	70	25	1.1	2.1
2005	111	39	0.7	7.9
2006	132	47.2	0	5



Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
2001	131	21.8	0.5	0.8
2005	110	26	0.05	2.9
2006	216	36	0.3	3.3

2005 survey reach length was 1.8 miles shorter than 2001 & 2006 surveys

