IV. CHANNEL HABITAT TYPE AND CHANNEL MODIFICATIONS

These two topics are considered together in this chapter because extensive channel modifications in the lower Lostine River have influenced channel confinement and sinuosity and, therefore, the basic Channel Habitat Type (CHT).

A Channel Habitat Type

Basic CHT Considerations:, Processes that govern instream and adjacent riparian features are strongly influenced by stream gradient, adjacent landforms that control stream confinement, composition of the channel substrate, etc. These features form the underlying basis for classification and designation of basic CHT, knowledge of which is useful for assessing various aspects of natural stream evolution, as well as stream response to human impacts, including both inappropriate land management practices and remedial actions.

As is described in OWAM, 17, Appendix III-A, there are at least six different methodologies for determination of CHT. These include both the Paustian, et al., method, which is elaborated in detail in OWAM, 17, and the Rosgen method (Rosgen, 18), which is described in part below and is applied to the preliminary designation of CHTs on the lower 14 miles of the Lostine River, i.e., within the Ext HUC 204 Priv area. The widespread application of the Rosgen method provides a common framework for evaluating CHT features of numerous rivers and streams.

As described by Rosgen's "Applied River Morphology," Rosgen, 18, page 3-5, the complete method proceeds on four increasingly detailed (and labor-intensive) levels. These levels comprise the following basic operations:

Level I—Geomorphic Characterization: Classify stream segments according to eight types, designated A through G, on the basis of stream gradient (slope), channel cross-sectional shape, and streamwise channel patterns.

Level II—Morphological Description: Add substrate characterization and refine stream type based on width/depth ratio, entrenchment ratio, and sinuosity.

Level III—Stream State or Condition: Define riparian vegetation, debris occurrence, meander, channel stability, sediment supply, deposition patterns, erosion potential, nature of altered channel state, etc.

Level IV—Validation: Perform sediment and stream-flow measurements; assess channel stability, erosion rates, changes in sediment storage, etc.

Fig. IV-1, taken from Rosgen, 18, page 5-5 (electronic version by courtesy of The Nature Conservancy of Oregon) illustrates the basic Level II Rosgen criteria for CHT classification. As shown by the figure, classification of each stream segment (reach) involves assignment to one of the eight stream types, A-G, and to one of six bed-composition types, designated 1 through 6.

Further elaboration of the Level II classification process, described in Rosgen, 18, pp 5-6 to 5-189, includes refinement of the basic stream type to one of 18, extending the range of slope for stream types A-G illustrated by Fig.IV-1 (excluding Da) and expanding the matrix to 18 x 6 = 102 possible CHTs.

Preliminary CHT Designation for the Lower Lostine River in Ext HUC 204 Priv: Fig. IV-2 illustrates the preliminary designation of CHTs for the lower river. The basic format of Fig. IV-2 follows that of R2, 4, Fig. 2-1, p 2-7 (see Ch II, Table 3 above), except our Reach 4 ends at the USFS boundary.

The elevation profile and (average) slope values in Fig. IV-2 are obtained by measuring the distance along the river, via a GIS stream coverage from Kasper, 31, between contours on the USGS topo map coverage from Smith, 25. The CHT designations illustrated by Fig. IV-2, where the streamwise position and extent of each CHT region is indicated by the associated arrow, were determined from the slope data shown by the figure, along with field-based knowledge of local agency personnel (Knox, et al., 32) applied per the Rosgen criteria of Fig. IV-1.

[NOTE: Unfortunately, the MS Excel software used to create the chart in Fig IV-2 places adjacent data points at equal incremental spacings along the abscissa, even though the measured and tabulated spacings are unequal, which distorts the plotted curves. However, the values of elevation, slope, and the numerical indication of position (River Mile) are correct for each data point.]

The CHT designations shown by Fig. IV-2 should be regarded as preliminary because they are primarily based on familiarity with the characteristics of different stretches of the Lostine River via Knox, et al., 32, rather than on actual field surveys to establish CHTs. Further, the CHT designations shown by Fig. IV-2 are strongly influenced by the magnitudes of the slopes over each CHT range, whereas the more elaborate classification described above admits a broader range of slopes for each basic stream type than is indicated by Fig. IV-1.

B Channel Modifications

The channel modifications illustrated by Fig. IV-3, which has the same format as Fig. IV-2, are of two basic types. Those occurring over extended regions, represented by the bars in the streamwise direction, are due to channel straightening and channelizing operations and were identified from aerial photographs covering the subject part of the Lostine River (Smith, 25). The second type is the more-or-less "point" modifications associated with the irrigation diversion structures at the indicated locations.

As was noted at the beginning of this chapter, in some cases the CHT classification is strongly influenced by past channel modifications. This is especially true of the strongly entrenched "F" sections, indicated within Reaches 1 and 2 of Fig. IV-2. In general, the A, B, and C classifications of CHT in the upper and lowest sections of the river are more influenced by natural hydrological and geomorphic factors.

C Summary

Table 6 below summarizes the specific type, location, and length of channel modifications in the lower section of the Lostine River as shown by Fig. IV-3, as well as describing the degree and type of associated impact.

Table 6: Channel Modifications and CHTs in the Lower Lostine River

Site No.	Type of Modification	Data Source	Channel Habitat Type	Location/Length (RM)	Degree of Impact	Type of Impact
1	Channel Modification	NRCS/ODFW	F3	1.12-2.21/1.09	H	Straighten/widen channel
2	" "	" "	C3/F3	2.83-4.54/1.71	M	" " "
3	" "	" "	C/F/B3	4.78-7.30/2.52	H	" " "
4	" "	" "	C/D3,4	9.20-9.26/0.06	M	" " "
5	" "	" "	C/D3,4	10.53-11.40/0.87	M	" " "
6	" "	" "	C/D3,4	12.73-13.14/0.40	M	" " "
7	Tulley Hill Ditch Diversion	USGS/R2 Rep.	F3	1.65	M	Fish barrier/dewater river
8	Clearwater " "	" "	F3	2.98	H	" " "
9	Miles " "	" "	C3/F3	5.18	M	" " "
10	Poley Allen " "	" "	C/F/B3	6.95	H	" " "
11	Lostine " "	" "	C/F/B3	7.32	M	" " "
12	Sheep Ridge " "	" "	C/D3,4	8.54	M	" " "
13	Westside " "	" "	C/D3,4	8.63	H	" " "
		Cumulative Length/% Total =		6.65 / 47.6	M	Fish habitat reduction

In Table 6, the Clearwater and Westside diversions are rated H (high) because of amounts of water withdrawn by each, the Poley Allen diversion is rated H because of large cumulative withdrawal in Reach 2 of the river. Note that nearly half (47.6 %) of the lower river has been subject to channel modifications.

The confidence evaluation for this chapter is given by Table 7, along with the recommendation for future field surveys to better evaluate CHT-designation factors and more specific channel-modification features.

Table 7: CHT and Channel Modification Confidence Evaluation

Resources Used:

X ODFW personnel	X Rosgen CHT Classification guide
X NRCS personnel	X USGS topo maps
X ODEQ stream map	

Confidence in assessment:

- ☐ **Low:** Unsure of procedures and/or used minimal resources.
- ☐ **Low to moderate:** Understood and followed most of the procedures, but minimal resources available and/or used.
- X **Moderate:** Understood and followed procedures, and used adequate number of resources but had moderate understanding of outcome.
- ☐ **Moderate to high:** Understood and followed procedures, used adequate number of resources, and had high understanding of outcome.
- ☐ **High:** Understood and followed procedures, used numerous resources, and had high understanding of outcome.
- ☐ **None of the above:** Describe your own confidence level and rationale:

Recommendations for further assessment or analysis:

CHT designation and CM evaluation based on detailed stream field surveys.

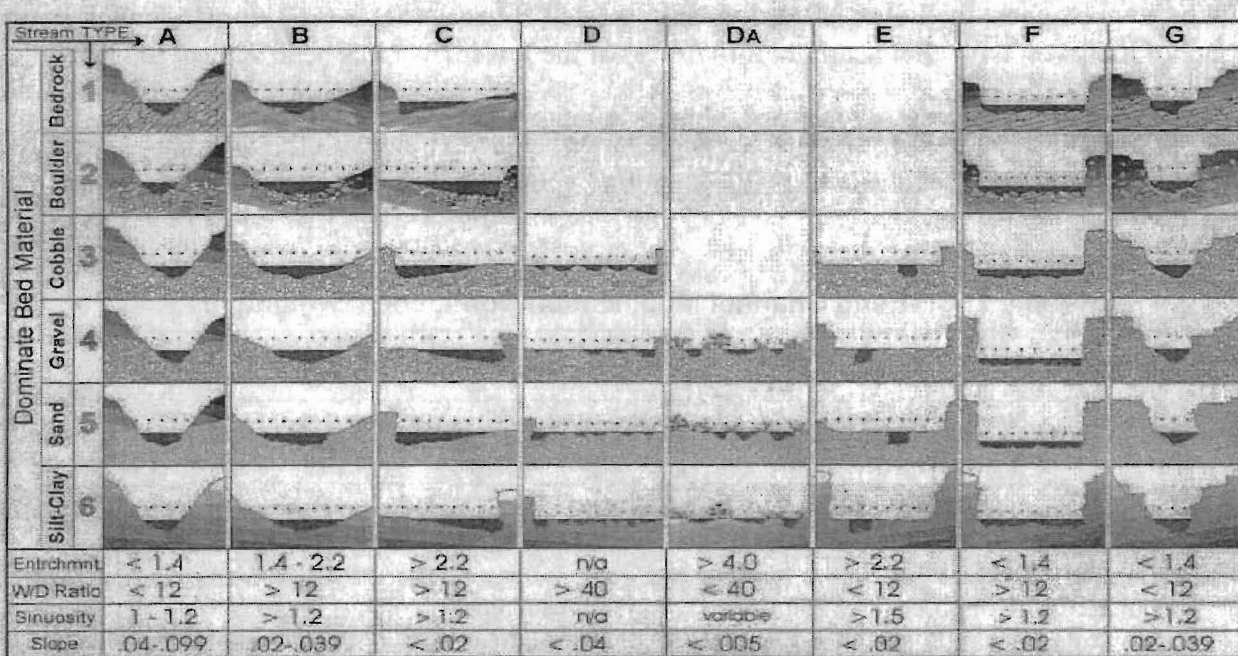


Figure IV-1: Primary Criteria for Rosgen CHT Classification

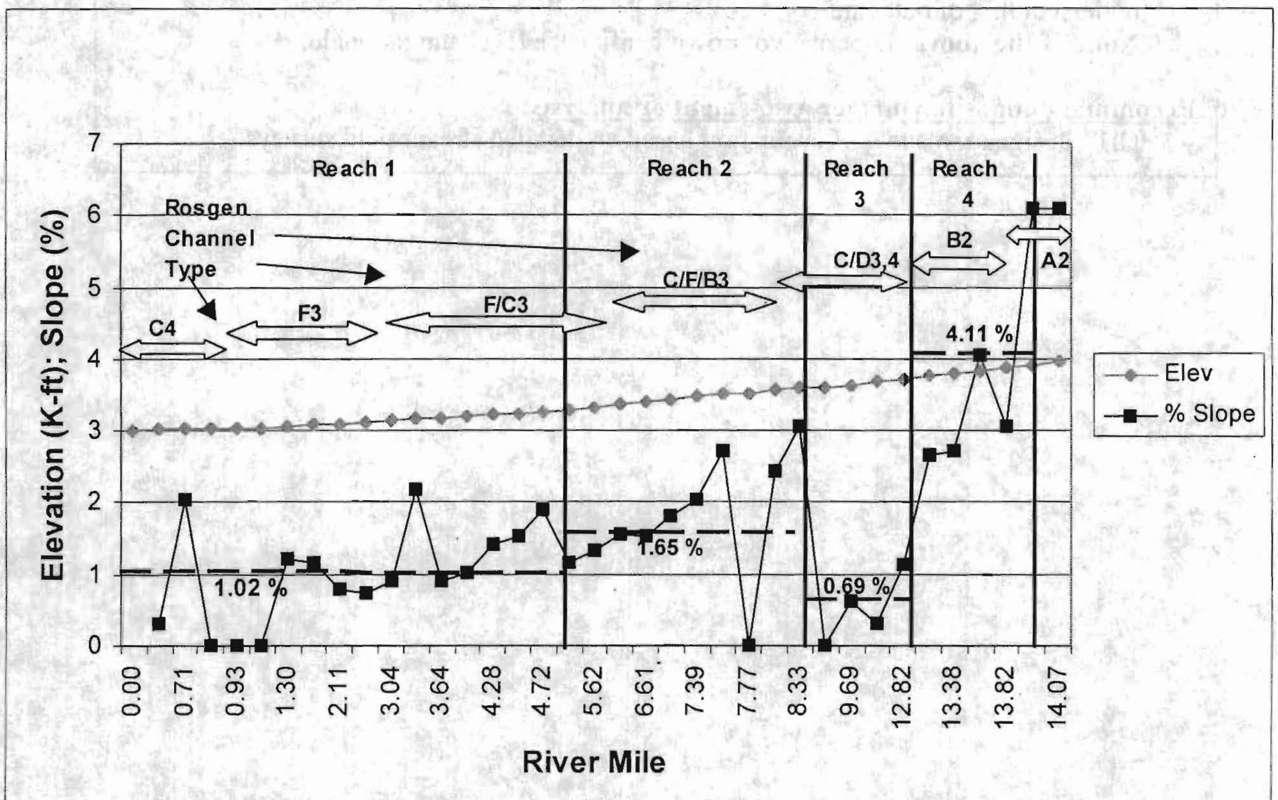


Figure IV-2: Lostine River Elevation Profile and Channel Habitat Type

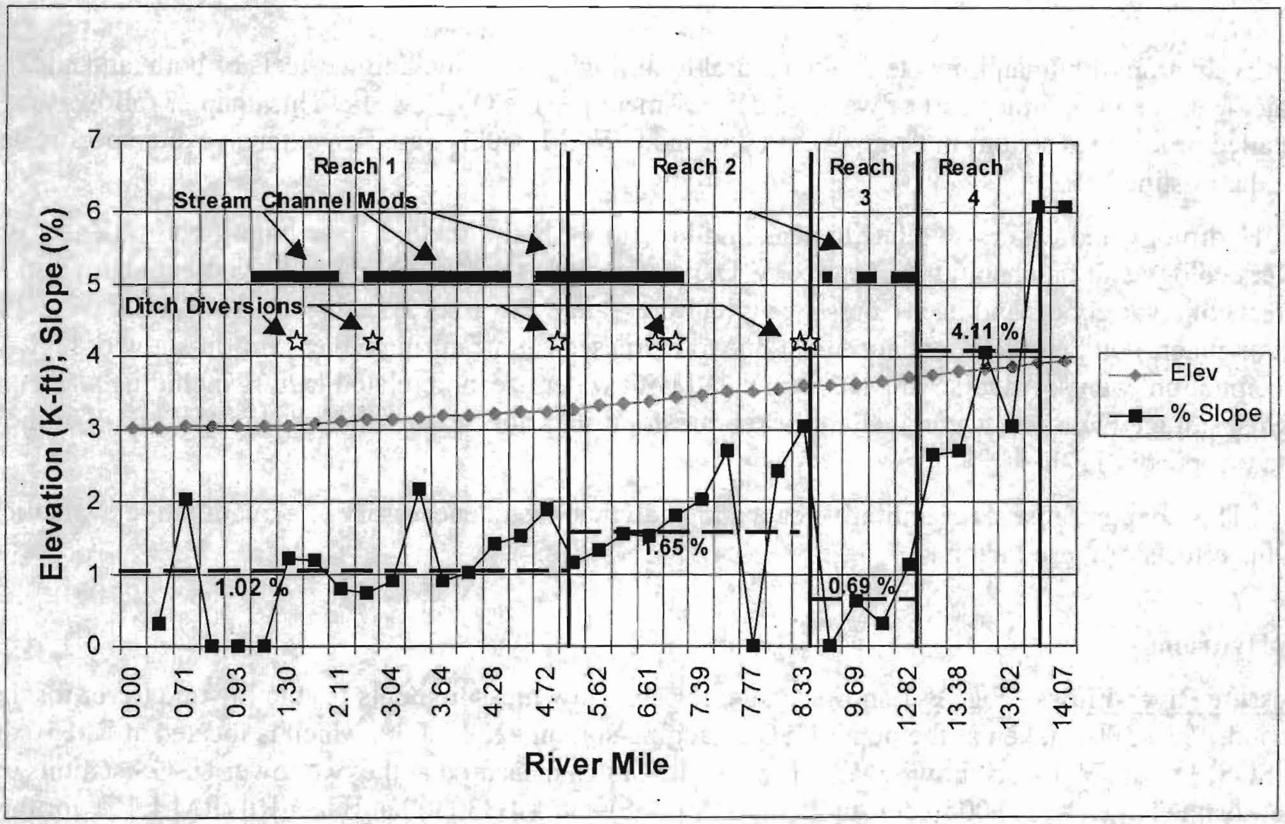


Figure IV-3: Lostine River Elevation Profile and Channel Modifications

V. HYDROLOGY AND WATER USE

Evaluation of human impacts on the natural hydrologic cycle, including effects of both land and water use, is an important part of watershed assessment per the OWAM, 17. This chapter follows the detailed procedures set out in Component IV of the OWAM, and is based on extensive site-specific data for the Lostine WS.

Hydrology and water use relate to peak and low flows, both of which have important influences on river ecology and fish habitat. Appendix IV-D, pages 1-5, of the OWAM describes potential adverse effects of a variety of land uses (forestry, agriculture, range use, road systems, and residential development) on peak-flow enhancement due to increased runoff during either rain-on-snow or high precipitation events. Adverse impacts associated with water use, and related factors including water rights, storage facilities, water availability, and restoration priorities are discussed on pages 5-9 of the cited Appendix IV-D.

This chapter presents quantitative data and analytical results necessary to a quantitative evaluation of the effects of these factors.

A Hydrology

Lostine River Flows: Fig. V-1 shows available peak-flow measurements for the Lostine River for the period, 1950-2001, taken at the upper USGS gauging station #13330000, which is located at RM 10.46 (USGS, 1). Fig. V-1 also shows available peak-flow rates measured at the two lower USGS stations on the Lostine River, #13330050 at Caudle Ln (RM 5.68) and #13330300 at Baker Rd (RM 1.15), for the period, 1995-2001 (USGS, 1).

Although the year-to-year peak flows fluctuate by factors of two and more, and suggest some longer-term cyclic behavior, the data for the upper station do not show any long-term change over the 50-year period. This lack of trend indicates that factors in the upper watershed affecting peak flows have not changed appreciably over the past 50 years. Longer-term data are not available for the two lower gauging stations per Fig. V-1, but the close tracking between peak flows at the various stations suggests relatively small effects of land-use practices in the lower watershed on peak river flow rates.

Fig. V-2 displays available monthly-averaged flow rates at the upper gauging station at three different times each year during 1950-2001. The three times of year correspond to the month of maximum average flow (typically May or June), as well as the months of July and August. Hydrographs covering the complete 12-month annual flow cycle will be discussed later, but Fig. V-2 emphasizes important features of interest as regards the current assessment of hydrology and water use.

Comparison between Figs. V-1 and -2 shows that the peak flows of Fig. V-1 are typically 1.8-to-2 times larger than the corresponding monthly-averaged maximum flows of Fig. V-2. Although the two data sets do not track precisely, their general similarity suggests the absence of any singular catastrophic flow events over the 50-year period.

Fig. V-2 also illustrates the dramatic decrease of average flow rates over the summer period, typically by a factor of 10-20 from the high May-June levels (800-1200 cfs) to the low levels (50-150 cfs) in August. This fall off is the major factor underlying the inadequacy of late-summer flows to meet the needs for both irrigation and fish, discussed in Chs I and II above.

Summary of General Watershed Characteristics: Data shown by Tables 8 and 9 below provide useful information for the subsequent hydrology analysis.

Table 8 summarizes a number of WS features previously discussed in Ch III (HUCs, topography, and precipitation; per Figs. III-1b,c and III-8 to -11). The table lists a variety of WS features that affect water availability and flow rates, as well as stream-gauge information. Footnotes to the table indicate the relevant data sources and GIS files used for data analysis.

Table 8: General Watershed Characteristics

Subwatershed Name	Subwatershed Area[(1)] (acres/mi^2)	Mean Elevation[(2)] (feet)	Minimum Elevation[(2)] (feet)	Maximum Elevation[(2)] (feet)	Mean Annual Precipitation[(2)] (inches)
-204	12,453/19.5	4028	3010	7410	24.9
-203	17,243/26.9	6139	3700	9050	44.7
-202	17,327/27.1	7157	4890	9500	60.7
-201	11,322/17.7	7651	5695	9200	64.6
Total Watershed	58,345/91.2	6285	3010	9500	49.1

Water Storage:

- Minam Lake—1000 acre-ft, ca 115 acres area (USFS, 9a)
- Pond, Lostine River Ranch—ca 60 acres area (Smith, 25, USGS map)

Watershed Changes Affecting Streamflows:

- Minam Lake storage/release, irrigation diversions (13)/Silver Creek and Lostine River, channel dredging and modifications

Stream Gauges:

- #13330000 (or #144), RM 10.5; #13330050 (Caudle Ln), RM 5.68; #13330300 (Baker Rd), RM 1.15
- #13330000 elevation and drainage area: 3650 ft and 70.9 sm

Footnotes:

(1) Watershed areas from current 2003 HUC data (Reid, 19, Walhuc GIS coverage)

(2) Elevation and precipitation data determined via ArcView analysis of primary GIS data, including elevation contours from the USFS (Fahey, 28) and precip_a_or.shp (Smith, 25) from the NRCS.

Table 9 shows the available land-use breakdown for the Lostine 6th-field HUCs and the ad hoc "Ext204 Priv HUC" discussed in Ch III above (see paragraph on land-use designations, Figs. III-1b,c, III-3 to –5, and Smith, 25 and WCPD, 26). Again, the footnotes to the table indicate relevant data sources and GIS files used for analysis, as well as quantitative listings of areas for specific land-use elements.

Table 9: Land Use Summary

Subwatershed Name	Area (acres)	Forestry		Agriculture and/or Range Land		Urban		Other	
		Acres	%	Acres	%	Acres	%	Acres	%
-204	12,453[(1)]	5,505[(2)]	44.2	6,700[(2)]	53.8	-----	----	248[(3)]	2.0
-203	17,243[(1)]	As is described in footnote (4) below, and in the description following line 5, HUCs -203, -202, and -201 are largely composed of USFS lands, a large fraction of which is in the Eagle Cap Wilderness.							
-202	17,327[(1)]								
-201	11,322[(1)]								
Ext 204 Priv[(4)]	14,069[(4)]	7,051[(5)]	50.1	6,670[(5)]	47.4	----	----	348[(5)]	2.5
Total Watershed	58,345[(1)]	Detailed land-use breakdown is provided only for private-state lands.							

Footnotes:

1. All HUC 5 and 6 boundaries and areas are taken from ArcView (A-V) project Walhuc 170601050.apr, View 1, 17060105.shp. (Reid, 19)
2. Areas for designations Agriculture/Range/Other are from A-V project Lost-ros-veg-soils.apr, View 4, Huc204-non-forest-veg.shp. Associated "Forestry" acres on this line include some USFS lands and consist of the total HUC 204 area less the 6700 acres designated Ag/Range and the 248 acres designated Other.
3. Includes lands identified as Other in footnote (5), excluding about 100 acres designated Rural Residential that are in –203 (i.e., outside –204).
4. This footnote and (5) below describe this modified (extended) watershed unit, designated "Ext 204 Priv," or simply "Ext 204" used for the principal hydrology analysis in this watershed assessment (see also Appendix A). This unit consists of 10,733 acres of non-USFS land in HUC –204 and 3,336 acres of non-USFS land in –203. The unit includes private and state lands lying outside USFS boundaries, including the complete –204 HUC less ca 1720 acres of USFS lands in the SW corner, as well as the 3336 acres of private and state (ODFW Big-horn Sheep winter range) lands in HUC –203. See A-V project Lost-ros-veg-soils.apr, View 4--Land Use-Run Off, Huc204/203.shp and Ext Huc204prvt.shp.
5. A-V project Lost-ros-veg-soils.apr, View 4, Ext204-PrvtLndUse.shp, shows the acreages for various land uses to be: Forestry (7051 acres) = timber grazing (5928 acres) + timber (110 acres) + ODFW (1012 acres), and Other (348 acres) = rural residential (223 acres) + riparian (77 acres) + headquarters (26 acres) + city water (22 acres). Total area (14,069 acres) from cited project and view, ExtHuc204prvt.shp.

Peak-Flow Processes and Rain-on-Snow (ROS) Risk Assessment for Forested Areas: Fig. III-14 and V-3, along with Tables 10 and 11 and their extensive footnotes, provide data and logical arguments to show that ROS events have low risk for increasing peak-flows in the Lostine watershed.

In summary, the situation is as follows. Fig V-3 shows that the Lostine HUC –203 has only 15 % area in the ROS zone, which does not reach the HUC –202 and –201 areas. Thus, by OWAM, 17, page IV-9, these HUCs and the total WS have low risk of ROS peak-flow enhancement because they have <

25% area in ROS zones (Tables 10, column 6, and Table 11, last column). The following arguments show that –204 also has low risk of peak-flow enhancement due to ROS events.

Fig. V-3 shows that 73 % of the HUC –204 area is in the ROS zone. The figure also shows that 58.1% of the –204 area (79.9 % of the corresponding ROS area) is in the Blue Mountain Basin Ecoregion, 11k, which is primarily unforested (vegetation-cover overlay from White, 33). The 11k ecoregion description (OWAM, 17, Appendix A) states that this ecoregion had <30% historic crown closure and, by OWAM, 17, page IV-10, has low risk of peak-flow increase due to ROS. Thus, the –204 area that is subject to ROS peak-flow enhancement is only 14.9% (73% - 58.1%) of the total –204 area, which is much less than the 25% threshold of OWAM, 17, page IV-9.

An alternative argument showing low ROS risk is based on analysis of only the forested area in –204. From Table 10 and Fig V-3, the forested ROS area above the Blue Mountain Basin Ecoregion is 9051- 0.581 x 12453 = 1816 acres. Per analysis of the GIS vegetation layer from White, 33, 826 acres (45.5% of the subject ROS area), has less than 36% crown-closure (Table 11, footnote 3). The percentage of forest land-use area (5505 acres from Table 9) included within the ROS zone is 1816/5505 x 100 = 33%. OWAM, 17, page IV-11, Fig. 3, shows all values less than 80% of the ROS area having less than 30% crown closure correspond to low ROS-enhancement risk for 33% forest land-use in the ROS zone. Thus, -204 has low risk of peak flow increase due to ROS. [Per Grizzel, 34, the abscissa of the cited Fig. 3 pertains to forest lands **within** the ROS zone, not to "areas **above** ROS elevation."]

Application of the ROS criteria for assessment of peak-flow enhancement for the larger ad hoc Ext HUC 204 Priv area is less straightforward. In this case, the total ROS area (sum of –204 and –203 ROS areas in Fig. III-14) is ca 80% of the Ext 204 area, whereas the Blue Mountain Basin ecoregion is only ca 51% of the Ext 204 area. Therefore, a much smaller fraction of ROS area is excluded due to low historic crown closure. Furthermore, the ODFW sheep range has relatively less cover than in the past due to the 1400-acre fire in 1966 (Ch II). Lack of evidence of landslides, etc., which accompany ROS events in the nearby Umatilla National Forest (USFS, 30), indicate low ROS risk in the Ext 204 area.

Table 10: Peak Flow Processes

Subwatershed Name	Area (acres)	Rain[1]		Rain-on-Snow[1] (ROS)		Spring Snowmelt[1]	
		Acres	%	Acres	%	Acres	%
-204	12,453	unk		9,051	73[1]	unk	
-203	17,243	unk		2,571	15[1]	unk	
-202	17,327	unk		0	0[1]	unk	
-201	11,322	unk		0	0[1]	unk	
Total Watershed	58,345	unk		11,622	19.9[1]	unk	

Footnote (1):

ROS evaluated per criteria developed by the USFS/Umatilla NF for NE Blue Mountain region; i.e., ROS zone = 3000-4500 ft elevation.

The OWAM, Appendix A, "Ecoregion Description" indicates any of rain, ROS, or spring snowmelt may contribute to peak flows in the complete Lostine watershed, which consists of Ecoregions: Blue Mt. Basins (11k), Wallowa/Seven Devils Mts. (11e), Mesic Forest (11l), and Subalpine (11m), (see ROS and Blue Mt. Ecoregion boundaries).

Footnote (1) Con't:

Detailed GIS analysis shows, however, that 79.6% of the -204 R-O-S area (7231 acres) corresponds to the Blue Mt. Basin 11k Ecoregion, which historically had less than 30% crown closure. 826 acres (6.6% of the –204 area) in the –204 R-O-S zone and lying outside the associated 11k Ecoregion has less than 35% crown closure (see Table 11 to follow and its footnote 3).

Only 15% of the –203 area falls within the R-O-S zone (table above), and only 8.4% (1440 acres) above the R-O-S zone is also outside the Eagle Cap Wilderness area.

Table 11: Rain-on-Snow Assessment in Forested Areas

Subwatershed Name or Number	Historic Crown-closure in ROS Areas (%)	Percent of subwatershed in ROS Areas (%)	Percent of ROS areas with <36% Current Crown-closure (%)	Risk of Peak-Flow Enhancement
-204	<30% over 79.6%[2]	73[1], [2]	86[3]	Low[3], [4]
-203	Unknown[1], [2A]	14.9[1]	48.8[3]	Low[5]
-202	0[1], [2A]	0[1]	0	Low[5]
-201	0[1], [2A]	0[1]	0	Low[5]
	Unknown[1], [2A]	19.9[6]	Unknown	Low[5]

Footnotes:

1. This assessment is based on Rain-on-Snow (ROS) criteria, i.e., areas between 3000 to 4500 feet elevation, developed and used by the Umatilla National Forest for the northwestern Blue Mountains of Oregon (USFS, 30). ROS boundaries for the -204/-203 HUCs are shown on the A-V Lost-ros-veg-soils.apr, View 2—Lost Rain-On-Snow; there are no ROS zones for for HUCs -202/-201 because the elevations are everywhere greater than 4500 ft.
2. The –204 ROS area (see A-V citation above) is 73% of the total –204 area, and the overlapping Blue Mt. Basin Ecoregion—11k covers 58.1% of the –204 area, or 79.6% of the subject –204 ROS area (same A-V citation). This latter area is not subject to ROS events because it historically had less than 30% forest crown-closure (OWAM, Appendix A, "Ecoregion Descriptions," page A-185).

(2A) The descriptions of other ecoregions occurring in the HUC -203/-202/-201 areas do not provide information required to establish historic crown closure, or to differentiate between ROS, rain, and spring-snowmelt peak-flow events (op cit., pages A-162, A-186, and A-191).

3. From data tables for Lost-ros-veg-soils.apr, View 2, Dslv-204-ros-utm-veg.shp and Dslv-Huc204-eco-bmb153-crc.shp, 826 acres of the –204 ROS area (6.6% of ROS area) have less than 36% forested crown closure and are outside the ecoregion BMB—11k boundaries. The sum of this area plus the BMB—11k area [(2) above] is 6.6% + 79.6% = 86.2% of the –204 area characterized by less than 36% crown closure. Dslv-203-ros-utm-veg.shp shows that 48.8% of –203 has less than 36% crown closure (27% unforested and 21% having 0-35% crown closure).

Footnotes Con't:

4. Per comment (2) above, ca 80% of the –204 ROS area is in the BMB-11k ecoregion, which historically had less than 30% crown closure and, therefore, low ROS risk (OWAM, page IV-10, Task 2). Per comment (3), only 6.6% of the remaining –204 ROS area has less than 36% crown closure. All forest areas having less than 18% ROS area with less than 30% forest crown-closure have low risk of ROS peak-flow enhancement (OWAM Figure 3, page IV-11). Therefore HUC 204 has low ROS risk.

   [Note: Throughout, the forest crown-closure data base is derived from GIS layers provided by White, 33. Associated definition of areas having less than 36% crown closure provides a conservative estimate of the probability of ROS-enhancement of peak-flow events because the OWAM ROS criteria are based on areas having less than 30% crown closure.]

5. OWAM, page IV-9, Task 1 states that any watershed having 75% or more area in non-ROS zones (i.e., rain or spring snowmelt zones), which is the case for HUCs –203/-202/-201/-total, has low potential for peak-flow enhancement due to ROS events.

6. By Table 10 (see Lost-ros-veg-soils.apr, View 2, Lost-ros-204-unf.shp and Lost-ros-203-unf.shp), the –204 ROS area is 9,051 acres and the –203 ROS area is 2,571 acres, giving a total ROS area of 11,622 acres or 19.9% of the total 58,345-acre area of the Lostine HUC.

Agriculture and Rangeland Runoff Assessment: This section, in particular the analytical results shown by Tables 13-15, indicate that the runoff from agricultural and rangelands due to typical high-precipitation storm events has low risk for enhancement of peak flows in the Lostine WS.

The basis for this runoff assessment per the OWAM, 17, pages IV-12-14, is summarized in the following. The underlying potential for high peak flows is associated with the 2-yr 24-hr storm event, which is described in Ch III, see Figs. III-12, -12a, and -13. As noted in CH III, this assessment corresponds to the Ext 204 Priv area. It is conducted separately for two parts of this area, the lower "–204 non-forested" agricultural area, and the higher-elevation "Ext 204 tg + ODFW" forested area [see Appendix A, note (1a)]. The two results are then combined for the overall assessment of private and state lands in the Lostine WS.

Fig. III-13 shows that the average 2-yr 24-hr precipitation in the lower –204 non-forested area is 1.29 in, in the higher –204 tg +ODFW area is 1.45 in, and in the complete Ext 204 area is 1.37 in.

The OWAM specification of potential risk for peak-flow enhancement is based on the changes in the current to "background" (historic) runoff depths resulting from the 2-yr 24-hr event as follows (OWAM, 17, page IV-14):

Peak-flow Enhancement Risk	Change in Runoff Depth (in)
Low	0-0.25
Moderate	0.25-0.75
High	> 0.75

Thus, the required change in runoff depth for the complete Ext 204 area to exceed low risk would be ca 18.2% of the 2-yr 24-hr precipitation level of 1.37 in, and the change would be ca 54.7% to exceed the moderate risk category.

Evaluation of changes in runoff proceeds as follows. Both the current and background runoff depths are evaluated for the corresponding hydrological conditions (represented by appropriate "curve number" values) per NRCS, 35 (Table 2-1, or B-4 in OWAM, 17). The following values are excerpted from the cited table to illustrate the process. As an illustrative example, the numbers enclosed in the box show that a change in curve number (historical to current) from 60 to 80 for a 1.4 in rainfall would increase the runoff depth by 0.24 in, approximately the threshold value shown above for change from low to moderate risk for peak-flow enhancement.

	Runoff Depth for Prescribed Curve Number and Rainfall (in)			
Curve Number	**40**	**60**	**80**	**98**
Rainfall (in)				
1.2	0	0	0.15	0.99
1.4	0	0	0.24	1.18
1.6	0	0.01	0.34	1.38

As suggested by the table, the runoff depth approaches 100% of the rainfall as the curve number approaches 100 (impervious surface) and the fraction also increases with increasing rainfall (increase above that required to saturate the surface).

Determination of the appropriate values of curve numbers corresponding to the hydrological conditions in the Lostine WS requires a rather lengthy and detailed analysis. Details of the process are summarized as follows, and the results are tabulated in Tables 12-15. The basis for determining the appropriate value of curve number for specified hydrological properties is provided by Tables 2-2a, -2b, and –2c of NRCS, 35 (B-1, -2, and –3 of OWAM, 17). These tables specify values of curve number for a wide variety of vegetative-cover types and treatments (cropland, pasture, meadows, woods, herbaceous, shrubs, etc.), hydrologic soil group (B, C, D for the Lostine WS, see Ch III), and condition (good, fair, poor). Figs. III-5, -6, -7a, and –7b show the GIS land-use and soil-group coverages needed to evaluate the area-extent of these properties within the Ext 204 area. Values of crown closure in designated forested areas (fraction of area having actual forest cover), necessary to the evaluation of associated runoff properties, are obtained from the DOF vegetation layer from White, 33 (based on satellite imagery).

Table 12 shows the area breakdown of the subject parts of the WS according to soil group. Columns 0 and 1 of Tables 13 and 14 display the area breakdown of the subject –204 non-forested and Ext 204 tg + ODFW areas according to both soil group and cover type. [Note: The area percentages in columns 0/1 are based on the total Ext 204 area, 14,069 acres. Footnote (1) of Table 12 shows the sum of agricultural, timber-grazing, and ODFW areas to be 13, 611 acres; whereas footnote (1) of Table 15 shows the sum of the areas having the specified cover types in Columns 0/1 of Tables 13/14 to be 13, 187 acres, as determined from the ArcView coverages. This discrepancy is due in part to the fact that the tables do not include some of the smaller areas having various miscellaneous uses, and in part to the typical 1-2% discrepancies in area-determination via the various ArcView coverages used.]

Table 12: Agricultural and Timber-Grazing Land Use Summary

1 Subwatershed Name	2 Area of Subwatershed in Agriculture or Range-Land Use (acres)	3 Hydrologic Soil Groups in Agricultural Lands or Grazed Range Lands (by approximate percentage)			
		A	B	C	D
Ext 204 Priv(1)	13,611(1)	----	53	29	18
--204 Non-forest(2)	6,860	----	59	29	12
--204/203 Timber-grazing + ODFW(3)	6,943	----	45	29	23
--203 (remainder)	No Agricultural use—soils data not available				
--202					
--201					
Entire Watershed	13,611(1)	Soils data not available for complete watershed			

Footnotes:

(1) See **APPENDIX A: Explanatory Notes for Lostine Watershed Hydrologic Runoff Analysis.** Area data from Lost-ros-veg-soils.apr, View 4, Lost-soils-bcd.shp.

[Note: The data tables for the various GIS layers used for analysis give slightly different values of area for Ext 204 Priv and other subwatershed elements (typical variations of order 1%). The subject 13,611 acres of agricultural or range lands corresponds to a total Ext 204 Priv area of 13,906 acres, composed of non-forested ag use, timber-grazing, timber, and ca 300 acres of non-ag, "Other," which includes a composite of riparian, headquarters, city water, etc.

(2) Data from above-cited .apr/View 4, Lost-soils-bcd-204-non-forest.shp.

(3) Data from above-cited .apr/View 4, Lost-soils-bcd-Ext204-tg+ODFW.shp. Parcels in this layer covering 183 acres, or 2.6% of area, had no soil ID.

Appendix A, notes (1b) through (7), describes the basis for assigning curve numbers to the hydrological features listed in columns 0/1/2 of Tables 13/14. Columns 3 and 4 of the subject tables list these curve numbers for current and background conditions, columns 5 list the appropriate values of 2-yr 24-hr rainfall depth cited above, and columns 6/7 list the runoff depths from NRCS, 35.

Columns 8 of Tables 13/14 list the values of changes in runoff depth for the various conditions. With the exception of one area having average crown-closure of only 17% and Group D soils (bottom entry, column 8, Table 14), all changes in runoff depth are substantially less than the 0.25 in threshold for transition from low- to moderate-risk of peak-flow enhancement. The average values of change in runoff for the –204 non-forested and the Ext 204 tg + ODFW areas are given by the bottom row (**bolded type**) of Tables 13 and 14, respectively.

Columns 8a of Tables 13/14 and columns 2-5 of Table 15 contain the various area fractions and area-weighted runoff values necessary to calculate average change in runoff for the individual soil groups (column 6a, Table 15), and for the complete Ext 204 area (lowest "Sum" entry, column 6b, Table 15).

Table 13: Curve number and Runoff-Depth Summary Table for Non-forest Agriculture and Rangeland

Subwatershed Name: Lostine/ Ext204 Private Land Use—Agriculture/Rangeland									Primary Hydrologic Soil Groups: B, C, and D
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**8a**
Soil Type and Area[(1)] (acres/% total)	**Cover Type/ Treatment and Area[(1)] (acres-% total)**	**Hydro-logic Condi-tion**	**Curve Number**	**Background Curve Number[(5)]**	**Rainfall Depth[(8)] (in)**	**Current Runoff Depth[(9)] (in)**	**Background Runoff Depth[(9)] (in)**	**Change from Background Col. 6-7 (in)**	**Incremental Change/Soil Group[(10)](in) [(Col 8) x (Col 1--area) ÷ Total Area--Soil (x)]**
Part A; --204 Non-forest (Agriculture and Range, excluding timber-grazing + ODFW)									
Soil B (4034 ac-28.6%)	Cropland (1310 ac-9.3%)	G/P[(2)]	75[(2)]	G—62[(5)]	1.3	0.10	0	0.10	0.0190
	Pasture (1598 ac-11.4%)	Fair[(4)]	69[(4)]	"	"	0.04	0	0.04	0.0093
	Hayland (510 ac-3.6%)	G/P[(2)]	75[(2)]	"	"	0.10	0	0.10	0.0074
	Rangeland (237 ac-1.7%)	Fair[(4)]	69[(4)]	"	"	0.04	0	0.04	0.0014
	CRP (120 ac-0.9%)	N/A[(3)]	58[(3)]	"	"	0	0	0	0
	Sum (3775 ac-26.8%)								Sum = 0.0371
Soil C (1993 ac-14.2%)	Cropland (562 ac-4.0%)	G/P[(2)]	83[(2)]	G—74[(5)]	"	0.27	0.09	0.18	0.0264
	Pasture (470 ac-3.3%)	Fair[(4)]	79[(4)]	"	"	0.17	0.09	0.08	0.0098
	Hayland (625 ac-4.4%)	G/P[(2)]	83[(2)]	"	"	0.27	0.09	0.18	0.0293
	Rangeland (170 ac-1.2%)	Fair[(4)]	79[(4)]	"	"	0.17	0.09	0.08	0.0035
	Sum (1827 ac-13.0%)								Sum = 0.069
Soil D (834 ac-5.9%)	Pasture/Range(758 ac-5.4%)	Fair[(4)]	84[(4)]	G--85[(5)]	"	0.30	0.33	-0.03	-0.0092
	Sum (758 ac-5.4%)								Sum = -0.0092
Total (6861 ac-48.8%)	Sum (6360 ac-45.2%)								
--204 Non-forest average change from background = 0.0782 in[(11)]									

Footnotes:

(1) Columns 0/1 Area % based on total area of Ext204-Priv-Lnd-Use.shp = 14,069 acres. See (10)/(11) and Table 15, FN (1) for areas/%s used for other Columns in Tables 13, 14, and 15.

(1)-(10)—See **APPENDIX A: Explanatory Notes for Lostine Watershed Hydrologic Runoff Analysis**

(11) Calculated from Col 8a sums/soil-type areas, Table 15, FN (1), as: 0.0371x6891/6360 + 0.069x 3834/6360 – 0.0092x2462/6360 = 0.0782 in.

Table 14: Curve number and Runoff-Depth Summary Table for Timber-grazing and ODFW

Subwatershed Name: Lostine/ Ext204 Private Land Use—Agriculture/Rangeland						Primary Hydrologic Soil Groups: B, C, and D			
0	1	2	3	4	5	6	7	8	8a
Soil Type and Area(1) (acres/% total)	Cover Type/ Treatment and Area(1) (acres-% total)	Hydro-logic Condi-tion(6)	Curve Number(6)	Background Curve Number(7)	Rainfall Depth(8) (in)	Current Runoff Depth(9) (in)	Background Runoff Depth(9) (in)	Change from Background Col. 6-7	Incremental Change/ Soil Group(10) [Col 8 x (Col 1-area) ÷ Total Area-Soil (x)]
Part B: --Ext204-Timber-grazing + ODFW									
Soil B (3115 ac-22.1%)	90% CrCl (123 ac-0.8%)	Fair	61	G--59	1.45	0	0	0	0
	58% CrCl (1393 ac-9.8%)	"	65	"	"	0.03	0	0.03	0.0061
	17% CrCl (1600ac11.4%)	"	69	"	"	0.06	0	0.06	0.0139
	Sum (3116 ac-22.1%)								Sum = 0.0200
Soil C (2024 ac-14.4%)	90% CrCl (96 ac-0.7%)	Fair	74	G--72	"	0.13	0.10	0.03	0.0008
	58% CrCl (1009 ac-7.2%)	"	76	"	"	0.17	0.10	0.07	0.0184
	17% CrCl (902 ac-6.4%)	"	80	"	"	0.27	0.10	0.17	0.0400
	Sum (2007 ac-14.3%)								Sum = 0.0592
Soil D (1621 ac-11.5%)	90% CrCl (30 ac-0.2%)	Fair	80	G--79	"	0.27	0.25	0.02	0.0002
	58% CrCl (438 ac-3.1%)	"	83	"	"	0.36	0.25	0.11	0.0196
Note: Per H-5, note (3), 183 ac have no soil ID	17% CrCl (1236 ac-8.8%)	"	87	"	"	0.51	0.25	0.26	0.1305
	Sum (1704 ac-12.1%)								Sum = 0.1503
Total (6943 ac-49.3%)	Sum (6827 ac-48.5%)								
--Ext204-Timber-grazing-ODFW average change from background = 0.1076 in(11)									

Footnotes:

(1) % CrCl (crown closure) in Column 1 refers to the average closure for the three closure ranges used for analysis, i.e., 90% for 81-100%, 58% for 36-80%, and 17% for 0-35%.

(1)-(10) See **APPENDIX A: Explanatory Notes for Lostine Watershed Hydrologic Runoff Analysis**

(11) Calculated from Col 8a sums/soil-type areas, Table 15, FN (1), as: 0.0200x6891/6827 + 0.0592x3834/6827 + 0.1503x2462/6827 = 0.1076 in.

Table 15: Agricultural/Rangeland Runoff--Consolidation of –204 Non-forest and Ext 204-Timber-grazing + ODFW

1 Hydro-logic Soil Group	2 --204 Non-forest-- Percent of Ag-Range Area in Soil Group[1] Table, FN (1) below	3 --204 Non-forest-- Average Fract. Change from Background[2] Table 13, Col. 8a	4 Ext204 T-G + ODFW Percent of Ag-Range Area In Soil Group[1] Table, FN (1) below	5 Ext204-T-G + ODFW Average Fract. Change from Background[2] Table 14, Col. 8a	6a Weighted Av. Change from Background--individual soil type and area Col. 3 + Col. 5	6b Incremental Weighted Av. Change from Background Col. 6a x (Col. 2 + Col. 4) / 100	7 Potential Risk of Peak-Flow Enhance-ment[3]
B	28.6	0.037[3]	23.6	0.020[3]	0.057[3]	0.030	Low[3]
C	13.9	0.069[3]	15.2	0.059[3]	0.128[3]	0.037	Low[3]
D	5.7	-0.009[3]	12.9	0.150[3]	0.141[3]	0.026	Low[3]
Total-	Sum (48.2)	----	Sum (51.8)	----	----	Sum (0.093) [3]	**Low[3]**
		Note: Units for all runoff changes in inches.					
Entire W-shed	The large fractions of –203, -202, -201 subwatershed areas in the Eagle Cap Wilderness suggest little or no difference between current and background runoff, i.e., low potential risk for peak-flow enhancement.						

Footnotes:

(1) The ("measured") areas from the GIS-layer runoff analysis and results given by Tables 13-15 are listed here for convenient reference.

A Soil Type	B --204 Non-forest Area (Acres) / % total Ext 204 [Ag/T-G/ODFW] Area	C Ext204-T-G/ODFW Area (acres) / % total Ext 204 [Ag/T-G/ODFW] Area	D Total Ext 204 [Ag/T-G/ODFW] Area (Cols. B + C) / % total Ext 204 [Ag/T-G/ODFW] Area (Cols. B + C)
B	3775 / 28.6	3116 / 23.6	6891 / 52.2
C	1827 / 13.9	2007 / 15.2	3834 / 29.0
D	758 / 5.7	1704 / 12.9	2462 / 18.6
All	6360 / 48.2	6827 / 51.8	13,187 / 100

(2) Recall that these average fractional changes (in runoff-depth) from Cols. 8a, Tables13 and 14, are weighted by the ratio of associated area, Cols. B/C in (1), to the total area of associated soil type (Col. D in (1) above.

(3) By OWAM, page IV-14, the NRCS-recommended threshold for change in runoff-depth differentiating low-to-moderate potential risk for peak-flow enhancement in Eastside watersheds is 0.25 in, well above the averaged values shown above. Columns 6-8 of Tables 13 and 14, show such potential can exist on type C and D soils, especially at higher elevations in forested lands having low crown closure.

As indicated by Column 7, Table 15, these area-averaged values of change in runoff indicate low risk of peak-flow enhancement due to the 2-yr 24-hr storm event in the subject part of the Lostine WS (lower than the 0.25 in threshold value specified by the OWAM for Eastern Oregon WSs). Although the higher precipitation levels in HUCs –201, -202, and portions of –203 (see Fig. III-12) tend to increase risk of peak-flow enhancement, the hydrological data necessary for runoff evaluation is not available for these areas. Furthermore, these areas are largely in the Eagle Cap Wilderness where current hydrological conditions may be expected to be similar to historical conditions.

Roads and Residential Runoff Assessment: The results shown by Tables 16a,b and 17a,b indicate that runoff associated with forest and rural roads, and with impervious residential area do not contribute significantly to increased risk of peak-flow enhancement in the Lostine WS.

Following the OWAM procedure (OWAM, 17, pages IV-15 and -16), Columns 4 and 5 of Tables 16a and 16b, respectively show the lengths and estimated areas of forested and rural roads in the indicated areas of the WS. Data for forested roads are from mapped roads on RY Timber lands (White, 36) and from USGS quad maps (Smith, 25). Rural road data are from the USGS maps.

Columns 6 of Tables 16a,b show the percentage of road areas relative to the forested and rural areas. Columns 7 indicate the risk for peak-flow enhancement is low because all values in Columns 6 are much smaller than the 4% OWAM threshold criterion for increasing peak-flow risk from low to moderate (OWAM, 17, page IV-15) . [Note: The cumulative forest- plus rural-road density in the Ext204 Priv area, 3.17 mi/mi^2, is 4%-10% less than the corresponding 3.3-3.5 mi/mi^2 cited in the USFS USFS, 9c (see Ch II.]

Tables 17a,b show results for assessment of residential runoff by two methods per the OWAM, 17, pages IV-16-19. Column 2 of Table 17a shows the fraction of rural residential area derived from the GIS layer indicated by FN 1. Column 5 shows the associated estimate of impervious area, where per the table in OWAM, 17, page IV-18, the impervious area is taken as 10% of the total residential area, which is appropriate for parcels greater than 2 acres in size. Column 6 shows low risk of peak-flow enhancement because the impervious-area value, 0.18%, is much smaller than the OWAM 5%-threshold impervious area to increase risk from low to moderate (OWAM, 17, pages IV-16, -17).

Table 17b shows results for an alternative OWAM-recommended method for estimation of potential peak-flow enhancement in residential areas (OWAM, 17, page IV-19). This method, based on urban road density, indicates zero risk because there are no urban areas in this watershed (the town of Lostine is not included in the Lostine WS HUC).

Table 16a: Forest Road Area Summary

1 Subwatershed Name	2 Area(2) (mi^2)	3 Area Forested(2) (mi^2)	4 Total Linear Length of Forest Roads (mi)	5 Roaded Area Col. 4 x SW (SW = Std. Width = 25 feet = 0.0047 miles) (mi^2)	6 Percent Area In Roads (Col. 5÷3)	7 Potential Risk for Peak Flow Enhancement
Ext204 Priv	21.9(1)	10.8	50.2	0.236	2.18	Low(3),(4)
-203Remainder(1)	21.6(1)	All	Unknown	Unknown	----	----
-202	27.1	"	"	"	----	----
-201	17.7	"	0	0	0	Low(3),(4)
Entire Watershed	91.2	**Note:** Most of –203 (Remainder), -202, and –201 are in the roadless Eagle Cap Wilderness. The Lostine River road area is in Table 16b below.				

Table 16b: Rural Road Area Summary

1 Subwatershed Name	2 Area(2) (mi^2)	3 Rural Area(2) (Ag/Range) (mi^2)	4 Total Linear Length of Rural Roads (mi)	5 Roaded Area Col. 4 x SW (SW = Std. Width = 35 feet = 0.0066 Miles) (mi)	6 Percent Area In Roads (Col. 5÷3)	7 Potential Risk for Peak-Flow Enhancement
Ext204 Priv	21.9(1)	10.4	19.2	0.13	1.25	Low(3),(4)
-203Remainder(1)	21.6(1)	Use total	4.8	0.032	0.15	Low(4)
-202	27.1	"	6.2	0.041	0.15	Low(4)
-201	17.7	"	0	0	0	Low(4)
Entire Watershed	91.2	76.8	30.2	0.203	0.23	Low(4)

Footnotes:

(1) Per Table 9, FN (4), -203 (Remainder) excludes 3400 acres of private/state lands included in Ext204 Priv. The 1720 acres of USFS land in the SW corner of –204 are not included in this summary.

(2) Per Table 9, FN (5), Rural Area = Ag + Range + Other, Forestry = timber-grazing + timber + ODFW.

(3) The sum of forest and rural roads in Ext204 Priv, 0.366mi^2, = 1.67% of the total Ext204Priv area.

(4) Per OWAM, pages IV 16-18, the threshold for increase from low to moderate potential for peak flow enhancement due to roads is for road areas that are 4% to 5% of the total area.

Table 17a: Method 1: Rural Residential Land Use Summary

1	2	3	4	5	6
Subwatershed Name	**Rural Residential Area** (%)	**Dominant Land Use**	**Average Percent Impervious Col. 2**	**Estimated Total Impervious Area** (%) (Col. 2 x Col. 4)	**Potential for Peak-Flow Enhancement**
Ext204 Priv	1.8(1)	Rural Residential	10	0.18	Low(2)
Note: There is no significant rural-residential use outside of Ext204 Priv.					

Table 17b: Method 2: Urban Road Density Summary

1	2	3	4	5	6
Subwatershed Name	**Area** (ml^2)	**Urban Area** (ml^2)	**Total Linear Distance of Roads** (mi)	**Road Density Col. 4/3** (ml/mi^2)	**Potential for Peak-Flow Enhancement**
N/A—There is no urban use within Lostine HUC 1706010502					None

Footnotes:

(1) Per Table 9, FN 5, and table of attributes for Ext204-prvt-lnd-us.shp, the rural residential area is 222.6 acres and the ranch "headquarters" area is 26.5 acres, giving a total of 249.1 acres, or 1.8% of the total Ext204 area.

(2) Per OWAM table, page IV-18, the risk of peak-flow enhancement is low for impervious areas less than 5% of the total area.

Summary of Land Use Impacts on Peak-flow Enhancement: Table 18 summarizes the assessment results, conducted according to OWAM procedures, which include potential land-use effects on peak flows associated with ROS in forest lands, and with major storm events in agricultural and grazing lands. Land uses considered are those that potentially influence runoff characteristics, including reduction of forest and other vegetative cover, as well as introduction of impervious surfaces for roads and residential uses (Tables 11, 13, 14, 15, 16a,b, and 17a,b). As shown by Table 18 and the other cited tables, none of the processes and land-use effects considered significantly increase risk of peak-flow enhancement.

It is important to recognize, however, that the OWAM procedures do not cover all potential physical circumstances associated with high peak flows. For example, large storm events, ROS, or rapid temperature increases where large snow packs exist, could generate large runoff on frozen ground. Such runoff characteristics may be strongly influenced by current vs historical hydrological factors such as changes in vegetative cover and surface infiltration.

As was noted in Ch II (Natural Disturbance Patterns), localized flood and land-disturbance events can occur without indications of anomalies on a larger scale (e.g., the May 1975 event at the Lapover Ranch discussed in Ch II does not correlate with peak flood levels in the Lostine River).

Nevertheless, as discussed at the outset in this chapter (Lostine River Flows), peak and monthly-averaged river flows measured over the past 50 years do not indicate significant trends due to changes in land-use practices.

Table 18: Summary of Potential Risks from Land Use Impacts on Hydrology

<table>
<tr><th rowspan="2">1

Subwatershed Name or Number</th><th colspan="2">2
Timber Harvest
(Table 11)</th><th colspan="2">3
Agriculture (Non-forest)
(Table 13/15)</th><th colspan="2">4
Forested Lands (timber-grazing)
(Table 14/15)</th><th colspan="2">5
Forest Roads
(Table 16a)</th><th colspan="2">6
Rural Roads
(Table 16b)</th><th colspan="2">7
Impervious Area
(Table 17a)</th></tr>
<tr><th>Result</th><th>Risk</th><th>Result</th><th>Risk</th><th>Result</th><th>Risk</th><th>Result</th><th>Risk</th><th>Result</th><th>Risk</th><th>Result</th><th>Risk</th></tr>
<tr><td>-Ext204 Priv</td><td>----</td><td>----</td><td>Runoff Depth</td><td>Low</td><td>Runoff Depth</td><td>Low</td><td>% Area</td><td>Low</td><td>% Area</td><td>Low</td><td>% Area</td><td>Low</td></tr>
<tr><td>-204</td><td rowspan="4">ROS Analysis</td><td>Low</td><td colspan="10">See Ext204 Priv above.</td></tr>
<tr><td>-203</td><td>Low</td><td colspan="10" rowspan="3">See Ext204 Priv above, otherwise associated areas are largely in the roadless and uninhabited Eagle Cap Wilderness and, therefore, are expected to have low risk for peak flow enhancement.</td></tr>
<tr><td>-202</td><td>Low</td></tr>
<tr><td>-201</td><td>Low</td></tr>
<tr><td>Entire Watershed</td><td>ROS Analysis</td><td>Low</td><td></td><td>Low</td><td></td><td>Low</td><td></td><td>Low</td><td></td><td>Low</td><td></td><td>Low</td></tr>
</table>

B Water Use

This section addresses use of water in the Lostine WS, primarily as regards the inadequate flow levels to support both irrigation and fish needs during the low-flow period, August-September. The following discussion is of two different types. The first two subsections follow the OWAM, 17 procedure for evaluation of water availability, pages IV-20 to –22, and the third presents extensive river and diversion flow data specific to the Lostine WS from Refs. 1, 2, and 5.

Water Availability Analysis, WABs and WARs: OWAM, 17, Appendix IV-D, pages 5-9, and the OWRD technical document on determination of surface water in Oregon, Cooper, 37, provide extensive material on factors that govern water availability for an individual WS. The OWRD uses the methodology described in Cooper, 37 to generate Water Availability Reports (WARs) for specific Water Availability Basins (WABs), consisting of all or part of a WS (HUC), which form the basis for the OWAM water-use assessment.

A basic requirement for evaluation of water availability is knowledge of existing water rights. The principal water rights in the Lostine WS are implemented by in-stream diversions from the river for irrigation, listed by diversion ditch in Table 19. As described in the footnotes to the table, the data included therein, which represent well over one hundred individual water rights, were acquired from several sources and were reviewed by regional OWRD staff for accuracy and completeness. The flow rates given by the table are based both on direct flow-rate specifications for "permitted" rights, and on the "early-" and "late-" season average rates for adjudicated rights as explained in footnote (2) to the

Table 19: Water Rights for Lostine Diversions on Record with OWRD[(1)-(3)]

Ditch Name	Early Season (before 7/31) Adjudicated Acres	Early Season Adjud Flow (cfs)	Early Season Permitted Flow (cfs)	Early Season Cumulative Flow (cfs)	Late Season (after 7/31) Adjud Flow (cfs)	Late Season Permitted Flow (cfs)	Late Season Cumulative Flow (cfs)
Upstream Ditches							
Silver Creek (3)			14	14		14	14
Westside	1264	31.6	13.3	44.9	10.5	13.3	23.8
Sheep Ridge	719	18	1.64	19.64	6	1.64	8.1
Lostine	767	19.1		19.1	6.4		6.4
Wood-Boatman	76.5	1.9		1.9	0.6		0.6
Bowman	44.8	1.1		1.1	0.4		0.4
Poley-Allen + MlsMgl	1219.5	30.5	0.28	30.78	10.2	0.28	10.2
Downstream Ditches							
Miles	520.5	13		13	4.3		4.3
Clearwater (3)	1718	43	1.94	44.94	14.3	1.94	16.24
Tulley Hill	119	3	0.2	3.2	1	0.2	1.2
Foster	788	19.7		19.7	6.6		6.6
Fitzpatrick	699	17.5	0.83	18.33	5.8	0.83	6.6
Chamberlain Pipe(3)						38.1	38.1
Total/Upstream Ditches	4090.8	102.2	29.22	131.42	34.1	29.22	63.5
Total/Downstream Ditches	3844.5	96.2	2.97	99.17	32	41.07	73.04
Total/All Ditches	7935.3	198.4	32.19	230.59	66.1	70.29	136.54

(1) **NOTE:** Per consultation with NE region OWRD staff, these data provide the best available description of water rights on record.

(2) From: HARZA report, "Lostine River Salmonid Passage Enhancement Study," Table 2.3, page 8; extended and modified per area table for Lostine irrigation ditches by C. Menton, private communications with Jason Spriet, and including area checks per Lostine River Irrigation Map. Adjudicated flow rates are averaged values, calculated from the permitted total water volume and flow-rate limitations assuming constant flow, i.e., 1.5 acre-ft/acre/30 days = 1/40 cfs for the early season, and 1.0 acre-ft/acre/60 days =1/120 cfs for the late season.

(3) These flow data correspond to water rights for both river and stream diversions within the Lostine 5th HUC (# 1706010502). The Silver Creek diversion (14 cfs), a large fraction of the Clearwater ditch diversion (44.9 cfs), and the Chamberlain Pipe flow (38.1 cfs) service water rights outside the WAB # 233. The latter two diversion flows, although taken from the Lostine River, are compensated by the permitted 88.6 cfs taken from the Wallowa River via the Cross-country ditch.

table. Variable seniority of water rights is not considered in this assessment. The OWRD determination of water availability, discussed in the following paragraphs, is based on an independent, presumably equivalent, determination of relevant water rights.

Table 20 presents a summary of estimated Lostine water-availability data by month derived from the OWRD WARs data shown in the following Table 21. The associated WAB #233 consists of the complete Lostine HUC, including the predominately private-lands HUC –204, and the WAB #30810514 consists of the upper WS, HUCs –203, -202, and –201, excluding the private lands in -204.

Table 20: Monthly Net Water Available by Water Availability Basin (cfs)

Water Availability Basins	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
#233	5.08	10.5	18.3	78.1	350.0	676.0	208.0	**-41.2**	**-35.8**	**-10.6**	**-12.0**	2.1
#30810514	43.3	44.9	47.0	99.3	411.0	793.0	319.0	70.6	47.3	41.9	49.2	41.6

The above data are taken from the last columns of the Water Availability Reports (WARs), Tables 21a and b, downloaded from the OWRD website. As shown by Watershed Availability Basin maps, also available from the OWRD website, WAB #233 includes the complete Lostine watershed, from the mouth to headwaters. WAB #30810514 includes the Lostine watershed upstream from Spring Creek, which is near the boundary between HUCs –204 and –203. The negative values of available water for WAB #233 during the late season are due to water diversions for irrigation and to in-stream water rights for fish.

More comprehensive data on Lostine River and diversion flows are given by Figures V-5 to V-22.

The bolded entries in Tables 20 and 21a, show negative values for estimated available water for the #233 WAB during August through November, i.e., estimated water use based on existing water rights exceed the available stream-flow during those months. As shown by Table 21b, the upper WS alone technically has 40-50 cfs of available water during the low-flow months (which is not available for other than in-stream uses because of the downstream deficiency).

Additional discussion of the WARs data in Table 21 is necessary to understand the basis for the inadequate water-availability estimates shown by Table 20, and for the discussion of the associated Table 22 below. The second columns of Tables 21a,b contain the monthly "50% Exceedance Flows" for the Lostine River, which per Cooper, 37 are statistical properties of the river flows for the period 1958 to present, i.e., flow levels that the actual river flows will statistically exceed 50% of the time.

The third columns of Table 21 are based on OWRD estimates of "consumptive plus storage" water use (see Cooper, 37, pages 38-54). The estimated consumptive use, primarily due to irrigation in the Lostine WS, is based on a complex of factors described in Cooper, 37, pages 40-46; including census of past water use; monthly water needs as dictated by crop acreage, type, and location; water use permitted by water rights; and modeling to infer the ratio of water consumed to the complete diversion amount (calculated to be 41% for irrigation in Eastern Oregon), where the remaining non-consumptive fraction (59%) is assumed to return to the river.

Table 21: Water Availability Reports for Lostine Water Availability Basins
(From OWRD WARs website—50% Exceedance Streamflow)

a—Watershed ID # 233—Lostine River at Mouth

Month	Natural Stream Flow	CU+Store Prior to 1/1/93	CU+Store After 1/1/93	Expected Stream Flow	Reserved Stream Flow	Instream Water Rights	Net Water Available
1	50.60	5.52	0.00	45.10	0.00	40.00	5.08
2	55.70	5.21	0.00	50.50	0.00	40.00	10.50
3	63.40	5.06	0.00	58.30	0.00	40.00	18.30
4	123.00	4.91	0.00	118.00	0.00	40.00	78.10
5	447.00	37.20	0.00	410.00	0.00	60.00	350.00
6	830.00	94.10	0.00	736.00	0.00	60.00	676.00
7	346.00	88.30	0.00	258.00	0.00	50.00	208.00
8	87.20	58.40	0.00	28.80	0.00	70.00	**-41.20**
9	52.70	18.50	0.00	34.20	0.00	70.00	**-35.80**
10	45.60	6.22	0.00	39.40	0.00	50.00	**-10.60**
11	54.10	6.12	0.00	48.00	0.00	60.00	**-12.00**
12	48.00	5.89	0.00	42.10	0.00	40.00	2.11
Store	133000	20300	0	113000	0	37400	81300

b—Watershed ID # 30810514—Lostine River at Spring Creek

Month	Natural Stream Flow	CU+Stor Prior to 1/1/93	CU+Stor After 1/1/93	Expected Stream Flow	Reserved Stream Flow	Instream Water Rights	Net Water Available
1	45.30	1.99	0.00	43.30	0.00	0.00	43.30
2	46.70	1.84	0.00	44.90	0.00	0.00	44.90
3	48.80	1.76	0.00	47.00	0.00	0.00	47.00
4	101.00	1.69	0.00	99.30	0.00	0.00	99.30
5	421.00	9.63	0.00	411.00	0.00	0.00	411.00
6	817.00	24.30	0.00	793.00	0.00	0.00	793.00
7	342.00	23.00	0.00	319.00	0.00	0.00	319.00
8	85.60	15.00	0.00	70.60	0.00	0.00	70.60
9	51.50	4.16	0.00	47.30	0.00	0.00	47.30
10	44.20	2.33	0.00	41.90	0.00	0.00	41.90
11	51.50	2.28	0.00	49.20	0.00	0.00	49.20
12	43.80	2.17	0.00	41.60	0.00	0.00	41.60
Store	127000	5470	0	121000	0	0	121000

Note: Per ODWR watershed maps, ID #233 corresponds approximately to the Lostine 5th level HUC and #30810514 to the 6th level HUCs –203, -202, and –201 (northern boundary near the #13330000 GS).

The consumptive-use portion and in-stream flow water rights (fish requirements) in Table 21 are subtracted from the natural stream flow to determine the net water available (last column of table). Although these data represent certain characteristics of the Lostine WS, e.g., river flow and agricultural acreage, they also depend on factors inferred from region-wide considerations, which introduces uncertainties as to the quantitative accuracy of the results for the Lostine WS per se.

Consumptive Use Fraction and Flow Restoration Priorities: Table 22 illustrates the fraction of the 50% Exceedance River Flow corresponding to the estimated consumptive use. Per the OWAM, page IV-22, values of the consumptive-use fraction exceeding 10% have been bolded as indicative of greater potential for flow restoration through conservation measures.

Table 22: Consumptive Use as a Percentage of 50% Exceedance Streamflow(1), (2), (3)

Water Availability Basins	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
#233	**10.9**(2)	9.4	8.0	4.0	8.3	**11.3**(2)	**25.5**(2)	**67.0**(2)	**35.1**(2)	**13.6**(2)	**11.3**(2)	**12.3**(2)
#30810514	4.4	3.9	3.6	1.7	2.3	3.0	6.7	**17.5**(2)	8.1	5.3	4.4	5.0

Footnotes:

(1) Values in table are ratios of corresponding entries in Column 3 ÷ Column 2 of the Lostine WARs, Table 21.

(2) OWAM, 17 (OWAM, Flow Restoration Priority Areas, Tasks 2 and 3, page IV-22), states that watersheds having greater that 10% consumptive-use ratio (high-lighted values above) "present the greatest opportunity for flow restoration through conservation measures, increased efficiency of use, and/or best management practices."

Reference to Fig V-7, minimum monthly-averaged flows in the Lostine River, shows that the high consumptive-use values for #233 in August and September do not represent the "worst case" situation. The referenced chart gives minimum river flow values for the "Upper" and "Caudle" gauging stations, respectively, as 50.2 cfs and 9.55 cfs for August. The corresponding September values are 25.7 cfs and 6.55 cfs. These values show the flow reductions between the Upper and Caudle stations (consumptive use?) have been as large or larger than **81%** for August, and **74.5%** for September. Daily records from the Caudle gauging station (not included here) show that the <10 cfs flow levels occur fairly frequently in August, and persist for several days to several weeks.

(3) Per references cited in the OWAM, 17, Flow Restoration Priority Areas, Task 1, the Lostine watershed has been identified as a priority WAB for flow restoration. Specifics of these priorities are given by the Fig. V-4 map, entitled "Flow Restoration Priorities for Recovery of Salmonids in Oregon," from *The Oregon Plan: Streamflow Restoration Priorities; Grande Ronde Basin; Summer,* [downloaded from www.wrd.state.or.us/programs/salmon/08priorities.pdf, accessed through the Streamflow Restoration Priorities section of the WRD website,]

The cited map shows that the rankings for the lower part of Lostine WAB #233 (HUC –204) are:

Flow Restoration Needs: High
Flow Restoration Opportunities: Good
State Flow Restoration Priorities: Priority

WAB #30810514 (HUCs –203 to –201) is not a priority for stream restoration.

The arrows and index notation in Figure V-4 indicate relevant flow restoration ratings given by the Oregon Plan, obtained from the OWRD website per footnote (3) of Table 22 above. As indicted by the map and the cited footnote (3) above, the lower Lostine WS is rated to have high need, good opportunity, and priority ranking for streamflow restoration via water conservation measures. The upper WS is not a priority area for streamflow restoration.

<u>Flow Levels in the Lostine River and the Irrigation Diversions:</u> Figs. V-5 and –6 show the multi-year, monthly-averaged Lostine River flows for the period 1995-2001 (USGS, 1). The 12-month hydrograph, Fig. V-5, is consistent with that from OWAM, 17 and OGC, 23 for the Blue Mountain/Seven Devils Ecoregion, 11e, but does not exhibit the higher early-spring flows given by the cited ecoregion material for the other three ecoregions in the Lostine WS, even though they cover a much larger fraction of the Lostine HUC than does 11e.

Fig. V-6, covering only the second half of the year, better illustrates the low-flow issues. The total cumulative water rights for the diversions listed in Table 19 for the early and late seasons, 230.6 cfs and 136.5 cfs, respectively, are indicated by the horizontal lines in Figs. V-5 and –6. The figures clearly show that the water rights associated with irrigation diversions substantially exceed the average river flow levels during the August-September period. Comparison of the flow levels measured at the three gauging stations also clearly shows the decreases in flow levels between the upper and Caudle gauging stations, due primarily to irrigation withdrawals, as well as the relative increases in flow levels between the Caudle and Baker Rd gauging stations due to water transfer from the Wallowa River to the Lostine River via the Cross Country ditch.

Fig. V-7 shows the minimum monthly-averaged flows from USGS, 1 for the indicated months during the 1995-2001 period (minimum July-September flows occurred in 2001, the October minimum in 1999, and the November minimum in 1998). These data show that the river flow levels can drop to below 10 cfs at the Caudle station during Aug-Sept, and exhibit significant increases in flow levels at the Baker Rd station due to introduction of Wallowa River water via the Cross Country ditch. The indicated minimum flows of 10 cfs and less at the Caudle station occur quite frequently during the Aug-Sept period, typically persisting for several days to weeks (USGS, 1).

Figs. V-8 and V-15 show the multi-year, monthly-averaged diversion-flow levels from Dyke, 2 and HARZA, 5 for each of the ditches, as well as the cumulative flows for the indicated "upstream" and "downstream" ditches, respectively, for the 1995-99 period. Figs. V-9 to –14 show the monthly-averaged flows in the upstream ditches by month and year, and Figs. V-16 to –20 show the same type of diversion-flow data for the downstream ditches.

Figs. V-21 and V-22 show the annual transfer flow-levels from the Wallowa to the Lostine River via the Cross Country ditch (-21, tail) by month, as well as the complete flow from the Wallowa River (-22, head). Fig 23 shows the net balance of flow in/out of the Lostine River due to the downstream diversion ditches. The net curve shows a major deficiency in flow to the Lostine during the June-Aug period, and a surplus thereafter.

Returning to Fig. V-8, note that the cumulative upstream diversion flow exceeds the average cumulative value permitted by the water rights from Table 19 during August, with diversion flows declining to permitted levels in September [strictly speaking, the average permitted flow of 49.5 cfs over the 60-day Aug-Sept period should be compared to the average diverted flow for the two months, i.e., (70.0 + 45.1) / 2 = 57.5cfs, which is ca 16 % above the average permitted value]. Fig. V-15 shows that the average cumulative downstream diversion flows are less than permitted values throughout. The cited values, both used and permitted, exclude the Silver Creek diversion for which no diversion-flow data are available.

More detailed ditch-by-ditch comparisons of actual water used relative to that permitted by water rights can be made using the water-rights data from Table 19 and the individual ditch data given by Figs. V-9 to –14 and V-16 to –20

.

C Summary

Detailed analysis in section A of this chapter clearly shows that land uses in the Lostine WS do not contribute significantly to the risk of peak-flow enhancement via the processes considered in the OWAM, 17. These results do not, however, exclude the possibility that current land uses contribute to increased runoff rates during the high-flow season, with corresponding decreased retention of water needed during the subsequent low-flow season.

Data presented in section B of this chapter, see especially Figs. V-6, -7, -8, and –15, show that: i) the mid-river region exhibits exceedingly low flows during the Aug-Sept period, ii) average diversion flows permitted by "late season" water rights substantially exceed average river flows during this period, and iii) the average late-season upstream diversion flows exceed that permitted by the corresponding cumulative water rights. These data support the general conclusions drawn from the OWRD water-availability and consumptive-use analyses discussed in connection with Tables 20-22 and Fig. V-4 in section B, i.e., the high ranking of the lower Lostine WS as regards needs for streamflow restoration.

A potential approach to alleviate the above shortages in "late season" water availability is indicated by Cooper, 37, pages 46 and 49 (Table 31). This involves diversion and irrigation use of excess water above and beyond crop requirements in the early season to build up soil moisture, thereby relieving water needs in the late low-flow season. Figs. V-5, -8, and –15 show that the average available water in the May-July timeframe substantially exceeds that permitted by irrigation water rights, and that the permitted diversion flows during this period are substantially higher than the actual diverted flows. Therefore, more early season water is clearly available. The essential practical question, which is beyond the scope of this assessment, is whether farming practices and soil water retention permit use of this water to relieve late-season requirements in the Lostine WS as in the other Eastern Oregon areas indicated by the cited Table 31 of Cooper, 37. This question might be readily answered by evaluating the late-season soil moisture content at various locations for increased early-season irrigation flows and decreased late-season flows, as limited by practical farming considerations and by water-rights constraints.

Data comparisons shown by Table 23 provide further information of interest as regards diversion flows and associated "de-watering" of the river. As was noted in the discussion of Table 21 in section B, the OWRD evaluation of the consumptive-use fraction for irrigation depends on regional factors, which may or may not accurately represent conditions specific to the Lostine WS. The following discussion, although not definitive, indicates that the consumptive-use fraction of water diverted for irrigation may be significantly higher that the 41% value cited in Cooper, 37, page 41.

Table 23a (data from Fig. V-7 as indicated) shows that the minimum river flows during the Aug-Sept period decrease by ca 75%-80% over the approximate 5 RM distance between the upstream and Caudle gauging stations (see Table 2 for locations). Table 23b shows similar data for multi-year average flows, in which case the Aug-Sept flow losses between the upper and Caudle gauging stations are ca 37%-55%.

The second to last row of Table 23c shows the cumulative fractions of (average) upstream river flow that are diverted via the upstream diversion ditches are ca 69%-85% for Aug-Sept. The last row of Table 23c gives the ratios of average river-flow losses to the cumulative diverted flows as ca 54%-64%. Although these river-flow losses may include factors other than irrigation diversion (e.g., river-surface evaporation or other ground water loss), the data show that consumption or other out-of-stream losses due to irrigation diversion could be as high as 64%. In addition to absolute consumptive loss, the time for diversion flows to return to the river may be an important issue, i.e., the time of out-of-stream retention of diverted water.

Table 23: Lostine River Flow Losses and Diversion Flows: Upper GS to Caudle GS

a—Minimum Flows (cfs)--1995-2001; See Fig V-7, data table

Flow	Month				
		Aug (2001) (1)	Sept (2001) (1)	Oct (1999) (1)	Nov (1998) (1)
Upper GS	126	50.2	25.7	38.4	40.7
Caudle GS	52.6	9.55	6.55	23	36.9
% Loss	58.2	**81**	**74.5**	40.1	9.3

b—Multi-year Average Flows (cfs)--1995-2001; See Fig. V-6, data table

Flow	Month				
	Jul	**Aug**	**Sept**	**Oct**	**Nov**
Upper GS	414.5	101.2	53.2	57	84.7
Caudle GS	392.9	63.4	24.2	45.1	73.3
% Loss	5.2	**37.4**	**54.5**	20.9	13.5

c—Cum Diversion / Multi-yr Av (%) and Cum Diversion / (Upper GS – Caudle GS) (%)

1995-1999; see Fig. V-8, data table, and b above

Flow	Month				
	Jul	**Aug**	**Sept**	**Oct**	**Nov**
Cum Diversion	84.9	70	45.1	16.2	6.7
Upper GS	414.5	101.2	53.2	57	84.7
Cum Div / Upper GS (%)	20.5	**69.2**	**84.8**	28.4	7.9
River Loss / Cum Div (%)	25.4	**54**	**64.3**	73.6	170.9

(1) Year of minimum flow for the indicted month, within the 1995-2001 period.

Table 24 summarizes the confidence level for Ch V.

Table 24: Hydrology and Water Use Confidence Evaluation

Resources Used:	
X USGS Web site	X Oregon Climate Service Web site
__ Hydrodata or Earthinfo CD-ROM	X NRCS Web site
__ USGS Open File Report 90-118	X USGS Water Supply Papers, Oregon
__ USGS personnel	X OWRD Web site
X NRCS personnel	X OWRD local Watermaster
X OWRD regional personnel	
Confidence in hydrology assessment:	
__ **Low:** Unsure of procedures and/or used minimal resources. __ **Low to moderate:** Understood and followed most of the procedures, but minimal resources available and/or used. __ **Moderate:** Understood and followed procedures, and used adequate number of resources but had moderate understanding of outcome. __ **Moderate to high:** Understood and followed procedures, used adequate number of resources, and had high understanding of outcome. X **High:** Understood and followed procedures, used numerous resources, and had high understanding of outcome. __ **If none of the above** categories fit, describe your own confidence level and rationale:	
Recommendations for further assessment or analysis:	
Continue monitoring and analysis of streamflow, individual and cumulative diversion flows, and relate to fish/fish habitat issues (see section IX Fish and Fish Habitat).	

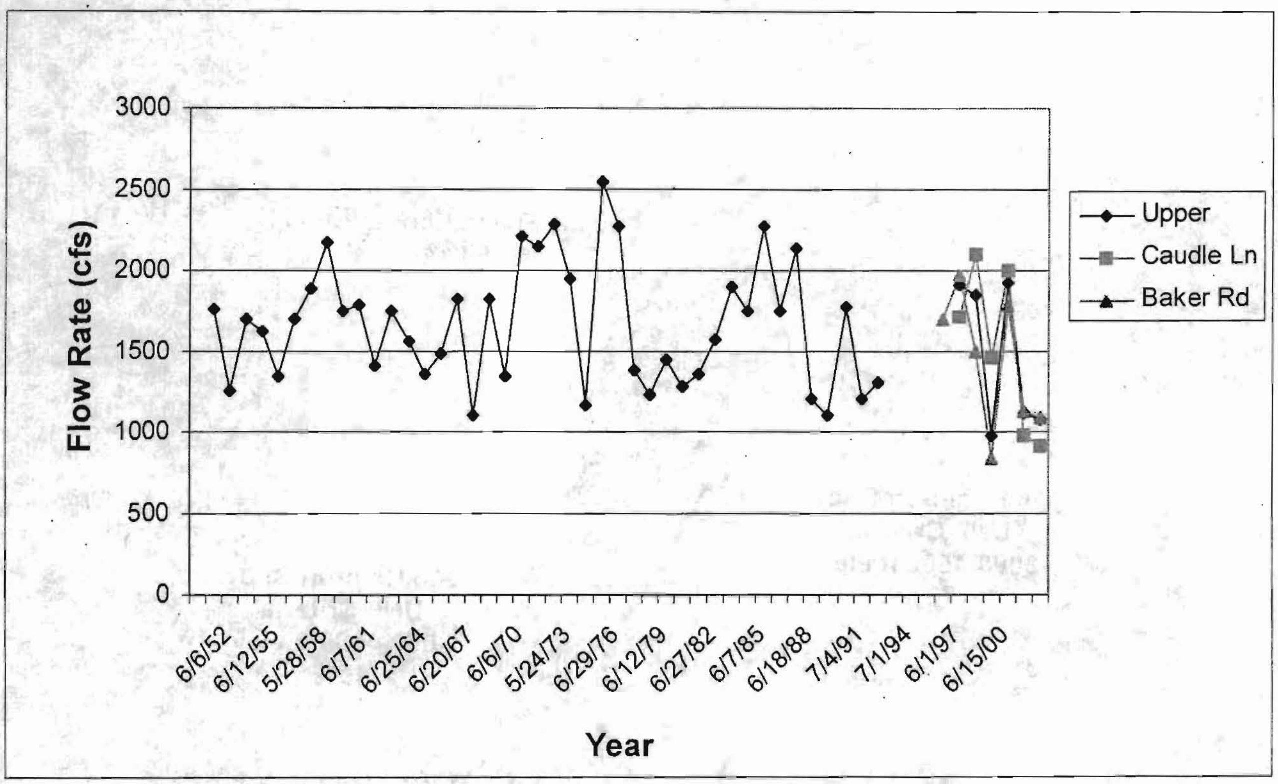


Figure V-1: Lostine River Peak Flows: 1950-2001

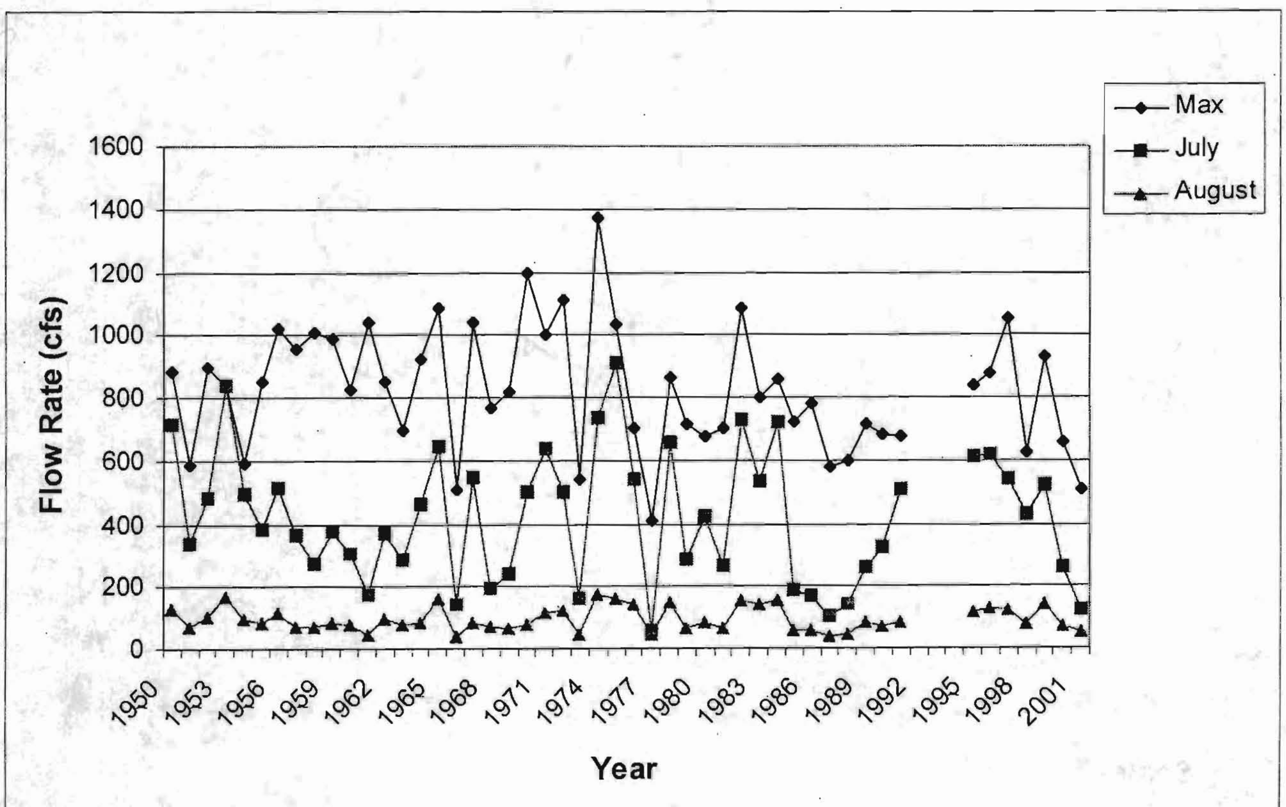


Figure V-2: Lostine River Flow Features: 1950-2001

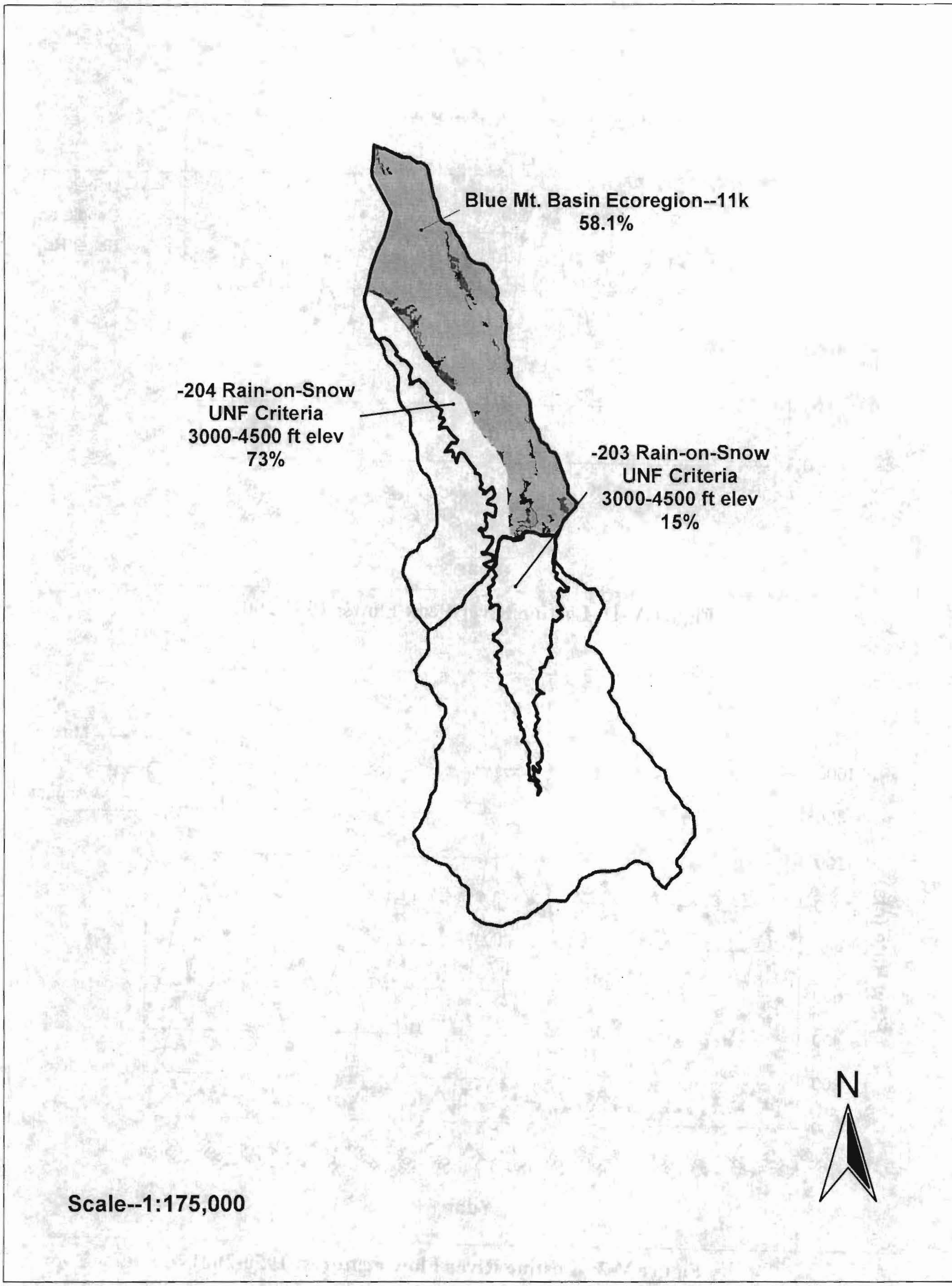


Figure V-3: Blue Mountain Basin Ecoregion and Rain-on-snow Zone

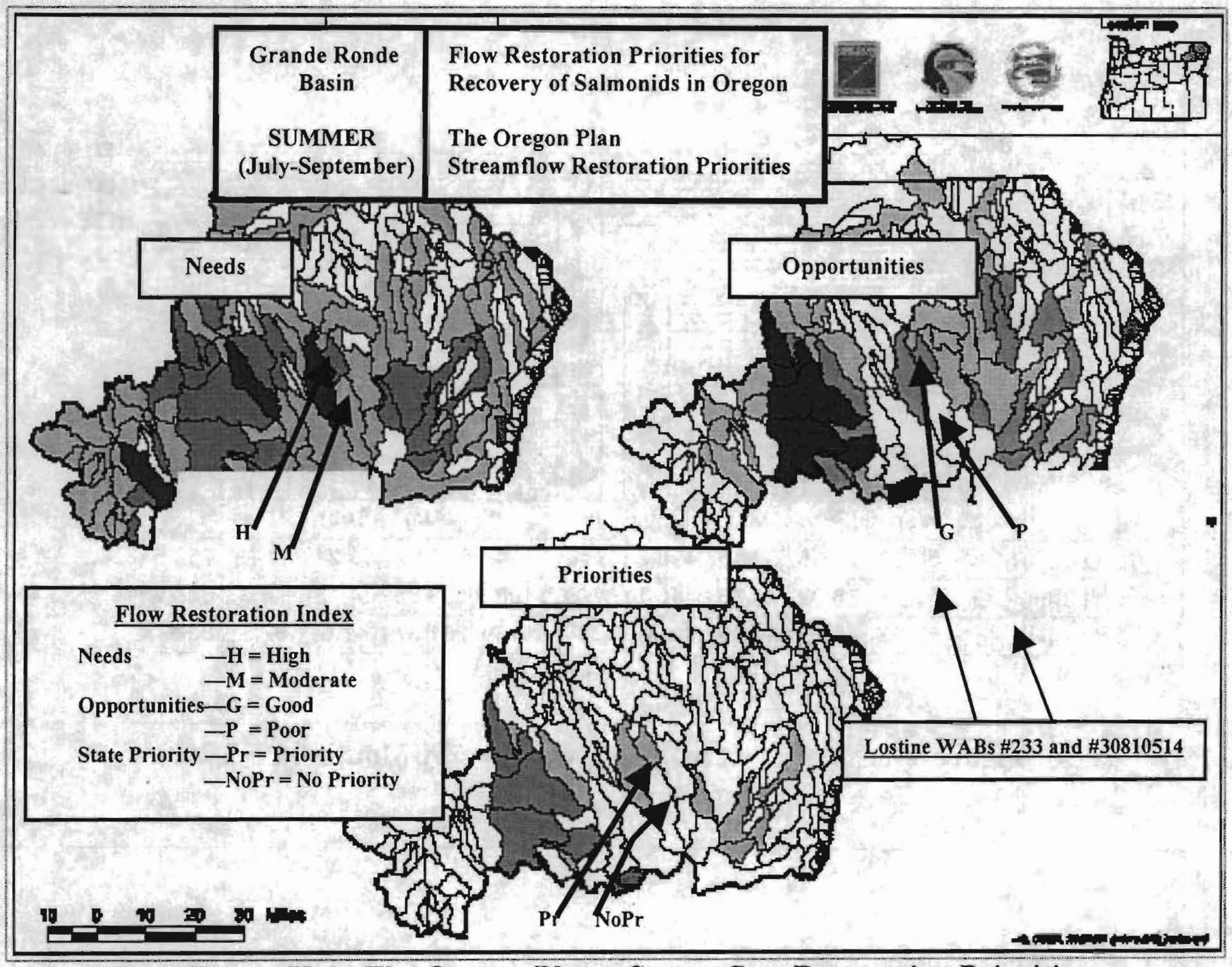
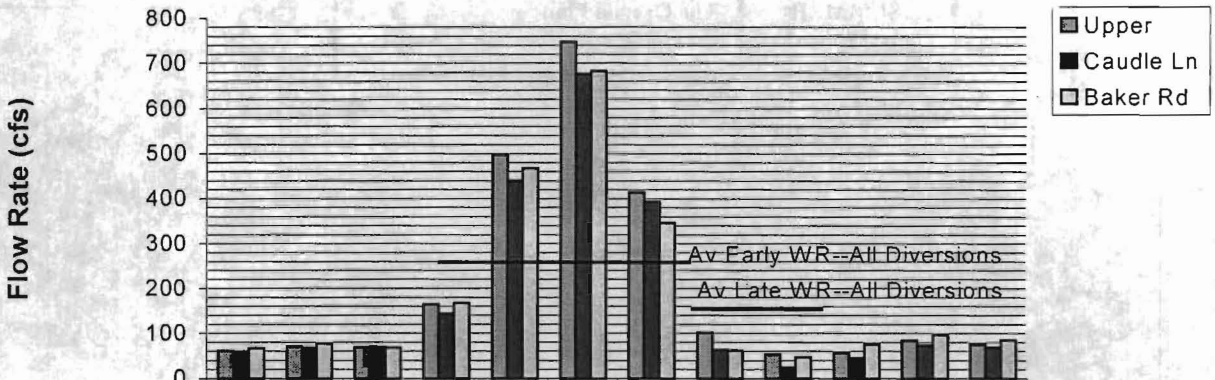


Figure V-4: The Oregon Plan—Streamflow Restoration Priorities



	Jan	Feb	Mar	May	Jun	Jul	Aug	Sept	Nov	Dec
Upper	60.83	70.95	69.15	498.2	748	414.5	101.2	53.21	84.73	75.25
Caudle Ln	59.07	68.02	70.43	440.7	676.8	392.9	63.38	24.15	73.3	69.28
Baker Rd	67.23	76.67	68.45	468	682.3	346.8	61.37	47.6	97.5	85.17

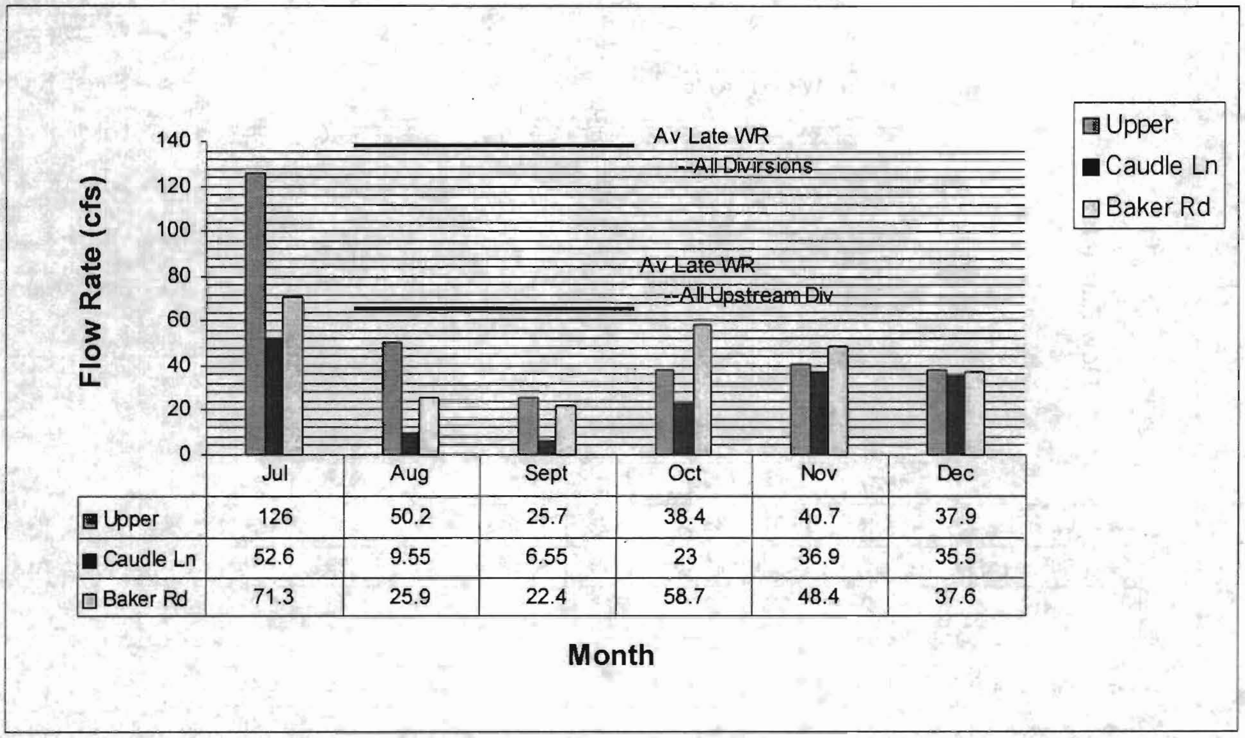
Month

Figure V-5: Average Lostine River Flows by Month—1995-2001

	Jul	Aug	Sept	Oct	Nov	Dec
Upper	414.5	101.2	53.2	57	84.7	75.3
Caudle Ln	392.9	63.4	24.2	45.1	73.3	69.3
Baker Rd	346.8	61.4	47.6	75.2	97.5	85.2

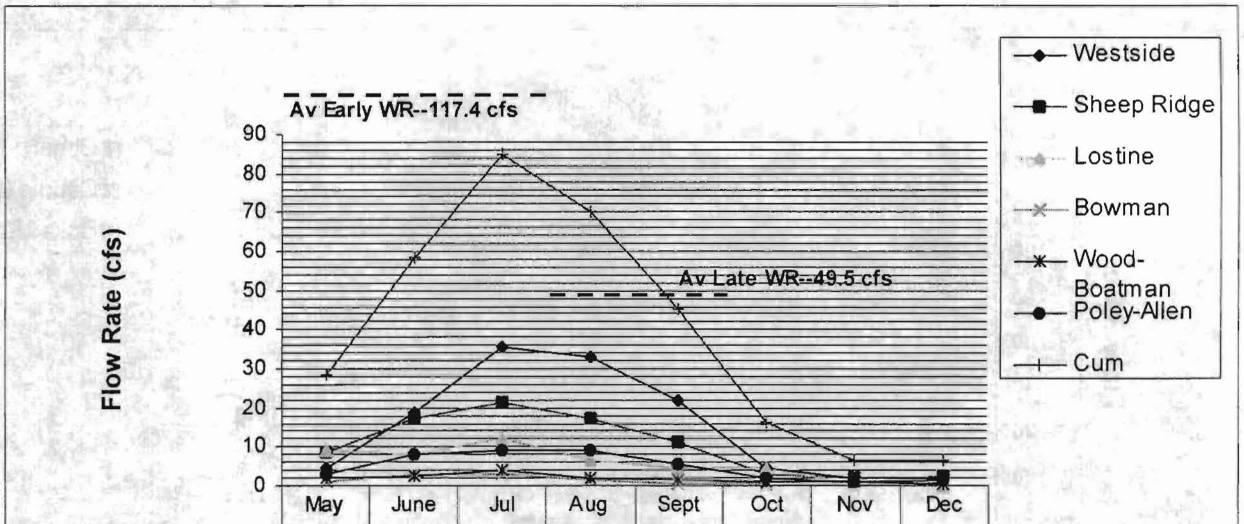
Month

Figure V-6: Average Lostine River Flows by Month; Second Half—1995-2001



	Jul	Aug	Sept	Oct	Nov	Dec
Upper	126	50.2	25.7	38.4	40.7	37.9
Caudle Ln	52.6	9.55	6.55	23	36.9	35.5
Baker Rd	71.3	25.9	22.4	58.7	48.4	37.6

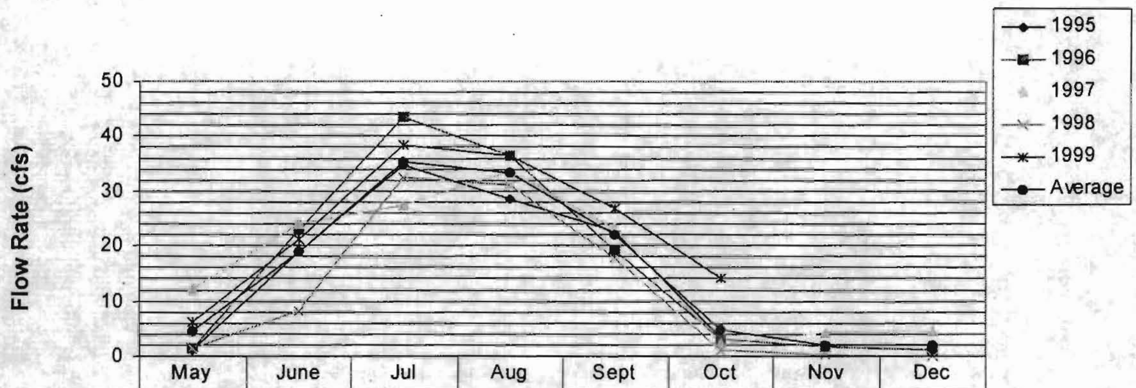
Figure V-7: Minimum Monthly-averaged Lostine River Flows—1995-2001



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Westside	4.48	19.01	35.34	33.26	21.94	4.79	2.1	1.96
Sheep Ridge	8.6	17.42	21.38	17.26	11.05	3.12	1.99	2.76
Lostine	9.2	8.05	12.05	6.73	4.59	4.75	0.45	0.22
Bow man	1.27	3.05	3.08	1.58	0.36	0.27		
Wood-Boatman	1.84	2.72	4.1	2.07	1.68	1.22	0.96	0.44
Poley-Allen	3.14	8.15	8.91	9.12	5.51	2.09	1.17	1.45
Cum	28.53	58.4	84.86	70.02	45.13	16.24	6.67	6.83

Month

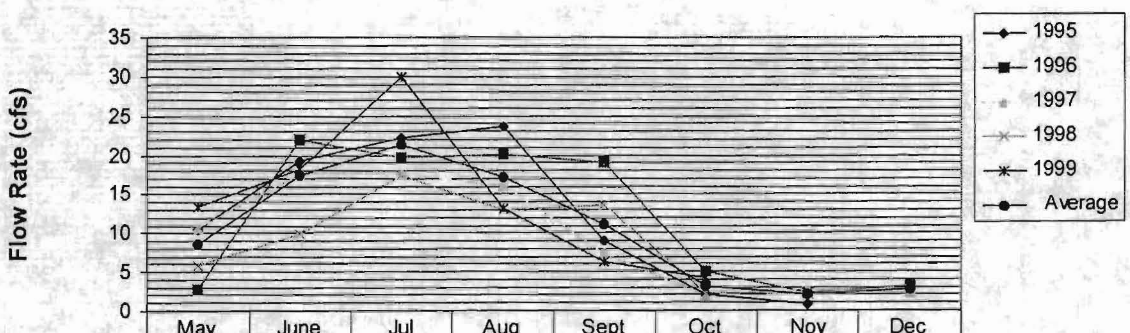
Figure V-8: Average Flows in Upstream Diversion by Month-1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	1.25	18.9	34.7	28.5	22.7	3.37		
1996	1.37	22.8	43.6	36.5	19.2	3.15	1.73	1.24
1997	12.2	24	27.4	33.7	23.2	2.3	4.16	4.65
1998	1.44	8.24	32.5	31.1	17.7	1.15	0.42	0
1999	6.13	21.1	38.5	36.5	26.9	14		
Average	4.478	19.008	35.34	33.26	21.94	4.794	2.1033333	1.9633333

Month

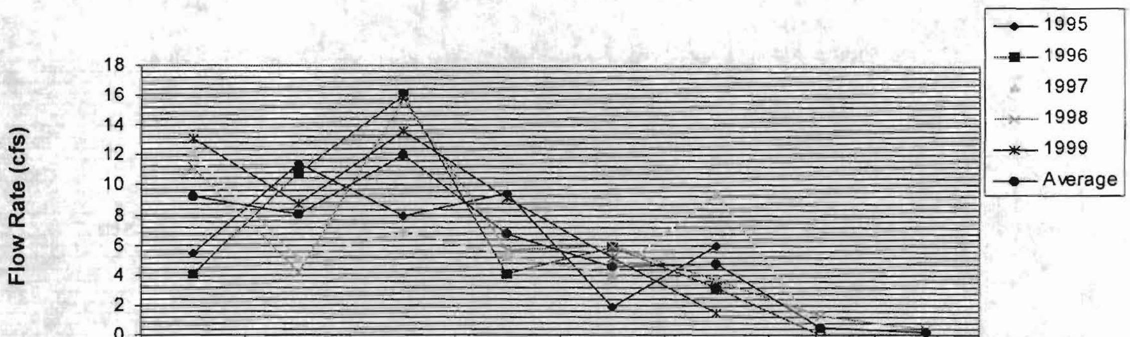
Figure V-9: Average Westside Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	10.4	19.3	22.2	23.6	9.04	2.07	0.82	
1996	2.68	22	19.7	20.2	19	4.95	2.37	3.24
1997	10.6	17.6	17.6	16.2	7.32	1.99	2.64	2.22
1998	5.91	9.91	17.4	13	13.6	2.34	2.14	2.81
1999	13.4	18.3	30	13.3	6.31	4.23		
Average	8.598	17.422	21.38	17.26	11.054	3.116	1.9925	2.756667

Month

Figure V-10: Average Sheep Ridge Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	5.49	11.4	7.97	9.46	1.88	5.98		
1996	4.11	10.8	16	4.09	5.91	3.19	0	
1997	12.1	5.07	6.99	5.26	4.03	9.45	0.052	0.068
1998	11.2	4.21	15.7	5.64	5.94	3.63	1.31	0.37
1999	13.1	8.77	13.6	9.19	5.17	1.5		
Average	9.2	8.05	12.052	6.728	4.586	4.75	0.454	0.219

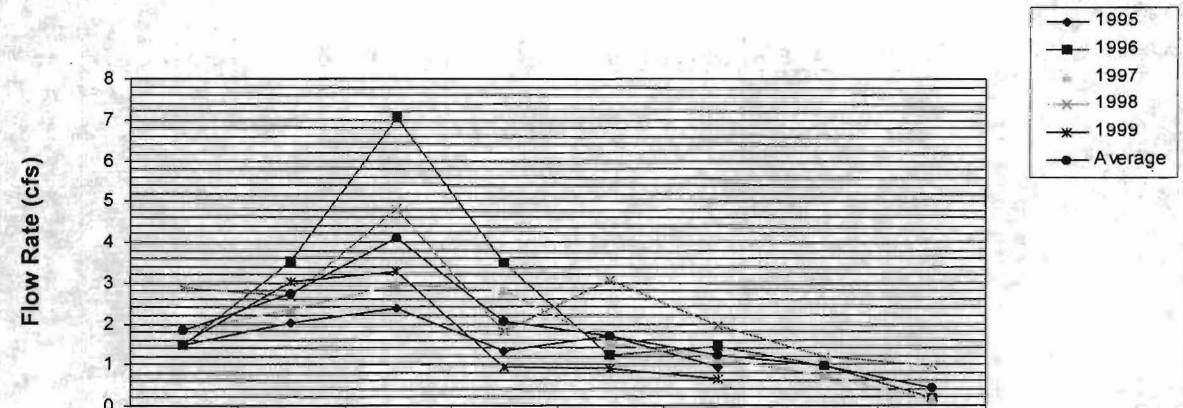
Month

Figure V-11: Average Lostine Diversion Flows by Month—1995-99

	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	1.25	2.53	3.35	1.78	0.48	0.3		
1996	0.36	6.3	4.1	1.37	0.66	0.47	0.11	0.079
1997	1.85	1.57	0.73	1.88	0.062	0.028		
1998	0.3	2.35	3.3	0.93	0.29	0.28		
1999	2.6	2.49	3.91	1.94	0.29	0.26		
Average	1.272	3.048	3.078	1.58	0.3564	0.2676		

Month

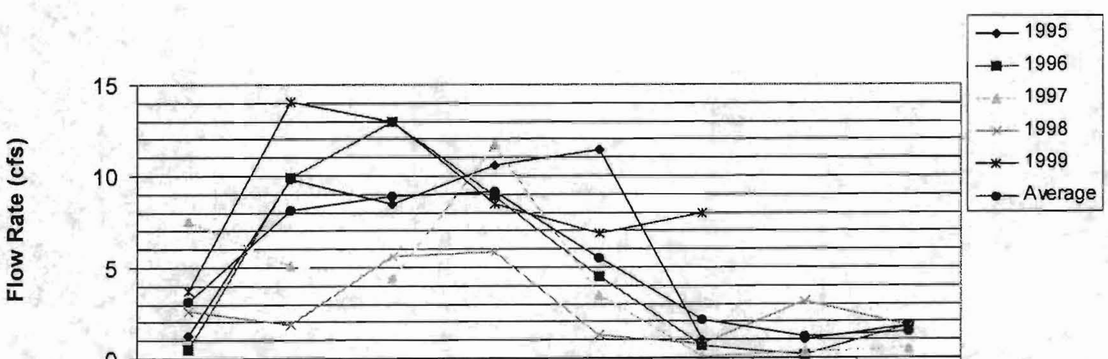
Figure V-12: Average Bowman Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	1.48	2.03	2.38	1.32	1.71	0.92		
1996	1.47	3.52	7.07	3.49	1.24	1.44	0.96	0.17
1997	1.83	2.36	2.95	2.8	1.5	1.16	0.72	0.15
1998	2.89	2.67	4.82	1.8	3.06	1.93	1.19	0.99
1999	1.52	3.03	3.28	0.94	0.9	0.65		
Average	1.838	2.722	4.1	2.07	1.682	1.22	0.9566667	0.4366667

Month

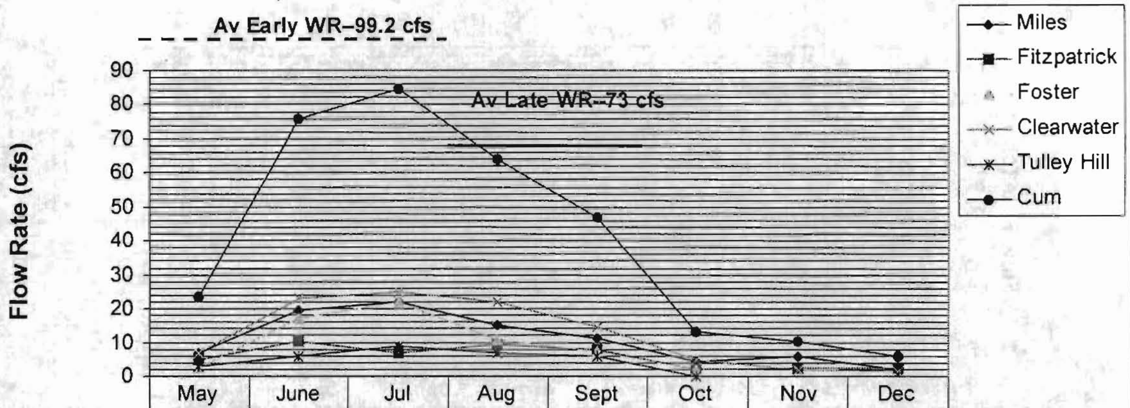
Figure V-13: Average Wood-Boatman Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	1.29	9.8	8.48	10.6	11.4	0.99	0.99	1.82
1996	0.53	9.88	13	8.9	4.49	0.65	0.2	1.77
1997	7.52	5.07	4.42	11.7	3.51	0.059	0.34	0.47
1998	2.63	1.88	5.63	5.87	1.31	0.74	3.16	1.75
1999	3.72	14.1	13	8.51	6.84	8		
Average	3.138	8.146	8.906	9.116	5.51	2.0878	1.1725	1.4525

Month

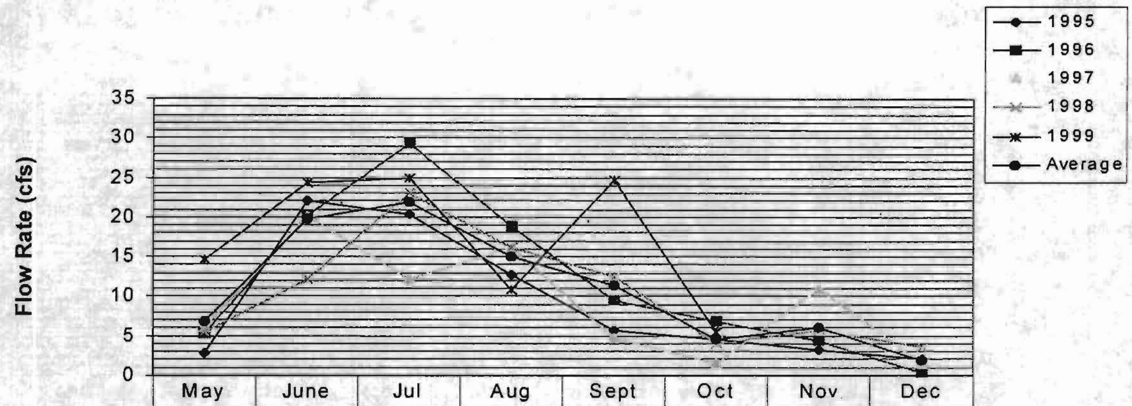
Figure V-14: Average Poley-Allen Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Miles	6.842	19.8	21.96	14.96	11.43	4.524	6.08	1.945
Fitzpatrick	5.02	10.404	6.604	9.516	7.694	1.874	2.38	2.235
Foster	2.262	16.888	22.04	10.886	7.252	1.828		
Clearwater	6.702	22.78	25.04	22.14	14.698	4.662	1.995	1.585
Tulley Hill	2.838	5.94	8.882	6.628	5.892	0.14		
Cum	23.664	75.812	84.526	64.13	46.966	13.028	10.455	5.765

Month

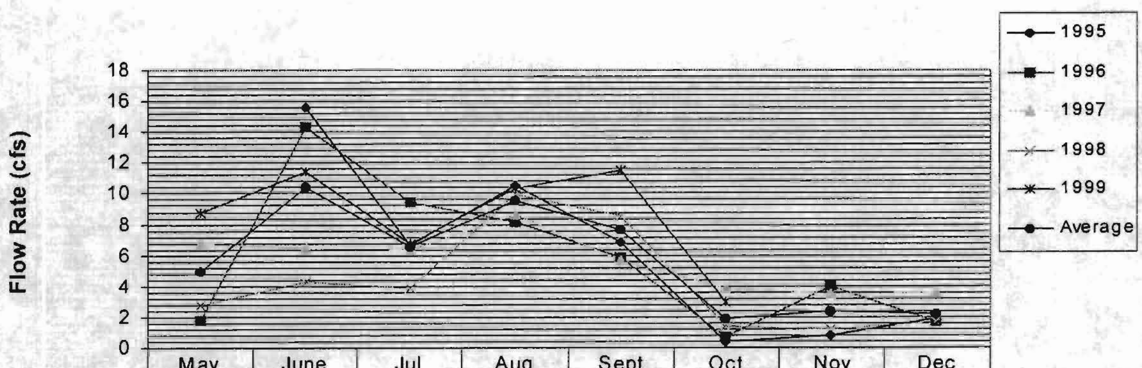
Figure V-15: Average Flows in Downstream Diversions by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	2.83	22.1	20.4	12.8	5.75	4.58	3.17	2.15
1996	5.3	20.1	29.3	18.8	9.44	6.89	4.35	0.45
1997	6.05	20.2	12.1	16.1	4.76	1.57	11.1	1.54
1998	5.43	12.2	23.1	16.2	12.5	4.08	5.7	3.64
1999	14.6	24.4	24.9	10.9	24.7	5.5		
Average	6.842	19.8	21.96	14.96	11.43	4.524	6.08	1.945

Month

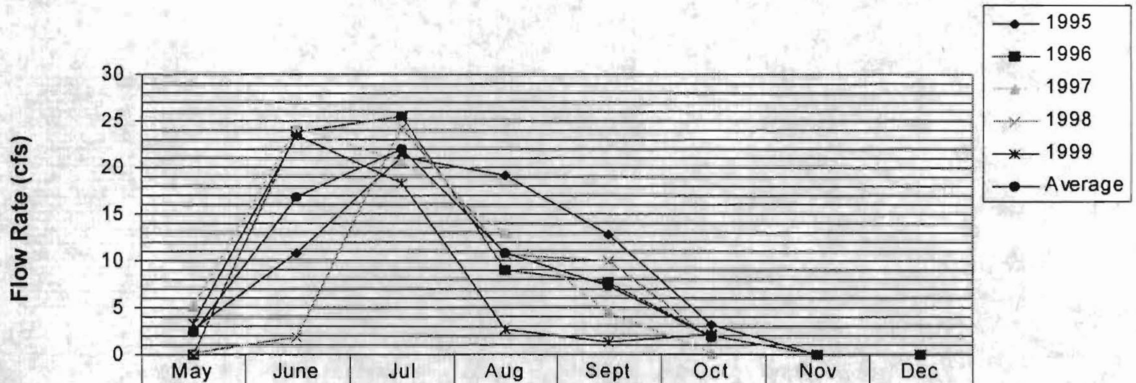
Figure V-16: Average Miles Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995		15.6	6.65	10.5	6.9	0.43	0.82	1.87
1996	1.76	14.3	9.4	8.16	5.87	0.69	3.95	1.71
1997	6.77	6.44	6.34	8.68	5.66	3.84	3.53	3.62
1998	2.78	4.28	3.91	9.94	8.54	1.44	1.22	1.74
1999	8.77	11.4	6.72	10.3	11.5	2.97		
Average	5.02	10.404	6.604	9.516	7.694	1.874	2.38	2.235

Month

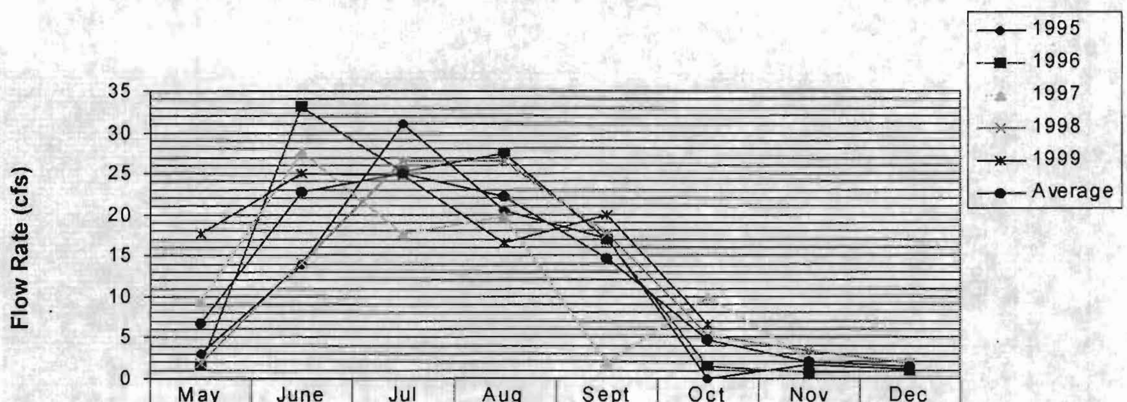
Figure V-17: Average Fitzpatrick Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	2.62	10.9	21.2	19.2	12.8	3.24	0	
1996	0.05	23.8	25.5	9.01	7.71	1.99	0.031	0
1997	5.13	24.4	20.7	13	4.43	0.15		
1998	0.17	1.84	24.4	10.6	9.99	1.65		
1999	3.34	23.5	18.4	2.62	1.33	2.11		
Average	2.262	16.888	22.04	10.886	7.252	1.828		

Month

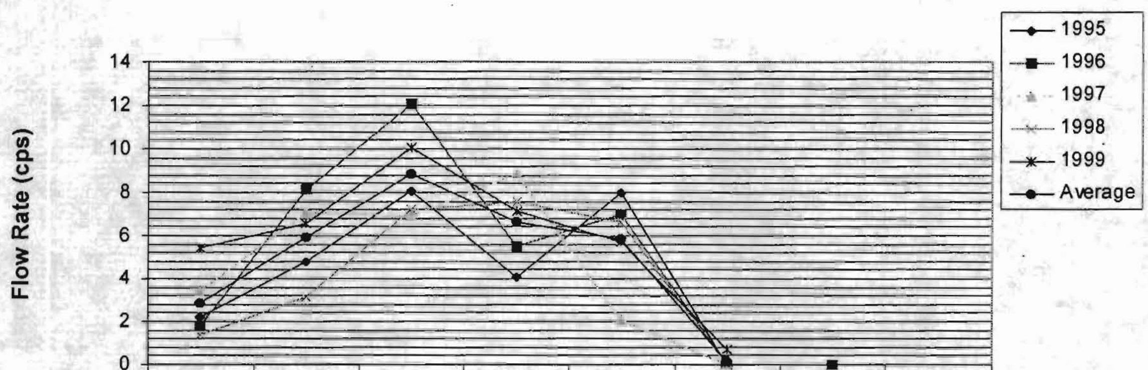
Figure V-18: Average Foster Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	2.99	13.9	31	20.5	17.2	0	1.72	1.08
1996	1.55	33.2	25.2	27.5	16.9	1.42	0.66	1.02
1997	9.42	27.6	17.7	19.7	1.89	9.98	2.21	2.27
1998	1.85	14.2	26.5	26.5	17.6	5.24	3.39	1.97
1999	17.7	25	24.8	16.5	19.9	6.67		
Average	6.702	22.78	25.04	22.14	14.698	4.662	1.995	1.585

Month

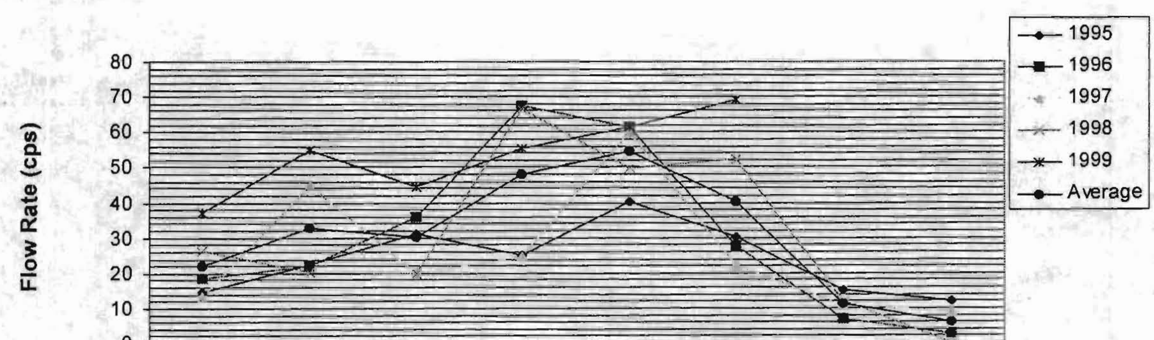
Figure V-19: Average Clearwater Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	2.21	4.78	8.05	4.06	7.97	0		
1996	1.76	8.11	12.1	5.48	7.03	0	0	
1997	3.4	7.09	6.91	8.84	2.06	0		
1998	1.36	3.16	7.25	7.59	6.65	0		
1999	5.46	6.56	10.1	7.17	5.75	0.7		
Average	2.838	5.94	8.882	6.628	5.892	0.14		

Month

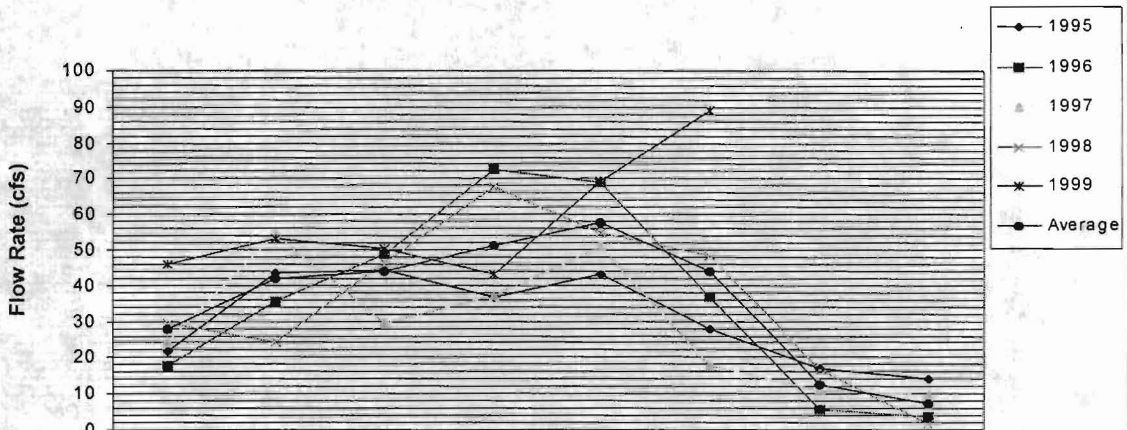
Figure V-20: Average Tulley Hill Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	14.7	22.7	31.3	25.1	40.1	30.3	15	12.2
1996	18.4	22.2	35.9	67.3	61.6	27.7	7	2.67
1997	13.4	45.1	19.7	24.6	59.9	21.9	10.7	9.18
1998	26.5	20.2	20	66.7	49.8	52.2	11.9	0.069
1999	37.2	54.9	44.7	55.4	61.2	69		
Average	22.04	33.02	30.32	47.82	54.52	40.22	11.15	6.02975

Month

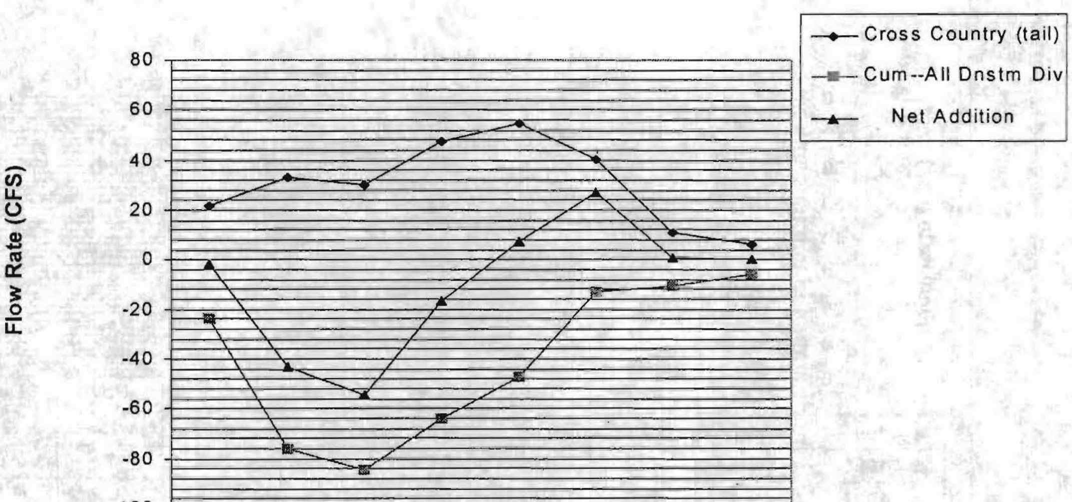
Figure V-21: Average Cross Country (tail) Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1995	21.8	43.4	44.4	36.5	43.2	27.9	17	14.3
1996	17.9	35.3	48.9	72.6	69	36.8	5.52	3.49
1997	24	54.3	29.5	37.1	51	17.9	11	9.84
1998	29.5	24.1	46.2	67.6	54.8	48.2	16.6	1.63
1999	46.1	53.3	50.4	43.2	69.5	89.3		
Average	27.86	42.08	43.88	51.4	57.5	44.02	12.53	7.315

Month

Figure V-22: Average Cross Country (head) Diversion Flows by Month—1995-99



	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Cross Country (tail)	22.04	33.02	30.32	47.82	54.52	40.22	11.15	6.03
Cum--All Dnstm Div	-23.66	-75.81	-84.53	-64.13	-46.97	-13.03	-10.46	-5.765
Net Addition	-1.624	-42.79	-54.21	-16.31	7.554	27.192	0.695	0.265

Month

Figure V-23: Downstream Diversion Inflow-Outflow Balance—Multi-year Average