COLVILLE TRIBE OKANOGAN BASIN MONITORING AND EVALUATION PROGRAM ANNUAL REPORT FOR 2004

BONNEVILLE POWER ADMINISTRATION

CCT/AF-2005-1 March 2005

Colville Confederated Tribes Fish and Wildlife Department

Anadromous Fish Division

Colville Tribes Okanogan Basin Monitoring and Evaluation Report for 2004

March 26, 2004 – March 1, 2005
CCT Project # 3159
BPA Project # 200302200

Prepared by

John Arterburn and Keith Kistler

Prepared for

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

May 2005

Acknowledgments

We would like to thank Paul Wagner and Chris Fisher for reviewing this report. Special thanks go out to Smith Condon, Sidryn Sam, Rhonda Dasher, Paul Wagner, John Nugent and Swede Albert for their help in field data collection then entering, and compiling data for this report. The administrative assistance of Jerry Marco, Loni Seymour, Shelly Clark, Cindy McCartney, Shelly Davis, Joe Peone, and the other Colville Fish and Wildlife Department staff members that helped this project succeed. KWA, Environmental Trust of the Colville Tribes, Okanogan Nation Alliance, Kim Hyatt, Washington State Department of Ecology, Washington Department of Fish and Wildlife and the USGS for their data collection efforts and willingness to share their data.

Funding for this Monitoring and Evaluation (M&E) program is provided by Bonneville Power Administration (BPA). We thank Sarah Branum, Christine L. Read, and Kimberly R. St Hilaire, of the BPA, Division of Fish and Wildlife, for their support and cooperation with various parts of this project.

Executive Summary

The Colville Tribes Anadromous Fisheries Department undertook this effort in the spring of 2004 to provide essential information on habitat conditions and fish populations. The information derived will be used in future planning efforts to improve the Okanogan Subbasin Plan and the Chief Joseph Dam Hatchery Evaluation Plan to determine status and trend for all salmon and steelhead populations within the Okanogan River basin, and provide baseline information for use in effectiveness monitoring.

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) is not another regional monitoring strategy. Rather, this plan draws from the existing strategies (ISAB, Action Agencies/NOAA Fisheries, and WSRFB) and outlines an approach for to the Upper Columbia Basin and more specifically the Okanogan River Basin. OBMEP addresses the following basic questions:

1. What are the current habitat conditions and abundance, distribution, life-stage survival, and age-composition of anadromous fish in the Okanogan River Basin (status monitoring)?
2. How do these factors change over time (trend monitoring)?
3. What effects do tributary habitat actions have on fish populations and habitat conditions (baseline effectiveness monitoring)?
4. What effects do fishery management actions have on fish populations (effectiveness monitoring)?

Previously unattained levels of coordination, standardization, performance, communication and cost-effectiveness, represent the by products and benefits of this closely integrated effort.

Table of Contents

Introduction

Federal hydropower projects and private power utility systems have had major negative impacts on anadromous fish that once flourished in the Columbia River and its tributaries. A coordinated and comprehensive approach to the monitoring and evaluation of status and trends in anadromous salmonid populations and their habitats is needed to support restoration efforts in the Columbia Cascade Province and in the Okanogan subbasin in particular. Currently, independent research projects and some monitoring activities are conducted by various state and federal agencies, tribes, and to some extent by watershed councils or landowners, but there has been no overall framework for coordination of efforts or for interpretation and synthesis of results until this monitoring program (OBMEP).

Managers often implement actions within tributary streams to improve the status of fish populations and their habitats. Until recently, there was little incentive to monitor such actions to see if they met their desired effects. Now, however, many programs require that funded actions include monitoring efforts and coordinated measures to reduce duplication or contrary effort and to provide a process for more universal reporting and strategic planning. Within the Upper Columbia Basin, several different organizations, including federal, state, tribal, local, and private entities currently implement tributary actions and conduct monitoring studies. Because of different goals and objectives, different entities use different monitoring approaches and protocols. In some cases, different entities are measuring the same (or similar) things in the same streams with little coordination or awareness of each others efforts (this is mainly a problem in the Wentachee subbasin). The Upper Columbia Regional Technical Team (RTT) is aware of this problem and desires a monitoring strategy or plan that reduces redundancy, increases efficiency, and meets the goals and objectives of the various entities.

We have used the structure and methods employed by the Monitoring Strategy for the Upper Columbia Basin (Hillman 2004, Nichols1997a; 1997b; 1999) and extended and modified it for the Okanogan subbasin. This project is identified as a high priority based on the high level of emphasis the NPCC Fish and Wildlife Program, Subbasin Plans, NOAA fisheries guidance, and the Independent Scientific Review Panel have placed on monitoring and evaluation. The overall goal of this program is to provide the real-time data needed to guide restoration and adaptive management in the region.

The Okanogan M&E program itself is specifically designed to monitor key components of juvenile fish production, habitat condition, water quality, and adult enumeration. The program will also fill identified data gasps, and examine the future research needs such as the use of selective fisheries gear types.

As adapted from Hillman (2004), we implemented the EMAP sampling framework, a statistically based and spatially explicit sampling design, to quantify trends in juvenile and adult salmonids and status and trends in stream and riparian habitats. In 2004, 12 randomly selected sites were sampled for juvenile salmonids and stream and riparian condition in the Okanogan River subbasin. Starting in 2005, 50 spatially balanced, randomly selected reaches will be sampled for redds, juvenile salmonids and stream and riparian condition in the Okanogan River subbasin from late March through October annually.

Methods

Methods used throughout this project were adapted from Hillman (2004). Protocols were developed specifically for the Okanogan Basin Monitoring and Evaluation Project. Habitat sampling protocols are in a final draft form, biological sampling protocols are in draft form and water quality sampling protocols are being developed. The protocols that are developed can be viewed in Appendix A.

Project Goals

This monitoring plan requires a long-term commitment as most outcomes will not be realized for 7 to 20+ years. This project is designed to ultimately achieve these goals:

1. Determine if there is a statistically significant difference in the abundance, survival, and timing and life history characteristics of summer/fall, spring Chinook, sockeye, and steelhead (7-20+ year time frame).
2. Determine if there is a statistically significant difference in selected physical habitat parameters and characteristics for summer/fall, spring Chinook, sockeye, and steelhead in the Okanogan basin (7-20+ year time frame).
3. Conduct a baseline Okanogan Basin inventory & analysis: a. Collect data, to raise physical habitat data to an empirical level for use in EDT. b.) Collect data on historical and current fish population distributions, and c.) Collect passage conditions throughout the basin for use in EDT modeling runs to assist in future enhancement planning processes (1-20+ year time frame).

This project is designed to address these questions and at the same time eliminate duplication of work, reduce costs, and increase monitoring efficiency, and efficacy. The implementation of valid statistical designs, probabilistic sampling, standardized data collection protocols, consistent data reporting methods, and selection of sensitive indicators will increase monitoring efficiency and compatibility with large scale data roll-up efforts.

For this plan to be successful, all organizations involved must be willing to cooperate and freely share information. Cooperation includes sharing monitoring responsibilities, adjusting or changing sampling methods to comport with standardized protocols, and adhering to statistical design criteria. In those cases where the standardized method for measuring an indicator is different from what was used in the past, it may be necessary to measure the indicator with both methods for a few years so that a relationship can be developed between the two methods.

RESULTS AND CONCLUSIONS

Objective 1: Assess Natural Production of Anadromous Salmonids within the Okanogan River Basin.

Task 1a. Coordinate with other agencies and PUD's determine data needs, establish/prepare sites, hire/train staff, establish protocols, and purchase equipment for collecting data on abundance, survival, timing and life history characteristics of summer/fall /spring Chinook, sockeye, and steelhead in the Okanogan basin beginning in 2005.

We have outlined all monitoring and evaluation activities occurring within the Okanogan Basin and have proceeded to plan this project in a manner that provides complementary information without duplicating data or effort. We view these activities as essential year round efforts to provide maximum information at the least cost. We have been involved with the CSMEP and PNAMP processes that are on-going to coordinate and standardize monitoring and evaluation activities throughout the Columbia River Basin. Each activity is scrutinized to insure that we remain consistence with these guidelines as information is made available. The Colville Tribes have been working with Keith Wolf and Associates and having monthly meetings that began in May, 2004 to insure that the latest information obtained from other regional and basin wide activities are being considered as we define the specifics of OBMEP. The list below is a record of meetings attended in order to maintain a high level of coordination with other efforts in the upper Columbia River Basin;

April through June

- Attendance of a 3-day CSMEP design workshop in Welches, OR. This conference provided protocol development and refinement, statistical design and database structure input for the **Okanogan Baseline Monitoring and Evaluation Program** (OBMEP). Specific products include:
    - table C1 structure for cataloging historic data for the Okanogan subbasin
    - updated matrix for ongoing M&E in the Okanogan

- Scheduled a July 13th meeting with NOAA fisheries to coordinate Okanogan database structure with that of Wenatchee and Methow (regional data sharing)

- NOAA meeting to work on second draft data management and QA/QC protocols
- Developed kick net training video
- Discussed field manual with T. Hillman
- Coordination on meeting in Methow with BOR to initiate Methow M&E program to comport with OBMEP

- Reviewed statistical design documentation related to Status Trend Monitoring and Evaluation.

- Reviewed Upper Columbia Monitoring and Evaluation Strategy and EDT attributes used in Okanogan Subbasin Plan.

- Integrated both data sets for comparison and determination of compatibility.

- Coordinated development of draft EMAP site map set of 180 sites based upon 6 panel EMAP design.

- Coordinated development of excel EMAP site spreadsheet with location coordinates.

- CCT staff meeting was held on June 3 to discuss selected EMAP sites, draft list of physical and biological indictors, and establish near-term personnel and equipment needs.

July

- A Power Point presentation was developed for training and presentation purposes for Colville staff and for use in presenting database design to Methow and Wenatchee M&E programs (regional consistency and coordination).

- Meeting with CCT staff occurred on July 6 to review and finalize indicator list, establish equipment and staffing needs, review revised map of additional potential sampling sites, and identify opportunities for program coordination.

- Review of Upper Columbia Strategy and OWEB documents.

August

- Work continued to secure landowners permissions secured for the project. Over 100 landowner letters were mailed out to the landowners living within the project sites along the mainstem Okanogan.

- GIS staff worked to determine sampling site ownership as necessary for establishment of access for field activities.

- CCT staff met internally to further refine/develop habitat assessment protocols, data collection forms, and field manual, and modification of data dictionary to accommodate 2004 field work.

- CCT (KWA) staff met with WDOE staff to review Wenatchee EMAP sampling program for coordination with OBMEP and participated in one day of field sampling in the Wenatchee subbasin.

- Contacted and coordinated with OWEB, EPA, and Upper Columbia M&E Strategy staff.

September

- Participated in RTT, CSMEP and PNAMP meetings (this work covered under another contract, no billings to OBMEP)

- Work conducted on development of the Practitioners Workshop (January 2005) design templates and protocols for monitoring fish population.

- Organized and conducted meeting of CCT, WDOE, and WDFW staff to coordinate data collection activities, and collection of historic data for OBMEP database.

- Contacted WDFW and NOAA Fisheries regarding 2005 smolt trapping activities and permits.

- Contacted USFS staff regarding Wenatchee Subbasin snorkel survey protocols.

October

- Met with WDFW staff to review redd capping and smolt trapping procedures and historical Okanogan redd count data.

- Contacted EPA EMAP staff to begin analysis of 2004 OBMEP data.

- Met with Bioanalyst staff (Tracy Hillman) to review and clarify Upper Columbia Strategy as related to OBMEP.

- Met with NOAA Fisheries staff regarding OBMEP permitting and historical data collection.

- Contacted BPA staff regarding OBMEP permitting and obtained permit template.

- Provided an overview of OBMEP to the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) in coordination with database development.

- Met with John Day Subbasin Monitoring and Evaluation Program staff to coordinate database development and compare sampling design and field protocols.

- Provided an overview of OBMEP to the Regional Technical Team (no hours billed to OBMEP).

- Reviewed DOE benthic macro-invertebrate sampling program and protocols.

- Contacted USFS staff (also contacted in September) regarding Wenatchee Subbasin snorkel survey protocols.

- Contacted DOE staff regarding coordination of water quality sampling in the Okanogan Subbasin.

November

- Reviewed PBI GIS physical habitat data for Okanogan Subbasin to determine applicability to OBMEP.
- Contacted WDFW staff to further review redd capping and smolt trapping procedures and historical Okanogan redd count data.
- Contacted PNNL staff to obtain background documents and information for possible redd capping study.
- Contacted BOR staff to obtain smolt trap.
- Contacted NOAA Fisheries staff regarding permit submittal.
- Contacted DOE and OID staff regarding coordination of water quality monitoring.

December

- Contacted WDFW staff requesting letter to NOAA Fisheries regarding smolt trapping authorization.
- Obtained cost information regarding OBMEP water quality monitoring from DOE and USGS.

January 05

- Provided EMAP site location information to NOAA Fisheries.
- KWA provided EMAP GIS data to CCT staff to assist in coordination with ONA.
- Obtained WDFW letter to NOAA Fisheries regarding smolt trapping authorization and delivered to NOAA Fisheries
- Contacted WDFW Fish Program and Habitat Program staff regarding state permit requirements.
- Contacted Okanogan County regarding county permit requirements.
- Submitted 2004 OBMEP habitat data and site coordinates to NOAA Fisheries for analysis.
- Attended Monitoring and Evaluation Practitioner's Workshop and presented OBMEP materials to workshop attendees.
- Wrote draft MOA between DOE and CCT for water quality sampling in the Okanogan and continued ongoing coordination activities with DOE.

February 05

- Coordinated with and delivered SEPA and JARPA applications to CCT permitting staff.
- Initiated coordination with USFWS regarding bull trout permitting requirements.
- Attended EPA/NOAA Fisheries/WDOE EMAP meeting in Olympia related to EMAP study design and protocols.
- Met with WDFW genetics staff and obtained genetics sampling kit for 2005 smolt trapping.
- Contacted WSDOT staff to determine ownership of Malott Bridge and approval requirements for use as an attachment location for smolt trap.

In other efforts we established our study sites for 2004, hired and trained staff, and purchased equipment for collecting data. We have established protocols and data sheets for habitat data collection and snorkel surveys at our study sites. We have subsequently implemented these protocols at 12 annual study sites.

Through all of our efforts we developed a strategy for implementing the OBMEP program that includes Colville Confederated Tribe (CCT) and Okanogan Nation Alliance (ONA) staff as well as the data collected by other agencies throughout the basin by establishing data sharing agreements.

Task 1b. Adult salmonid enumeration: Select sites and determine infrastructure (e.g., traps, weirs, video counting etc.) needs to monitor escapement of hatchery and wild origin salmonids to the Okanogan subbasin.

We have identified our procedures: weirs, traps, broodstock information and video counting. We have been meeting with consultants and other fisheries professionals to accumulate information about the best methods, costs, and feasibility of completing this task. We have determined that adult enumeration is the most critical information to obtain for fish monitoring over the long-term. We have also determined that using methods that estimate population size or adult returns are inaccurate and often biased. We have been collecting data on a number of fish counting technologies that can provide accurate data under the widest range of possible conditions. We will be soliciting bids for work to begin installation of infrastructure in FY-2005, 2006, and 2007, once the 2005 contract is in place. The Omak Creek weir is completed and a pilot project to help evaluate possible options in the field will begin in 2005 at this site.

We subcontracted with LGL limited to help us develop and identify our video counting locations (Appendix B). We also participated this fall with WDFW in Sockeye spawning surveys and Chinook carcass counts. Adult enumeration data is contained in this report under Task 2a.

Task 1c. Adult salmonid survival and artificially produced juvenile marking enumeration: Establish agreements for coordinating data needs from outside the basin and develop systems for PIT tagging/CWT tagging fish for the Okanogan Basin beginning with locally adapted steelhead released into Omak Creek and summer/fall Chinook from acclimation sites to determine out-migrant survival, adult survival, and harvest for the Okanogan Basin in out-years.

We subcontracted implantation and data archiving tasks though BioMark and data was provided to the Fish Passage Center (FPC) and PAC Fish for evaluation of juvenile out-migration and adult returns possibly in 2004 through 2006.

On April 19, 2004, a total of 3,456 juvenile steelhead were tagged with a Passive Integrated Transponder (PIT). On April 20, 2004, there were 5 mortalities and one shed tag. This resulted in 3,450 PIT tagged juvenile steelhead released at approximately RM 0.2 on Stapaloop Creek on April 29, 2004. To date (August 1, 2004), none of the PIT tagged juvenile steelhead from this group have been detected during the outmigration of the Columbia River. However, sampling of juveniles is not comprehensive and does not necessarily indicate a large percentage of mortality.

During a 2 day period in fall 2004, a PIT-tagging crew from Biomark, Inc. tagged 18,933 juvenile steelhead (*Oncorhynchus mykiss*) at Cassimer Bar Hatchery. Approximately 3.4% (668) of the total fish (19,601) were not tagged due to length, disease, sign of injury, or possessing a tag but no tag being detected. Mortalities were collected from ponds and raceways immediately following the tagging effort. A total of 129 PIT-tagged mortalities and six shed tags were collected over the course of the project. The total number of fish tagged was slightly less than the goal due in part to small fish size and actual number of fish available for marking.

We also coordinated with WDFW to provide additional pit tagged steelhead from the Wells Hatchery. As data becomes available this information will be reported to BPA but to date no fish have been interrogated at pit-tag detection sites. We were informed that until adult fish return that this finding represented a lack of information and should not be considered mortality. We are waiting for data to be returned from PAC-Fish, FPC, or Pittagis when some analysis will be conducted.

Coded Wire Tag (CWT) data is almost impossible to use for mortality estimates because it is impossible to determine when or where a CWT tag might be recovered throughout the life cycle of a fish. Because not all tags can be accounted for, estimates of mortality would be highly biased. These data will not be collected in future years of this program as other programs and agencies are already attempting to compile these data as part of hatchery evaluation projects and this is outside of the scope of this project.

Task 1d. Select EMAP sites and set-up rotating panels for sampling effort in out-years, purchase necessary equipment, determine appropriate protocols for each site. Train staff

to determine salmon and steelhead production using appropriate methods for Chinook, sockeye, and steelhead in the Okanogan Subbasin.

A total of 600 possible sites have been generated from EPA as possible EMAP sites. One hundred and fifty of these sites have been selected, six rotating panels consisting of 17 sites in the US and 8 sites in Canada. We are in the process of verifying these sites in the field. We have purchased equipment and supplies for documenting sites, surveyed habitat and conducted preliminary snorkeling efforts.

We have established protocols for habitat sampling and snorkeling. Temporary and permanent staffs have been trained to implement our protocols. We have determined the best matrix of indicators that balances the amount of resources needed to gather data (least cost approach) with those that provide the most functional data for monitoring and evaluation of fish and habitat in the Okanogan basin. We have met with leaders of other monitoring and evaluation projects in the Columbia Basin to help coordinate our efforts and to be consistent with other projects. We have field tested and verified the protocols for habitat sampling and fall snorkeling for steelhead production. Field protocols have been written-up for future use and training (Appendix A). Modification and expansion is still needed on our protocols to meet the needs of OBMEP and should be completed some time in 2006 or 2007.

Sampling will be conducted at the annual panel (0) and one of the rotating panels (1-5) each year with each panel sampled once every five years. All panel sites have been finalized and, pending landowner permissions on tributary streams, and that the site is physically accessible the sites in Figure 1 represents the final locations of all EMAP sampling sites within the United states portion of the Okanogan Basin and the panel they are assigned.

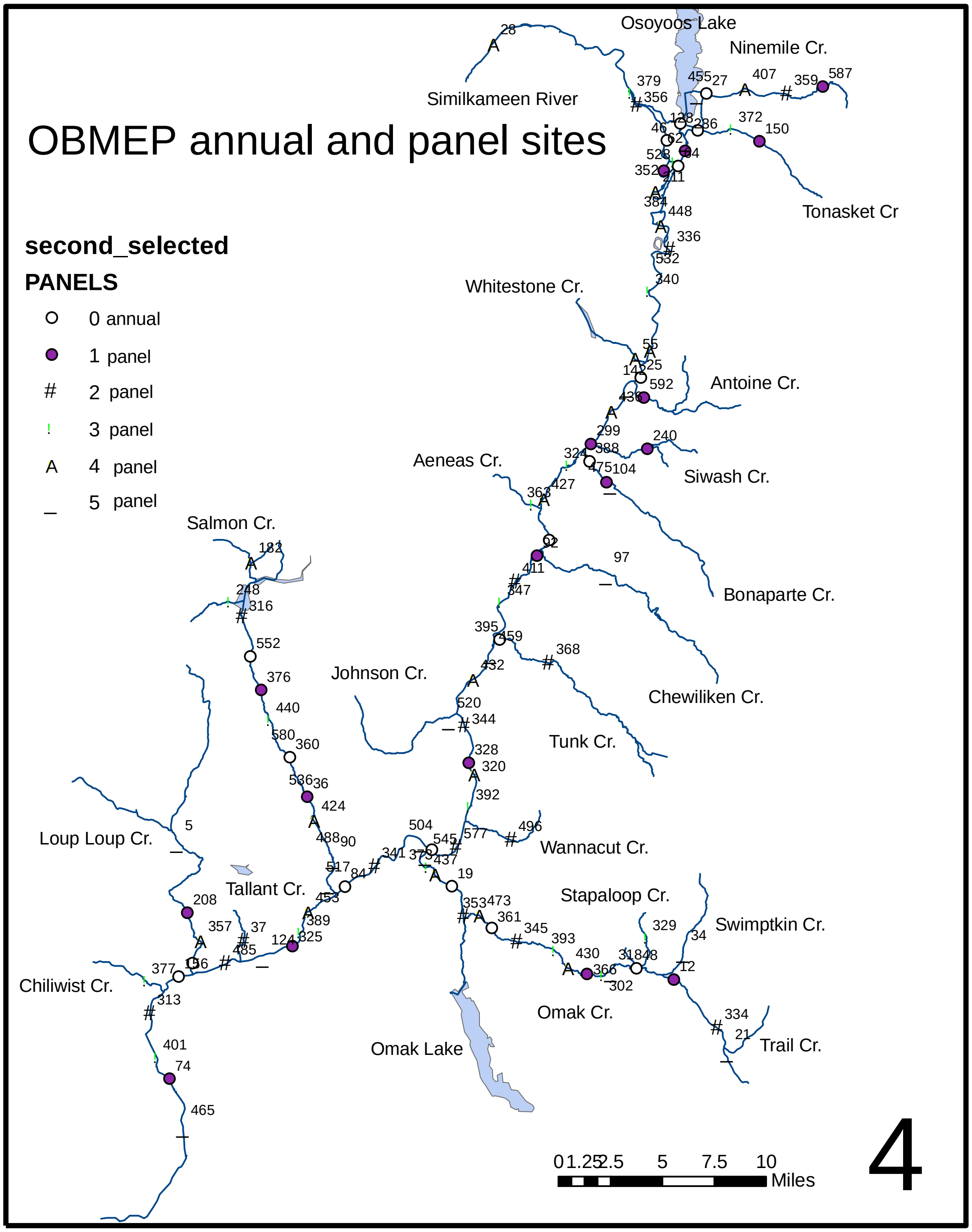

Figure 1. –The location and assigned panel for all EMAP sites selected for monitoring and evaluation within United States portion of the Okanogan River basin.

Data Management and Reporting

Objective 2. Coordinate and consolidate all monitoring and evaluation data for the Okanogan basin and complete all reporting requirements for data distribution.

Task 2a. - Historical data collection: Compile quantitative historical adult return, redd survey, and juvenile data associated with abundance, run timing, migratory survival, telemetry, harvest, and habitat from WDFW, CCT, ONA, DFO, conservation Districts, PUD's, and other agencies working in the Okanogan basin to establish a baseline of existing knowledge.

We have compiled data on: adult and juvenile anadromous fish passage at Wells dam, redd surveys from the Washington Department of Fish and Wildlife (WDFW), Flow and temperature data from the United States Geological Survey (USGS) and the Washington State Department of Ecology(WDOE), Water quality parameters from WDOE, and juvenile sockeye data from the Department of Fisheries and Oceans Canada(DFO). The data that follows is represented in graph and table form from these sources. In our analysis we went back to 1977, when wells dam was established and there is a historic record of fish passage at this dam. We chose to represent the fish passage data in ten year intervals: 1986-1977, 1996-1987, 2004-1997(eight year interval) and the current year 2004.

Additional historical data collection activities included: compilation of quantative historical adult return, redd survey, and juvenile data associated with abundance, run timing, migratory survival, telemetry, harvest, and habitat from WDFW, CCT, ONA, DFO, conservation Districts, PUD's, and other agencies working in the Okanogan basin to establish a baseline of existing knowledge.

Historical habitat and biological data and/or meta-data was requested or acquired from all known existing U.S. sources in the Okanogan Sub-basin. Information pertaining to habitat was also obtained from Canadian sources. Only information available in electronic form was acquired (i.e., no hard copy data). This information was coarsely filtered to remove large amounts of extraneous information such as that specifically pertaining to other sub-basins. All information was transferred to the OBMEP fttp site data repository.

Work under this task specifically required direct coordination with NPCC Sub-basin Planning and the Coordinated System-wide Monitoring and Evaluation Project (CSMEP). Information which was used to conduct EDT Assessment in the Okanogan Sub-basin Plan was obtained, filtered, and transferred to the OBMEP repository. The C1 Table format was developed through the CSMEP process and was used as an OBMEP data index template for both the biological and habitat data. It is expected that use of this template format will provide cross compatibility and ease of data sharing between OBMEP and CSMEP.

Historic and current anadromous fish counts over Wells dam.

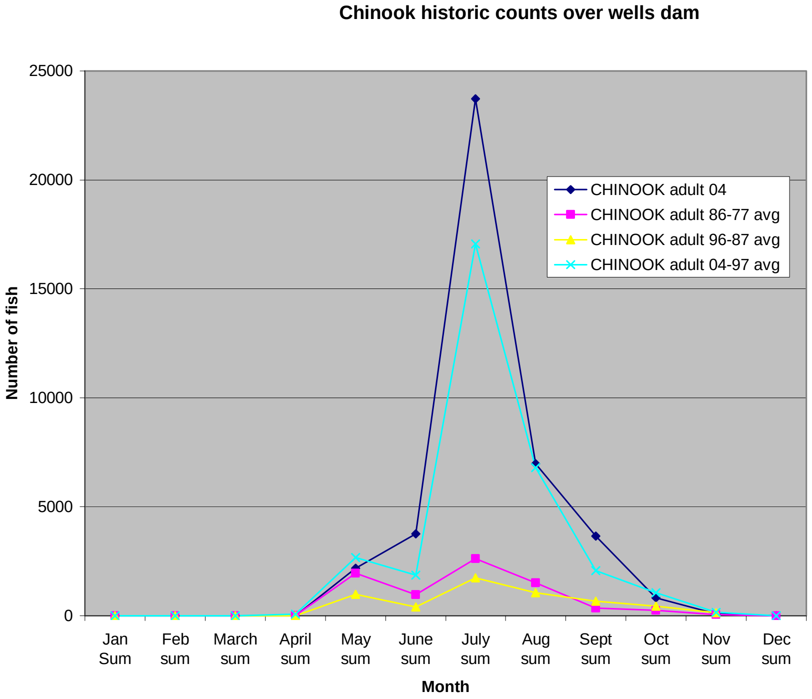

Figure 2: Adult Chinook returns over Wells Dam from 1977 to present in ten year intervals compared to last year (http://www.cqs.washington.edu/dart/dart.html).

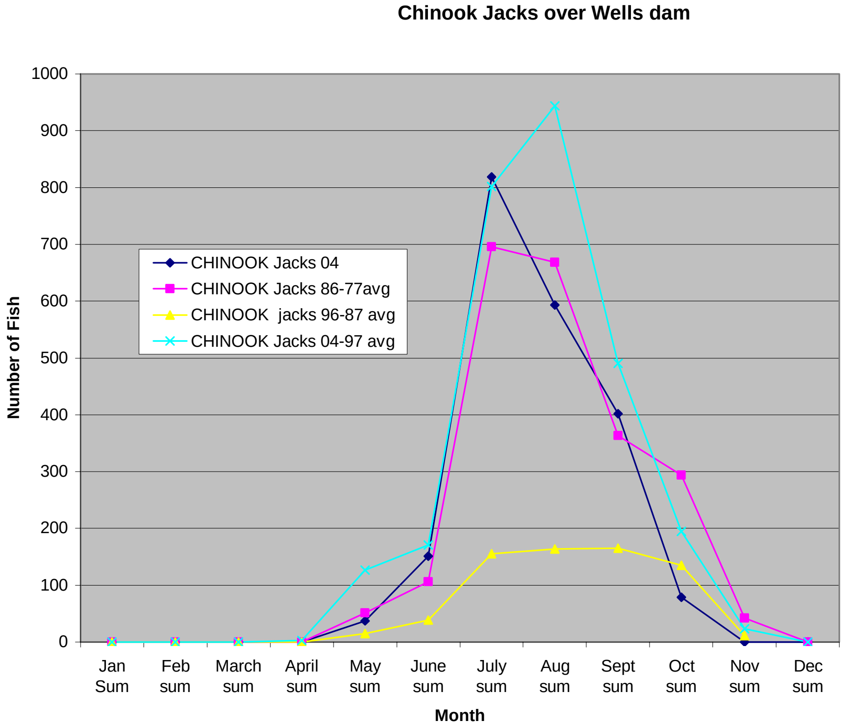

Figure 3: Jack Chinook returns over Wells Dam from 1977 to present in ten year intervals compared to last year (http://www.cqs.washington.edu/dart/dart.html).

Adult Chinook returns to Wells Dam have increased dramatically since 1986 with 2004 being above the last 8 year average. Most salmon stocks throughout the Columbia River have shown increased abundance over this period due to improved ocean productivity. Another reason for increased adult Chinook returns above Wells Dam is supplementation by fish hatcheries specifically releases from Turtle Rock that are acclimated at the WDFW pond located on the Similkameen River (Figure 2). Adult Steelhead passage in 2004 was above average in 2004 compared to ten year interval data from 1977.

The returns of Jack Chinook have often been used as an indicator of the next years adult returns because Jacks are fish that return from the ocean a year ahead of schedule. However, the trends in Jack returns above Wells Dam do not support this assumption therefore the use of jack returns as an indicator of the next years adult returns are unlikely to be closely correlated and should be avoided for predicting returns above Wells Dam (Figure 3).

Sockeye passage in 2004 was dramatically greater than ten year averages that were recorded since 1977. No hatchery supplementation has occurred for this species in recent years. Improvements to spawning habitat, egg to fry survival, rearing conditions and ocean survival have all contributed to increases since 1987 but the dramatic increase in 2004 are unprecedented. Dramatic between year fluctuations in abundance are not uncommon in this population coupled with improved water management and increased ocean productivity and the returns of 2004 show what is possible for sockeye restoration efforts (Figure 4).

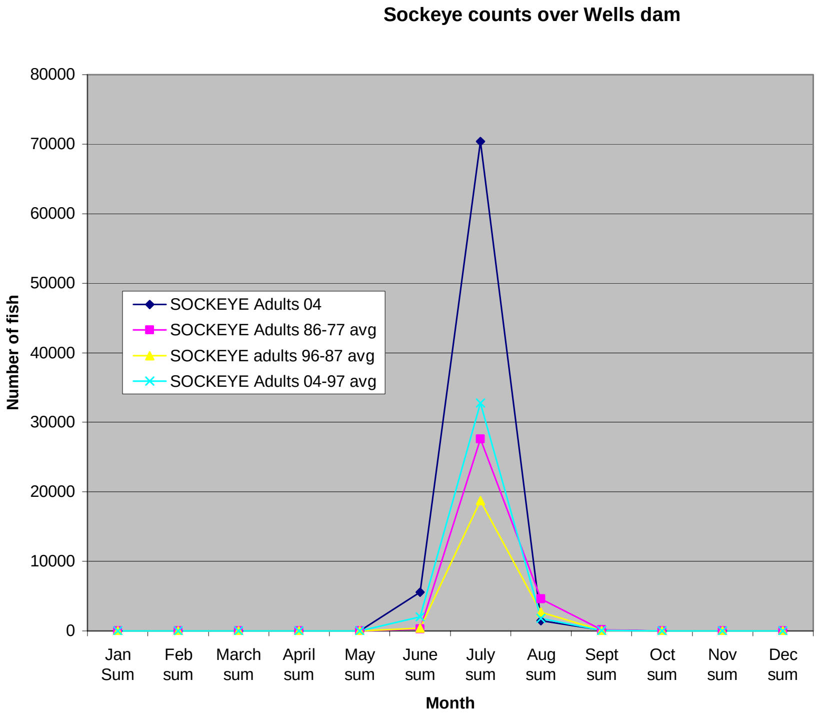

Figure 4: Adult sockeye salmon returns over Wells Dam from 1977 to present in ten year intervals compared to last year (http://www.cqs.washington.edu/dart/dart.html).

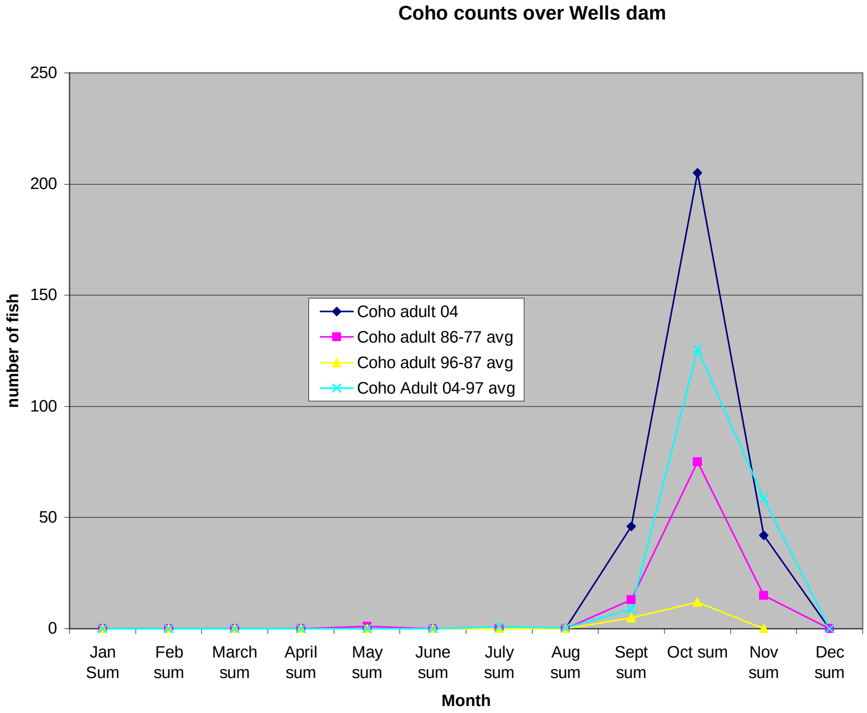

Figure 5: Adult coho salmon returns over Wells Dam from 1977 to present in ten year intervals compared to last year (http://www.cqs.washington.edu/dart/dart.html).

Coho have been counted sporadically since 1977. The current increase in numbers in 2004 is attributable to coho reintroduction efforts conducted by the Yakima Indian Nation. The increases in abundance are mainly the result of hatchery supplementation released into the Wenatchee and Methow subbasins (Figure 5). No adult coho returns are know to have occurred in the Okanogan subbasin from these efforts although a few fish have entered this river for short periods.

Okanogan River summer/fall Chinook Redd surveys

Annual aerial redd counts have been conducted by WDFW for summer/fall Chinook in the Okanogan basin since 1956 and follow-up annual ground counts have been added since 1989 on both the Okanogan and Similkameen Rivers. The historic number of Redds counted on the Okanogan River with aerial and ground surveys is represented in Table 1. The number of redds counted during spawning ground surveys in 2004 was 1,327 (Table 2). The 2004 total redd count was 77.2% greater than the 378 redds enumerated in 2003 (Table 3). In 2004, the number of redds enumerated in the Similkameen River was 1,660 (Table 4). For additional information related to redd surveys from 1956-2004 see (Appendix C).

Table 1. Historic and Current redd counts on the Okanogan River

Okanogan		
Year	Aerial	Ground
1956	37	--

Okanogan		
Year	Aerial	Ground
1981	55	--

1957	53	--
1958	94	--
1959	50	--
1960	29	--
1961	--	--
1962	--	--
1963	9	--
1964	112	--
1965	109	--
1966	389	--
1967	149	--
1968	232	--
1969	103	--
1970	656	--
1971	310	--
1972	182	--
1973	138	--
1974	112	--
1975	273	--
1976	107	--
1977	276	--
1978	195	--
1979	173	--
1980	118	--
1982	23	--
1983	36	--
1984	235	--
1985	138	--
1986	197	--
1987	201	--
1988	113	--
1989	134	--
1990	88	47
1991	55	64
1992	35	53
1993	144	162
1994	372	375
1995	260	267
1996	100	116
1997	149	158
1998	75	88
1999	222	369
2000	384	549
2001	883	1108
2002	1958	2667
2003	1099	1035
2004	1310	1327

(Adapted from WDFW 2005)

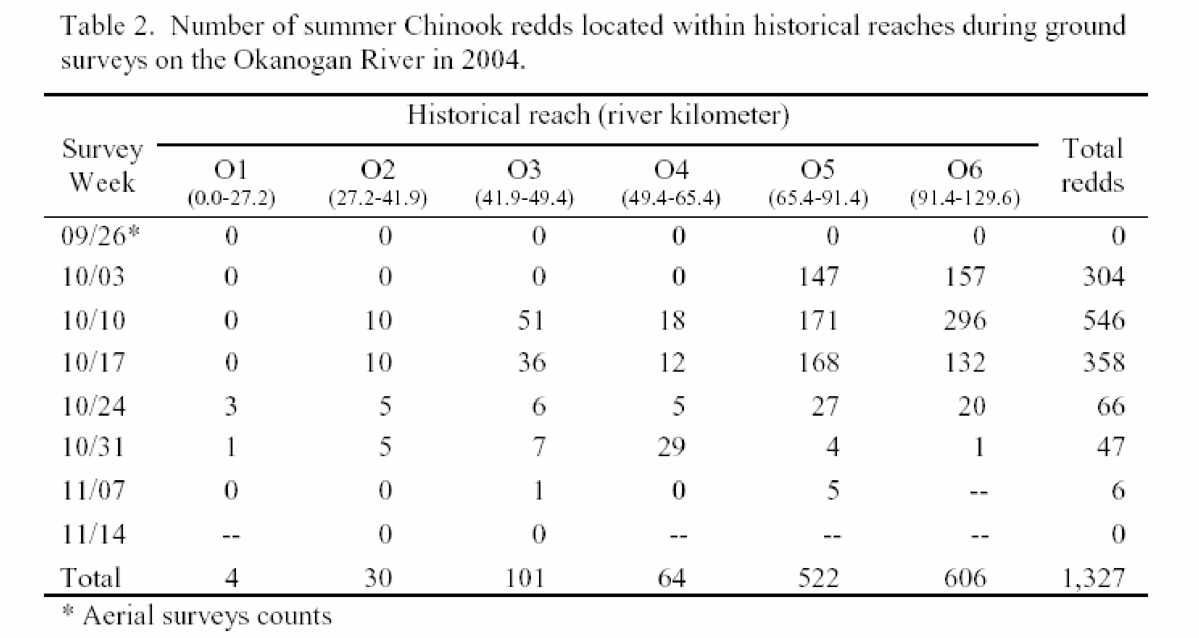

Table 2. Number of summer Chinook redds located within historical reaches during ground surveys on the Okanogan River in 2004.

Survey Week	Historical reach (river kilometer)						Total redds
	O1 (0.0-27.2)	O2 (27.2-41.9)	O3 (41.9-49.4)	O4 (49.4-65.4)	O5 (65.4-91.4)	O6 (91.4-129.6)	
09/26*	0	0	0	0	0	0	0
10/03	0	0	0	0	147	157	304
10/10	0	10	51	18	171	296	546
10/17	0	10	36	12	168	132	358
10/24	3	5	6	5	27	20	66
10/31	1	5	7	29	4	1	47
11/07	0	0	1	0	5	--	6
11/14	--	0	0	--	--	--	0
Total	4	30	101	64	522	606	1,327

* Aerial surveys counts

(Adapted from WDFW 2005)

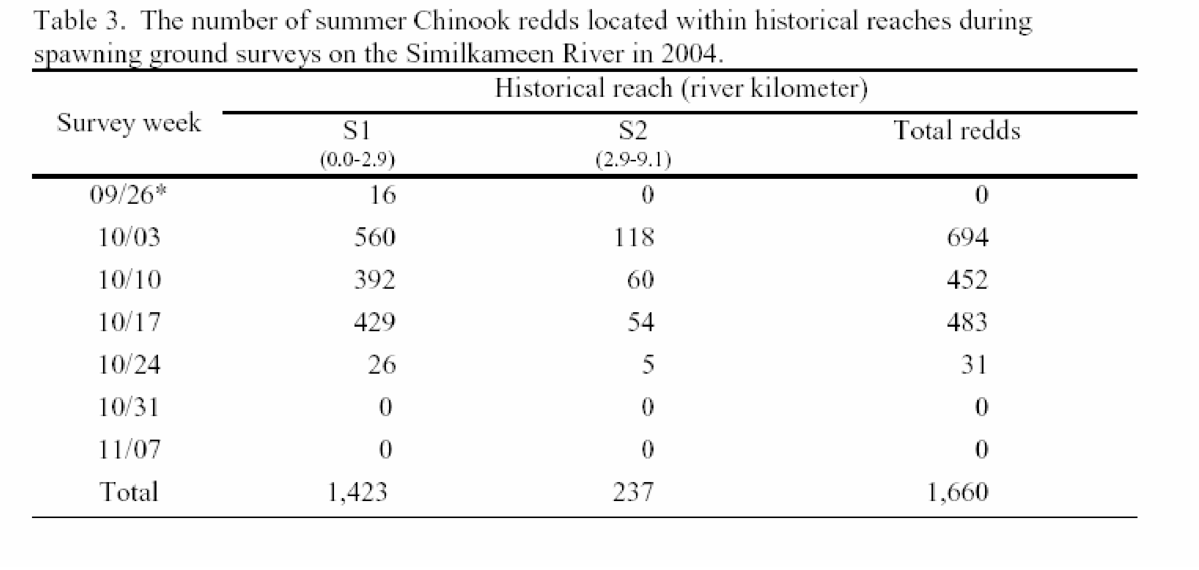

Table 3. The number of summer Chinook redds located within historical reaches during spawning ground surveys on the Similkameen River in 2004.

Survey week	Historical reach (river kilometer)		
	S1 (0.0-2.9)	S2 (2.9-9.1)	Total redds
09/26*	16	0	0
10/03	560	118	694
10/10	392	60	452
10/17	429	54	483
10/24	26	5	31
10/31	0	0	0
11/07	0	0	0
Total	1,423	237	1,660

Table 4. Historic and Current redd counts on the Similkameen River

Similkameen		
Year	Aerial	Ground
1956	30	--
1957	30	--
1958	31	--
1959	23	--
1960	--	--
1961	--	--
1962	17	--
1963	51	--
1964	67	--
1965	154	--
1966	77	--
1967	107	--
1968	83	--
1969	357	--
1970	210	--
1971	55	--
1972	64	--
1973	130	--
1974	201	--
1975	184	--
1976	139	--
1977	268	--
1981	121	--
1982	56	--
1983	57	--
1984	301	--
1985	309	--
1986	300	--
1987	164	--
1988	191	--
1989	221	370
1990	94	147
1991	68	91
1992	48	57
1993	152	288
1994	463	777
1995	337	616
1996	252	419
1997	297	486
1998	238	276
1999	903	1275
2000	549	993
2001	865	1540
2002	2000a	3358

1978	268	--
1979	138	--
1980	172	--

2003	103	378
2004	2127	1660

a. unable to accurately count due to superimposition of redds

Okanogan River Tributary Discharge

Discharge measurements included in the following tables were taken by WSDOE and represent, at best, monthly grab sample data currently available.

Table 5. Monthly discharge data collected from Nine-mile and Tonasket Creeks from 2002 to 2004 by WDOE.

Month	Nine mile cr. mean flow grab sample 2004 (CFS) DOE	Nine mile cr. mean flow grab sample 2003 (CFS) DOE	Nine mile cr. mean flow grab sample 2002 (CFS) DOE	Month	Tonasket cr. mean flow grab sample 2004 (CFS) DOE	Tonasket cr. mean flow grab sample 2003 (CFS) DOE	Tonasket cr. mean flow grab sample 2002 (CFS) DOE
January	NA	NA	NA	**January**	NA	NA	NA
February	NA	NA	NA	**February**	NA	NA	NA
March	5.7	NA	NA	**March**	1.3	NA	NA
April	0.6	6.8	NA	**April**	0.3	9.25	NA
May	NA	NA	NA	**May**	NA	NA	NA
June	0.3	NA	0.42	**June**	NA	NA	0.86
July	NA	NA	0.13	**July**	NA	0.2	0.1
August	0.3	NA	0.2	**August**	NA	NA	NA
September	NA	NA	0.25	**September**	NA	NA	NA
October	NA	1.1	NA	**October**	NA	NA	NA
November	1.3	NA	NA	**November**	0.00	NA	NA
December	0.7	NA	NA	**December**	NA	NA	NA

Ninemile Creek is known to have flow all year and support steelhead spawning and rearing. Tonasket Creek goes dry during part of the year and is currently does not support steelhead spawning or rearing in most years. Tonasket Creek had discharge only from March through July in the period from 2002 to 2004 (Table 5).

Johnson and Antoine Creeks flow year round in most years but in 2004 zero discharge was recorded for Antoine Creek during November and December of 2004. Neither creek is known to support steelhead spawning (Table 6). Most tributary streams show low flow characteristics from August through January in the United States portion of the Okanogan River basin (Figure 10). The Okanogan River watershed along with most of eastern Washington has been experiencing drought condition over the last 3 years and 2003 was a considerably wetter year than 2004 or 2002 (Tables 5&6).

Table 6. Monthly discharge data collected from Johnson and Antoine Creeks from 2002 to 2004 by WDOE.

Month	Johnson Cr. mean flow grab sample 2004 (CFS) DOE	Johnson Cr. mean flow grab sample 2003 (CFS) DOE	Johnson Cr. mean flow grab sample 2002 (CFS) DOE	Month	Antoine Cr. mean flow grab sample 2004 (CFS) DOE	Antoine Cr. mean flow grab sample 2003 (CFS) DOE	Antoine Cr. mean flow grab sample 2002 (CFS) DOE
January	NA	NA	NA	**January**	NA	NA	NA
February	NA	NA	NA	**February**	NA	NA	NA
March	0.1	NA	NA	**March**	1.5	NA	NA
April	0.4	0.1	NA	**April**	0.7	NA	NA
May	NA	1.5	NA	**May**	NA	NA	NA
June	0.7	4.3	0.43	**June**	1	NA	1.43
July	NA	NA	0.45	**July**	NA	NA	2.5
August	0.1	NA	NA	**August**	NA	NA	4
September	NA	NA	NA	**September**	0.5	NA	NA
October	NA	0.2	NA	**October**	NA	NA	NA
November	0.50	NA	NA	**November**	0.00	NA	NA
December	1.60	NA	NA	**December**	0.00	NA	NA

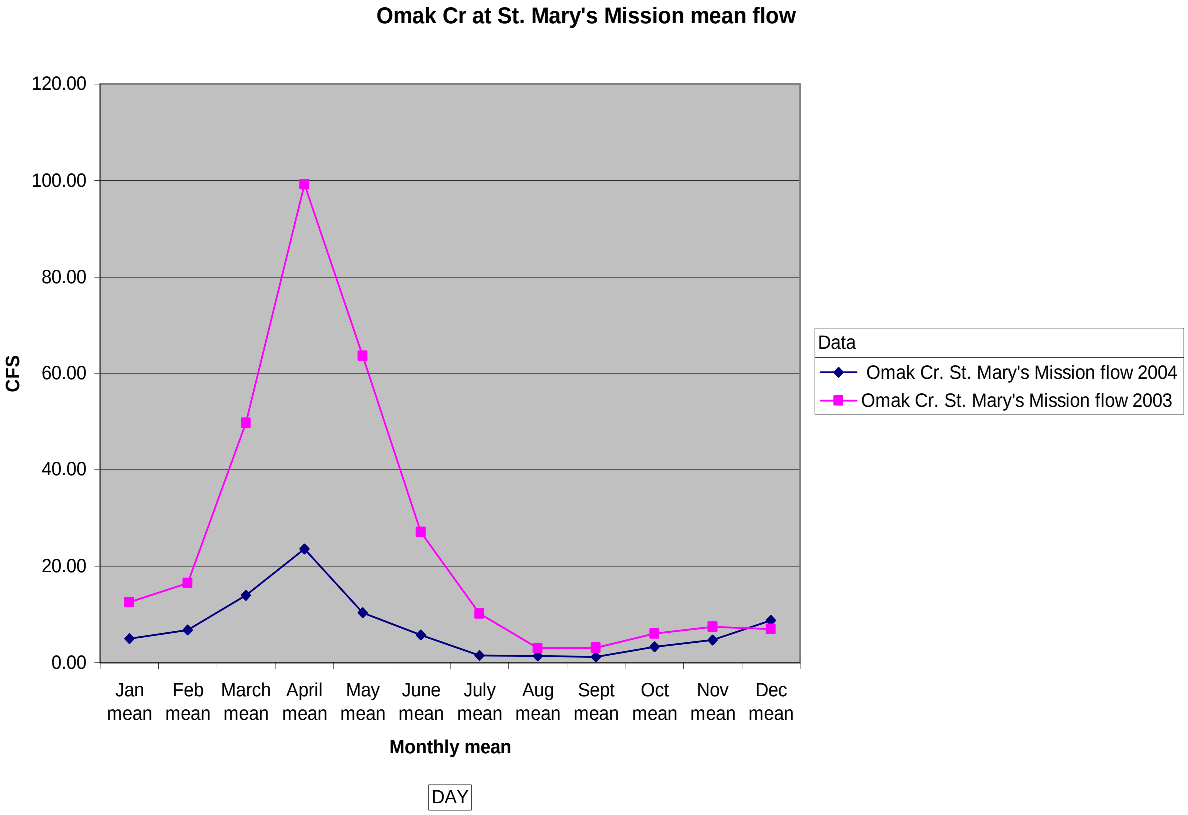

Figure 6. Real-time discharge for WDOE gauge on Omak Creek in 2003 and 2004.

Discharge data collected for Omak Creek is monitored by WDOE at a real-time telemetry gauging station located near the Saint Mary's Mission. Discharge and temperature data have been recorded consistently since 2003. The hydrograph of discharge in Omak Creek typically shows a narrow high flow peak (April) with rapidly increasing/decreasing limbs occurring in March, May and June and low flows typically occurring in the period from August through February with base flows in August and September (Figure 6). Low flows were relatively consistent in 2003 and 2004 with 2003 having a much greater peak discharge in April 2004 (Figure 6).

Discharge data collected for Tunk Creek is monitored by WDOE at a real-time telemetry gauging station located a short distance above Tunk Falls. Discharge and temperature data have been recorded consistently since 2003. The hydrograph of discharge in Tunk Creek typically shows a high flow during the period from March through May with rapidly increasing/decreasing limbs occurring in February and June and low flows typically occurring in the period from July through October with base flows in August (Figure 7). Low flows were relatively consistent in 2003 and 2004 with 2003 having a much greater peak discharge in April and May of 2004 (Figure 7).

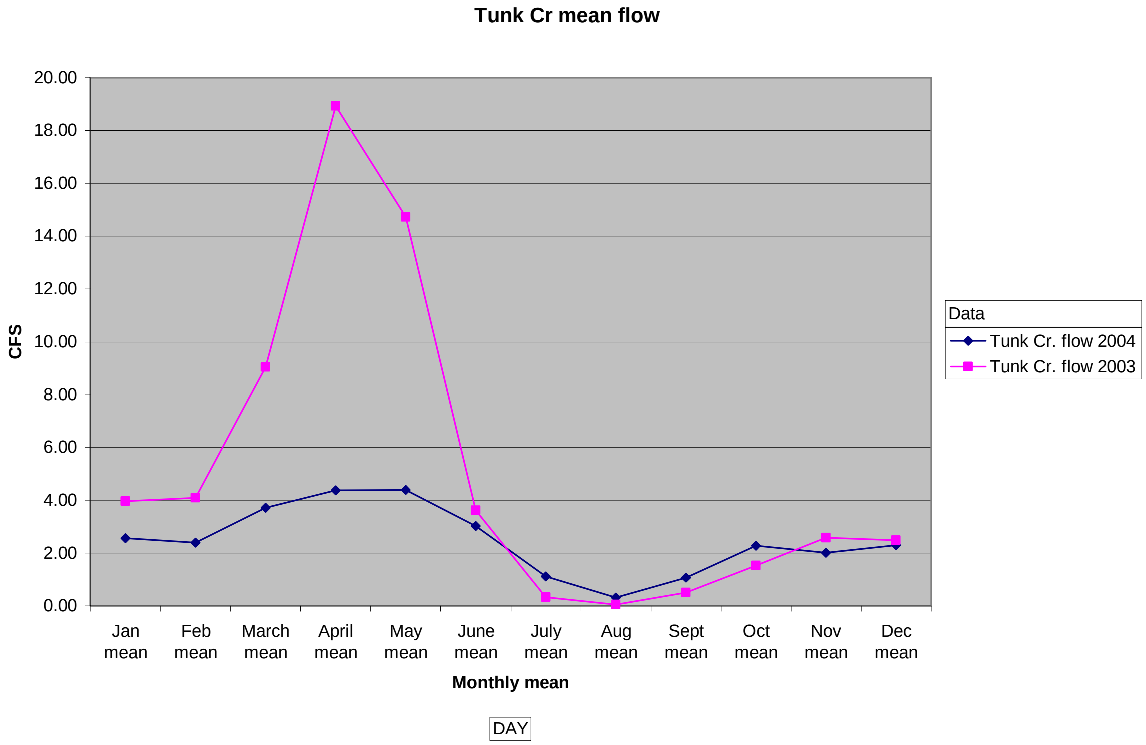

Figure 7. Real-time discharge for WDOE gauge on Tunk Creek in 2003 and 2004.

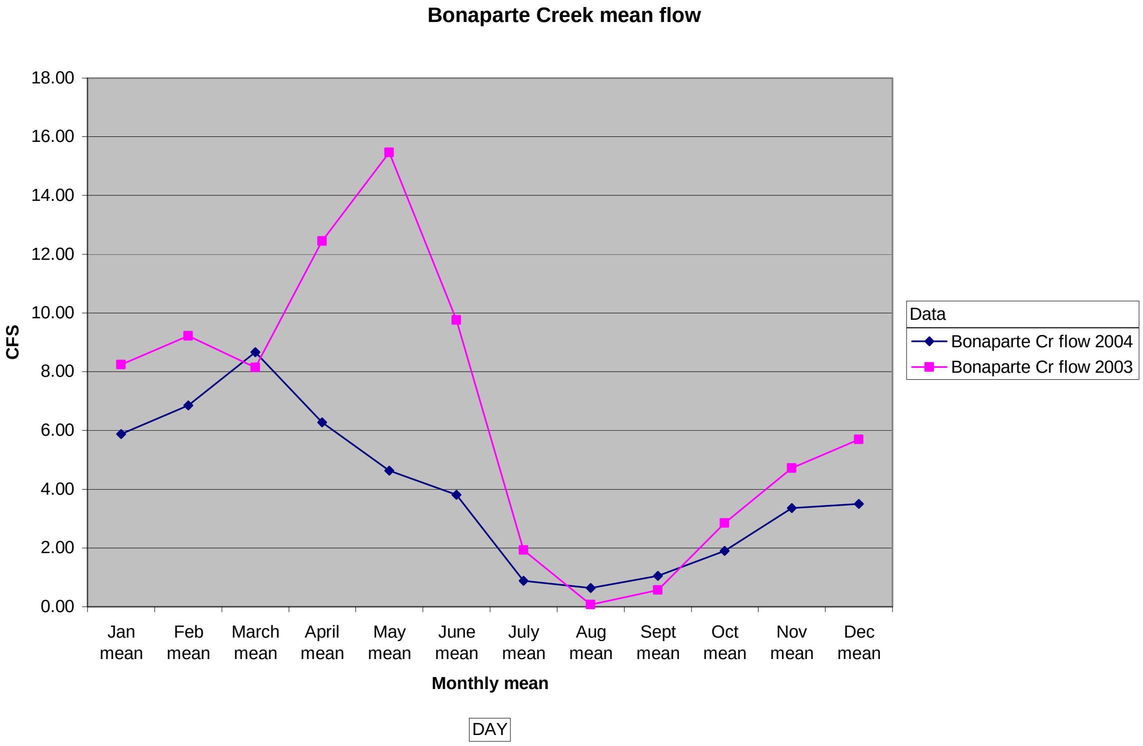

Figure 8. Real-time discharge for WDOE gauge on Bonaparte Creek in 2003 and 2004. Discharge data collected for Bonaparte Creek is monitored by WDOE at a real-time telemetry gauging station located at the Highway 97-bridge in the town of Tonasket, Washington. Discharge and temperature data have been recorded consistently since 2003. The hydrograph of discharge in Bonaparte Creek typically shows a high flow during the period from March through June with low flows typically occurring in the period from July through October and base flows in August winter rain typically increase flows to an intermediate level during the period from November through February (Figure 8). Low flows were relatively consistent in 2003 and 2004 with 2003 having a much greater peak discharge in April, May, and June of 2004 (Figure 8).

Okanogan River main stem discharges

Most of the flow monitoring is conducted by the United States Geological Survey (USGS) with the exception of one site on the Similkameen River operated by WDOE and one site near the town of Oliver in Canada operated by the Ministry of Land, Water, and Air Protection (MLWAP). All the United State gauging stations provide real-time discharge data but the site in Canada is only a near real-time station and data are not posted until results are one year old. For each site we compared average flows from 1977, start of Wells dam fish counts, to 2004 with flows in 2004 provided when the data was available. Okanogan River flows were higher in 2003 than 2004 but peaked at the same time, in late April to early May. The data from Orville is confusing due to no data available for May of 2004 (Figure 9). We were unable to compare flows on the Okanogan River in Canada due to data being unavailable for 2004 at the time of this document (Figure 10). We were able to see that peak flows were consistent between the United States and Canadian flow monitoring sites. The Similkameen River peak flow was consistent with the other downstream monitoring stations and the graph is a good illustration of how much flow the Similkameen River contributes to the United States portion of the Okanogan River (Figure 11). Peak flow on the Similkameen was 16,000 CFS in 2003 compared to the peak flow on the Okanogan River at Orville of 1,200 CFS (92.5%).

The Okanogan River draining out of Canada is regulated at dams located at outlets of the following lakes; Osoyoos (Figure 9), Skaha (Figure 10), and Okanogon. Because this river acts to drain three major lake basins and the releases are managed for flood control, to maintain lake elevation, irrigation, and to enhance fish production the hydrograph is muted with lower peak flows, higher low flows. Peak high flow typically occur in May and low flows in December and January. The remainder of the year is contained in the ascending limb (February to May) or descending limb (June to November) of the hydrograph (Figure 9).

The Similkameen River is a free stone river and has a much flashier hydrograph than the Okanogan River. The hydrograph for the Similkameen River has a sharp high flow period from May through June and a low flow period that lasts from August to March because most of the flow in this drainage is generated directly from snowmelt. In 2004 drought conditions existed in the Similkameen drainage along with the rest of the Okanogan watershed as indicated by the peak flows that are well below historical averages (Figure 11).

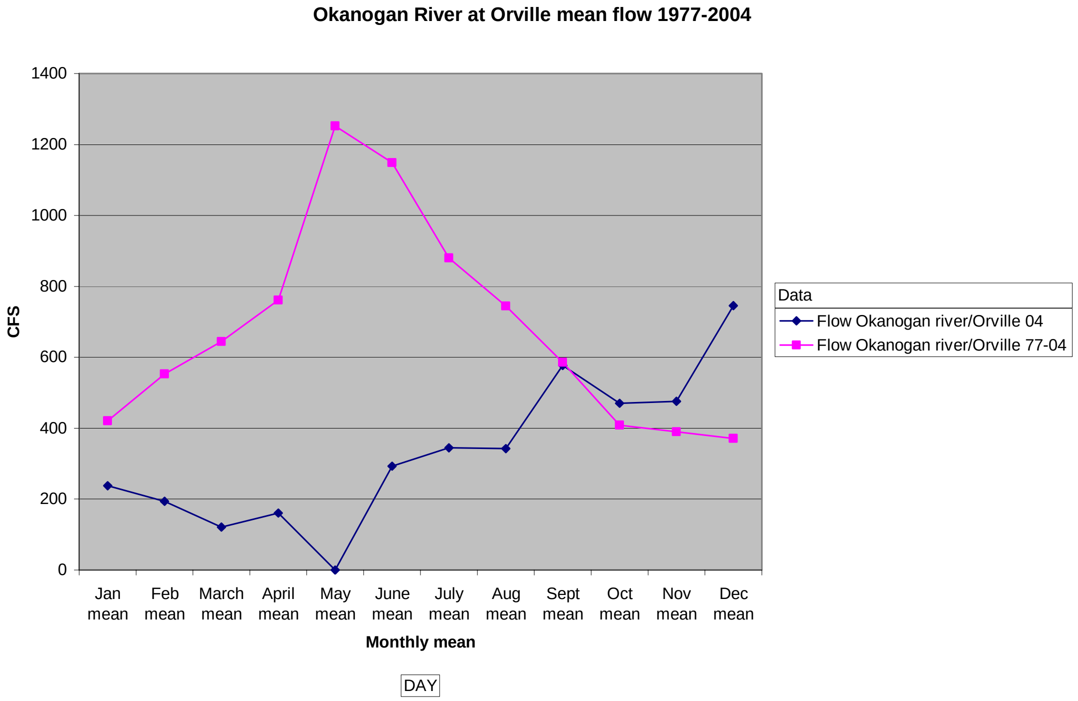

Figure 9. Real-time discharge for USGS gauge on Okanogan River located at the Highway 97 Bridge at the town of Oroville comparing the historic average from 1977 to present and 2004. *The zero reading in 2004 in May is due to data being unavailable at this time.

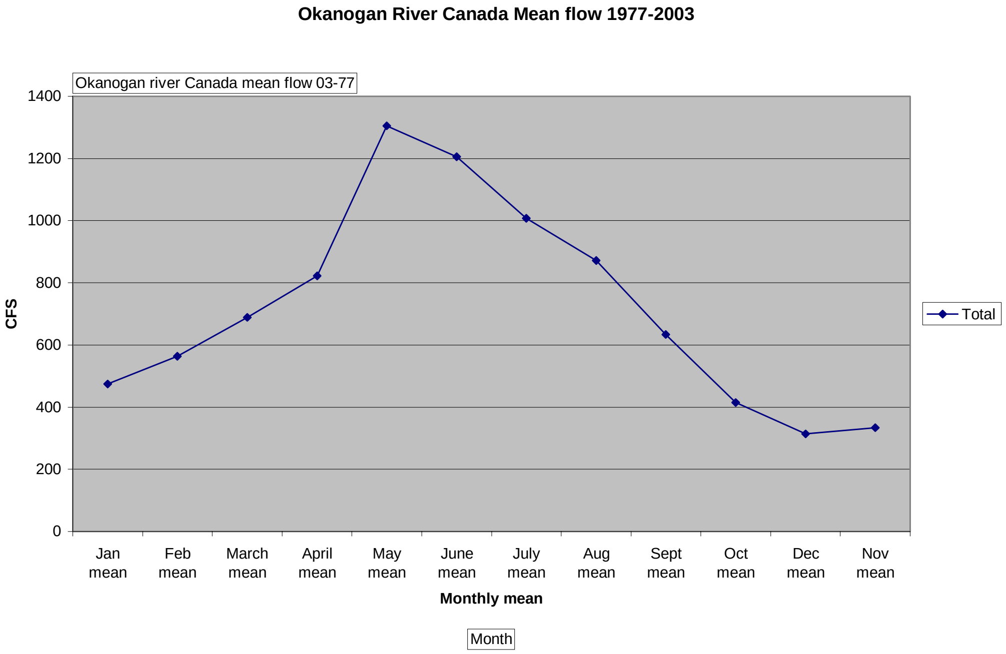

Figure 10. Real-time discharge for MLWAP gauge on Okanogan River located at the town of Oliver in Canada showing the historic average from 1977 to present.

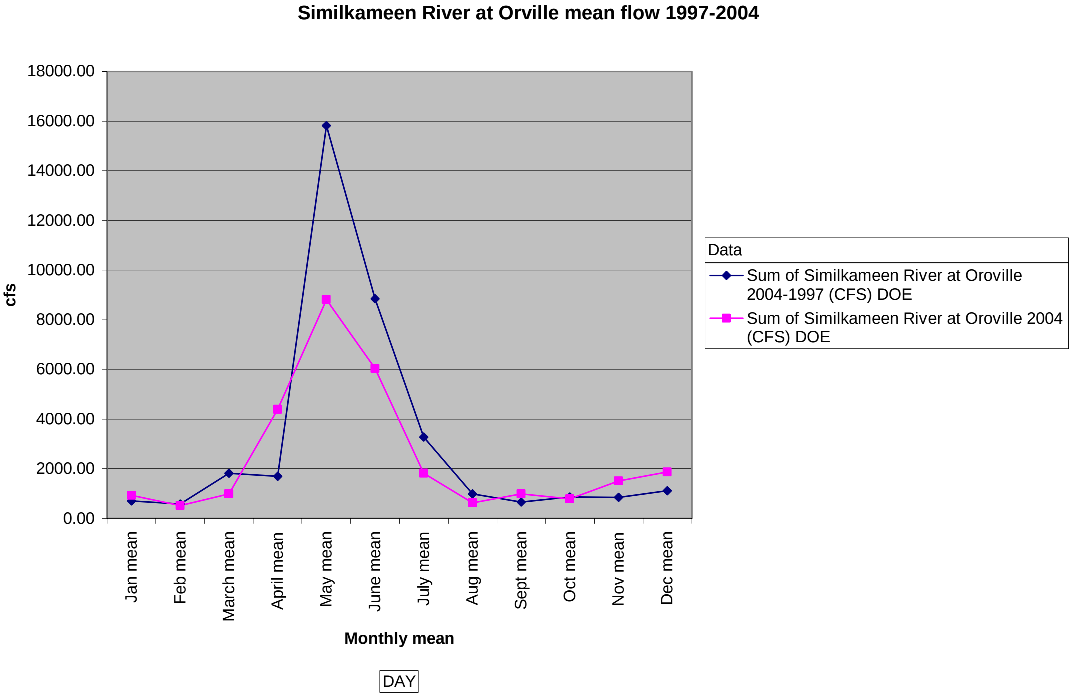

Figure 11. Real-time discharge for WDOE gauge on Similkameen River located at the town of Oroville comparing the historic average from 1997 to present and 2004.

The Okanogan River main-stem downstream of the confluence with the Similkameen River is monitored by the USGS at two sites; one near the town of Tonasket (Figure 12) and one near the town of Mallott, Washington (Figure 13). Flows in 2004 were much closer to the long-term average then for gauging stations further up stream. This indicates that in 2004 a lack of water in the basin was more sever in the northern portion of the watershed and stream flows were closer to normal or above normal in the southern portion of the basin. The USGS stream gauge at Mallott had discharges that approximated the long-term average while more disparity occurred as you moved northward in the basin with the Okanogan River showing greater disparity from normal than the Similkameen River.

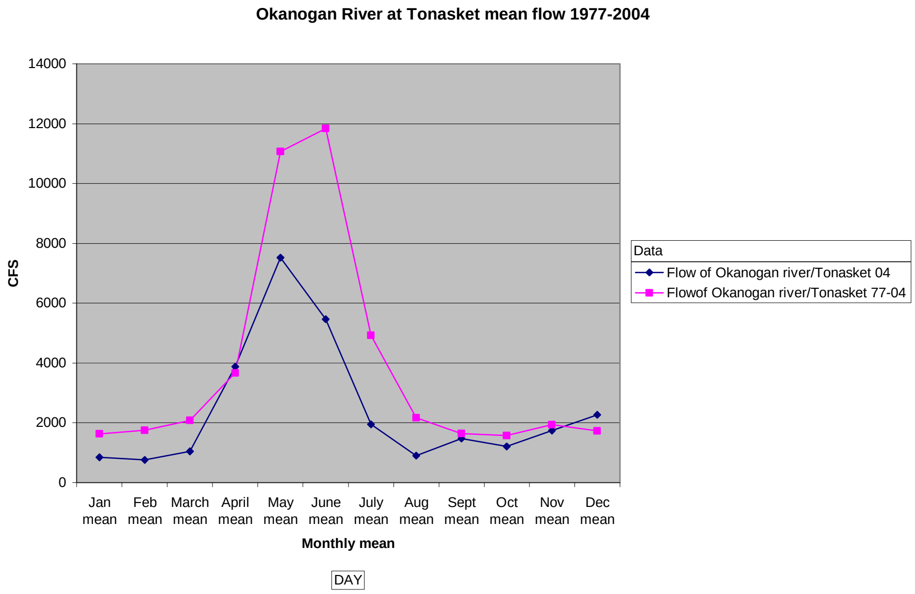

Figure 12. Real-time discharge for USGS gauge on Okanogan River located near the town of Tonasket, Washington comparing the historic average from 1977 to present and 2004.

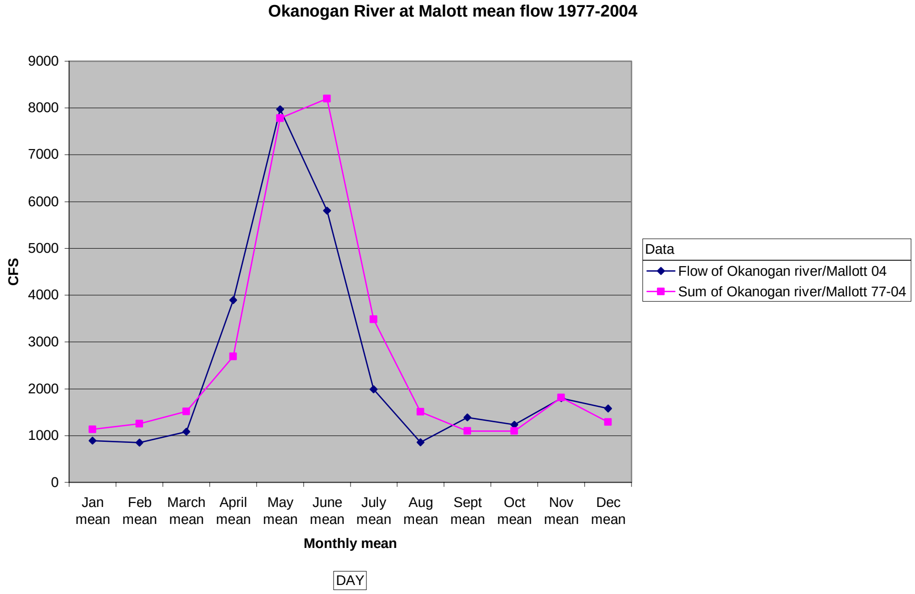

Figure 13. Real-time discharge for USGS gauge on Okanogan River located near the town of Mallott, Washington comparing the historic average from 1977 to present and 2004.

Water Quality

Water quality data reported here was collected by the WDOE. The graphs combine data collected on the Okanogan River in Orville (up river), Malott (down river) and in the Similkameen River at Oroville (up river) to help us see if there are differences in parameters we chose to analyze between upper and lower river sites. These parameters compared include: temperature, conductivity, turbidity, dissolved oxygen, PH, Ammonia, Nitrogen and Phosphorous. We compared averages from 1977-2004 with data collected in 2004.

Temperature

Temperature was consistent between the 1977-2004 average and 2004 data at both the upper and lower Okanogan River sites (Figure 14). The upper Okanogan River site had consistently higher peak temperatures than the lower site by one or two degrees Celsius and this is believed to be a result of releases at Zosel dam coming from the upper layers of Osoyoos Lake. The upper layers of Osoyoos Lake often reach higher temperatures because the lake has a large amount of surface area and is relatively shallow at the southern end. These conditions combine to heat the water more than would be the case if the water was contained within a river channel. In 2004 the lack of discharge being released from Osoyoos Lake magnified this temperature differential but the small volume of warm water from this source made the temperature graph for the Similkameen River very similar to the lower Okanogan River Site (Figure 15).

Temperatures above 21◦C are known to be stressful to most salmonids and direct mortality occurs at temperatures above 25◦C (Jenkins and Burkhead 1993). During the month of August the Okanogan River water temperatures rarely exceed 25◦C but salmonids do exhibit avoidance behavior for waters that are warmer than 20◦C and this occurs in most years (Figure 14). Typically the upper Okanogan River reaches temperatures above 20◦C as early as July and this was the case in 2004 (Figure 14). In 2004, salmonids did not encounter temperatures greater than 20◦C on average until august in the lower Okanogan and Similkameen Rivers. The effect of warm waters exiting Canada in the Okanogan River sets up a trap in the Similkameen River above the confluence because fish migrate above this point and avoid the upper Okanogan River. Because the lower Okanogan River reaches stressful temperatures earlier than the Similkameen River (Figure 14 & 15) fish become trapped in the Similkameen River during stress full temperature periods in the month of August and over time this results in higher pre-spawn mortality for early migrants compared to fish that arrive later and remain in the Columbia River until such time as temperature conditions favor migration. This typically occurs in September (Figure 14).

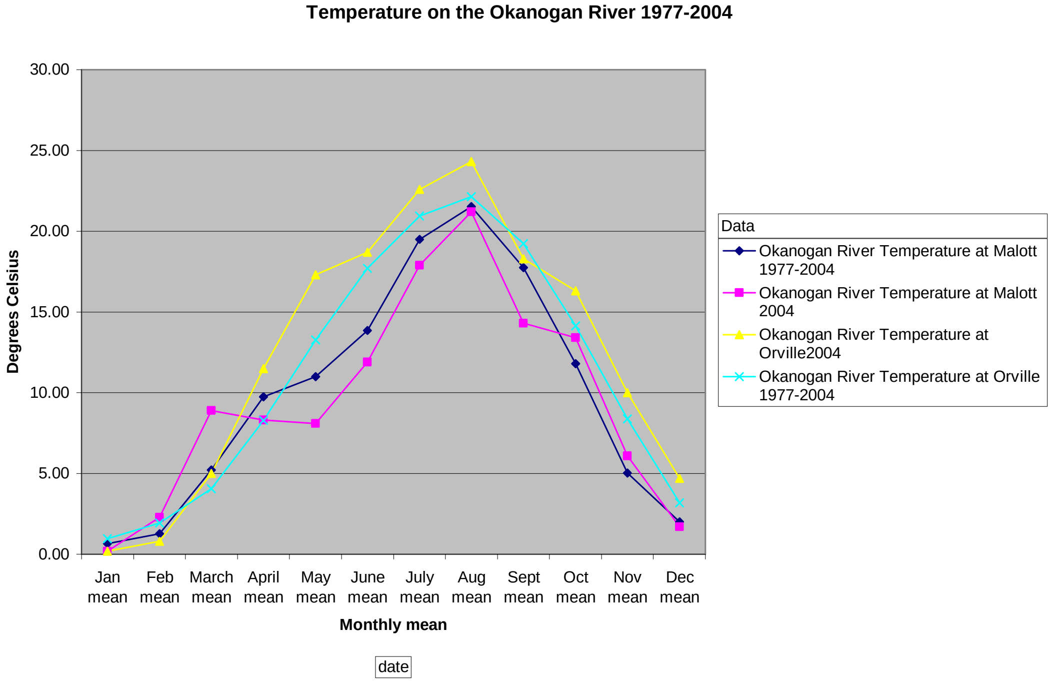

Figure 14. Real-time temperature data for the Okanogan River from sites located near the towns of Mallott and Oroville, Washington comparing the historic average from 1977 to present and 2004.

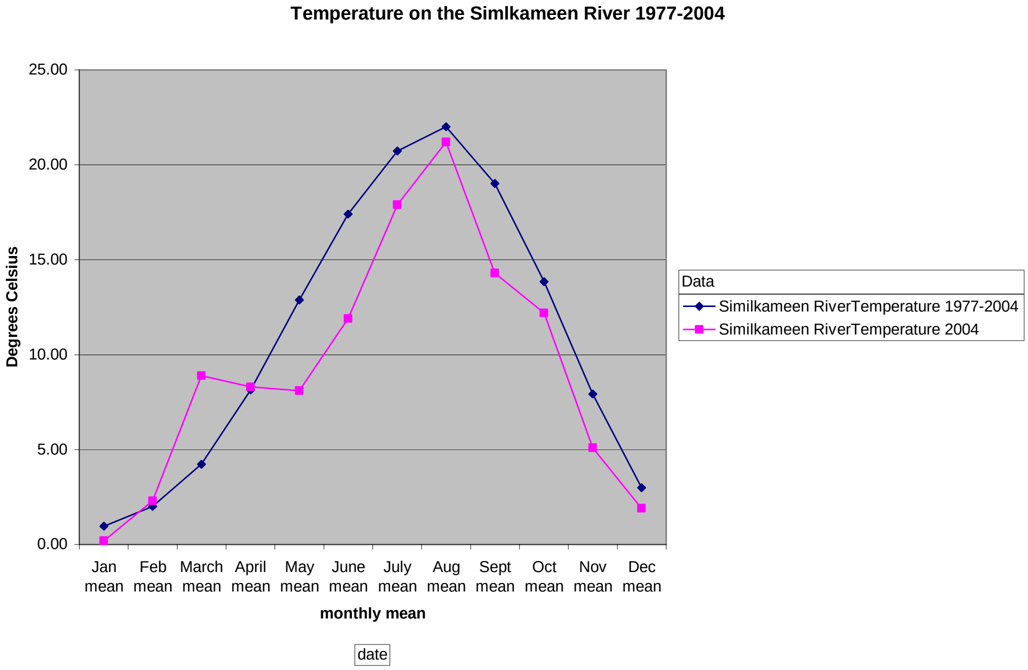

Figure 15. Real-time temperature data for the Similkameen River site located at the town of Oroville, Washington comparing the historic average from 1977 to present and 2004.

Dissolved Oxygen

Oxygen is critical for fish and when oxygen levels drop below 6mg/l adult salmonids can become stressed, this is rarely the case in fluvial environments (Davis 1975). The amount of oxygen that can be dissolved in water is a function of temperature and pressure to reach solubility's below 6mg/l requires temperatures greater than 25◦C and atmospheric pressures below 560 mm Hg (Colt and Tomasso 2001).

The average barometric pressure in the Okanogan Valley is 760 mm Hg and temperatures rarely exceed 25◦C therefore the theoretical minimum dissolved oxygen would be approximately 8mg/l (http://WWW.weatherunderground.com). In the Okanogan basin dissolved oxygen readings below 8ppm can only result from biological oxygen demands or extreme dewatering and for fluvial systems these impacts are isolated due to air to surface water exchange processes that are enhanced through the turbulence of moving waters. Research has determined that as salmonid eggs begin to hatch, correlation between the rate of development and survival of salmonids with dissolved oxygen levels exists. If dissolved oxygen levels are below 8mg/l survival and development at time of hatching reduces rapidly. At levels above 8mg/l survival and development continue to benefit salmonids at a slower rate until 10mg/l.

Most experts believe that at 8mg/l or more dissolved oxygen is considered to be excellent for salmonids and that levels above 6mg/l are adequate provided no eggs are actively hatching. In 2004, dissolved oxygen levels on the upper Okanogan River fell below 8mg/l during the month of September but only adult fish are present during this time and no eggs are hatching therefore this reading had no biological impact on salmonids (Figure 16). Dissolved oxygen levels in the Similkameen River were excellent in 2004 (Figure 17). Dissolved oxygen levels in the Okanogan and Similkameen River typically range from around 14 mg/l in the period from January to March and reach there lowest levels around 9 mg/l in the period from July to September.

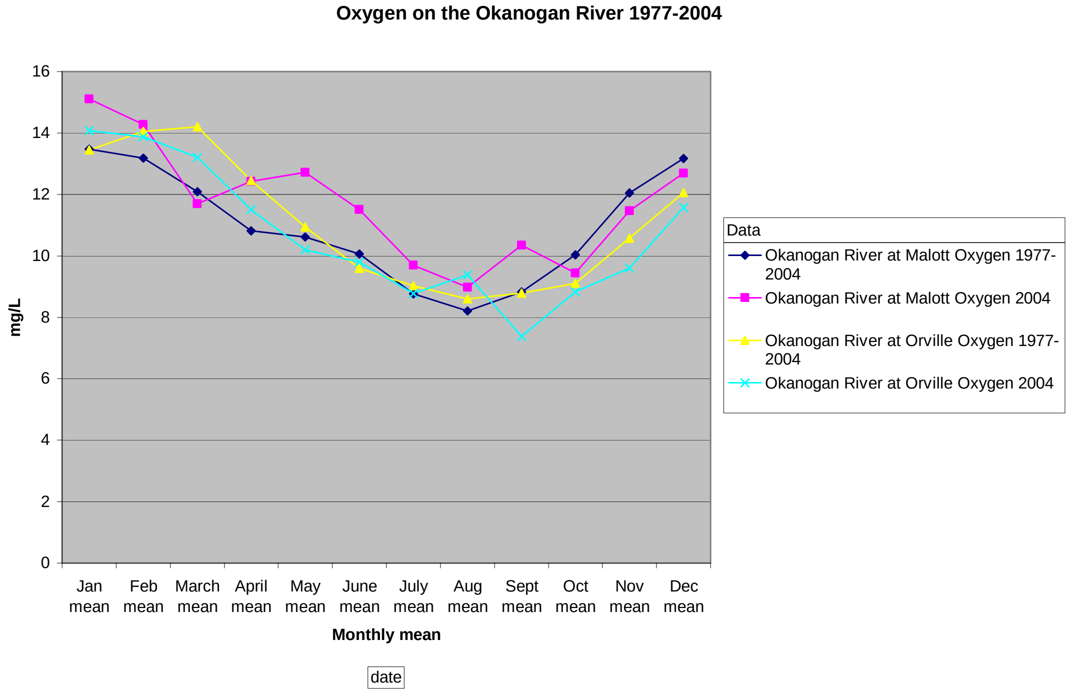

Figure 16. Grab sample data for dissolved oxygen collected by WDOE for the Okanogan River site located near the town of Malott, and Oroville, Washington comparing the historic average from 1977 to present and 2004.

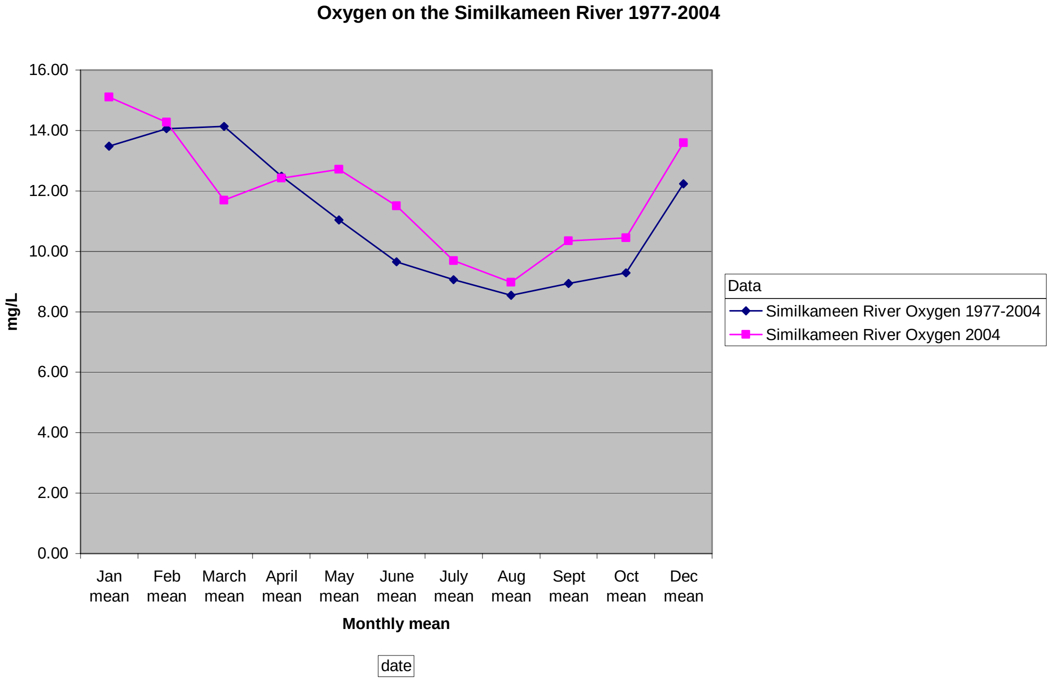

Figure 17. Grab sample data for dissolved oxygen collected by WDOE for the Similkameen River site located at the town of Oroville, Washington comparing the historic average from 1977 to present and 2004.

Turbidity

In most streams, there are periods when the water is relatively turbid and contains variable amounts of suspended sediments (Bjornn and Reiser 1991). Turbidity has been found to be linked to primary productivity (g O_2/m^2) and increases from 1 NTU to 170 NTU reduces productivity by 50% and productivity can be reduced to zero at turbidities of 1,100 NTU or higher (LaPerriere et al 1983, VanNieuwenuyse and LaPerriere 1982). An Increase of 25 Ntu over normal background levels has been found to reduce primary productivity from 13 to 50% (Lloyd et al. 1987). Newly emerged salmon and steelhead fry show reduced growth and tend to emigrate from areas were turbidities ranged from 25-50 NTU (Sigler et al. 1984). Juvenile salmon avoid areas with turbidities above 70 NTU whereas older fish appear to be little affected by ephemerally high concentrations of suspended sediments (Bisson and Bilby 1982, Sorenson et al. 1977).

In 2004 and historically, turbidities coming out of Canada were well below any threshold of biological importance. This is most likely due to the large lakes that are contained within this watershed that act as very effective sediment traps. Historical averages from the Okanogan and Similkameen Rivers show that turbidities typically occur at levels that would have no impact on salmonids as levels are below 25 NTU throughout the year (Figure 18&19). However, in 2004 a spike of sediments that originated in the Similkameen River and continued downstream through the lower Okanogan River turbidity levels jumped from 1 NTU to 45 NTU and stayed at that level for the period from April to May (Figure 18&19). This level of turbidity likely reduced primary productivity perhaps by as much as 50% and reduced growth of newly hatched summer/fall Chinook salmon and possibly triggered premature emigration to the Columbia River.

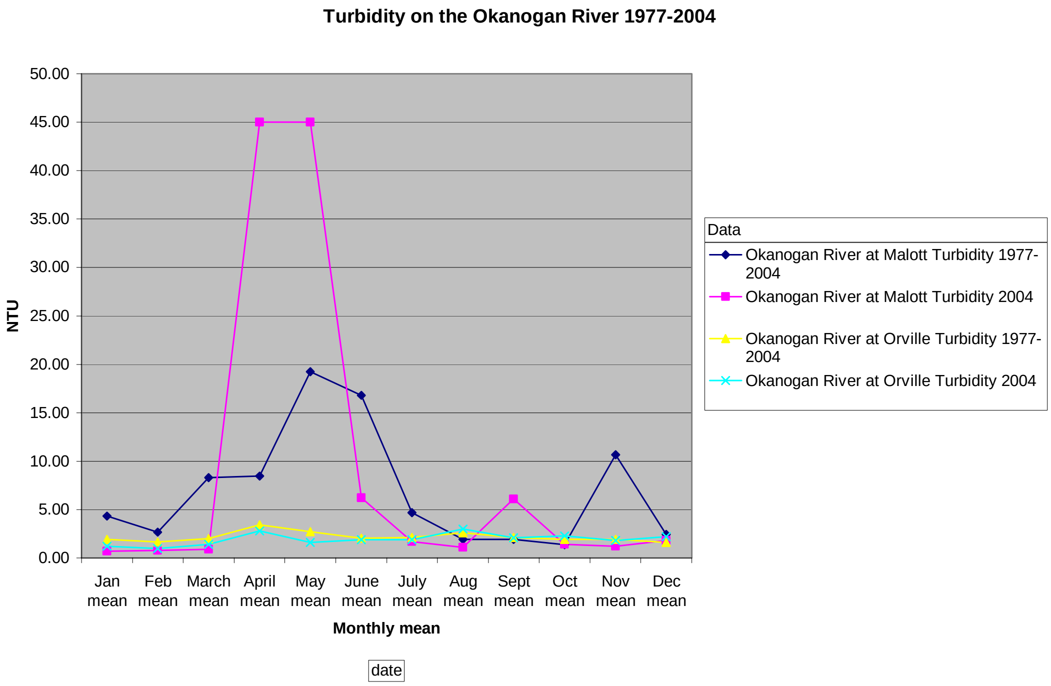

Figure 18. Grab sample data for turbidity collected by WDOE for the Okanogan River site located near the town of Malott, and Oroville, Washington comparing the historic average from 1977 to present and 2004.

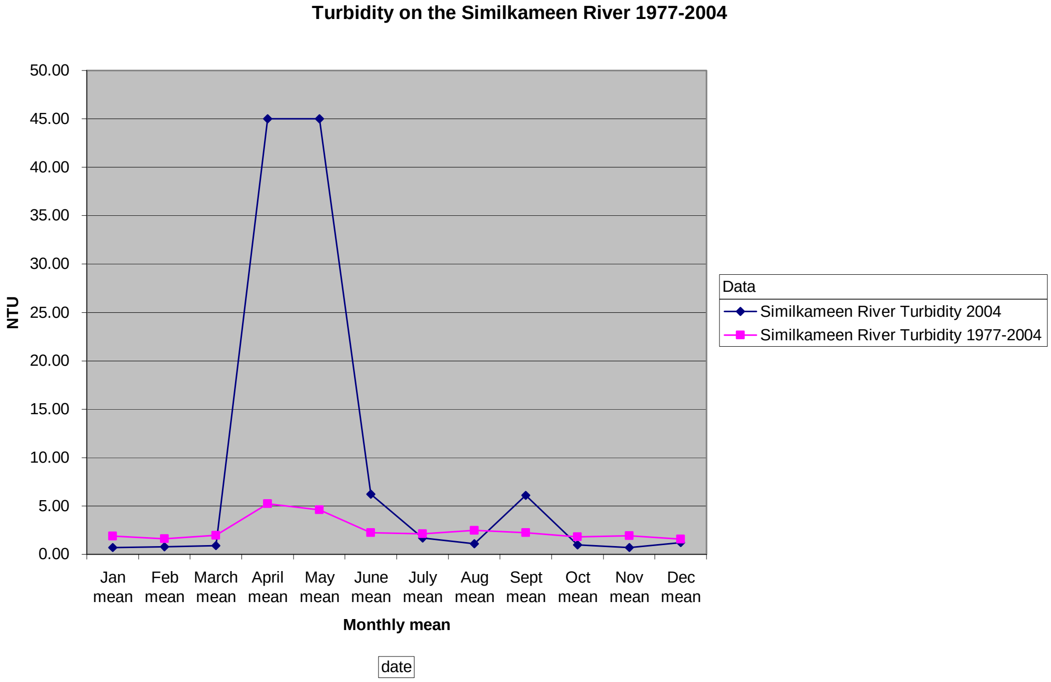

Figure 19. Grab sample data for turbidity collected by WDOE for the Similkameen River site located at the town of Oroville, Washington comparing the historic average from 1977 to present and 2004.

pH

The sensitivity of fishes to extremes of pH varies; however, a range of 6.5-9.0 is recommended for salmonid species (Piper et al. 1982). Environmental pH affects the toxicity of ammonia, hydrogen sulfide, metals, and other pollutants. Alkalinity is a measure of the buffering capacity of water therefore it has a major impact on the fluctuation of pH values. Ph remained consistent in both the upper and lower Okanogan River sites and Similkameen River sites both in 2004 and when compared with the 1977-2004 average (Figure 20). The lack of fluctuation between space and over time indicates that the Okanogan River basin has excellent buffering characteristics that protect it from fluctuating Ph levels. With a stable reading for pH between 7.5 and 8.7 the water would be considered weakly basic and excellent for invertebrates and fish (Figure 20). The stability of pH values means that pH should be given a low level of importance when evaluating other water quality indicators.

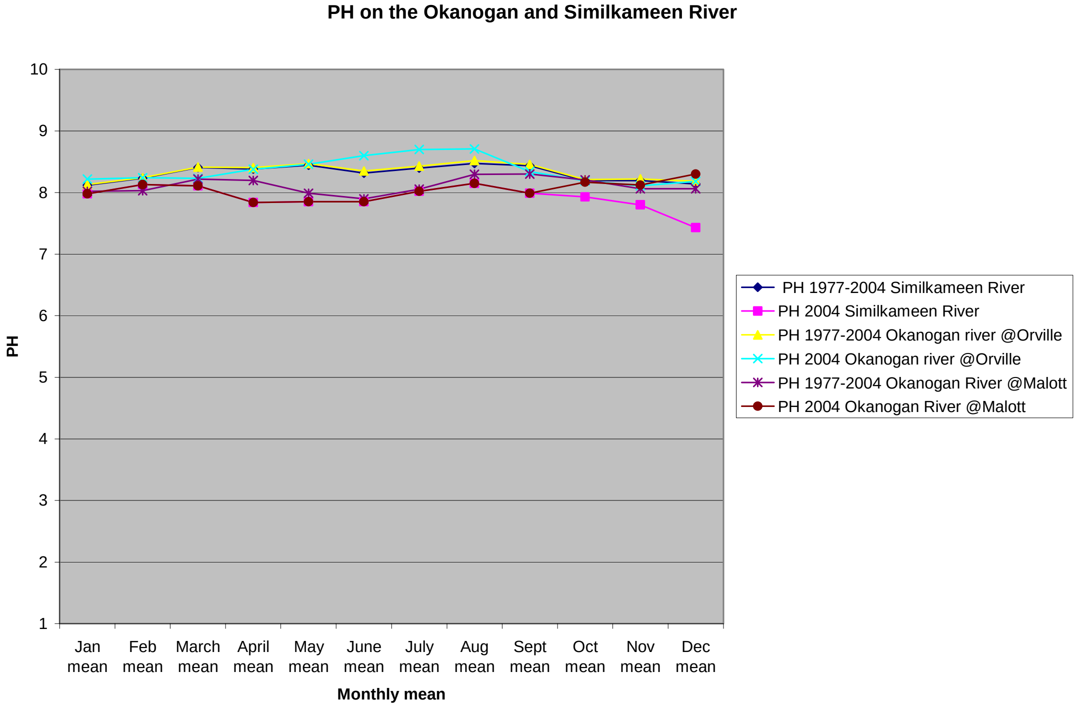

Figure 19. Grab sample data for pH collected by WDOE for the Similkameen and upper Okanogan River site located at the town of Oroville, WA plus the lower Okanogan River site near the town of Malott, WA comparing the historic average from 1977 to present and 2004.

Ammonia

Ammonia in its un-ionized form (NH_3) is highly toxic to fish but the ionized form, (NH_4^+) usually referred to as ammonium is not toxic. The amount of each form found in water is mainly influenced by the ionic concentration, pH and temperature of the water. If the pH is below 7 no un-ionized ammonia exists. On the Okanogan River pH may reach 8.8 (Figure 20) and temperature can exceed 20◦C (Figures 14 & 15) during the months of July and August therefore as much as 20% of the ammonia-nitrogen measured could be in the un-ionized form. Salmonids are known to be highly sensitive to ammonia (NH_3) toxicity and concentrations below 0.03 mg/l are considered optimal (Wedemeyer 1996). Ammonia concentrations between 0.05 and 0.2 mg/l are not typically considered lethal for salmonids but have been shown to significantly reduce growth (Wedemeyer 1996) and long-term exposures can cause physiological and histopathological effects along with gill hyperplasia that can result in indirect mortalities (Piper 1975, Burrows 1964). The literature shows that rainbow trout have a minimum lethal level for ammonia (NH_3) of 0.2 mg/l (Norris et al 1991) however the instantaneous mortality concentrations are more widely believed to occur at levels greater than 0.32 mg/l for salmonids (Summerfelt et al 2001).

Values recorded by WSDOE are for ammonia-nitrogen which is a measure of total ammonia in both ionized and un-ionized form. Because only the un-ionized form has a bearing on fish health and given the information already documented for the Okanogan and Similkameen Rivers (pH, Temperature) a maximum of 20% of the measured ammonium-nitrogen would be found in the un-ionized form (Piper et al. 1982). Concentrations of ammonia-nitrogen should not exceed 0.15 mg/l of optimum water quality (Piper et al. 1982). Ammonia-nitrogen levels below 0.25mg/l are unlikely to result in any adverse impacts to salmonids and levels below 1 mg/l are unlikely to have any impact during months outside of the June through September period.

Ammonia readings along the Okanogan River showed very minor variation at all sites and over time (Figure 21). The Similkameen River site located at the town of Orville, Washington showed very comparable results to the downstream Okanogan River site (Figure 21 &22). The long-term data set collected by the WDOE illustrates that ammonia levels are well below any level that would have a biological impact making continued monitoring of this indicator of questionable value in this watershed. The highest values for the Okanogan River for the period from June through September are below 0.03 mg/l both historically and in 2004 (Figure 21). The highest values for the Similkameen River for the period from June through September are below 0.03 mg/l both historically and in 2004 (Figure 22). The most common reading during all the hot summer months since 1977 is 0.01 or less as this is the lowest reading possible given the methodology employed by WDOE.

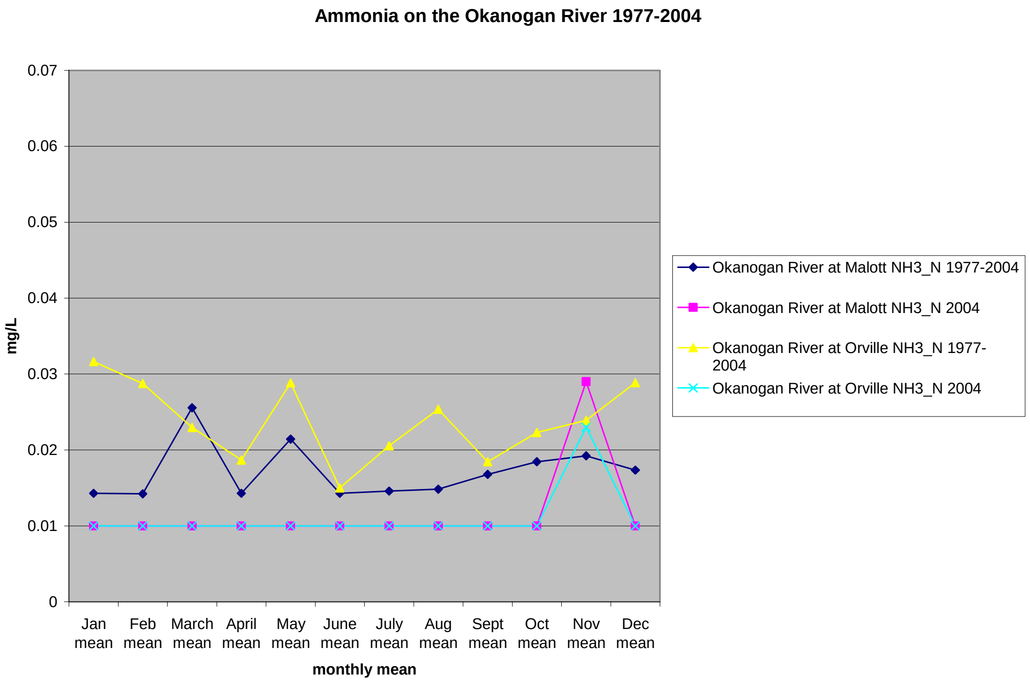

Figure 20. Grab sample data for Ammonia-nitrogen* collected by WDOE for the Okanogan River site located near the town of Malott, and Oroville, Washington comparing the historic average from 1977 to present and 2004. *The maximum of 20% of this value is un-ionized ammonia (NH_3).

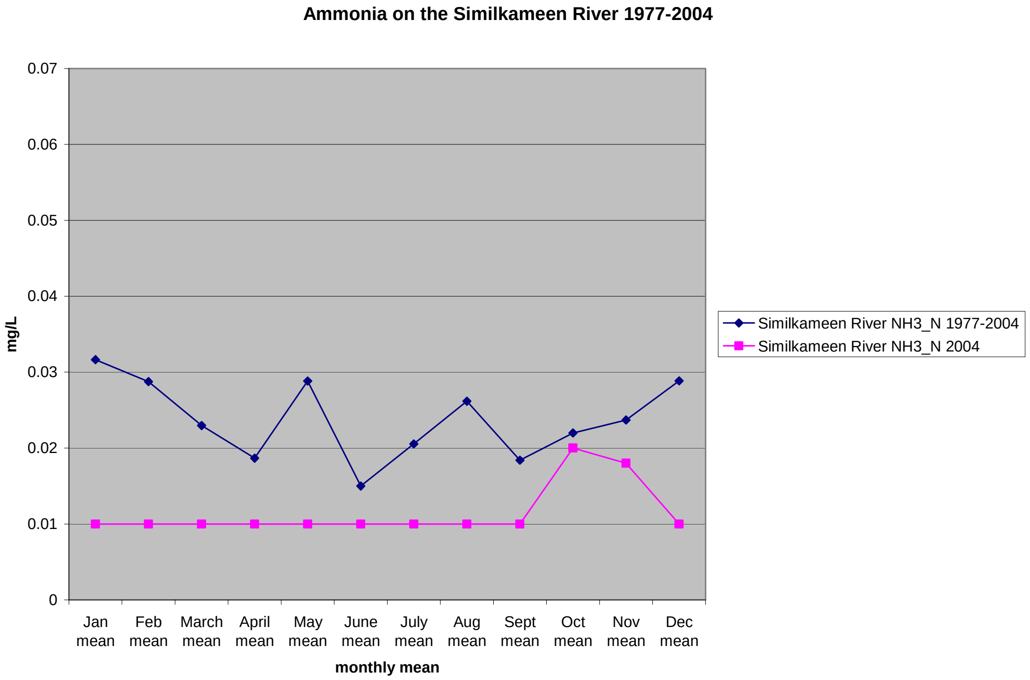

Figure 21. Grab sample data for Ammonia-nitrogen* collected by WDOE for the Okanogan River site located at Oroville, Washington comparing the historic average from 1977 to present and 2004. *The maximum of 20% of this value is un-ionized ammonia (NH_3).

Nitrogen and Phosphorus

Total nitrogen as measured by WSDOE measures the amount of both Nitrite (NO_2), and Nitrate (NO_3). Nitrogen is an oxidation product of mainly ammonia in aquatic systems the primary source of these nutrients is from fish waste, and both inorganic and organic fertilizers. Nitrogen nutrients are transformed by autotrophic bacteria from ammonia to nitrite to nitrate. Ammonia and nitrite are both toxic for fish but nitrate is not. However, for nitrite to be toxic it must be diffused across the gill membrane in the form of nitrous acid (HNO_2) but nitrous acid is not found at pH levels below 6. In the Okanogan River the only Nitrite is of possible concern and this form can only enter freshwater fish by the active chloride pump system (Summerfelt et al. 2001). Nitrite oxidizes the iron in hemoglobin, reducing oxygen transport of blood and can cause asphyxiation even when dissolved oxygen levels are not limiting (Russo and Thurston 1991). Nitrite toxicity is known as “brown blood disease” and is dependent on species, life stage, and the concentration of other ions especially chloride and calcium (Russo et al. 1981, Russo and Thurston 1991, and Wedemeyer 1996). Nitrite is more toxic for salmonids than other fishes and can kill rainbow trout at concentrations above 0.2-0.4 mg/l (Wedemeyer 1996). The presence of dissolved chloride or calcium at concentrations of at least 50mg/l can increase fish tolerance to nitrite by 50 fold.

Phosphorus is not considered to be toxic for fish at levels that are likely to be found in aquatic systems. However, the ecological relationships between nitrogen and phosphorous can increase or hinder growth that results from increased algal growth by as much as 50%. The ratio of nitrogen and phosphorus (N: P) is used to determine which nutrient is limiting a given system.

A ratio of 10 or less means that nitrogen is limiting while levels above 10 indicate phosphorus limited systems. Only the nutrient that is limiting is of biological value as the level of the other nutrient that is usable is limited by the limiting nutrient.

In the Okanogan basin we have phosphorous levels that are up to twice as high as nitrogen levels but N:P ratios are in all cases below 10 (Figure 22 & 23). Therefore nitrogen is always limiting in the Okanogan and Similkameen River from the Canadian border to the confluence with the Columbia River. Future monitoring should continue to be focused on nitrogen levels and more specifically nitrite levels as these would have the most potential for biological impacts. Levels of nitrite as measured by WDOE are consistently from 2 to 10 times below and potentially harmful level and have been since 1977 to present and this measure includes both nitrite and nitrate but the proportion of each is unknown at present (Figure 22 & 23). Specific nitrite levels are likely 4 to 20 times below the levels currently monitored (Figure 22).

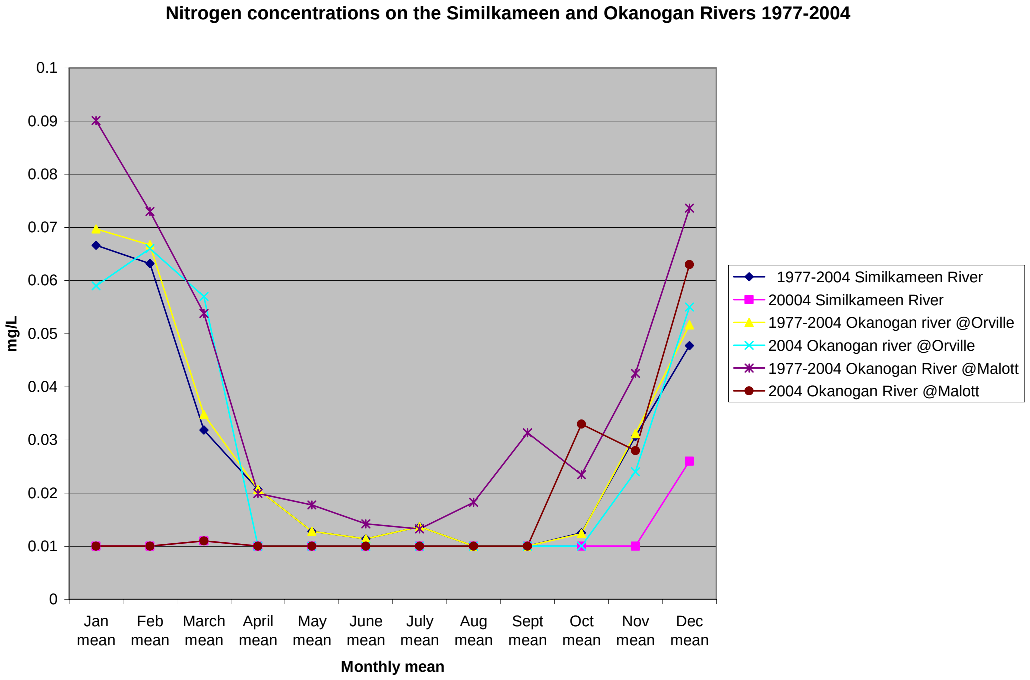

Figure 22. Grab sample data for total nitrogen (nitrate + nitrite) collected by WDOE for the Similkameen and upper Okanogan River site located at the town of Oroville, WA plus the lower Okanogan River site near the town of Malott, WA comparing the historic average from 1977 to present and 2004.

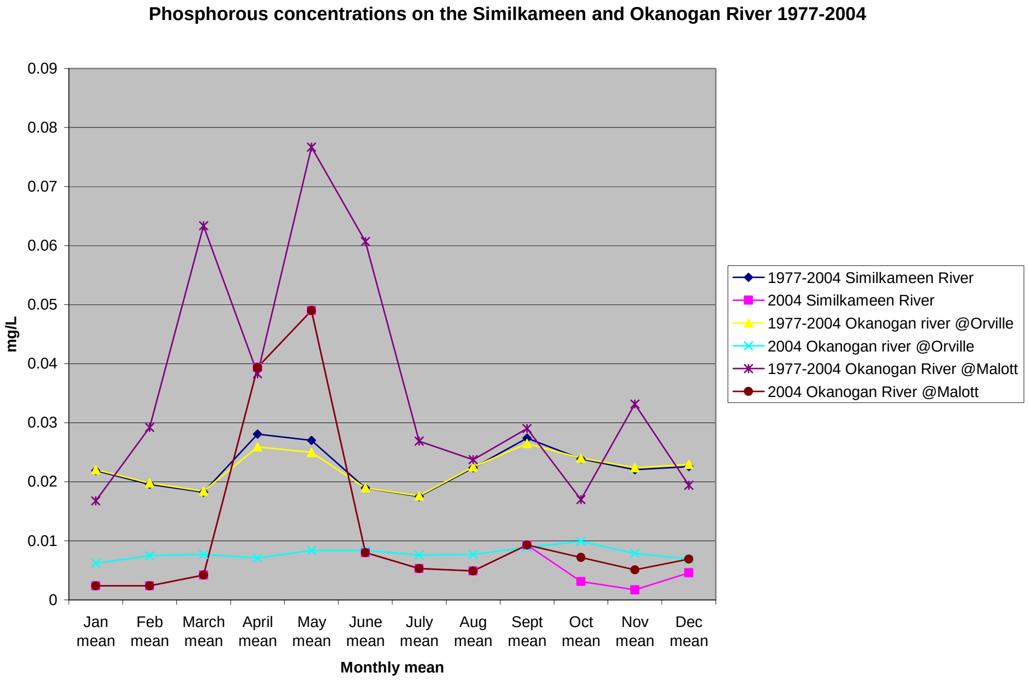

Figure 23. Grab sample data for total phosphorous collected by WDOE for the Similkameen and upper Okanogan River site located at the town of Oroville, WA plus the lower Okanogan River site near the town of Malott, WA comparing the historic average from 1977 to present and 2004.

Conductivity

Water conductivity is directly related to total ion concentration and increases with water temperature. Water containing mostly inorganic compounds conduct electricity better than those containing mostly organic compounds because the later are more likely to dissociate in solution (APHA 1992). Distilled water has very low conductivity (0.5-3.0 µS/cm), Freshwater typically has conductivity ratings from 50 to 1,500 µS/cm and seawater is typically 500 times more conductive (Reynolds 1996). Conductivity has no direct biological impact on salmonids but is easily measured using inexpensive electronic meters. Water conductivity is the most important environmental factor that impacts electro-fishing. Extreme conductivity, whether low or high, exceeds the capacity of most power sources and reduces efficiency (Reynolds 1996).

Conductivity on the Okanogan River near Malott and on the Similkameen River as measured near the town of Oroville varied similarly in 2004 and for averages from 1977 through 2004 (Figure 24). The historic average readings ranged between 260 µS/cm in February and 290 µS/cm in August (Figure 24). In 2004, conductivity readings were consistently below the historic average and changes were far more dramatic with readings of 200 µS/cm in February, 110 µS/cm in April, 70 µS/cm in May, 80 µS/cm in June, and 170 µS/cm in August (Figure 24). During the winter of 2004, the Similkameen River conductivity remained very low while the Okanogan River returned to near historic levels near Malott. The upper Okanogan River flowing out of Canada showed considerable stability both between years and between months

(Figure 24). In 2004, readings stayed above historic averages by approximately 20 to 40 µS/cm until December when the readings dropped to a similar level below the historic average (Figure 24).

Along the Okanogan and Similkameen River main-stems conductivity is of little biological value and a long-term data set has been established by WDOE therefore addition data collection for this indicator is unwarranted for the purposes of salmon recovery. Although collecting additional conductivity data on tributary habitats would have some benefits from an information perspective. The largest benefits would be derived by collecting conductivity data only when attempting to do electro-fishing because of the very low conductivity that is known to exist in the Okanogan River basin.

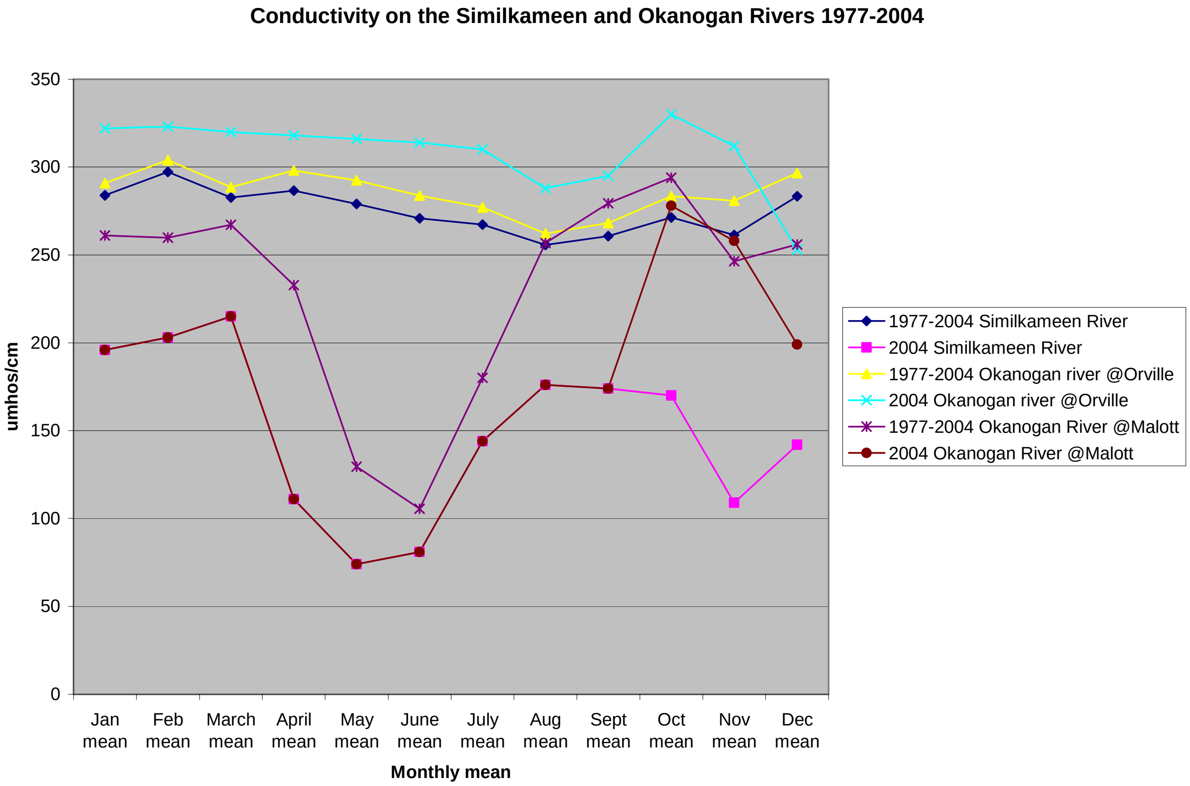

Figure 24. Grab sample data for conductivity collected by WSDOE for the Similkameen and upper Okanogan River site located at the town of Oroville, WA plus the lower Okanogan River site near the town of Malott, WA comparing the historic average from 1977 to present and 2004.

Historic Juvenile Salmonid Data

Data has been collected by the Department of Fisheries and Oceans, Canada (DFO) and the Okanogan Nation Alliance on juvenile Sockeye in Osoyoos Lake. Currently this is the only available rearing habitat for juvenile sockeye whose origin is in Canada. This data was collected from Osoyoos Lake using hydroacoustic methodologies.

(Adapted from Hyatt and Rankin 2004)

Table 1. Osoyoos Lake sockeye egg to fry survival for Broodyear 2001.

		Age Composition			Sex Ratio(b)		
Brood Year	**Spawning Escapement(a)**	**1.1**	**1.2**	**1.3**	**Females**	**Males**	**Potential Eggs-c**
2001	33,971	0.03	0.944	0.023	0.55	0.45	35,368,907
	(AUC units)						
	74,453						
	(Wells units)						
Brood Year	**Spawning Escapement(a)**	**Acoustic Survey Date**		**Estimated juvenile numbers**	**95% CI**	**Egg to fry Survival**	**Fry per female**
2001	33,971	23-Apr-02		3,309,000	21%	9%	177.1
	(AUC units)	29-Oct-02		1,833,000	18%	5%	98.1
		25-Nov-02		2,081,000	20%	6%	111.4
	74,453	24-Feb-03		1,877,000	12%	5%	100.5
	(Wells units)						
		Age Composition			**Sex Ratio(b)**		
Brood Year	**Spawning Escapement(a)**	**1.1**	**1.2**	**1.3**	**Females**	**Males**	**Potential Eggs-c**
2001	33,971	0.03	0.944	0.023	0.55	0.45	53,791,380
	(AUC units)						
	74,453						
	(Wells units)						
Brood Year	**Spawning Escapement(a)**	**Acoustic Survey Date**		**Estimated juvenile numbers**	**95% CI**	**Egg to fry Survival**	**Fry per female**
2001	33,971	23-Apr-02		3,309,000	21%	6%	177.1
	(AUC units)	29-Oct-02		1,833,000	18%	3%	98.1
		25-Nov-02		2,081,000	20%	4%	111.4
	74,453	24-Feb-03		1,877,000	12%	3%	100.5
	(Wells units)						

a. AUC estimate of Okanogan River Sockeye spawners in 2001 (CNAT 2.0). AUC estimates rather than Wells Dam estimates of escapement have been used In survival calculations because AUC estimates are believed to better reflect the number of fish that spawn successfully.

b. Average female to male ratio from selected years between 1952 and 2000. n=22 years

c. Assumes average fecundity as reported in ONFD biosampling sheets
d. Assumes average fecundity from Okanogan River biosampling program as reported in Peters and Marmorek 2003.

(Adapted from Hyatt and Rankin 2004)

Table 2. Osoyoos Lake sockeye egg to fry survival for Broodyear 2002.

		Age Composition			Sex Ratio(b)		
	Spawning Escapement(a)	**1.1**	**1.2**	**1.3**	**Females**	**Males**	**Potential Eggs-c**
Brood Year	5,991	0.05	0.6	0.35	0.55	0.45	7,964,136
2002	(AUC units)						
	10,586						
	(Wells units)						
Brood Year		**Acoustic Survey Date**		**Estimated juvenile numbers**	**95% CI**	**Egg to fry Survival**	**Fry per female**
2002	5,991	26-May-03		2,052,000	22%	26%	622.8
	(AUC units)	21-Sep-03		822,000	10%	10%	249.5
		2-Mar-04		434,000	14%	5%	131.7
	10,586						
	(Wells units)						
		1.1	**1.2**	**1.3**	**Females**	**Males**	**Potential Eggs-c**
Brood Year	**Spawning Escapement(a)**	0.05	0.6	0.35	0.55	0.45	9,486,449
2002	5,991						
	(AUC units)						
	10,586						
	(Wells units)						
		Acoustic Survey Date		**Estimated juvenile numbers**	**95% CI**	**Egg to fry Survival**	**Fry per female**
Brood Year	**Spawning Escapement(a)**	26-May-03		2,052,000	22%	22%	622.8
2002	5,991	21-Sep-03		822,000	10%	9%	249.5
	(AUC units)	2-Mar-04		434,000	14%	5%	131.7
	10,586						
	(Wells units)						

a. AUC estimate of Okanogan River Sockeye spawners in 2002 (H.Wright pers com)
b. Average female to male ratio from selected years between 1952 and 2002. n=24 years
c. Assumes average fecundity as reported in ONFD biosampling sheets

d. Assumes average fecundity from Okanogan River biosampling program as reported in Peters and Marmorek 2003.

Task 2b. -. Develop new data repository: Establish a database system for all new and existing monitoring and evaluation data as delivered in task 2a and set-up spreadsheets and information technology for analysis and upload and downloading new data.

A high-capacity data repository server was purchased, configured, and installed at the CCT Fisheries office in Omak. A structure for the data Repository was created and implemented for use via File Transfer Protocol (FTP) access. A file structure for housing the data was created and refined. The file structure will help ensure the orderly collection and retrieval of data from the archive. A master database of all data being incorporated into the repository was created, and is being populated with information such as data source, contact information, ranges of location and dates, data reliability, and data format. Methods for conversion of non-electronic data into electronic form have been discussed (for example, scanning of documents, and conversion to text via Optical Character Recognition (OCR)).

Long-term database needs were assessed by looking at the data requirements discussed in OBMEP. Preliminary database conceptual designs were created to support the efforts of OBMEP. These include preliminary database designs, with detailed conceptual field definitions. We participated in numerous local and regional workshops and meetings where database structure and standards were discussed. The decisions and guidance from these workshops and discussions will be used to guide further database development. This is critical to ensure the seamless sharing and 'roll-up' of data from the regions to the ESU to the Columbia Basin, an essential requirement for both BPA and NOAA Fisheries. The database structure continues to be defined and modified as discussions continue and as standards emerge. We expect to have an initial physical implementation of the database created and running by 2nd Quarter of 2005.

In addition, protocols for field data collection were assessed, and database dictionaries created to support data collection by field personnel, so that all data that need to be collected in the field are supported in a master database. The data dictionaries were written so they can be used with Trimble hand-held data collectors in the field. We have purchased or uploaded all of the appropriate GIS software and have been using the program Arcmap to create maps of our selected sites.

Task 2c. - Report writing, permitting, NOAA fisheries consultations, BPA contracting and presentation of results.

We have written submitted all quarterly reports and this annual report in accordance with BPA contractual obligations. Completed consultations with BPA and all work completed this year could be completed under the HIP BIOP. We have begun writing a biological opinion for smolt trapping activities that will occur in the spring of 2006 following consultations with NOAA Fisheries. We have been in contact with subcontractors and consultants to help with this task. We have been in contact and have reported repeatedly to BPA contracting on our accounting and progress on the Okanogan Monitoring and Evaluation project especially in regard with protocol development. We have presented results on setting up a monitoring and evaluation program at regional American Fisheries Society Meetings in early November and various local forums were used to inform other agencies and local stakeholders about out progress, data, and future direction.

NOAA Fisheries, Washington Department of Wildlife (Habitat and Fish Program), Okanogan County, USFWS, and COLVILLE TRIBAL Planning/Permit Department Staff were contacted regarding permit requirements to conduct smolt trapping beginning in year 2005. Permit applications for 2005 smolt trapping activities were completed during this contract period. These included applications for NOAA Fisheries Section 10 Incidental Take Permit and Washington Department of Fish and Wildlife Scientific Collection Permit as well as JARPA and SEPA documents which were submitted to the COLVILLE TRIBES Planning Department as required for HPA and Shoreline permits. A Statement of Work specific to this activity complete with site diagrams and schematics was also completed to satisfy permit application requirements. The USFWS was contacted regarding permit requirements related to potential take of ESA Threatened Bull Trout which may possibly occur in the Okanogan Sub-basin. A letter of concurrence from the USFWS authorizing the smolt trapping activities is expected.

Research Selective Fishing Gear

Objective 3. Research selective fishing gears for potential effectiveness and sites, and possible future use for selective Tribal subsistence fisheries and/or broodstock collection programs.

Cooperative efforts between the Colville Tribes and WDFW resulted in an effort to collect and release summer/fall Chinook using both gill and tangle nets to determine which would be best suited for future possible selective gear fisheries. Although few fish were collected as part of this effort we did learn several things that can be used to help in future decision making and planning efforts. Details on this research can be found in appendix D of this document. The primary findings of this effort were;

1) Tangle nets collected more fish of a variety of non-target species and also collected more debris than gill nets.
2) Gill-nets could possibly more effective for a selective gear fishery but would need to have short soak times and be closely monitored.
3) Tangle nets potentially are poorly suited for brood-stock collection because they are more likely to collect male fish.
4) More research is needed to make statistical analysis possible.

Habitat Inventory and Analysis

Objective 4. – Collect current physical data for habitat, and passage conditions throughout the basin to meet EMAP and EDT requirement and to prioritize future management and rehabilitation efforts.

Considerable progress has been made in planning and implementing data collection activities. Equipment has been purchased and employees hired to carry out this task. The EMAP sites were selected, indicators determined, and data collected for this year. We collected habitat data at 12 sites in the Okanogan Basin in September and early October. We conducted rapid barrier surveys on Antonie, Nine-mile, Inkameep, McIntyre, Bonaparte, and Tunk Creeks. Barriers to anadromus fish were verified and located by GPS on five of the six creeks. We have visited numerous EMAP sites and have determined there potential for salmonid production. We have selected 100 EMAP sites as possible study sites and continue to confirm there potential for our rotating panels and get landowner permission to access tributary sites.

The following summary tables (Table 3-10a) are from our data collected in 2004 at twelve of our annual EMAP sites. The summary tables compare data between sites and are divided into tributary and main stem Okanogan River sites. These tables represent only selected values the complete spreadsheet can be obtained from the Colville Tribes by contacting John Arterburn at (509)-422-7424 or by E-mail at john.arterburn@colvilletribes.com.

We reviewed the literature to determine if specific measures or values for habitat perimeters could be analyzed on there own merit. Habitat suitability curves, properly functioning condition values, and other modeling efforts have attempted to quantify specific habitat variables with very limited success. The large number of covariates and the dynamic nature of aquatic environments confound most attempts to validate connections between habitat variable and fish production. Gross measures of habitat values have been developed for identifying areas were certain species are highly unlikely to be found but these values do little to assist in recovery efforts for marginal populations of salmonids. Salmonids are found in such diverse habitats that this type of analysis is unlikely to ever evolve to a high level of specificity.

We were unable to set a specific list of variable by which to determine good habitats from bad. We therefore believe the best measures of habitat variables will utilize status and trend over time to determine if each individual variable is getting better or worse in relation to population levels specifically in the Okanogan River basin. However, this will require several years of data before any such analysis can move forward so we are only presenting raw habitat and summary habitat data rather than hypothesizing on what the observed values could mean for anadromous fish.

Table 3. Channel Condition Parameters (Means)

Site ID	Tributary	Wetted Width	Bankful width (m)	Bankful depth (m)	Bankful width/depth Ratio
520	Johnson Creek	2.95	5.32	1.20	4.77
360	Middle Salmon Creek	8.84	10.62	3.21	10.04
388	Bonaparte Creek	2.42	4.20	0.71	6.24

177	Lower McIntyre Creek	11.10	16.41	1.15	14.68
535	Inkaneep Creek	3.89	7.52	0.88	8.93
19	Omak Creek at Moomaws	5.35	7.81	0.84	9.57
27	Lower Nine-mile Creek	1.86	6.51	0.90	7.34
48	Omak Creek Below Stapaloop cr.	6.38	7.32	0.93	9.97
	Mainstem Habitats				
156	Okanogan River at Malott	102.42	106.22	2.82	38.02
64	Okanogan River at Dricole	33.16	39.87	1.81	25.23
84	Okanogan River at Oak street bridge	86.07	88.56	3.43	27.58
46	Smilkameen River at Orville	65.06	67.91	2.18	32.70

Table 3a. Channel Condition Parameters (Means)

Site ID	**Tributary**	**Depth across transect (cm)**	**Pool/Riffle Ratio**	**Channel Embedded-ness (%)**	**Canopy Cover %**	**Riparian Width**
520	Johnson Creek	6.93	0.10	68.52	89.71%	4.95
360	Middle Salmon Creek	24.01	3.23	66.65	71.39%	16.85
388	Bonaparte Creek	9.38	0.48	76.41	89.97%	No data
177	Lower McIntyre Creek	9.28	0.02	37.58	20.05%	9.55
535	Inkaneep Creek	7.58	0.55	66.29	75.53%	10.65
19	Omak Creek at Moomaws	7.16	1.38	71.14	76.74%	19.20
27	Lower Nine-mile Creek	1.88	0.50	75.57	96.52%	10.99

48	Omak Creek Below Stapaloop cr.	18.89	4.70	75.87	68.72%	14.43
	Mainstem Habitats					
156	Okanogan River at Malott	93.21	10.00	98.67	19.92%	14.98
64	Okanogan River at Dricole	41.91	5.34	76.71	31.02%	13.55
84	Okanogan River at Oak street bridge	128.08	10.00	87.33	35.70%	12.64
46	Smilkameen River at Orville	61.82	0.00	69.90	31.82%	15.20

Table 4. Snorkeling data-Fish detected per transect (Means)

Site ID	Tributary	Total Salmonids	Salmonids <100mm	Salmonids 100-300mm	Salmonids 100-300mm
520	Johnson Creek	0.00	0.00	0.00	0.00
360	Middle Salmon Creek	18.67	0.20	0.00	0.60
388	Bonaparte Creek	23.80	0.30	0.00	0.00
177	Lower McIntyre Creek	No data	No data	No data	No data
535	Inkaneep Creek	0.50	0.00	0.10	0.00
19	Omak Creek at Moomaws	3.10	0.00	0.00	0.00
27	Lower Nine-mile Creek	3.10	10.00	0.00	0.00
48	Omak Creek Below Stapaloop cr.	20.89	1.57	0.11	0.00
	Mainstem Habitats				

156	Okanogan River at Malott	No data	No data	No data	No data
64	Okanogan River at Dricole	0.20	0.00	0.00	0.00
84	Okanogan River at Oak street bridge	No data	No data	No data	No data
46	Smilkameen River at Orville	No data	No data	No data	No data

Table 4a. Snorkeling data-Fish detected per transect (Means)

Site ID	Tributary	Total O.Mykiss	O. Mykiss <100mm	O. Mykiss 100-300 mm	O. Mykiss >300mm	Total Non-Salmonids
520	Johnson Creek	0	0	0	0	0
360	Middle Salmon Creek	16.6	1.1	8.9	6.6	0.8
388	Bonaparte Creek	23.3	14.6	6.4	2.3	0.2
177	Lower McIntyre Creek	No data	No data	No data	No data	No data
535	Inkaneep Creek	0	0	0	0	0
19	Omak Creek at Moomaws	3.1	2.3	0.8	0	0
27	Lower Nine-mile Creek	2.9	2	0.9	0	0
48	Omak Creek Below Stapaloop cr.	8.67	7.22	1.44	0	9.1
	Mainstem Habitats					
156	Okanogan River at Malott	No data	No data	No data	No data	No data

64	Okanogan River at Dricole	0	0	0	0	0.8
84	Okanogan River at Oak street bridge	No data	No data	No data	No data	No data
46	Smilkameen River at Orville	No data	No data	No data	No data	No data

Table 5. Snorkeling data-Total Fish counted

Site ID	Tributary	Total Salmonids	Salmonids <100mm	Salmonids 100-300mm	Salmonids 100-300mm
520	Johnson Creek	0	0	0	0
360	Middle Salmon Creek	168	2	0	6
388	Bonaparte Creek	238	3	0	0
177	Lower McIntyre Creek	No data	No data	No data	No data
535	Inkaneep Creek	5	4	1	0
19	Omak Creek at Moomaws	31	0	0	0
27	Lower Nine-mile Creek	31	2	0	0
48	Omak Creek Below Stapaloop cr.	217	29	1	0
	Mainstem Habitats				
156	Okanogan River at Malott	No data	No data	No data	No data
64	Okanogan River at Dricole	2	0	0	0
84	Okanogan River at Oak street bridge	No data	No data	No data	No data
46	Smilkameen River at Orville	No data	No data	No data	No data

Table 5a. Snorkeling data-Total Fish counted

Site ID	Tributary	O. Mykiss <100mm	O. Mykiss 100-300 mm	O. Mykiss >300mm	Total Non-Salmonids
520	Johnson Creek	0	0	0	0
360	Middle Salmon Creek	89	66	166	8
388	Bonaparte Creek	64	23	233	2
177	Lower McIntyre Creek	No data	No data	No data	No data
535	Inkaneep Creek	0	0	0	0
19	Omak Creek at Moomaws	8	0	31	0
27	Lower Nine-mile Creek	9	0	29	0
48	Omak Creek Below Stapaloop cr.	17	0	96	91
	Mainstem Habitats				
156	Okanogan River at Malott	No data	No data	No data	No data
64	Okanogan River at Dricole	0	0	0	8
84	Okanogan River at Oak street bridge	No data	No data	No data	No data
46	Smilkameen River at Orville	No data	No data	No data	No data

Table 6. Percent occurrence of habitat types

Site ID	Tributary	Primary Pool	Beaver Pool	Pool Tail out	Glide
520	Johnson Creek	8%	0%	3%	0%
360	Middle Salmon Creek	4%	32%	7%	0%
388	Bonaparte Creek	13%	0%	4%	10%
177	Lower McIntyre Creek	8%	0%	2%	0%
535	Inkaneep Creek	9%	11%	2%	8%
19	Omak Creek at Moomaws	23%	0%	3%	11%
27	Lower Nine-mile Creek	21%	0%	4%	1%
48	Omak Creek Below Stapaloop cr.	18%	52%	7%	3%
	Mainstem Habitats				
156	Okanogan River at Malott	0%	0%	0%	100%
64	Okanogan River at Dricole	13%	0%	4%	55%
84	Okanogan River at Oak street bridge	0%	0%	0%	100%
46	Smilkameen River at Orville	0%	0%	0%	0%

Table 6a. Percent occurrence of habitat types

Site ID	Tributary	Large Cobble Riffle	Small Cobble Riffle	Side Channels	Backwaters	Rapids	Cascade/ Falls
520	Johnson Creek	12%	0%	0%	0%	34%	44%
360	Middle Salmon Creek	35%	23%	34%	0%	0%	0%

388	Bonaparte Creek	5%	55%	0%	0%	14%	0%
177	Lower McIntyre Creek	21%	0%	100%	0%	71%	1%
535	Inkaneep Creek	69%	0%	0%	0%	0%	1%
19	Omak Creek at Moomaws	59%	4%	4%	0%	0%	0%
27	Lower Nine-mile Creek	18%	54%	0%	0%	0%	2%
48	Omak Creek Below Stapaloop cr.	5%	15%	9%	0%	0%	0%
	Mainstem Habitats						
156	Okanogan River at Malott	0%	0%	0%	0%	0%	0%
64	Okanogan River at Dricole	5%	23%	0%	0%	0%	0%
84	Okanogan River at Oak street bridge	0%	0%	0%	0%	0%	0%
46	Smilkameen River at Orville	100%	0%	0%	0%	0%	0%

Table 7. Percent occurrence of substrate types

Site ID	Tributary	Bedrock	Boulder	Large Cobble	Small Cobble
520	Johnson Creek	0%	30%	9%	0%
360	Middle Salmon Creek	0%	0%	21%	27%
388	Bonaparte Creek	0%	1%	7%	10%
177	Lower McIntyre Creek	0%	7%	40%	31%
535	Inkaneep Creek	0%	4%	46%	10%
19	Omak Creek at Moomaws	0%	3%	13%	21%

27	Lower Nine-mile Creek	0%	0%	6%	13%
48	Omak Creek Below Stapaloop cr.	0%	6%	6%	3%
	Mainstem Habitats				
156	Okanogan River at Malott	0%	0%	0%	0%
64	Okanogan River at Dricole	0%	0%	8%	19%
84	Okanogan River at Oak street bridge	0%	1%	6%	16%
46	Smilkameen River at Orville	0%	0%	50%	21%

Table 7a. Percent occurrence of substrate types

Site ID	Tributary	Coarse Gravel	Fine Gravel	Sand	Silt/Clay/ Muck (Fines)	Wood	Other
520	Johnson Creek	3%	43%	6%	0%	10%	0%
360	Middle Salmon Creek	9%	5%	6%	30%	2%	0%
388	Bonaparte Creek	6%	2%	3%	63%	7%	3%
177	Lower McIntyre Creek	7%	2%	1%	10%	1%	0%
535	Inkaneep Creek	7%	0%	15%	16%	3%	0%
19	Omak Creek at Moomaws	13%	0%	5%	41%	4%	0%
27	Lower Nine-mile Creek	8%	3%	4%	60%	7%	0%
48	Omak Creek Below Stapaloop cr.	9%	3%	25%	47%	2%	0%
	Mainstem Habitats						

156	Okanogan River at Malott	31%	2%	47%	20%	0%	0%
64	Okanogan River at Dricole	35%	13%	5%	20%	0%	0%
84	Okanogan River at Oak street bridge	2%	2%	60%	13%	0%	0%
46	Smilkameen River at Orville	8%	0%	2%	19%	1%	0%

Table 8. Percent occurance of measured vegetation parameters

		Canopy Shading		**Understory shading**	
	Riparian Vegetation	**Big trees (>0.3m, DBH & >5m high)**	**Small trees (<0.3m, DBH & >5m high)**	**Woody shrubs/saplings (0.5 to 5m high)**	**Non-woody (0.5 to 5m high)**
Site ID	**Tributary**	**(%)**	**(%)**	**(%)**	**(%)**
520	Johnson Creek	3%	24%	48%	4%
360	Middle Salmon Creek	5%	45%	39%	10%
388	Bonaparte Creek	6%	26%	23%	7%
177	Lower McIntyre Creek	0%	10%	20%	2%
535	Inkaneep Creek	21%	40%	45%	5%
19	Omak Creek at Moomaws	0%	54%	53%	7%
27	Lower Nine-mile Creek	7%	37%	50%	7%
48	Omak Creek Below Stapaloop cr.	0%	36%	57%	22%
Mainstem Habitats					
156	Okanogan River at Malott	24%	30%	34%	49%

64	Okanogan River at Dricole	15%	22%	50%	25%
84	Okanogan River at Oak street bridge	20%	30%	48%	6%
46	Smilkameen River at Orville	6%	15%	53%	10%

Table 8a. Percent occurance of measured vegetation parameters. Ground Cover (<0.5m high)

	Riparian Vegetation	**Woody shrubs/ saplings**	**Non-woody**	**Barren dirt/duff**	**LWD**
Site ID	**Tributary**	**(%)**	**(%)**	**(%)**	**(%)**
520	Johnson Creek	21%	17%	24%	2%
360	Middle Salmon Creek	13%	34%	33%	7%
388	Bonaparte Creek	8%	29%	17%	6%
177	Lower McIntyre Creek	11%	11%	30%	5%
535	Inkaneep Creek	29%	45%	24%	9%
19	Omak Creek at Moomaws	29%	50%	33%	9%
27	Lower Nine-mile Creek	25%	29%	56%	9%
48	Omak Creek Below Stapaloop cr.	26%	74%	8%	7%
Mainstem Habitats					
156	Okanogan River at Malott	22%	51%	49%	7%
64	Okanogan River at Dricole	31%	68%	25%	8%
84	Okanogan River at Oak street	32%	32%	37%	10%

	bridge				
46	Smilkameen River at Orville	39%	45%	36%	8%

Table 9. Percent occurance of human influence

Site ID	Tributary	Wall/ Dike/ Revetment /Riprap /Dam	Buildings	River access site	Pavement/ Road/ Railroad
520	Johnson Creek	5%	0%	18%	50%
360	Middle Salmon Creek	0%	0%	0%	0%
388	Bonaparte Creek	0%	50%	27%	36%
177	Lower McIntyre Creek	5%	0%	0%	0%
535	Inkaneep Creek	14%	0%	14%	9%
19	Omak Creek at Moomaws	0%	0%	36%	27%
27	Lower Nine-mile Creek	0%	0%	5%	100%
48	Omak Creek Below Stapaloop cr.	0%	0%	5%	0%
	Mainstem Habitats				
156	Okanogan River at Malott	0%	0%	5%	0%
64	Okanogan River at Dricole	0%	18%	32%	0%
84	Okanogan River at Oak street bridge	95%	55%	32%	36%
46	Smilkameen River at Orville	50%	27%	14%	59%

Table 9a. Percent occurance of human influence

Site ID	Tributary	Pipes (inlet/ outlet)	Garbage pile	Cleared lot/ Lawn	Orchard/Row Crops	Pasture/ Range/ Hay Field	Logging
520	Johnson Creek	5%	0%	0%	0%	0%	0%
360	Middle Salmon Creek	0%	0%	0%	0%	45%	0%
388	Bonaparte Creek	5%	14%	82%	0%	0%	0%
177	Lower McIntyre Creek	0%	0%	0%	0%	0%	55%
535	Inkaneep Creek	0%	0%	0%	0%	82%	0%
19	Omak Creek at Moomaws	0%	0%	0%	0%	18%	9%
27	Lower Nine-mile Creek	0%	14%	36%	50%	0%	0%
48	Omak Creek Below Stapaloop cr.	0%	0%	0%	0%	14%	32%
	Mainstem Habitats						
156	Okanogan River at Malott	0%	5%	0%	50%	41%	0%
64	Okanogan River at Dricole	14%	0%	5%	50%	0%	0%
84	Okanogan River at Oak street bridge	0%	27%	55%	0%	23%	0%
46	Smilkameen River at Orville	5%	5%	55%	5%	14%	0%

Table 10. Number of logs with differing large end diameters (LED) and lengths

Site ID	Tributary	Logs With LED (0.1<0.3m) & Length (1.5<5m)	Logs With LED (0.1<0.3m) & Length (5<15m)	Logs With LED (0.1<0.3m) & Length (>15m)	Logs With LED (0.3<0.6m) & Length (1.5<5m)

520	Johnson Creek	50	7	0	0
360	Middle Salmon Creek	87	16	0	3
388	Bonaparte Creek	8	1	0	3
177	Lower McIntyre Creek	34	4	0	6
535	Inkaneep Creek	19	7	0	1
19	Omak Creek at Moomaws	44	8	0	0
27	Lower Nine-mile Creek	16	0	0	1
48	Omak Creek Below Stapaloop cr.	70	13	1	9
Mainstem Habitats					
156	Okanogan River at Malott	24	4	0	3
64	Okanogan River at Dricole	49	3	0	29
84	Okanogan River at Oak street bridge	60	10	0	24
46	Smilkameen River at Orville	6	6	0	0

Table 10a. Number of logs with differing large end diameters (LED) and lengths

Site ID	**Tributary**	**Logs With LED(0.3<0.6m) & Length (5<15m)**	**Logs With LED (0.3<0.6m) & Length (>15m)**	**Logs With LED (0.6<0.8m) & Length (1.5<5m)**	**Logs With LED (0.6<0.8m) & Length (5<15m)**	**Logs With LED (0.6<0.8m) & Length (>15m)**	**Logs With LED (>0.8m) & Length (1.5<5m)**
520	Johnson Creek	0	0	0	0	0	0
360	Middle Salmon Creek	0	0	1	0	0	0

388	Bonaparte Creek	0	0	1	0	0	0
177	Lower McIntyre Creek	0	0	1	2	0	0
535	Inkaneep Creek	0	0	0	0	0	0
19	Omak Creek at Moomaws	0	0	0	0	0	0
27	Lower Nine-mile Creek	0	0	0	0	0	0
48	Omak Creek Below Stapaloop cr.	3	0	0	0	0	1
Mainstem Habitats							
156	Okanogan River at Malott	6	0	0	2	0	0
64	Okanogan River at Dricole	23	0	2	5	0	0
84	Okanogan River at Oak street bridge	10	6	6	1	1	0
46	Smilkameen River at Orville	0	0	0	0	0	0

Literature cited

Armantrout, N. B., Compiler. 1998. Glossary of Aquatic Habitat Inventory Terminology. American Fisheries Society, Bethesda, Maryland.

APHA, 1992. Standard Method for the examination of water and wastewater, 19th edition. American Public Health Association, Washington, D.C.

Aquatic and Riparian Effectiveness Monitoring Program (AREMP) Staff Multi-federal Agency Monitoring Program and PACFISH/INFISH (PIBO) Effectiveness Monitoring Program Staff. 2004. Effectiveness Monitoring for Streams and Riparian Areas within the Pacific Northwest. Stream Channel Methods for Core Attributes. Corvallis, OR. Logan, UT.

Bisson, P.A., and R.E. Bilby. 1982. Avoidance of suspended sediment by juvenile coho salmon. North American Journal of Fisheries Management 2:371-374.

Burrows, R. E. 1964. Effects of accumulated excretory products on hatchery reared salmonids. U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife Research Report 66.

Colt, J. E., J. R. Tomasso. 2001. Hatchery water supply and treatment. Pages 91-186 in G. A, Wedemeyer, editor. Fish hatchery management, second edition. American Fisheries Society, Bethesda, MD.

Davis, J. C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. Journal of the Fisheries Research Board of Canada 32:2295-2332.

Hawkins, C.P. and 10 co-authors. 1993. A hierarchical approach to classifying stream habitat features. Fisheries (Bethesda) 18(6): 3-12.

Hillman, T.W. 2004. Monitoring Strategy for the Upper Columbia Basin. Draft Report. February, 2004. 107 pages.

Hyatt, K.D. and D.P. Rankin. 2004. Fish and Water Management Tools (FWMT) Project Assessments: Osoyoos Lake juvenile sockeye salmon (Oncorhynchus nerka) production associated with the 2001 and 2002 brood year returns of adults to the Okanogan R. British Columbia. Report to file: JSIDS-SRel-04. Stock Assessment Division, Fisheries and Oceans Canada, Nanaimo, B.C., V9T 6N7

Jenkins, R. E., and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD.

Kauffman, P.R., P. Levine, E.G. Robinson, C. Seeliger, and D.V. Peck. 1999. Quantifying physical habitat in wadeable streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.

LaPerriere, J. D., and 5 coauthors. 1983. Effects of gold placer mining on interior Alaska stream ecosystems. Pages 12/1-12/34 in j. w. Aldrich, editor. Managing water resources for Alaska's development. University of Alaska, Institute of water resources report IWR-105, Fairbanks, AK.

Lestelle, L.C. 2004. Guidelines for Rating Level 2 Environmental Attributes in Ecosystem Diagnosis and Treatment (EDT). Mobrand Biometrics Inc.

Lloyd, R., J. P. Koenings, and J. D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

Moore, K., K. Jones and J. Dambacher. 1998.. Methods for stream habitat surveys aquatic inventory project. Oregon Department of Fish and Wildlife. Corvallis, OR. 36p.

Moore, K., K. Jones, J. Dambacher, J. Burke, and C. Stein. 1999. Surveying Oregon's Streams "A Snapshot In Time": Aquatic Inventory Project Training Materials and Methods for Stream Habitat Surveys. P. Bowers, ed. Oregon Department of Fish and Wildlife. Portland, OR. 272 pp.

Nickelson, T.E., M.F. Solazzi, S.L. Johnson, and J.D. Rodgers. 1992. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in in Oregon coastal streams.Canadian Journal of Fisheries and Aquatic Sciences 49:783-789.

Norris, L. A., H. W. Lorz, and S. V. Gregory, 1991. Forest Chemicals. American Fisheries Society Publication 19:207-295.

Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). Unpublished draft. Environmental Monitoring and Assessment Program - Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. EPA/XXX/X-XX/XXXX. U.S. Environmental Protection Agency, Washington, D.C.

Piper, R. G., and five coauthors. 1982. Fish hatchery management. U.S. Fish and Wildlife Service, Washington, D.C.

Reynolds, J. B. 1996. Electrofishing. Pages 221-253 *in*: B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Rosgen, D., 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Russo, R. C., V. R. Thurston. 1991. Toxicity of ammonia, nitrite, and nitrate to fishes. Pages 58-89 in D.E. Brune and J. R. Tomasso, editors. Aquaculture and water quality. World Aquaculture Society, Baton Rouge, LA.

Russo, R. C., V. R. Thurston, and K. Emerson. 1981. Acute toxicity of nitrite to rainbow trout (*salmon gairdneri*): effects of pH, nitrite species, and anion species. Canadian Journal of Fisheries and Aquatic Sciences 38:387-393.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transaction of the American Fisheries Society 113:142-150.

Sorenson, D. L., M. M. McCarthy, E. J. Middlebrooks, and D. B. Porcella. 1977. Suspended and dissolved solids effects on freshwater biota. U. S. Environmental Protection Agency, EPA-600/3-77-042.

Summerfelt, S., J. Bebak-Williams, and S. Tsukuda. 2001. Controlled systems: water reuse and circulation. Pages 285-395 in G. A, Wedemeyer, editor. Fish hatchery management, second edition. American Fisheries Society, Bethesda, MD.

Van Nieuwenhuyse, E. E., and J. D. LaPerriere, 1986. Effects of placer mining on primary production in subarctic streams of Alaska. Water Resources Bulletin 22:91-99.

Washington Department of Fish and Wildlife. 2000. Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual. Habitat Program. Environmental Restoration Division. SSHEAR Section. 158 pages including appendices.

Wedemeyer, G. A. 1996. Physiology of fish in intensive culture sysyems. Chapman and Hall, New York.

Appendix A

OBMEP Field Protocols