

THE COLVILLE TRIBES OKANOGAN BASIN MONITORING AND EVALUATION PROGRAM 2007 ANNUAL REPORT



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**Colville Tribes
Fish & Wildlife Department
Anadromous Fish Division**

**Okanogan Basin Monitoring & Evaluation Program
2007 Report**

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Executive Summary

The Colville Tribes Anadromous Fisheries Department began this project in the spring of 2004 to provide essential information on habitat conditions and fish populations. The collected data has already greatly expanded the level of knowledge being used in planning efforts and for fisheries management in the Okanogan basin. Information related to status and trend for all salmon and steelhead within the Okanogan River basin requires a long-term vision and commitment to provide answers about population level action effectiveness.

The Okanogan Basin Monitoring and Evaluation Program is not just another regional monitoring strategy. Rather, this plan draws from the existing strategies (ISAB, Action Agencies/NOAA Fisheries, and WSRFB) and outlines an approach for addressing questions specifically related to salmon recovery in the Upper Columbia Basin specifically within the Okanogan River Basin. This project is also specifically designed to monitor key components of the ecosystem related to anadromous salmonids including biological, physical habitat, and water quality parameters plus serve to develop baseline research where data are currently unavailable.

We had another productive year in 2007, by completing work elements related to collection of habitat, snorkel, temperature, steelhead redd, adult enumeration, and smolt production data. We catalogued, archived, analyzed, and reported on these data. Additional cooperative efforts resulted in redd and carcass data collection for summer/fall Chinook, real-time temperature and stream discharge data collection, and international coordination with Canada. All our data and reports are accessible through the World Wide Web and can be accessed through the Okanogan Basin Monitoring and Evaluation Program website, located at:
<http://nrd.colvilletribes.com/obmep/>.

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Introduction

Federal hydropower projects, private power utility systems, habitat degradation, excessive harvest, and human development have negative impacts on anadromous fish that once flourished in the Columbia River basin. A coordinated and comprehensive approach to monitoring and evaluating the 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 sub-basin in particular. Currently, independent research projects and some monitoring activities are conducted by various agencies, tribes, watershed councils, and landowners but there has been no overall framework for coordinating data collection efforts or for the interpretation and synthesis of results prior to 2004.

Fisheries managers implement actions designed to improve the status of fish populations and their habitats within main stem and tributary systems. Until recently, there was little incentive to monitor such actions to see if they met their desired outcome, but funding agencies are increasingly aware of the need for long-term monitoring and evaluation. Limited funding requires elimination of duplicative or contrary efforts and establishment of a process for universal reporting and strategic planning.

Beginning in 2002, the Upper Columbia Regional Technical Team (RTT) attempted to standardize and improve monitoring by developing the Monitoring Strategy for the Upper Columbia Basin (Hillman 2006). A proposal for funding the Okanogan River portion of this strategy was submitted to the Northwest Power and Conservation Council (NPCC) and received a high priority rating from both the Columbia Basin Fish and Wildlife managers and the Independent Scientific Review Panel. Funding for this project was approved in 2003. The Colville Tribes' Anadromous Fisheries Division began implementing this project in the spring of 2004 to provide essential information on habitat threats and fish population viability. The collected data has already greatly expanded the level of knowledge being used in planning efforts and for fisheries management in the Okanogan basin. Information related to status and trend for all salmon and steelhead within the Okanogan River basin requires a long-term vision and commitment to provide answers about population level actions and effectiveness.

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) is not just another regional monitoring strategy. Rather, this program draws from existing strategies (ISAB, Action Agencies/NOAA Fisheries, ISEMP, PNAMP, CSMEP, and WSRFB) and outlines an approach for addressing questions specifically related to anadromous fish management and recovery in the Upper Columbia and more specifically the Okanogan River basins. Therefore, OBMEP is specifically designed to monitor key components of the ecosystem including biological, physical habitat, and water quality parameters. This program also establishes baseline information where data are currently unavailable thus allowing future status and trend analyses to occur.

Methods

As adapted from Hillman (2006), OBMEP developed a set of specific protocols to allow standardized data collection in a rigorous and scientific manner. Snorkel surveys, water quality monitoring, and physical habitat condition sampling are monitored at sites selected using a random spatially balanced rotating panel design (EMAP sites). These EMAP sites are monitored throughout the Okanogan River sub-basin from late March through February 2007. Migrating adult and emigrating juvenile fish are monitored at fixed sites and redd surveys are conducted using a census approach.

Protocols were developed specifically for OBMEP. The current versions of these protocols can be viewed at our web-site:

<http://nrd.colvilletribes.com/obmep/>.

This report is a synopsis of all data collection and reporting efforts conducted under OBMEP for the year of 2007. Additional information relative to specific data collection activities, or links to previous year's reports can be found at:

<http://nrd.colvilletribes.com/obmep/default.htm>

or through the BPA web site at:

<http://www.efw.bpa.gov/searchpublications/#>.

Technical reports or updates completed this year are included in the appendices that follow this report.

Accomplishments

Work Element B: Annual Report

Each year OBMEP produces an annual report. Several additional reports were completed as end products for deliverables. Most of these reports and conclusions are included in this document under the specific data collection work element. This year OBMEP also completed a compilation report related to historic water quality data collection activities in the basin that was in addition to what occurred under OBMEP in 2005 and 2006. The abstract of the water quality report can be read below.

Fish need water of sufficient quality and quantity in order to survive and reproduce. The list of primary water quality indicators appropriate for monitoring of anadromous fish, as identified by the Upper Columbia Monitoring Strategy, includes: discharge, temperature, dissolved oxygen, pH, turbidity, conductivity, nitrogen, phosphorus and ammonia. The Colville Tribes' Fish and Wildlife Department began evaluating these water quality indicators in 2005 and this report represents data collected from October 1, 2005 through September 30, 2006. We collected empirical status and trend data from various sources to evaluate each water quality indicator along the main stem Okanogan and Similkameen Rivers along with several tributary streams. Each water quality indicator was evaluated based upon

potential impacts to salmonid survival or productivity. Specific conductance levels and all nutrient indicators remained at levels acceptable for growth, survival, and reproduction of salmon and steelhead. These indicators were also considered of marginal value for monitoring environmental conditions related to salmonids within the Okanogan subbasin. However, discharge, temperature, turbidity, dissolved oxygen and pH in that order represent the water quality indicators that are most useful for monitoring watershed health and habitat changes and will help to evaluate threats or changes related to salmon and steelhead restoration and recovery. On the Okanogan River minimum flows have decreased over the last 12 years at a rate of 28.3CFS/year as measured near the town of Malott, WA. This trend is not beneficial for salmonid production and efforts to reverse this trend should be strongly encouraged. Turbidity levels in Bonaparte and Omak Creek were a concern because they had the highest monthly average readings. Major upland disturbance in the Bonaparte Creek watershed has occurred for decades and agricultural practices within the riparian areas along this creek have lead to major channel incision and bank instability. High sediment loads continue to threaten the Omak and Bonaparte sub-watersheds. Major rehabilitation efforts are needed within these sub-watersheds to improve salmonid habitats. We found that for the past 12 years dissolved oxygen levels have been on a slightly downward trend during summer/fall Chinook egg incubation. Dissolved oxygen readings in early October, for summer/fall Chinook and from June 4 through early July for summer steelhead can occasionally drop to the range from 8 to 10 mg/L and therefore warrant continued monitoring. Levels of pH represent an indicator that has little monitoring value throughout most of the subbasin. The Similkameen River drainage showed dramatic annual changes in the mean pH values and a declining trend for pH thus warranting continued monitoring. Average daily temperatures, in 2006, exceeded 25°C for eight days in July in the Okanogan River at Malott. Due to increased warm water temperatures, delays in migration have increased at a rate of 1.82 days per year over the last 10 years. Increases in water temperature can be linked to many anthropogenic activities. Increasing water temperatures within the Okanogan River watershed represent the single most limiting factor facing salmonids in main-stem habitats.

A complete report can be downloaded from the OBMEP web site at:

<http://nrd.colvilletribes.com/obmep/pdfs/2006waterqualityreportfinal.pdf>

Or at the BPA web site at:

<http://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P105142>

The full report is provided as Appendix A of this document.

Work Element C: Produce Environmental Compliance Documentation

Permit applications were developed and submitted for operation and collection of fish at our rotary screw trap. All permits were procured before active trapping began. The permits and issuing agencies are as follow:

- | | | |
|-------------------------------------|-----------|----------------|
| • Section 10 Incidental Take Permit | #1520 | NOAA Fisheries |
| • Hydraulic Project Approval (HPA) | #104024-2 | WDFW |
| • Scientific Collection Permit | #07-114 | WDFW |

- Bridge Attachment Permit #7687A WSDOT
- Shoreline Exemption #1040 City of Okanogan

In addition to the above permits OBMEP staff worked with BPA to develop compliance with the HIP-BIOP for all other activities.

Work Element D: Juvenile summer steelhead snorkel surveys at all EMAP sites

The Colville Tribes' Fish and Wildlife Department conducted snorkel surveys in established EMAP sites throughout the Okanogan basin as part of the Okanogan Basin Monitoring and Evaluation Program. In 2007, snorkel surveys were conducted within tributary streams of the Okanogan in both the United States (US) and Canada; main stem sites were snorkeled only in Canada. Eleven different species of fish were identified. The most abundant families of fish observed were Salmonidae and Cyprinidae, and the most abundant species were steelhead/rainbow trout (*Oncorhynchus mykiss*). The majority of juvenile *O. mykiss* were found in the tributary streams accessible to returning summer steelhead adults. Bonaparte Creek had the highest density of juvenile *O. mykiss* in the United States and Inkaneep Creek had the highest density in Canada. A very low number of juvenile *O. mykiss* were counted within main stem Okanogan River sites in Canada. No snorkeling was performed in main stem sites within the US due to funding limitations. Consistent numbers of juvenile *O. mykiss* were again detected this year at annual US tributary sites and reinforce the assumption that coldwater tributaries are vital to the survival of steelhead in the Okanogan basin. Continued efforts to support, preserve, and reestablish steelhead access to cold water tributaries in the US and Canada is warranted. Snorkel surveys should continue measuring the biological response to habitat improvements as they are implemented.

A full copy of this report can be viewed on our website:

http://nrd.colvilletribes.com/obmep/pdfs/2007OkanoganBasinSnorkelReport_Final.pdf

The full report is provided as Appendix B of this document.

Work Element E: Rotary screw trapping for summer /fall Chinook smolt and juvenile steelhead outmigration enumeration at Highway 20 site

The Colville Tribes Fish & Wildlife Department continued enumerating juvenile salmonids using rotary screw traps in 2007. Anadromous forms of *Oncorhynchus* with verified natural production in the Okanogan basin are targeted for this study, including: summer Chinook (*O. tshawytscha*), sockeye (*O. nerka*), and summer steelhead (*O. mykiss*).

Two rotary screw traps were deployed on the Okanogan River from the Highway 20 Bridge in Okanogan, Washington. Traps operated nightly between 01 April and 24 June 2007. An existing 5-foot trap was used to sample a secondary-flow channel near the west bank. A new 8-foot trap was used to sample the main channel of the river and significantly reduced trap mortality from the previous year. The total combined, seasonal salmonid mortality was 2.02%.

Juvenile summer Chinook salmon were the most abundant species trapped in 2007 (234 alevin, 16,073 fry and 4,777 smolts), followed by sockeye (353 parr and 5,771 juvenile) and steelhead (1,346 smolts). Most of the sockeye, and all of the sub-yearling Chinook were of wild origin, and >99% of the Chinook smolts were hatchery-reared. A total of 92% of the steelhead smolts were hatchery-reared. Twenty-four juvenile Pacific lampreys were also enumerated. Positive identification of *L. tridentata* was received from Molly Hallock (WDFW) who viewed photographic evidence and Bao Le (Douglas Co. PUD) after examining a voucher specimen. A specimen was delivered to Christina Luzier (USFWS) but no response was received.

Raw Okanogan River trap counts are posted on the Columbia River DART website:

http://www.cbr.washington.edu/dart/trap_com.html

A complete technical report is currently under review and will be posted shortly to both our web-site at: <http://nrd.colvilletribes.com/obmep/Reports.htm> and uploaded to the BPA web page shortly thereafter.

Work Element F: Adult salmonid enumeration (Video) at Zosel Dam

The OBMEP is using underwater video to collect baseline data on the run timing and abundance of adult salmonids passing into the Canadian portion of the Okanogan River basin. These data provide information that helps establish basin wide and tributary-specific spawner distributions, status and trends of adult returns, and origin information.

Adult fish passage data were collected between 01 January and 31 December 2007 at the video counting station deployed on the main stem Okanogan River at Zosel Dam, near Oroville, Washington. Species-specific data for all fish passing the Zosel Dam fishways was collected throughout the year. Data were also collected for evaluating the counting facility, modifying custom made video equipment, and to review our operating protocols. Data collection was suspended between 18 June and 16 July for retrofit and repairs to video chutes. A complete description of the apparatus and methodology can be found at the OBMEP web site listed below:

<http://nrd.colvilletribes.com/obmep/pdfs/VideoManual070312FinalMR.pdf>

Historic results from all years of operation are posted to the Columbia River DART website:

<http://www.cbr.washington.edu/dart/adult.html>

A complete technical report is currently under review and will be posted shortly to both our web-site at: <http://nrd.colvilletribes.com/obmep/Reports.htm> and upload to the BPA web page shortly thereafter.

Work Element G: Conduct steelhead redd counts from throughout the Okanogan River subbasin

The Okanogan Basin Monitoring and Evaluation Program collected data related to spring-spawning anadromous salmonid stocks across the entire Okanogan River basin. Data were collected using redd surveys, traps, underwater video, and PIT-tag technology then

summarized and analyzed using simple estimate models. An estimated 1,266 summer steelhead spawned in the Okanogan River basin and constructed 552 redds; 152 of these fish were of natural origin. Of these, 121 summer steelhead, including 29 of natural origin, created an estimated 70 redds in the Canadian portion of the Okanogan basin. Summer steelhead spawner escapement into each sub-watershed was estimated along with the number from natural origin, and the number and density of redds. Several new issues were documented including; 1) Desiccated redds were documented in Loup Loup Creek due to irrigation withdrawals; 2) Habitat utilization in Salmon Creek by salmonids was observed as a result of a new water lease program, and; 3) 10 spring Chinook returned to Omak Creek. High water through most of the redd survey period resulted in development of new modeling techniques and allowed for surveys in additional tributaries including the observation of summer steelhead spawning in Wanacut Creek. These 2007 data provide additional support that redd surveys conducted within the United States are well founded and provide essential information for tracking the recovery of listed summer steelhead. Conversely, redd surveys do not appear to be the best approach for enumerating steelhead spawners or their distribution within Canada. OBMEP also identified that spawning distributions within the Okanogan River basin vary widely and stocking location may play an important roll in this variability.

Data on spring spawners can be viewed on our website at:

http://nrd.colvilletribes.com/obmep/pdfs/2007steelheadspawningFinal_000.pdf

Or at the BPA web site at:

<http://pisces.bpa.gov/release/documents/DocumentViewer.aspx?doc=P104142&session=90e36948-01e6-4f35-8ea6-12db6ca21f92>

The complete report is also attached as Appendix C.

Work Element H: Collection of physical habitat data at EMAP sites in the United States (34) and Canada (16).

The Colville Tribes Anadromous Fisheries Department undertook habitat surveys in the summer of 2004 as part of the Okanogan Basin Monitoring and Evaluation Program (OBMEP) to provide essential information on habitat conditions throughout the Okanogan Basin. Habitat degradation and human development have had major negative impacts on anadromous fish that once flourished in the Columbia River and its tributaries. Currently, the Colville Confederated Tribes is the only organization collecting comprehensive fish habitat data throughout the Okanogan Basin in the United Sates and Canada. Habitat surveys are designed to address status and trend questions and at the same time eliminate duplication of work, reduce costs, and increase monitoring efficiency. Cooperation includes the sharing of monitoring responsibilities between the Colville Tribes and the ONA (Okanagan Nation Alliance), adjusting or changing sampling methods to comport with standardized protocols, and adhering to strict statistical design criteria.

Physical habitat data was collected at 50 EMAP sampling sites (25 annual panel, 25 rotating panel) consistent with protocols developed by the Colville Tribes. 34 sites were surveyed in

the United States portion of the Okanogan Basin by the Colville Tribes and 16 sites were surveyed in the Canadian portion of the Okanogan Basin by the ONA.

Physical habitat data is collected in electronic format on Trimble GPS data loggers. Information collected pertains to: the presence and composition of large woody debris; riparian vegetation structure; canopy cover; human disturbance; substrate composition; stream channel habitat types (pool, riffle, glide, etc.); and channel morphology. All data is compiled on the OBMEP server located at the Colville Tribes, Fish and Wildlife offices in Omak, WA. A comprehensive habitat report on all data collected from 2005 through 2009 will be forthcoming in 2010. Specific information request can be directed to the Colville Tribes, Fish and Wildlife Department, Anadromous Fish Division, 23 Brooks Tracts Rd. Omak, WA 98841, (509) 422-7424. Past reports related to habitat data can be down loaded at:

<http://nrd.colvilletribes.com/obmep/Reports.htm>

Work Element I: Operate & maintain real-time discharge, water temperature gauging stations in the Okanogan subbasin.

Real time temperature data was collected at three sites on the Okanogan River in the United States at Oroville, Malott and Tonasket by the United States Geological Service under contract with the Colville Tribes. Data has been assimilated into on-going data collection activities within the USGS web sites. This data is available on the World Wide Web to provide transparent public access and appropriate credit given to BPA and the Colville Tribes for making these data available. Data links for sites on the Okanogan River:

Malott: http://waterdata.usgs.gov/wa/nwis/dv?dd_cd=01%2C02%2C05%2C05%2C05&format=gif&period=365&site_no=12447200

Tonasket: <http://waterdata.usgs.gov/wa/nwis/uv?12445000>

Oroville: http://waterdata.usgs.gov/wa/nwis/dv/?site_no=12439500&agency_cd=USGS.

Ninemile Creek: <http://nwis.waterdata.usgs.gov/nwis/uv?12438900>

The Okanogan River watershed, especially the Canadian portion, has several tributaries with unknown discharge or temperature regimes. OBMEP continued pursuing cooperative agreements between the Okanogan Nation Alliance, the Ministry of Environment, Environment Canada, and the Colville Tribes to address these data gaps for Inkaneep, McIntyre, and Shuttleworth creeks. To view data go to:

<http://scitech.pyr.ec.gc.ca/waterweb/disclaimerB.asp>

1. In the “View all Real Time Stations within” window, Select British Columbia and Choose the Order By: Station Name.
2. Scroll down the page and Click “I accept”.
3. Scroll through the station list and select the station :
INKANEEP CREEK NEAR THE MOUTH (08NM200)
VASEUX CREEK NEAR THE MOUTH (08NM246)
SHUTTLEWORTH CREEK AT THE MOUTH (08NM149)

Work Element J: Collect water temperature data throughout the Okanogan River basin

The OBMEP program began in May of 2005 deploying Onset® temperature data loggers in streams at all annual and panel tributary EMAP sites. The OBMEP also funded real time temperature data gathering at three USGS gauging sites on the Okanogan River: Oroville, Tonasket and Malott in the US, and three Environment Canada gauging sites on Inkaneep, Vaseux and Shuttleworth creeks. Data collection at these sites began in March of 2005. All Onset temperature data is compiled on the OBMEP server located at the Colville Tribes, Fish and Wildlife offices in Omak, WA. Specific information request can be directed to the Colville Tribes, Fish and Wildlife Department, Anadromous Fish Division, 23 Brooks Tracts Rd. Omak, WA 98841, (509) 422-7424. A report documenting changes in temperature over the last decade is in preparation and we hope to complete this report within the next year or two.

Work Element L: Coordination

Biologists working under OBMEP have contacted and coordinated directly with other entities performing monitoring and evaluation (M&E) related activities throughout the region to ensure compatibility with other regional M&E and salmon recovery efforts. Private landowners have been contacted under this task so that OBMEP field personnel may gain access to EMAP sampling sites. Landowner contacts and other coordination activities have been documented through a variety of minutes and notes.

This program was developed under a regional M&E scheme involving coordination with multiple entities through both The Columbia Systemwide Monitoring and Evaluation Project (CSMEP) and the Pacific Northwest Aquatic Monitoring Project (PNAMP) to ensure that our project is compatible with efforts spanning the entire Pacific Northwest. Continued coordination with these entities will be necessary as region wide M&E efforts continue to evolve. The Okanogan subbasin is a transboundary watershed and therefore international coordination with Canadian entities has been necessary as well including regular quarterly meetings with the Okanogan Nation Alliance.

Biologists from OBMEP contributed to regular monthly meetings of the Upper Columbia Regional Technical Team (RTT) and monitoring and data management subcommittees. Data has been shared at these meetings along with field protocols and strategies for field sampling, data archiving, manipulation, and analysis. Ongoing coordination within the Upper Columbia ESU is essential to make sure data can be rolled up to larger spatial scales for ESU related recovery analysis to take place and to measure progress toward recovery of listed salmonid stocks.

Many OBMEP survey sites fall within areas of private ownership. Therefore, landowners must be contacted (public outreach) and access granted before field crews can conduct surveys. Biologists and field staff working under OBMEP have made many contacts with landowners throughout the Okanogan basin to gain access to EMAP sampling sites, redd survey sites, and to keep them updated. Most contacts have been positive and access to

perform work under this contract would be impossible with cooperation and coordination efforts.

Work Element N: Manage, and Maintain Database.

At the end of our contract in 2006, OBMEP was using an Access® database developed by Summit Environmental Consultants Ltd. that contains tables of all collected data. The OBMEP database and data are contained on the OBMEP server located the Colville Tribes Fish and Wildlife Department offices located in Omak, WA. Summit Environmental Consultants developed protocols for transferring data collected on Trimble® handheld data loggers, data forms and the internet into the database. Considerable progress has been made and the elements of a database have been assembled that provide a framework for functional data management. Queries have been written by Summit Environmental and Bio-Analysts that are fully consistent with the needs of the Okanogan River basin, Colville Tribes, Upper Columbia ESU, State of Washington, Pacific Northwest, National Marine Fisheries Service, Bonneville Power Administration, and the Northwest Power and Conservation Council. Data collected and queries written are fully consistent with metadata and data management standards developed by CSMEP, Stream-Net, and Northwest Environmental Data workgroup for M&E projects within the Columbia River basin. NOAA Fisheries is working on creating a similar database structure through the Integrated Systemwide Status and Effectiveness Project (ISEMP). We are making certain that the OBMEP database is capable of providing compatible data with all recommended and necessary metadata. A draft protocol document for translating data base components into the OBMEP database has been completed and can be seen at:

<http://nrd.colvilletribes.com/obmep/pdfs/ProtocolforenteringdataintotheOBMEPdatabaseDRAFT.pdf>

This document is attached as Appendix D.

Conclusions

The OBMEP project completed yet another year of data collection, coordination, and reporting. All tasks were completed on time and within budget. Some deliverables such as the video monitoring report of Zosel Dam fell behind due to the magnitude of our reporting requirements. In the future rather than attempting to complete annual reports related to each type of data collection we will compile data for 5 years and report on one subject in each succeeding year. Annual spring spawning reports have been among the most valued reports to date and will continue to be produced annually. Other reports will be consolidated and produced once every 5 years beginning with our Temperature report in 2008, our habitat and snorkel report in 2009, our video enumeration report in 2010, smolt trapping report in 2011, then our water quality and quantity report in 2012. These technical documents will be compiled into the annual report requirement for Bonneville Power Administration and posted on the OBMEP and BPA web sites for public access. Interim access to OBMEP data will be handled though the Upper Columbia Salmon recovery board data steward, the Columbia Basin Fish and Wildlife Authorities state of the resource report, Fish Passage Center, United States Geologic Survey, and The Columbia River Data Access in Real Time (DART).

This program has grown from a few simple data collection activities to a large multifaceted cutting edge program. We continue to improve the program by using the latest in technology and scientific knowledge. We hope to expand our video monitoring project to include multiple tributaries and integrate these with pit tagging technology for synergies toward both methodologies. We are experimenting with novel ways to look at and analyze habitat data in order to consolidate a multitude of variables into a habitat condition composite that then can be used to measure status and trend analysis using the EDT models already widely utilized across the Columbia River basin. As these efforts mature we hope to contribute to improve data collection and status and trend monitoring throughout the entire Columbia River basin while we in turn learn from other projects' developments.

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**Appendix A- The Okanogan Subbasin Water Quality and Quantity Report
for Anadromous Fish in 2006**

**The Okanogan Subbasin Water Quality and
Quantity Report for Anadromous Fish in 2006**

BPA Project # 200302200

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Abstract

Fish need water of sufficient quality and quantity in order to survive and reproduce. The list of primary water quality indicators appropriate for monitoring of anadromous fish, as identified by the Upper Columbia Monitoring Strategy, includes: discharge, temperature, dissolved oxygen, pH, turbidity, conductivity, nitrogen, phosphorus and ammonia. The Colville Tribes' Fish and Wildlife Department began evaluating these water quality indicators in 2005 and this report represents data collected from October 1, 2005 through September 30, 2006. We collected empirical status and trend data from various sources to evaluate each water quality indicator along the main stem Okanogan and Similkameen Rivers along with several tributary streams. Each water quality indicator was evaluated based upon potential impacts to salmonid survival or productivity. Specific conductance levels and all nutrient indicators remained at levels acceptable for growth, survival, and reproduction of salmon and steelhead. These indicators were also considered of marginal value for monitoring environmental conditions related to salmonids within the Okanogan subbasin. However, discharge, temperature, turbidity, dissolved oxygen and pH in that order represent the water quality indicators that are most useful for monitoring watershed health and habitat changes and will help to evaluate threats or changes related to salmon and steelhead restoration and recovery. On the Okanogan River minimum flows have decreased over the last 12 years at a rate of -28.3CFS/year as measured near the town of Malott, WA. This trend is not beneficial for salmonid production and efforts to reverse this trend should be strongly encouraged. Turbidity levels in Bonaparte and Omak Creek were a concern because they had the highest monthly average readings. Major upland disturbance in the Bonaparte Creek watershed has occurred for decades and agricultural practices within the riparian areas along this creek have lead to major channel incision and bank instability. High sediment loads continue to threaten Omak and Bonaparte sub-watersheds. Major rehabilitation efforts are needed within these sub-watersheds to improve salmonid habitats. We found that for the past 12 years dissolved oxygen levels have been on a slightly downward trend during summer/fall

Chinook egg incubation. Dissolved oxygen readings in early October, for summer/fall Chinook and from June through early July for summer steelhead can occasionally drop to the range from 8 to 10 mg/L and therefore warrant continued monitoring. Levels of pH represent an indicator that has little monitoring value throughout most of the subbasin. The Similkameen River drainage showed dramatic annual changes in the mean pH values and a declining trend for pH thus warranting continued monitoring. Average daily temperatures, in 2006, exceeded 25°C for eight days in July in the Okanogan River at Malott. Due to increased warm water temperatures, delays in migration have increased at a rate of 1.82 days per year over the last 10 years. Increases in water temperature can be linked to many anthropogenic activities. Increasing water temperatures within the Okanogan River watershed represent the single most limiting factor facing salmonids in main-stem habitats.

Introduction

The Okanogan River Basin

The Okanogan River watershed covers approximately 2,123,800 hectares. The confluence with the Columbia River is located in north-central Washington State, but 70% of the watershed is located in Canada. The Okanogan River is like two rivers in one: the United States (US) portion of the river is strongly influenced by the Similkameen River, which provides most of the water and sediment from a flashy, snowmelt-driven watershed; while the Okanogan River above the Similkameen confluence provides a lesser quantity of water from a stable, clear, lake-drained watershed.

The Fisheries Resource

The Okanogan River is the most northern watershed accessible to anadromous fish in the entire Columbia River basin. Due to an extremely low gradient, high water temperatures during summer months and turbid water, the habitat in the mainstem Okanogan River differs greatly from the traditional environments most people consider ideal for anadromous fish production. Returning fish must transverse nine major hydroelectric dams and several smaller impediments. Many tributary streams of the Okanogan basin have been diverted in part or whole to support the agrarian economy of the region. In spite of all this, a healthy stock of summer Chinook, and the most robust stock of sockeye salmon remaining in the Columbia River Basin call the Okanogan River home along with endangered summer steelhead.

Historical Data Collection

The Washington State Department of Ecology (WDOE) has collected monthly water quality grab samples along the mainstem Okanogan and Similkameen Rivers for many years. The United States Geological Survey (USGS) and Environment Canada have collected discharge information along the main-stem Okanogan and Similkameen Rivers for many years. Recognizing the importance of monitoring discharge and temperature, WDOE expanded their data collection efforts to a select group of tributary streams beginning in 1997. Discharge and temperature data collection has also expanded due to the Okanogan Basin

Monitoring and Evaluation Program (OBMEP) since 2004. Water quality information on tributary streams of the US and Canadian portions of the Okanogan basin had not expanded beyond the main-stem reaches until the efforts of OBMEP in 2005.

Expanded monitoring through OBMEP

OBMEP was developed in an attempt to improve our understanding of the anadromous fish populations and habitat that exists within the Okanogan River basin. The water quality/quantity and temperature part of OBMEP is designed to document water quality, discharge and temperature changes over time by addressing the question: is there a statistically significant difference in selected water quality parameters for the Okanogan basin over time (7-20+ year time frame).

Since 2004, the Okanogan Basin Monitoring and Evaluation Program (OBMEP) has contributed monetarily to the collection of real time temperature data at the USGS flow monitoring sites along the main-stem Okanogan River. Additionally, since 2005, this project has installed new real-time discharge and temperature gauging stations in four tributaries throughout the US and Canada. Temperature and discharge data will continue to be collected in future years by the Colville Tribes in cooperation with USGS, Environment Canada, and WDOE until 2024 or as long as funding is continued.

In March of 2005, OBMEP began water quality surveys throughout the US. Twenty-five sites were surveyed for dissolved oxygen, pH, specific conductivity, turbidity and temperature. Water quality surveys occurred three times a month at tributary and selected main-stem sites. Data was collected at nineteen sites on small tributary streams and five sites on the main-stem Okanogan River, and one site on the Similkameen River.

In 2006, twenty-five sites were surveyed in the US including; 19 sites on small tributary streams and 5 sites on the Okanogan River with 1 site on the Similkameen River. An additional 16 sites were monitored in Canada by the Okanogan Nation Alliance (ONA.) including; 12 sites on small tributary streams and 4 sites on the main-stem Okanogan River (Benson et al 2006). These OBMEP water quality surveys were concluded at the end of February 2007 due to a lack of funding provided from the Northwest Power and Conservation Council and Bonneville Power Administration. The Colville Tribes hope to reinstate these data collection activities in the near future if alternative funding can be secured.

Methods

Water Quality and temperature data was collected in 2006 at all EMAP sites located on tributary streams of the Okanogan River as identified in the Colville Tribes physical habitat protocol (Arterburn et al. 2006). Discharge, Temperature, and water quality data was gathered from WDOE, Environment Canada, and USGS real-time gauging locations along the Okanogan and Similkameen Rivers (Figures 1&2). Temperature data was also collected at all tributary EMAP sites by OBMEP, these data will be compiled into a future report.

Limited temperature data was compiled for this report primarily for the purpose of explaining results of other water quality indicators that are covariates with temperature.

Water Quality data collected as part of the OBMEP by the Colville Tribes in the US or the ONA in Canada follows specific protocols (Arterburn et al. 2005). The Colville Tribes water quality protocols were developed to be consistent with, but expand from, the Upper Columbia strategies (Hillman 2006). The OBMEP water quality protocols can be viewed at: (<http://nrd.colvilletribes.com/obmep/Reports.htm>). The Colville Tribes and ONA collected pH, conductivity, dissolved oxygen, and turbidity data using a Eureka Manta® water quality probe coupled to a Eureka Amphibian® field recorder. Measurements at each site were collected three times per month.

Discharge grab samples were measured at the downstream extent of Ninemile Creek, Tonasket Creek, and Antoine Creek. Discharge grab samples were not collected on a consistent basis but rather haphazardly. The Okanogan Conservation District and WDOE are primarily responsible for these data but the Colville Tribes are attempting to supplement this information through a coordinated effort when crews are available to do so. When collecting discharge data we used a Marsh-McBirney Flo-Mate model 2000. The Flo-Mate measures flow using the Faraday law of electromagnetic induction. This law states that as a conductor moves through a magnetic field, a voltage is produced. The magnitude of this voltage is directly proportional to the velocity at which the conductor moves through the magnetic field. We divided the width of the channel into equal segments, did a velocity profile and calculated the flow for each segment and finally summed the segment flows for the total flow.

Water quality data was compiled from WDOE's four real-time flow monitoring stations, three periodic grab sample stations and three water quality grab sample stations within the Okanogan River basin following the Quality Assurance Monitoring Plan for a streamflow Gauging Network (Butkus 2005). OBMEP compiled discharge and temperature data from the USGS at three flow and temperature monitoring sites on the Okanogan River and one on Ninemile Creek. Data collected at these sites follows the protocols outlined in the document titled "Surface-Water Quality-Assurance Plan for the Washington District, U.S. Geological Survey, Water Resources Discipline" (Kresch and Tomlinson 2004).

Environment Canada discharge and temperature data is collected from 4 sites. These real-time data are available on their web site and is fed from both satellite (data collection platforms) and land-line (telephone) transmissions from the hydrometric stations. Satellite transmissions are on a scheduled basis, typically every 1 to 3 hours. Land-line hydrometric stations are polled on a scheduled basis varying from every hour to once a day, depending on the station. The real-time data acquisition and decode is managed by NewLeaf™. Once data is decoded in NewLeaf™, it is transferred to an Oracle™ database which feeds the web site. Data transfer between the two systems occurs on a scheduled basis every hour.

US Water Quality, Water Quantity and Temperature Survey Sites 2005-2007

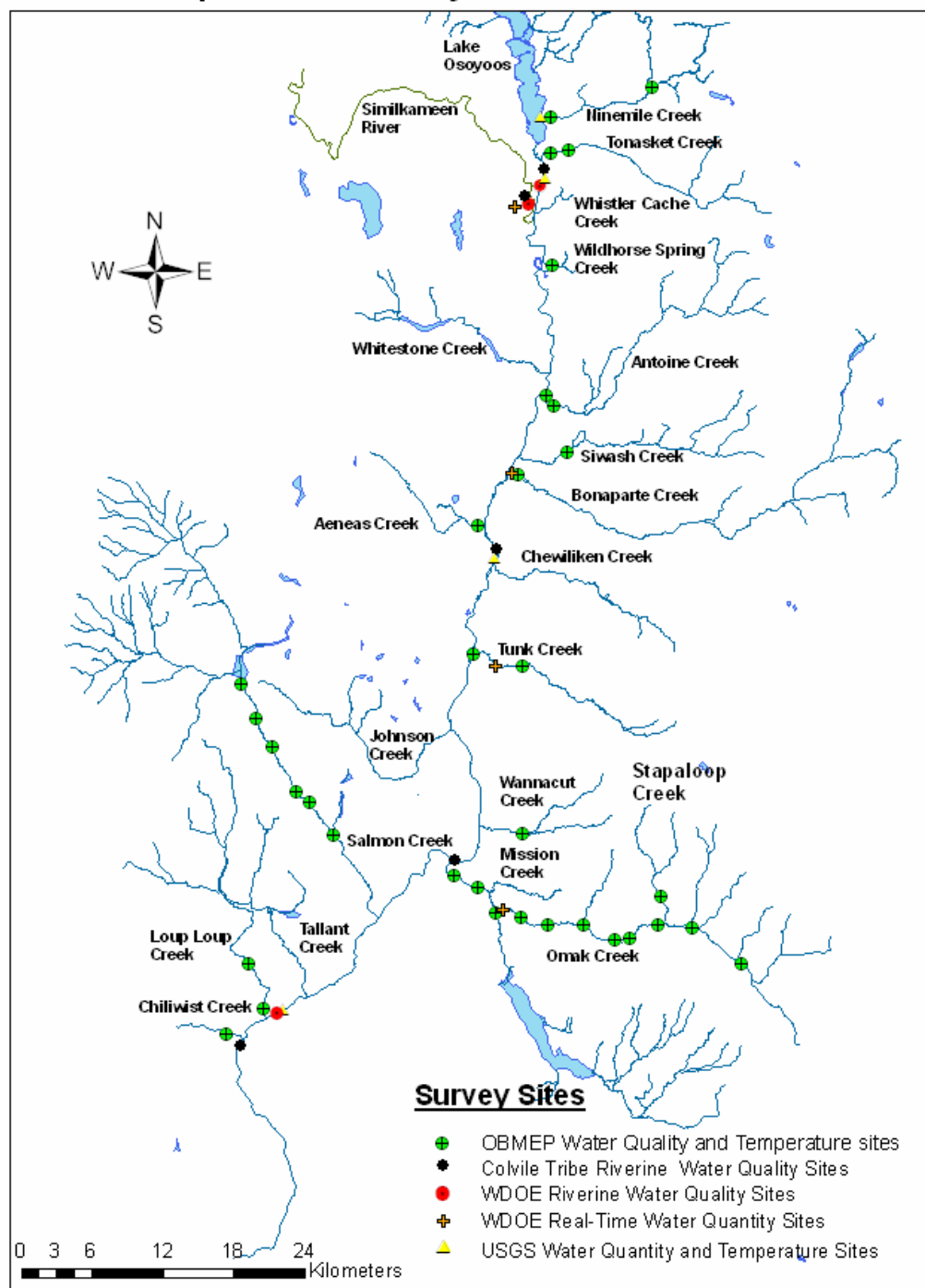


Figure 1: Water quality, quantity, and temperature data collection sites throughout the US portion of the Okanogan Basin, 2005 to 2007.

Canada Water Quality, Water Quantity and Temperature Survey Sites 2006-2007

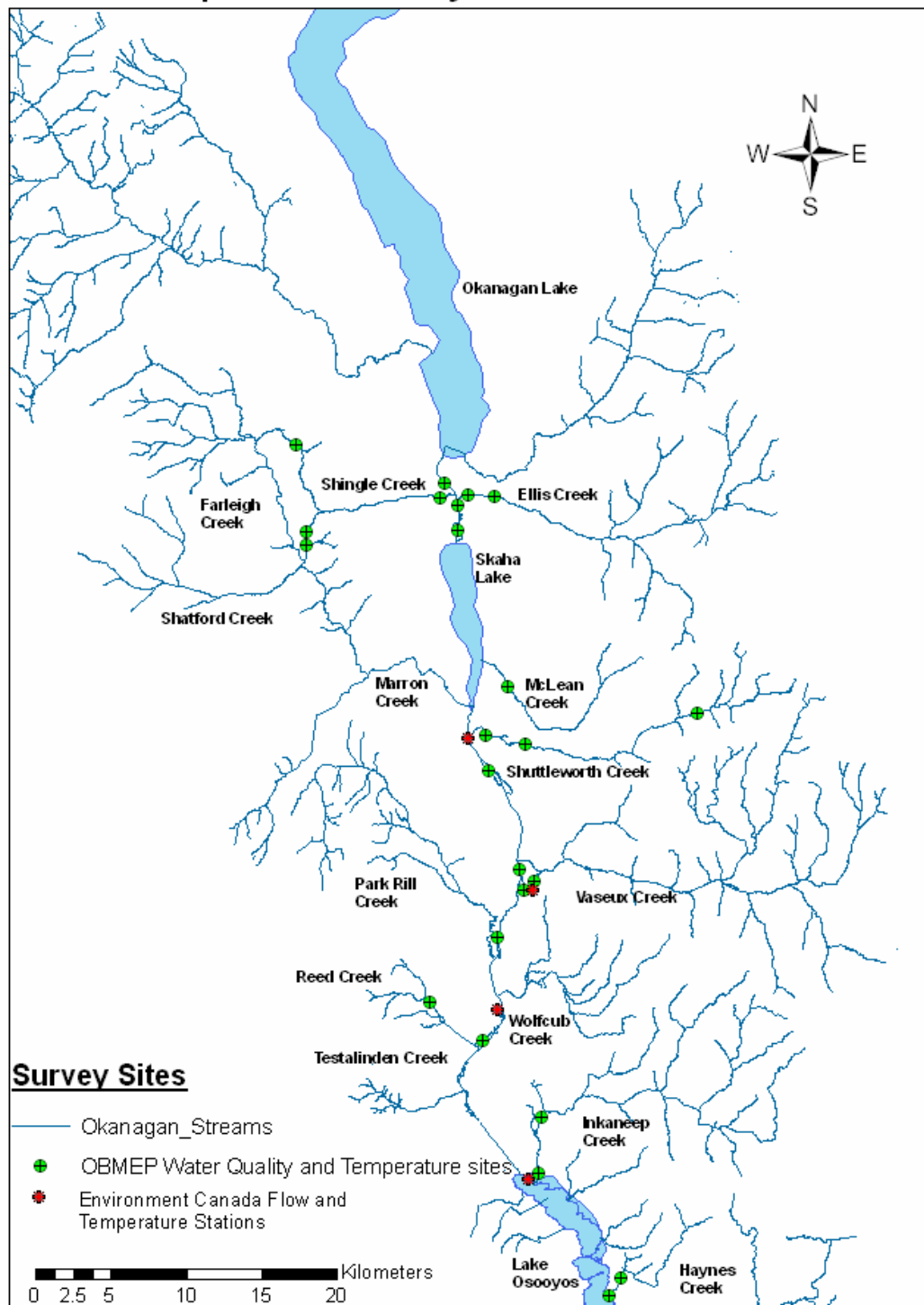


Figure 2: Water quality, quantity, and temperature data collection sites throughout the Canadian portion of the Okanagan Basin, 2005 to 2007.

Results and Discussion

Discharge

Discharge impacts survival of salmonids by manifestation of the first law of fisheries which states that; “fish need water”. When discharge reaches zero so do the supportable fish populations. At discharge readings above zero the quantity of habitat available is directly related to the amount of discharge and this is especially true during low or base flow periods. In the Okanogan River basin low flow periods typically occur during the months of August and September. During mild or extremely cold winters this low flow period can extend from August all the way through February. Activities that occur during these periods such as spawning, incubation, and juvenile rearing can heavily influence the annual production of summer steelhead and Chinook salmon. The minimum amount of discharge during these life stages influences the maximum amount of habitat available to fish during each of their life stages.

Status data within a given year can be used to help determine; if any production is possible by determining if discharge remained above zero throughout the year and secondly, determine if the amount of habitat available for critical life stages were higher or lower than recent historical averages. Further trend analysis can be used to determine if these conditions only apply to this year or are part of an ongoing issue that is likely to impact the population over the longer-term.

Water quality, discharge, and temperature data presented in this report is for the 2006 water year (October 2005-September 2006) unless otherwise noted. Discharge data is represented in cubic feet per second (CFS) for all US and Canadian sites. Twelve year trend data for discharge was only possible for the USGS gauging station sites along the Okanogan and Similkameen Rivers. Real-time discharge information for Okanogan River tributary streams have only been collected for 4-years therefore no trend analysis was conducted.

Discharge-Tributaries

Discharge data is divided into two categories; 1) grab sample data that are sporadically collected by measuring width, depth, and velocity then calibrating these measures to a staff gauge and stage discharge curve. Streams where this type of data is collected include Nine-mile Creek, Tonasket Creek, and Antoine Creek. The second category is; 2) Real-time gauging station data that is collected electronically several times each day and is much more accurate and reliable. Streams with real-time gauging stations include; Nine-mile (as of July 2006), Omak, Tunk, and Bonaparte creeks.

In 2006, most tributary streams show low-flow characteristics from August through January in the US portion of the Okanogan River basin. Peak discharges occurred during the months of April and May depending on the size and altitude of the drainage. Low flows in most tributary streams occur during the months of August or September when air temperatures are the highest, precipitation is the least, and irrigation demand is the highest.

Ninemile Creek

Stream measurements have been taken since 2002 by WDOE

<https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49J060>. Discharge or staff gauge measurements taken when no water was present are extremely rare. However, base flow periods are typically less than 1-CFS. The Colville Tribes in cooperation with the USGS installed a real-time flow and temperature gage at river mile 1.1 of Ninemile Creek. This data began being collected on 7/17/2006 and can be viewed at: <http://nwis.waterdata.usgs.gov/nwis/uv?12438900>. Comparing data collected from grab samples with that collected at the real-time gauge show good correlation for the short period of overlap.

In 2006, peak discharge was recorded at the WDOE staff gauge on 5/4/2006 at 11.1-CFS. The lowest discharge was recorded for the period from 8/15/2006 through 8/17/2006 at 0.28-CFS at the USGS gauging site. However, on 8/15/2007 a staff gauge reading at the WDOE site was recorded at 0.7-CFS and this reading represented the largest discrepancy during the entire overlap period to date. Staff gauge readings are much more susceptible to human error and have much more variation when compared to electronic equipment used at the USGS site. We compiled grab sample data collected by WDOE from 2002 to 2006 at the WDOE gauging site and real time data collected by the USGS further upstream (Figure 3). Peak discharge in 2006 was slightly less than twice the average discharge recorded from 2002-2006 with the low discharge period in 2006 being similar to historic averages. Peak discharge occurred in May, 2006 rather than in April, as in previous years. Although minimal, discharge was conducive to salmonid production for the entire period of record from 2002-2006. Efforts to increase discharge would have a positive benefit toward salmonid production especially during the low flow period from mid-June through September when discharge occasionally reaches zero as in 2005.

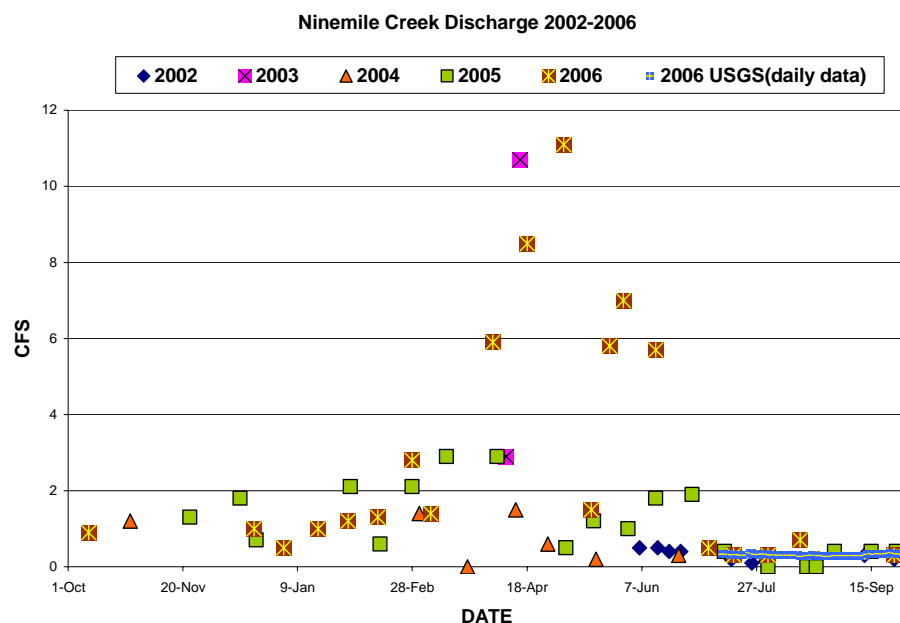


Figure 3: Ninemile Creek discharge showing all data collected in 2002-2006(data from the period of record at this site).

Tonasket Creek

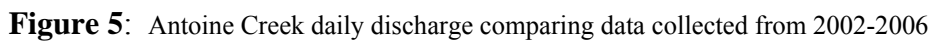
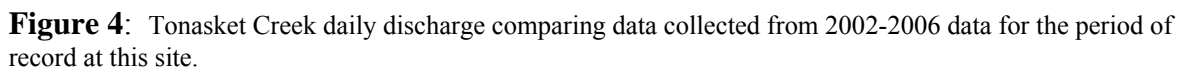
Based upon data collected at the WDOE staff gauge, lower Tonasket Creek would be considered intermittent. In most years, water is present from March through July <https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49H080>. However, very few data points are collected on an annual basis.

In 2006, measurable flows were present prior to 3/7/2006 when the first readings for the water year were taken and after 5/24/2006 when the last readings for the water year were taken (Figure 4). Peak discharge was measured on 5/4/2006 by WDOE personnel at 15.0-CFS. This peak discharge was the highest recorded during the period of record with the next closest value being 12.7-CFS, recorded on 4/15/2003. Although summer steelhead are known to spawn in Tonasket Creek a lack of water throughout most of the year severely limits any opportunity for steelhead smolt production.

Antoine Creek

Antoine Creek is a regulated watershed so discharge measurements are highly influenced by operations at Fancher Dam. Based upon data collected at the WDOE staff gauge, lower Antoine Creek would be considered a perennial stream.

Discharge measurements spanned from 1/3/2006 to 9/25/2006 with base flows of approximately 2 to 3-CFS. Peak discharge was measured on 5/24/2006 by WDOE personnel at 28.4-CFS surpassing the old record discharge of 11.1-CFS taken on 11/23/2004. High discharge in 2006, provided rare access to spawning areas for adult summer steelhead and redds were observed (Arterburn and Kistler 2006). However, two data points were collected as a zero in the summer of 2006 (Figure 5) which likely resulted in a loss of summer steelhead production. <https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49G060>. Preliminary information suggests that with improved water management sufficient water quality and quantity would exist for consistent summer steelhead spawning and smolt production.



Omak Creek

A review of past discharge data suggest that Omak Creek is a perennial stream

<https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49C100>. 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 at this site since 2003. The hydrograph of Omak Creek typically shows a narrow high flow peak (April) with rapidly increasing (March)/decreasing (May) limbs and base flows that typically range from 3-4 CFS in August and September (Figure 6).

In 2006, a record peak mean daily discharge was measured on 4/9/2006 at 228-CFS with an instantaneous peak of 283-CFS. The previous record discharge was measured on 4/25/2003 at 195-CFS with an instantaneous peak of 227-CFS. The lowest discharge measured in 2006 was 1.7-CFS on 10/1/2006 which was well above the minimum discharge record in both 2004 and 2005 of 0.7-CFS. High spring discharge provided good access to spawning habitats for adult salmonids and good base flows of between 3-4 CFS provide for plentiful rearing habitat. Because 2006, was a good water year summer steelhead smolt production was likely higher than it has been for the last couple of years. Increased summer steelhead smolt production likely benefited from flows being maintained throughout the year along the lower mile of Omak Creek during the months of August and September. In 2004 and 2005 the lower mile section went dry. Missing data was due to malfunctions caused by ice.

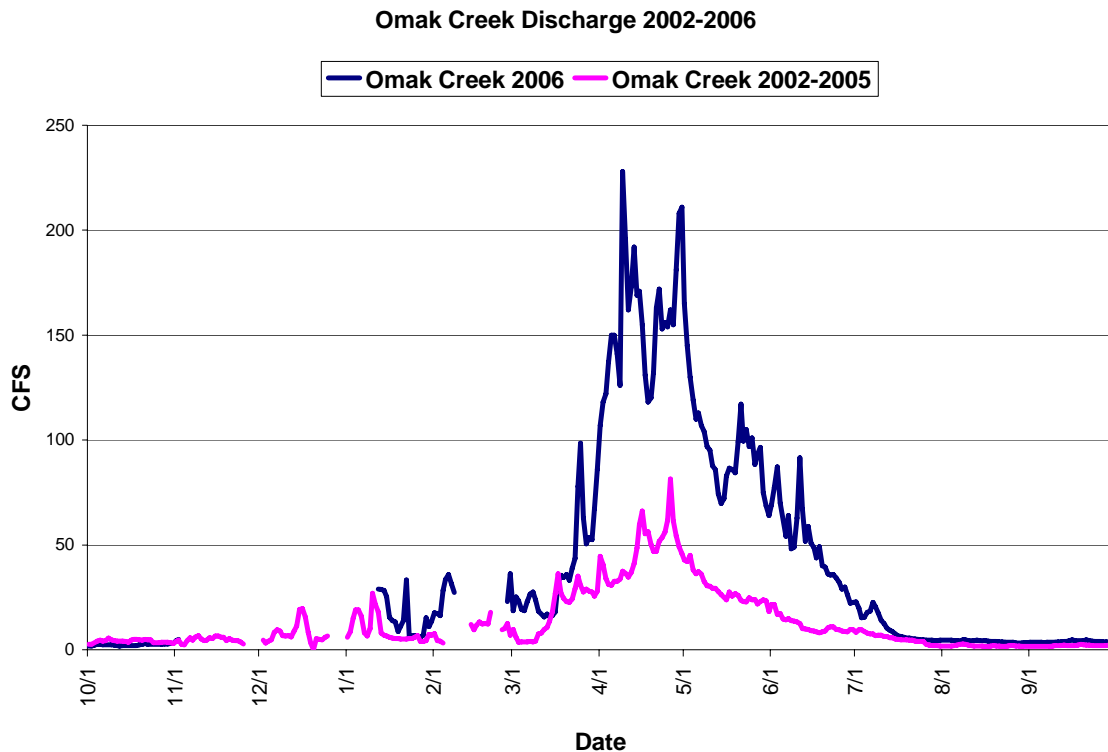


Figure 6: Omak Creek mean daily discharge hydrograph comparing data collected in 2006 with mean discharge from 2002-2005.

Tunk Creek

Discharge data has been collected for Tunk Creek since 2003 at a real-time telemetry gauging station owned and operated by WDOE that is located a short distance above Tunk Falls <https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49E080>. From these data it could be presumed that Tunk Creek is perennial but based on field observations of the lower reach (below Tunk Falls) it would more properly be defined as intermittent. Since 2005, OBMEP has attempted to conduct annual snorkel surveys but on August 30th of 2005 and again on August 28th of 2006 no water was present at the mouth of Tunk Creek so no snorkel surveys were possible (Kistler et al. 2006, Kistler and Arterburn 2007). Upon review of discharge data collected upstream it has been determined that any flows below 0.2-CFS at the WDOE gauge results in a dry stream bed below Tunk Falls. These conditions typically occur from mid-July through the first week in September. The lack of persistent overland flows downstream of Tunk Falls greatly reduces the likelihood that summer steelhead production in Tunk Creek will add to overall smolt production for the Okanogan River population. The typical hydrograph peaks in April with low flows in August (Figure 7). In 2006, a record peak mean daily discharge was measured on 4/12/2006 at 54.8-CFS with an instantaneous peak of 83.8-CFS. The previous record discharge was measured on 4/25/2003 at 38.3-CFS with an instantaneous peak of 45.5-CFS. The lowest discharges measured in 2006 were 0.2-CFS and this occurred on several dates from 8/7/2006 through 9/10/2006. These minimum discharge readings have been correlated with zero discharge at the mouth of Tunk Creek. Although, discharge data show sufficient water was available for good access to spawning habitats for adult steelhead, discharge during the fall was reduced to the point that no production was likely to occur from any redds that were created.

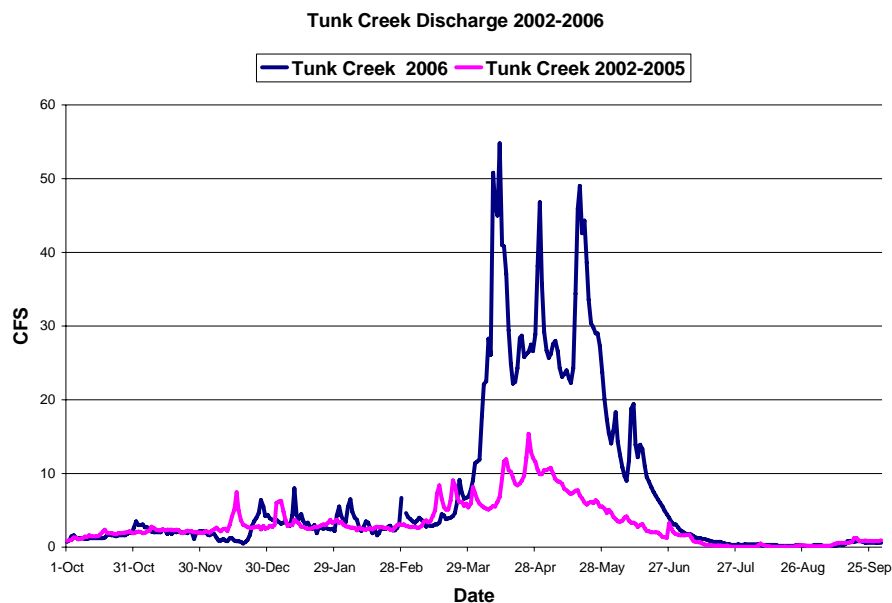


Figure 7: Tunk Creek mean daily discharge hydrograph comparing data collected in 2006 with mean data from 2002-2005.

Bonaparte Creek

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 2006 compared to average flow data from 2002 to 2006. In 2006, a record peak mean daily discharge was measured on 5/27/2006 at 38-CFS. The lowest discharge measured in 2006 was 0.3-CFS on 08/25/2006 which was thirty times above the minimum discharge record in 2003 to 2005 of 0.01 CFS. Data from 2006 shows a greater peak discharge and a steeper ascending limb than the average of previous years (Figure 8). Missing values for 2003-2005 represent isolated days when no data was being collected due to ice or other equipment malfunctions.

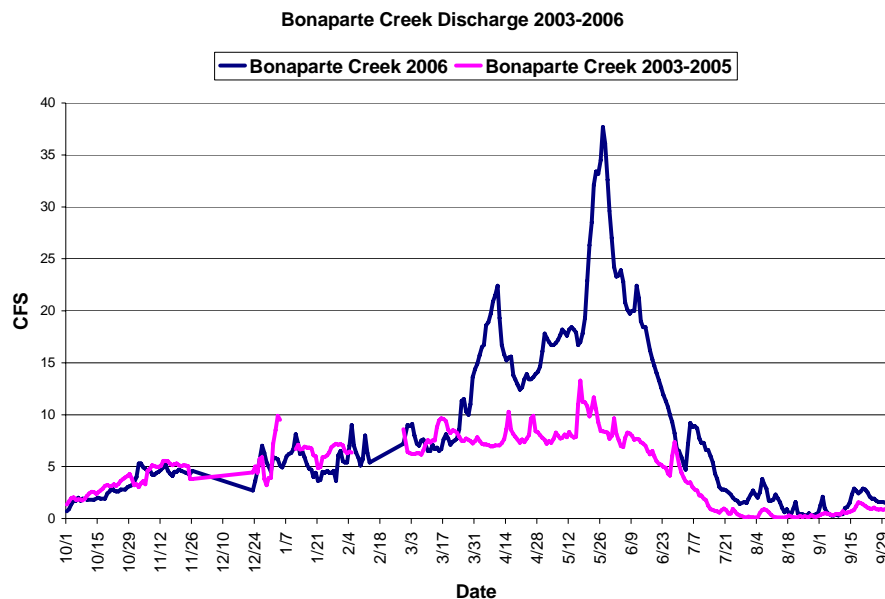


Figure 8: Discharge for Bonaparte Creek in 2006 compared to the average flow from 2003-2005.
Tributaries in Canada

Flow data in Canada on tributary streams near the mouth have been collected by the Colville Confederated Tribes OBMEP program through a contract with Environment Canada. Data has been collected at Vaseux, Inkaneep, and Shuttleworth creeks since March of 2006. Vaseux Creek had a very steep ascending limb and a prolonged high flow period from April 26th to June 16th. The highest mean daily discharge was 556 CFS on 5/20/2006 and the low mean daily discharge was zero from 7/28/06 to 11/29/06. This is a snow pack driven watershed as it drains Mount Baldy. This stream is perennial in most portions of the watershed and there is a lot of potential here for salmon and steelhead spawning and rearing.

However, the lower portion of the creek has gone dry in recent years (Figure 9) likely resulting in minimal production.

Inkaneep Creek is a perennial stream that drains the west side of Mount Baldy emptying into the northern basin of Osoyoos Lake. Anadromous fish are able to access 2.4 river miles of the creek from the confluence with the lake. In 2006, there was a steep ascending limb to reach peak discharge. Mean daily peak flow of 157 CFS, occurred on 5/21/06. The low flow value was, 0.9 CFS and occurred on 8/29/06. *Oncorhynchus Mykiss* have been live trapped in the creek (Long 2006). At the present time this creek supports the majority of summer steelhead spawning and smolt production in Canada (Kistler 2006, Arterburn 2006, 2007). Shuttleworth Creek currently is outside the range of anadromous fish due to McIntyre Dam which is located south of Okanogan Falls, BC. This creek appears to be perennial and has the potential for steelhead spawning and rearing once passage at McIntyre Dam is achieved. The mean daily peak flow of 95 CFS occurred on 5/20/06 and the lowest value recorded in 2006 was 0.03 CFS from 7/25/06 to 9/11/06. The impacts to coldwater salmonids in this stream from extremely low discharge such as occurred during 2006 are not well understood. Little is currently known about the mechanisms that control, regulate, or impact discharge in Shuttleworth Creek.

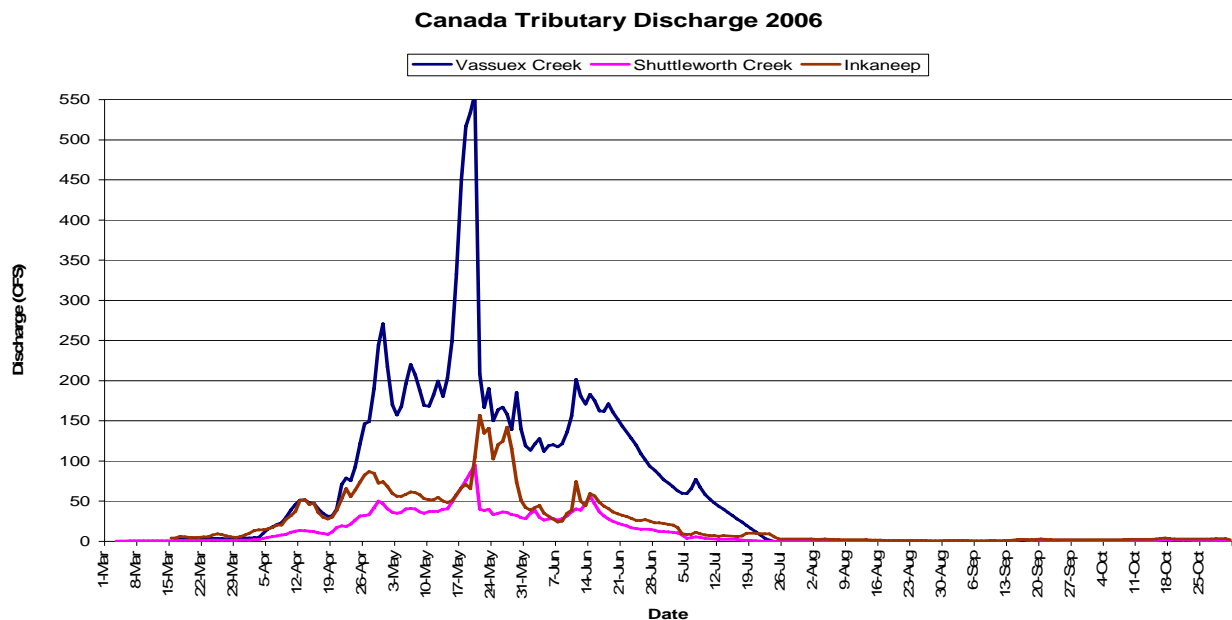


Figure 9: Real-time discharge for Environment Canada gauge on Vaseux, Inkaneep and Shuttleworth Creeks in 2006.

Discharge-Mainstem Rivers

Most mainstem 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 Environment Canada. All the United States gauging stations provide real-time discharge data but the site in Canada is only a near real-time station and complete yearly data are not posted until results are one year old.

The Okanogan River as it flows out of Canada is regulated at dams located at outlets of Okanagan, Skaha, Vaseux, and Osoyoos lakes. Because discharge from these lakes is highly 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 and higher inter-daily variability than would be expected from the historically unregulated system (Figures 10&11). Flows typically peak in late May to early June with low flows in October to January. The remainder of the year is contained in the ascending limb (February to May) or descending limb (July to October) of the hydrograph (Figure 10).

Once in the United States the Similkameen River dominates the hydrograph of the Okanogan River. During peak flows the Similkameen River contributes about 6.5 times more water than the Okanogan carries coming out of Canada. However, during the heat of summer (July through September) and base flow periods (October through January) each river contributes approximately equal amounts of water to the confluence. Peak discharge typically occurs in late May to early June with an ascending limb that occurs from mid-March through early May and a descending limb that exists from July through September.

Okanogan River at Oliver, BC

In 2006, an abundance of snow produced a peak discharge of 2758 CFS on 06/11/2006 (Figure 10). However, flow management resulted in discharges that were considerably below the historic averages during the periods from November through January, late March to early May, and late July through early September. Due to the low flow periods the total amount of water produced from the Okanogan River basin was only slightly above average. Because these flows are managed for the benefit of sockeye salmon using a Fish & Water Management Tool (<http://www.essa.com/projects/descriptions/1250.htm>) it is likely that these flows are highly productive for this species and other fall spawners. However, the full impacts resulting from these managed flows on spring spawning salmon and steelhead remain unknown. In 2006, steelhead spawning likely occurred during flows that were less than historic flows. Peak runoff however, was closely aligned with the emergence timing for Okanogan River summer steelhead whereas historic data align summer steelhead emergence with the descending limb of the hydrograph.

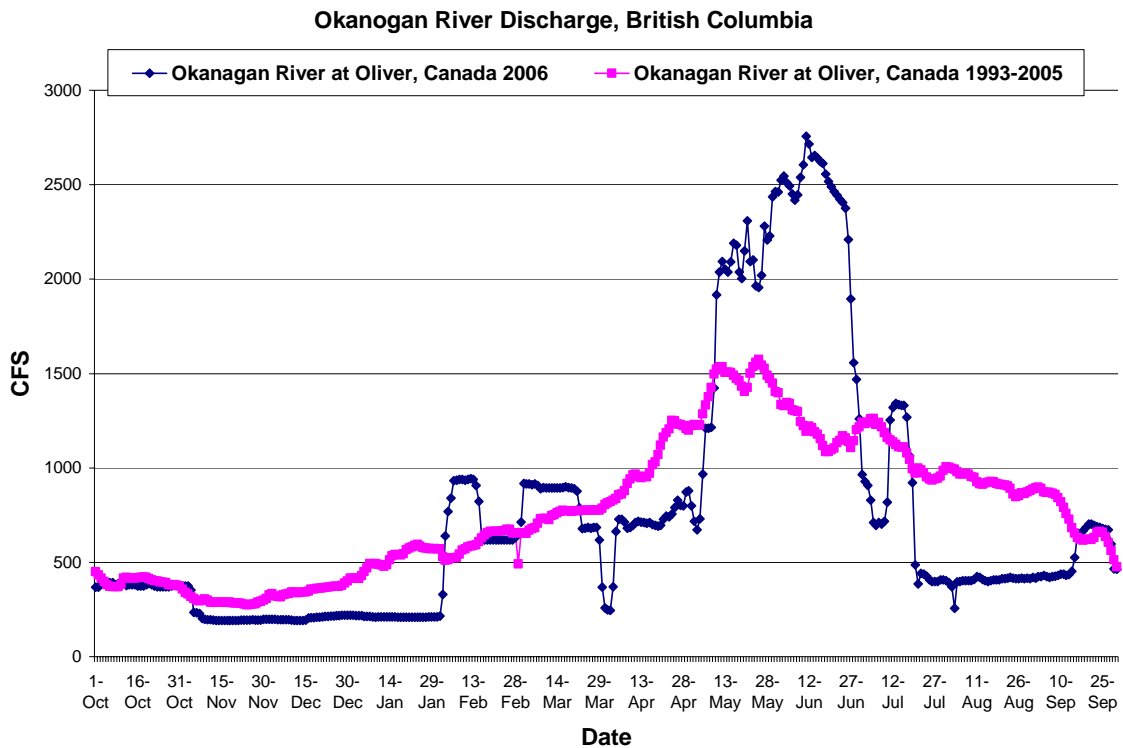


Figure 10: Real-time discharge from gauge on the Okanogan River located at the town of Oliver in Canada showing the historic average from 1993 to 2005 compared to 2006.

Okanogan River at Oroville, WA

In 2006, peak flows were 2,640 CFS on June 17th, compared to the average peak flow in May of 1,500 CFS (Figure 11). Multiple flow manipulations upstream resulted in discharges that were considerably below the historic averages during the periods from late November through early February, and from Late July through September. Discharge was highly volatile from February through May. The total amount of water produced from the Okanogan River basin was only slightly above average. However, discharges below Zosel Dam are highly regulated by the rules set forth by the International Joint Commission and flows released by Canadian water managers who have agreed to use the FWMT. These rules result in major operational constraints that can result in discharge patterns that are not beneficial to salmonid using habitats downstream. For example, extremely low discharges during early April have negative impacts on spawning summer steelhead by encouraging them to spawn in areas that will become scour zones during high flows, resulting in high egg to fry mortalities. Approaches to reduce these impacts and increase operational flexibility to meet multiple uses for water from Osoyoos Lake are currently being considered by WDOE who owns Zosel Dam.

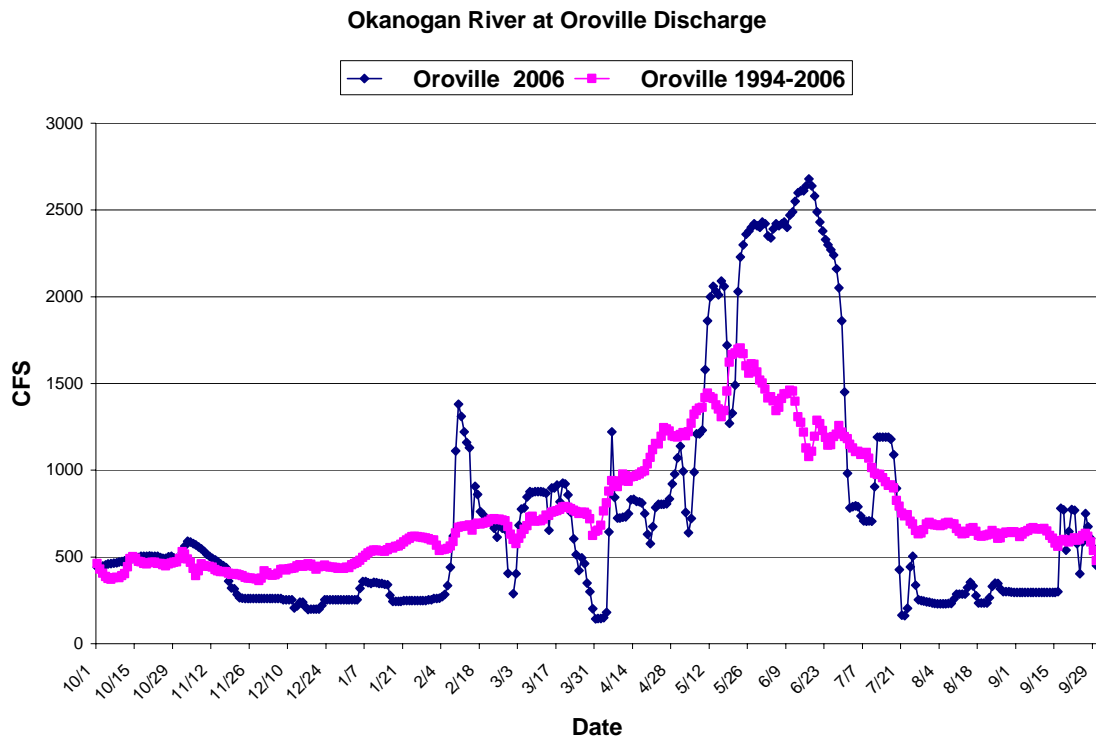


Figure 11: Real-time discharge for USGS gauge on Okanogan River located at the Highway 97 Bridge at the town of Oroville in 2006 compared to the historic average from 1993 to 2005. Flows are highly regulated resulting in an irregular hydrograph.

Similkameen River at Oroville, WA

The hydrograph for the Similkameen River shows a high flow period from May through mid-June and a low flow period that lasts from August to March (Figure 12). Most of the flow in this drainage is generated directly from snowmelt. In 2006, daily average peak flow data was 19,500 CFS on the 22nd of May, compared to the average daily peak flow from 2002-2005 of 9,885 CFS on the 12th of June. Run-off was delayed by 2 weeks in 2006 compared to the historical averages and peaked rapidly in May. However, the low flow period from October to March and from July through September approximated the historical averages. For example, extremely low discharges during early April could have encouraged spawning summer steelhead to build redds in areas that will become scour zones during high flows, potentially resulting in higher than normal egg to fry mortalities.

Okanogan River below the Confluence with the Similkameen River

The mainstem Okanogan River downstream of the confluence with the Similkameen River is monitored by the USGS at two sites; one near the town of Tonasket (Figure 13) and one near the town of Malott, Washington (Figure 14). Peak flows in 2006 were approximately 6,000 CFS higher than the twelve year average. Peak flows were 16,700 CFS at Tonasket and 17,600 CFS at Malott on May 21st. Twelve year, average daily peak flows were on May 31st and only reached 10,855 CFS at Tonasket and 11,180 CFS at Malott. Peak flows in 2006 were ten days earlier in May than average peak flows at both gauges. Base

flow conditions from October to mid-March and again in September approximated normal compared to the historic averages.

The 2006 water year had an abundance of water due to above average snow packs in the mountains but run-off proceeded rapidly resulting in a tall but narrow hydrograph. The extreme discharges recorded in 2006 are likely to have benefited the spawning reaches along the main-stem Okanogan River by disturbing gravels and flushing fine sediments from areas that would be used for spawning in normal water years. Although eggs in the gravels may have experience scouring in 2006 this disturbance will likely benefit main-stem salmonid production for the next several years to come. Missing data was due to malfunctions caused by ice.

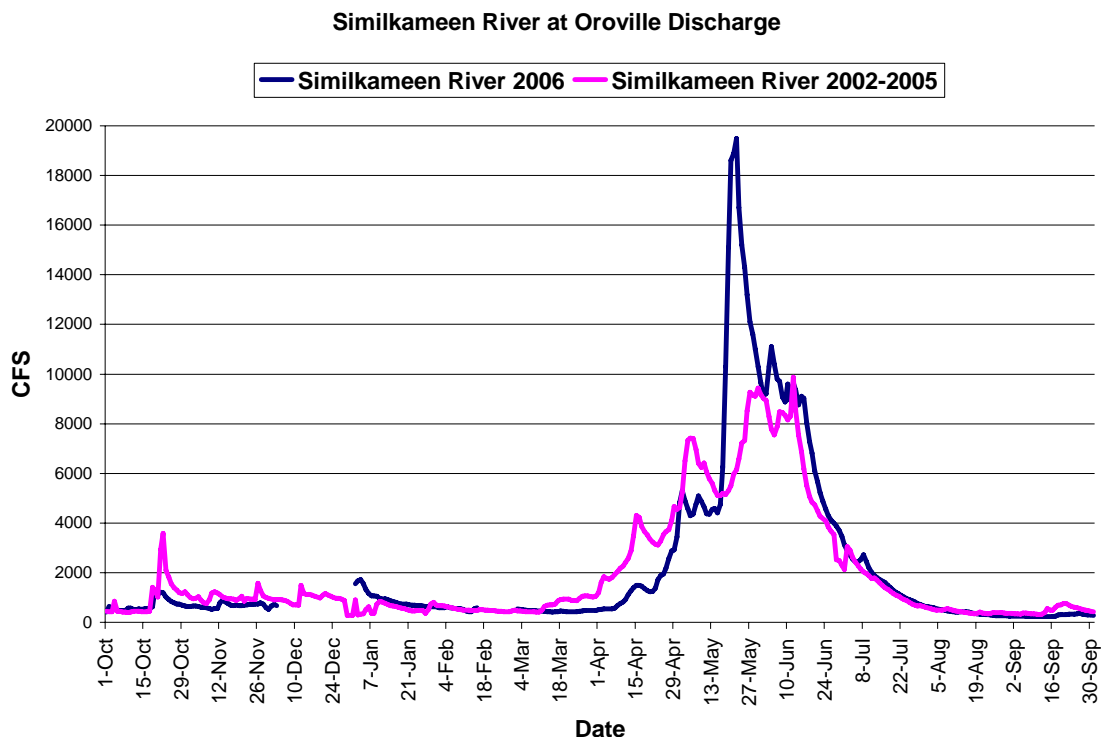


Figure 12: Real-time discharge for WDOE gauge on Similkameen River located at the town of Oroville comparing the historic daily average from 2002 to 2005 to 2006.

Twelve Year Discharge trends on the Okanogan and Similkameen Rivers

We graphed 12 year discharge trends for the Okanogan River subbasin at; Oliver, British Columbia, Oroville and Malott, Washington, and on the Similkameen River at Nighthawk, Washington. We compared the minimum mean daily discharge value across the 12 year period from 1995-2006. We selected the minimum mean daily value because it ultimately influences the maximum amount of rearing or spawning habitat that would be available to salmonids within a given year reflecting the maximum carrying capacity.

Our results indicate that in general, the discharge trend supports that headwater areas remain little impacted by changes to minimum instream flows with the impact becoming more

defined as you move down stream through the watershed. All sites graphed had what appeared to be a slightly decreasing trend. However, based upon our statistical analysis we discovered that the Similkameen River as it flows into Washington State did not have a discernible trend and should therefore be considered stable in regard to minimum annual discharge. On the Okanogan River minimum flows have decreased over the last 12 years and the rate of change was estimated at -2.1CFS/yr at Oliver, -7.4CFS/yr at Oroville, and -28.3CFS/year at Malott (Figure 15). This trend is not beneficial for salmonid production and efforts to reverse this trend should be strongly encouraged.

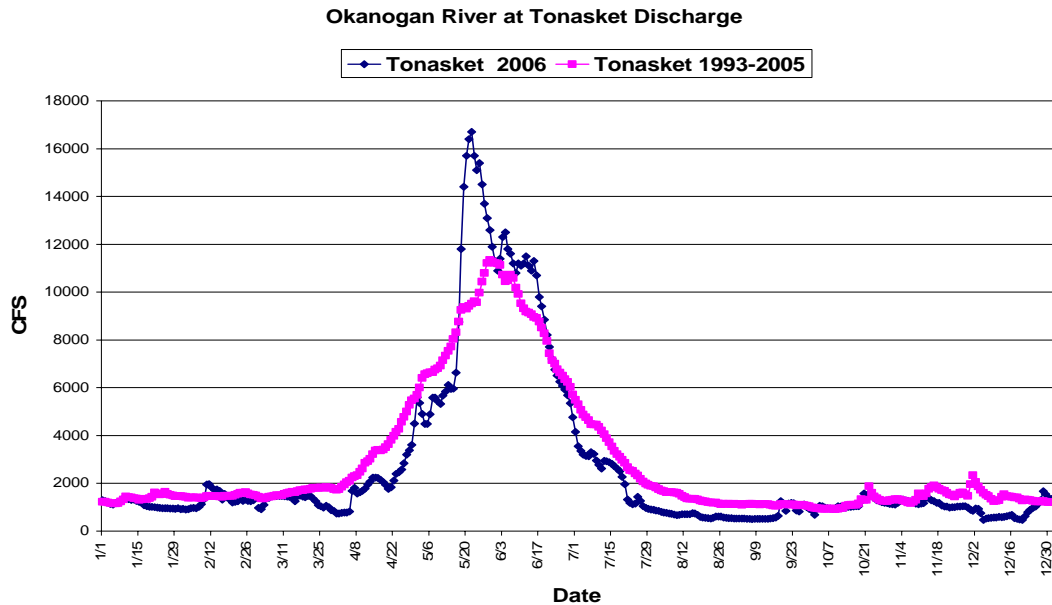


Figure 13. Real-time discharge from the USGS gauge on the Okanogan River located near the town of Tonasket, WA comparing 2006 to the historic daily average from 1993 to 2005.

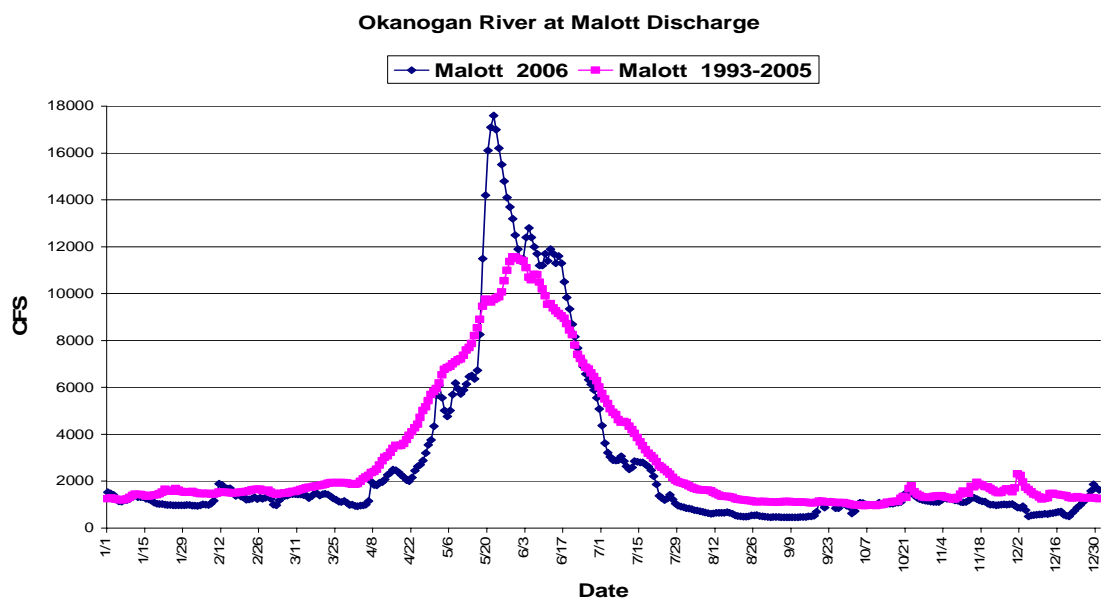


Figure 14. Real-time discharge for WDOE gauge on the Okanogan River located near the town of Malott comparing the historic daily average from 1993 to 2005 compared to 2006 data.

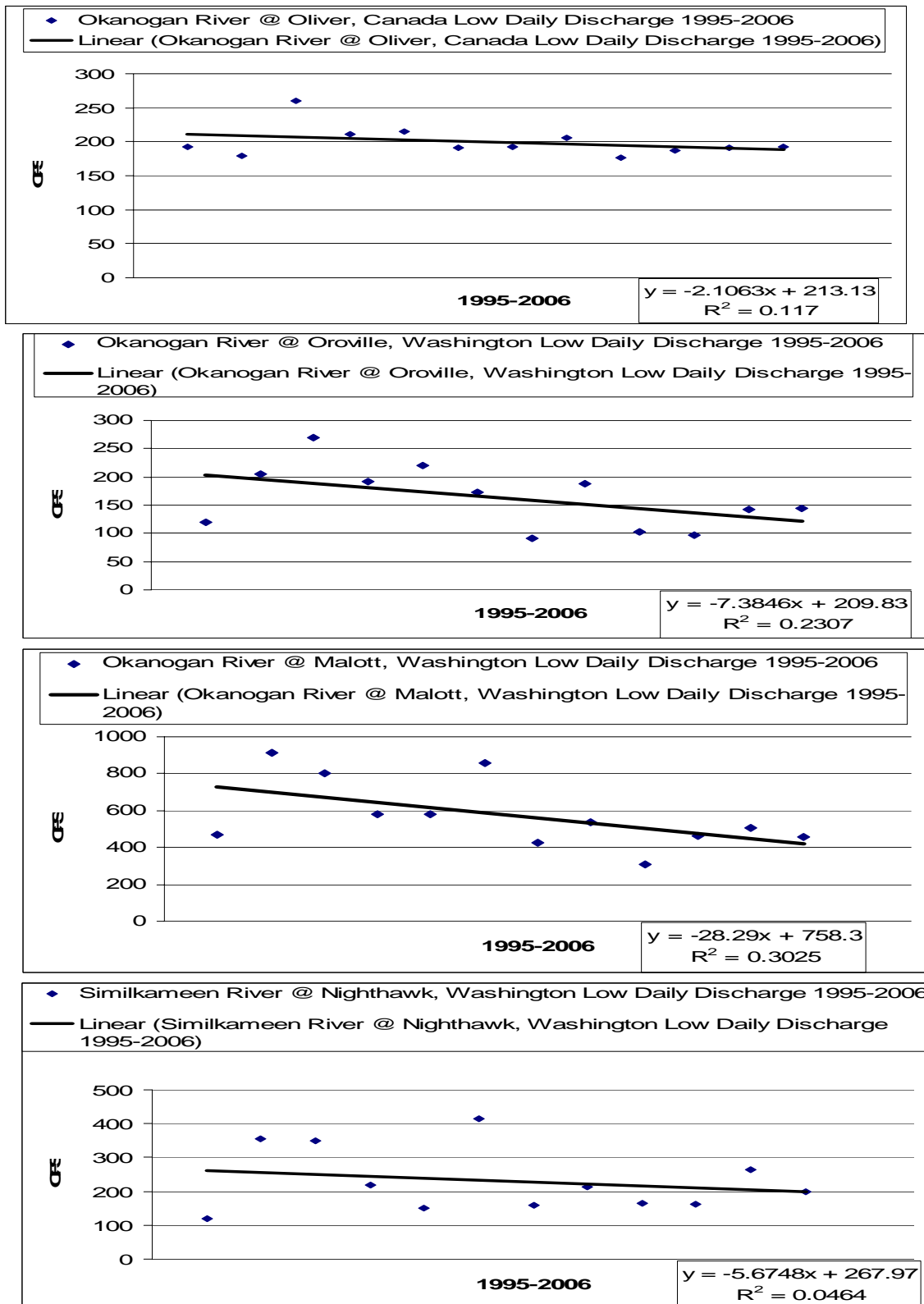


Figure 15. Minimum, mean daily discharge trend over a 12 year period from 1995-2006 taken from real-time gauging stations located along the Okanogan and Similkameen rivers

These results indicate that consumptive uses of water are magnified as you progress downstream resulting in less water remaining instream during low discharge periods. Although changes in headwater areas appear small by comparison to the cumulative impacts of many headwater areas that helps contribute to large downstream changes. Many of the impacts to headwater streams occurred many years ago (i.e. diversions, etc.) thus, little water remains during the low flow periods. Small headwater changes as measured on the mainstem Okanogan and Similkameen Rivers could mask major changes within certain sub watersheds. Future discharge monitoring should attempt to expand real or near real-time gauging sites to additional tributary watersheds in the future and then use these data to analyze changes over time.

Water Quality indicators other than discharge and temperature

Water Quality information other than discharge and temperature were collected as part of OBMEP at all EMAP sites located on tributary streams of the Okanogan River (Figure 1 & 2). During the 2007-2009 Northwest Power and Conservation Councils, Fish and Wildlife Program funding allocations, insufficient funds were awarded for continued water quality data collection under the OBMEP project. Therefore, these data were only collected from May of 2005 through February of 2007. This decision has greatly reduced or at least delayed the twenty year experimental OBMEP design for water quality data in the tributaries. Regardless, information is collected by WDOE at fixed sites located at the Okanogan River in Oroville (upper Okanogan River), Malott (lower Okanogan River) and on the Similkameen River at Oroville. The WDOE sites collect additional data such as nutrient parameters which were always considered beyond the OBMEP scope due to fiscal limitations.

For this report we have compared and analyzed the following water quality indicators for each WDOE monitoring site: dissolved oxygen, turbidity, pH, ammonia, nitrogen phosphorous and conductivity. When and where possible we compared twelve year status averages from 1993-2005 with status data collected in 2006 and developed trends for the period from 1994-2006. Because no historical data exists for the OBMEP tributary sites only between site status comparisons based on 2006 data were possible. The biological linkages for each water quality parameter on anadromous fish found within the Okanogan River basin are provided as part of each indicators description. Water quality information is presented for each indicator and presented in graphic form below (Figures 16-35).

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). Research has determined that a correlation between the rate of development and survival of salmonid eggs with dissolved oxygen levels exists as they begin to hatch (Piper et al. 1982). If dissolved oxygen levels are below 8mg/L survival and development at time of hatching reduces rapidly. At levels above 8mg/L salmonid survival and development benefits increase at a slower rate until 10mg/L. The amount of oxygen that can be dissolved in water is a function

of temperature and pressure. To reduce solubility below 6mg/L requires temperatures greater than 25°C and atmospheric pressures below 560 mm Hg (Colt and Tomasso 2001). For fluvial systems these impacts are isolated due to air to surface water exchange processes that are enhanced through the turbulence of moving waters. In the Pacific Northwest dissolved oxygen readings below 8mg/L are isolated to lentic environments, areas with high biological oxygen demands (i.e. sewage returns), or during times when streams become dewatered.

The average barometric pressure in the Okanogan valley is 760 mm Hg and water temperatures rarely exceed 25°C therefore the theoretical minimum dissolved oxygen would be approximately 8mg/L (<http://www.weatherunderground.com>). 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. Although it is unlikely that barometric pressures will likely change in the foreseeable future global warming issues could result in increased water temperatures in the near term that could result in reduced dissolved oxygen levels.

Dissolved Oxygen-Main-stem Status and Trend

Empirical data collected from 1993 to 2005 supports the scientific literature findings that show a close correlation between temperature and dissolved oxygen. In the Okanogan River subbasin this mean high levels of dissolved oxygen (12-14 mg/l) present from December through March during the cold water months and low levels of dissolved oxygen occurring from mid-July through September during the warm water months. In 2006, dissolved oxygen levels on the lower Okanogan River stayed just above 8mg/L, with the lowest reading of 8.2 mg/L occurring on September 14, 2006 (Figure 16). Dissolved oxygen levels in the Similkameen River stayed above 8 mg/L for all of 2006, with the lowest reading of 8.78 mg/L on September 14, 2006 (Figure 17). Egg incubation and hatching occurs for summer/fall Chinook from October through January and for summer steelhead late-March through early-July. Dissolved oxygen readings typically exceed 10 mg/l during this timeframe and therefore this indicator is unlikely to adversely impact these fish species. Dissolved oxygen readings in early October for summer/fall Chinook and from June through early July for summer steelhead can occasionally drop to the range from 8 to 10 mg/L and therefore warrants continued monitoring. Especially near Oroville which is near primary spawning areas to ensure that readings do not drop below 8 mg/l in the future.

We studied 12 year trends for mean dissolved oxygen levels in the Okanogan and Similkameen Rivers for the period from 1995 to 2006. We focused our trend analysis on the time of egg incubation for summer/fall Chinook (October thru January, Figure 18) and summer steelhead (late-March through early-July, Figure 19). We found that for the past 12 years dissolved oxygen levels have been on a slightly downward trend during summer/fall Chinook egg incubation. Reductions in the mean dissolved oxygen levels are occurring at a rate from -0.054 to -0.086 mg/L/yr at the Similkameen River and Okanogan River at Oroville sites respectively (Figure 18). Trends for the summer steelhead incubation period were less defined. Statistics indicated that dissolved oxygen levels at the Similkameen River and Okanogan River at Malott remained stable. A slightly downward trend was marginally detectable for the site on the Okanogan River at Oroville with dissolved oxygen levels

declining at a rate of -0.033 mg/l/yr (Figure 19). The cause for these declining trends in dissolved oxygen levels is likely related to increasing water temperatures but the extent that other factors could be influencing these results remains unknown. Although this trend is moving in a direction that is of concern, dissolved oxygen levels are high enough, at present, that they are unlikely to have a negative impact on salmonids.

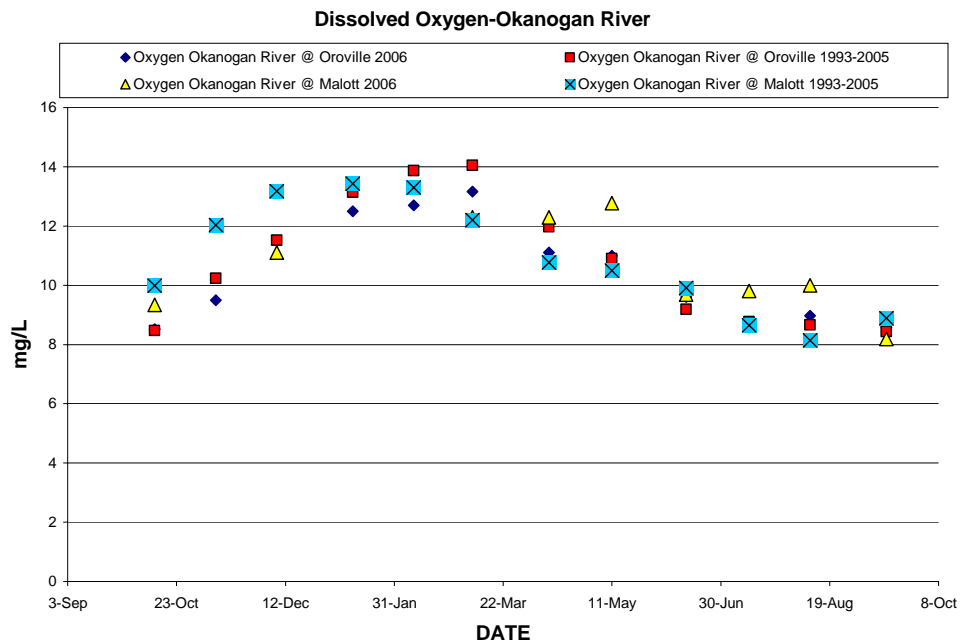


Figure 16. Status data for dissolved oxygen levels collected by WDOE for the Okanogan River sites located near the town of Malott, and Oroville, Washington comparing the historic average from 1993 to 2005 compared to 2006 data.

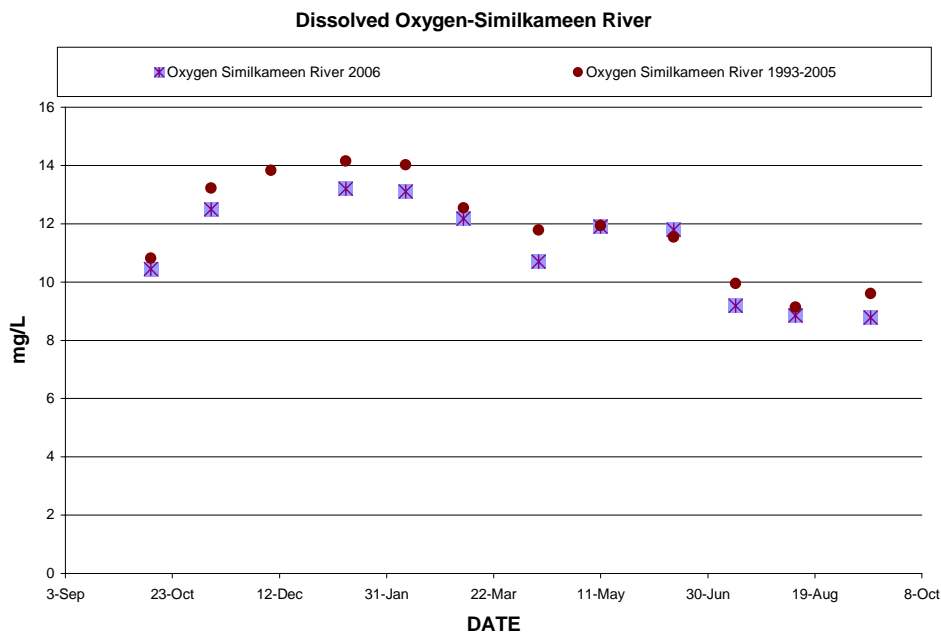


Figure 17. Status data for dissolved oxygen levels collected by WDOE for the Similkameen River sites located near the town Oroville, Washington comparing the historic average from 1993 to 2005 compared to 2006 data.

Dissolved Oxygen 12 year Trend During Summer/Fall Chinook Egg Incubation in the Okanogan and Similkameen Rivers

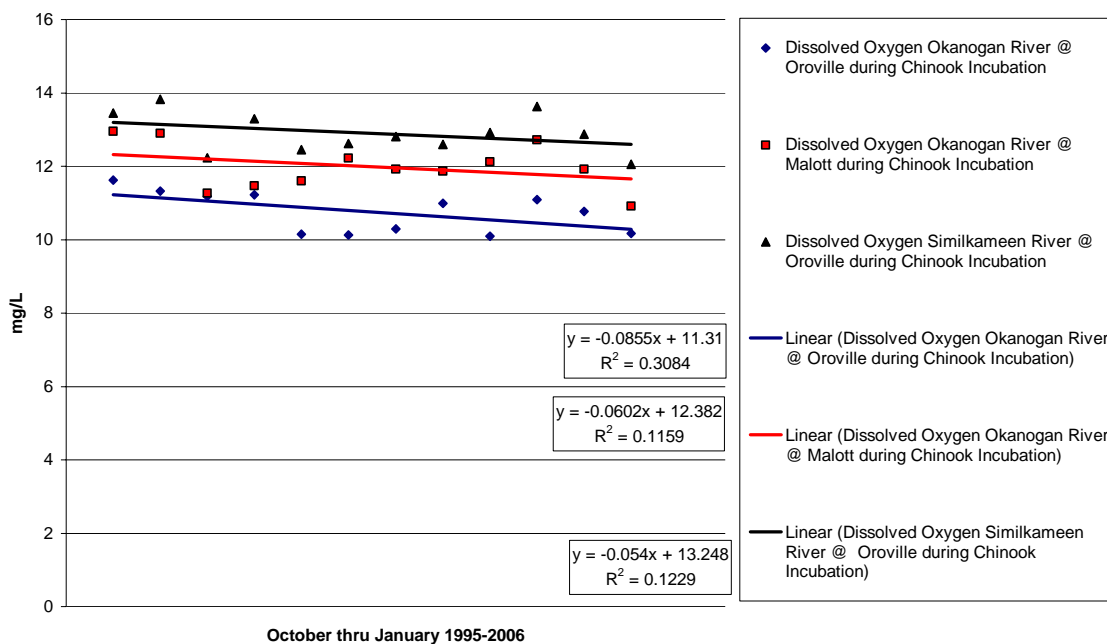


Figure 18. Mean annual dissolved oxygen levels recorded for the period from October through January (when summer/fall Chinook eggs are incubating) from 1995 to 2006. Dissolved oxygen levels represent the mean values that were derived using WDOE grab sample data for the Okanogan River and Similkameen River sites located near the town of Malott, and Oroville, Washington.

Dissolved Oxygen 12 Year Trend During Steelhead Egg Incubation in the Okanogan and Similkameen Rivers

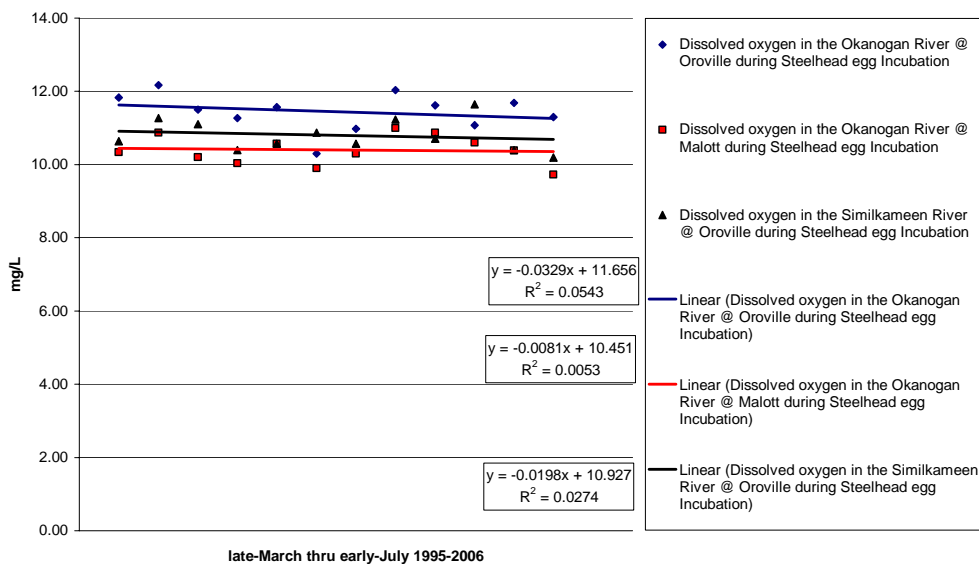


Figure 19. Mean annual dissolved oxygen levels recorded for the period from March through May (when summer steelhead eggs are incubating) from 1995 to 2006. Dissolved oxygen levels represent the mean values that were derived using WDOE grab sample data for the Okanogan River and Similkameen River sites located near the town of Malott, and Oroville, Washington.

Dissolved Oxygen-Tributary Status

Temporal patterns of dissolved oxygen levels in the tributaries were similar to those observed along the main stem sites with high levels occurring during cold water months and low levels occurring during the warm water months. Dissolved oxygen levels at tributary sites bottomed out earlier than main-stem sites which is consistent with temperature patterns that show warm temperatures peaking earlier in small tributaries. However, with only one year of data to look at making accurate and meaningful statements is difficult and potentially misleading. However, our data suggests that low dissolved oxygen levels in the tributaries remained above 8 mg/L throughout 2006. The lowest monthly average reading occurred on Mill Creek and was 8.16 mg/L along with the second lowest mean value of 8.45 mg/L which occurred in August. Mill Creek has extensive grazing activities throughout this watershed therefore it is likely that biological oxygen demand is higher for this stream than others. The lowest reading on a perennial stream was 8.91 mg/L on Salmon Creek during the month of June. All dissolved oxygen readings in tributary streams were within the acceptable parameters for salmonid production (Figure 20).

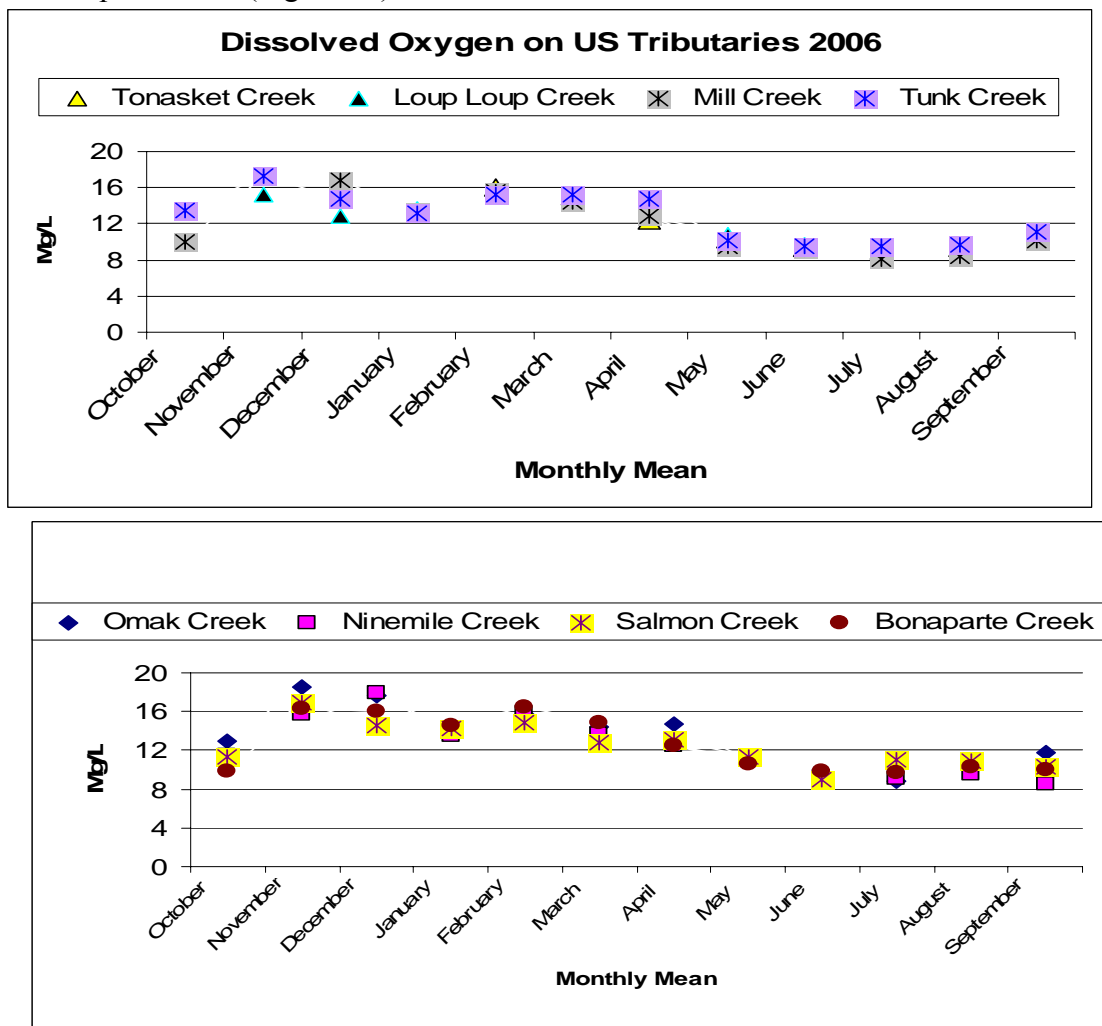


Figure 20: Status data for dissolved oxygen levels collected by OBMEP for the tributary sites sampled in 2006. Top graph represents streams that have sections which are intermittent and bottom graph represents streams that are considered perennial.

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 ($\text{g O}_2/\text{m}^2$) 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 where 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).

Turbidity-Main-stem Status and Trend

In 2006, and historically, the Okanogan River exiting Canada had turbidity levels well below any threshold of biological importance, see, Okanogan River at Oroville (Figure 21). 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 lower Okanogan and Similkameen Rivers show that turbidities from July to March typically occur at levels that would have no impact on salmonids as levels are below 30 NTU throughout this time of the year (Figure 21). The historic twelve year average and 2006 data on the lower Okanogan River at Malott show turbidities from May through June approaching 30 NTU. The Similkameen River in 2006 peaked at 70 NTU in May with historic averages of 30 NTU. Juvenile steelhead and summer/fall Chinook are in the river at this time. The 2006 level of turbidity in the Similkameen had the potential to reduce primary productivity and reduce growth of newly hatched fish. This level may also have been helpful as a catalyst for smolt out-migration as juvenile fish are known to avoid areas with turbidities over 70 NTU.

We looked at the trend in the Okanogan and Similkameen Rivers of the level of turbidity during salmonid egg hatching and smolt outmigration, the months of April thru June. Over the last 12 years, the Okanogan River at Oroville turbidity levels were stable at below 5 NTU's. The Okanogan River site at Malott and the sampling site on the Similkameen River at Oroville had a marginally detectable decreasing trend in turbidity (Figure 22). However, these data were highly variable and appear to be more influenced by the magnitude of spring runoff than by changes in upland conditions or road densities. The rate of change was greatest for the Similkameen River at -1.2 NTU/yr. A trend toward reduced turbidity would be considered a positive for the Okanogan River and with average values below 40 NTU in all years it is unlikely that turbidity levels are having a negative impact on salmonid populations.

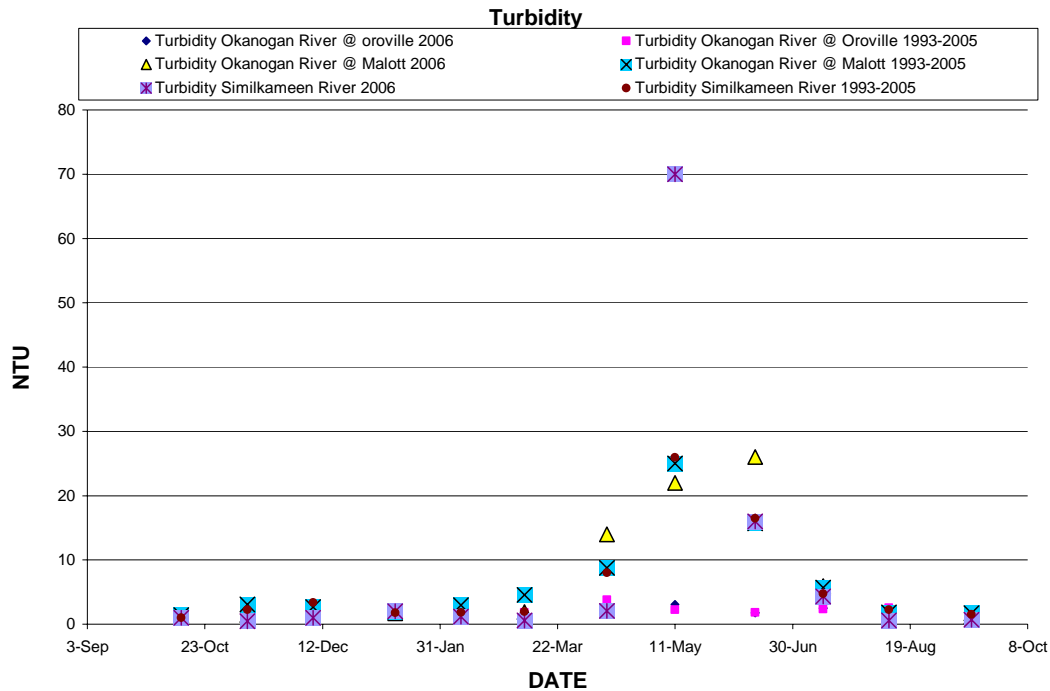


Figure 21. Turbidity levels for the Okanogan River and Similkameen River sites located near the town of Malott, and Oroville, Washington comparing 2006 data to the historical average from 1993 to 2005.

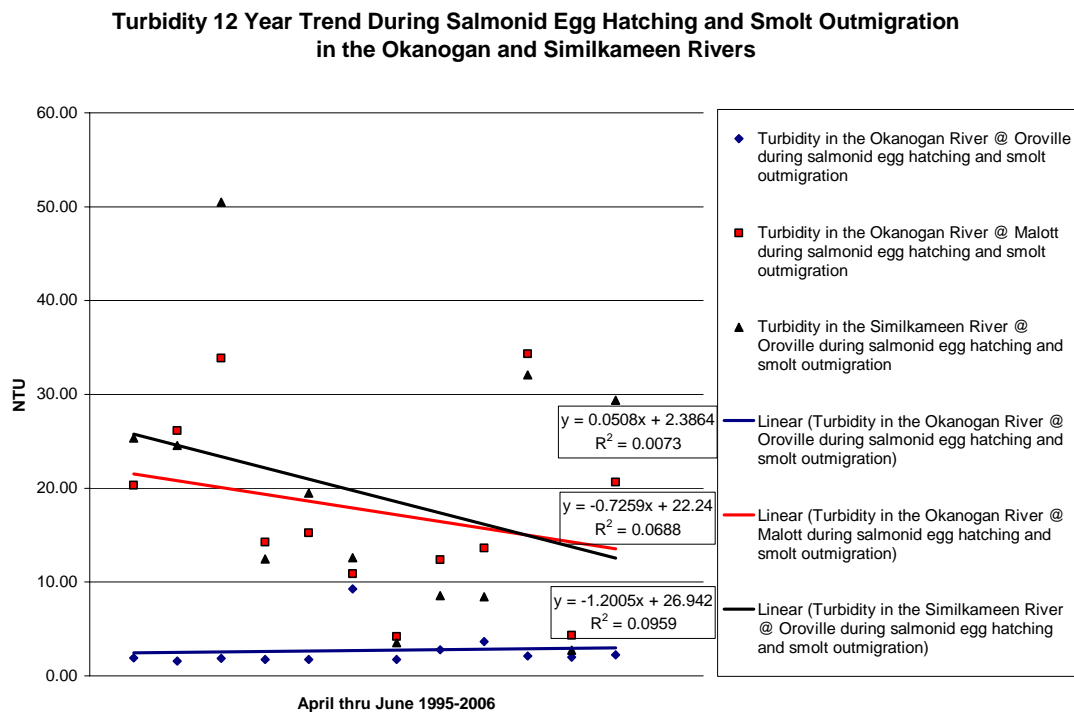


Figure 22. Trend data for turbidity collected from 1995 to 2006 during salmonid egg hatching and smolt outmigration (April through June) by WDOE for the Okanogan River and Similkameen River at sites located near the town of Malott, and Oroville, Washington.

Turbidity-Tributary Status

We collected data on turbidity levels at OBMEP tributary sites along the Okanogan River in 2006. Grab samples at the tributary sites were collected three times a month and averaged by month and between sites for each of the eight sub watersheds where data were collected (Figure 23). Empirical data at these sites were highly variable when it came to the NTU levels but using averaged data defined more consistent patterns. Turbidity levels peaked during spring runoff and remained low during the low discharge time frame. However, two intermittent tributaries had high turbidity levels during the winter months that are unexplained but likely linked to localized runoff events. Bonaparte and Omak Creek were the only tributaries that had monthly average readings above 70 NTU (Figure 23). Major upland disturbance in the Bonaparte Creek watershed has occurred for decades and agricultural practices within the riparian areas along this creek have led to major channel incision and bank instability. High sediment loads continue to threaten this watershed and reduce the salmonid productivity of this tributary. Major rehabilitation efforts are needed within the Bonaparte Creek sub watershed to improve salmonid habitats. Within the Omak Creek watershed major sediment loads due to extremely high road densities and years of high sediment inputs will take decades to be processed by natural means. Extensive rehabilitation efforts over the past few years to replace culverts decommission roads, and exclude livestock from riparian areas will help reduce sediment inputs. Measurable changes in turbidity levels are unlikely to occur in the near future.

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-Main-stem Status and Trend

pH remained relatively consistent in 2006 when compared to the 1993-2005 average for all the Okanogan and Similkameen rivers sites with one notable exception (Figure 24). During 2006, the pH values for the Similkameen River dropped to near 7 in April and the exact cause of this remains unknown. However, this value was still within the recommended range for salmonid species.

The 12 year trends for pH indicate that levels are remaining stable along the entire Okanogan River (Figure 25.). However, within the Similkameen drainage dramatic annual changes in the mean pH values have occurred resulting in a declining trend for pH at a rate of -0.024 pH units/yr. The high variability in these data could be the result of sporadic acidic inputs or a lack of sufficient buffering to stabilize this indicator. The long history and present day mining activities within the Similkameen drainage have the potential to produce point sources of a highly acidic nature. Sporadic releases from mining activities would closely mimic the data that we observed in figure 25 but the sources of these inconsistent acidic release events remain unknown. Other possible explanations for the acidification occurring within the Similkameen drainage might include such things as increased densities of conifer trees or acid rain but both would be more likely to result in gradual changes in average pH

levels. Although pH values are within the optimal range for salmonids localized impacts from acidic point sources could negatively impact salmonid production within the Similkameen River and warrant further investigation.

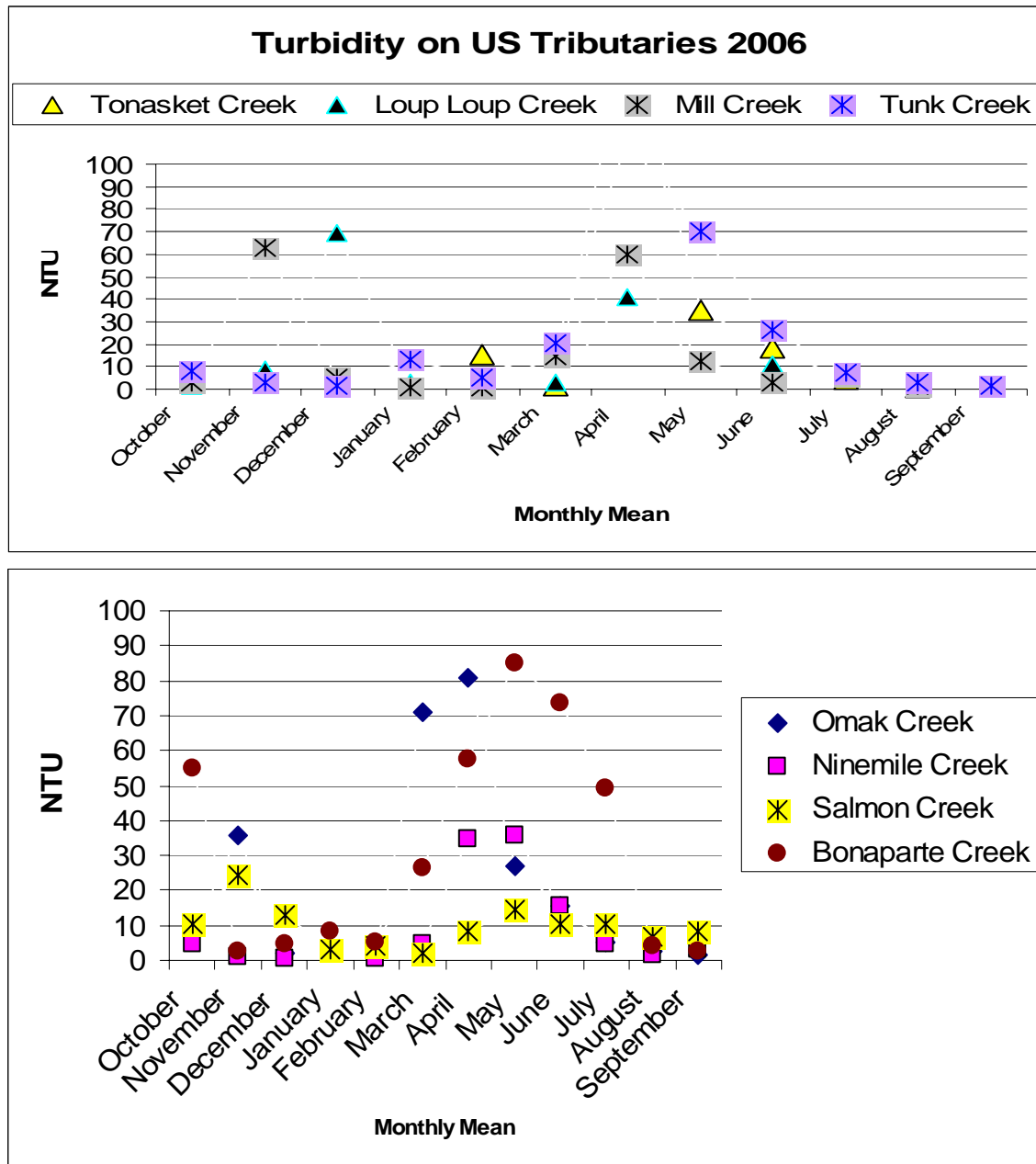


Figure 23. Average monthly turbidity for 2006 from 8 tributary sub watersheds within the Okanogan River basin.

pH-Tributary Status

pH was consistently within the recommended range for salmonid fish species at all the OBMEP tributary sites surveyed by the Colville Tribes during 2006 (Figure 26). The lack of fluctuation between space and over time indicates that these tributaries have excellent buffering characteristics that protect them from fluctuating pH levels. With a stable reading for pH between 7.2 and 8.7 these waters would be considered weakly basic and excellent for invertebrates and fish (Figure 26). The stability of pH values means that pH levels are likely to remain so in the future. Monitoring efforts for this indicator could be reduced to the most downstream site within each sub watershed if data are to be collected in the future.

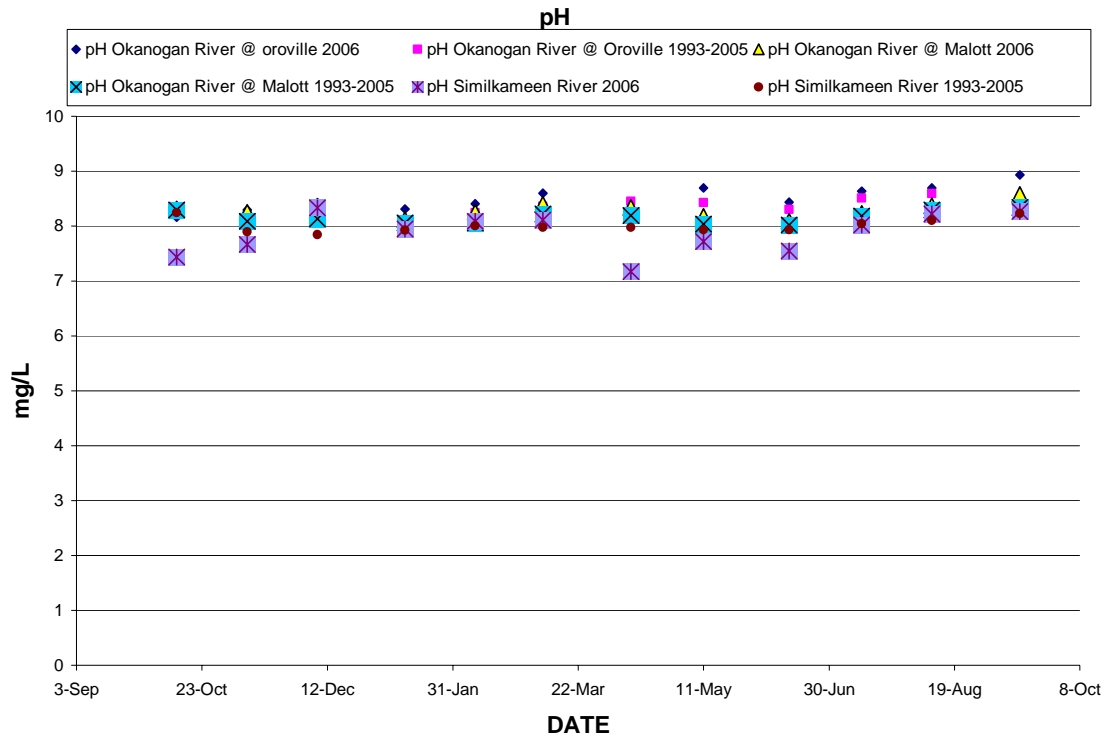


Figure 24. Status data for pH comparing 2006 values to the average values recorded from 1993 to 2005 on the upper Okanogan River and Similkameen River site located at the town of Oroville, WA, and the lower Okanogan River site near the town of Malott, WA.

pH 12 Year Trend in the Okanogan and Similkameen Rivers

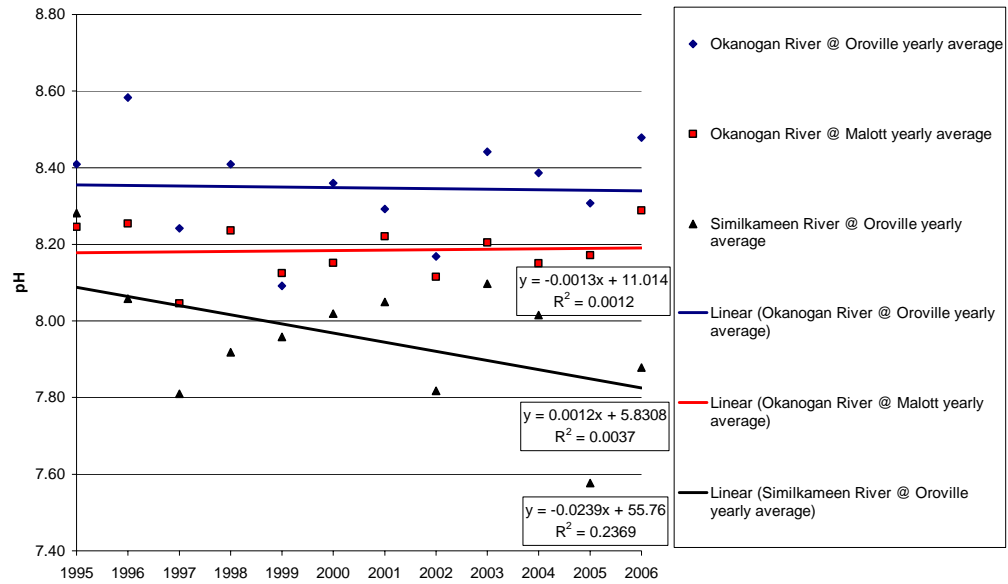


Figure 25. Mean annual pH values collected at WDOE sites along the Okanogan River and Similkameen River near the towns of Malott, and Oroville, Washington over a 12 year period from 1995 to 2006.

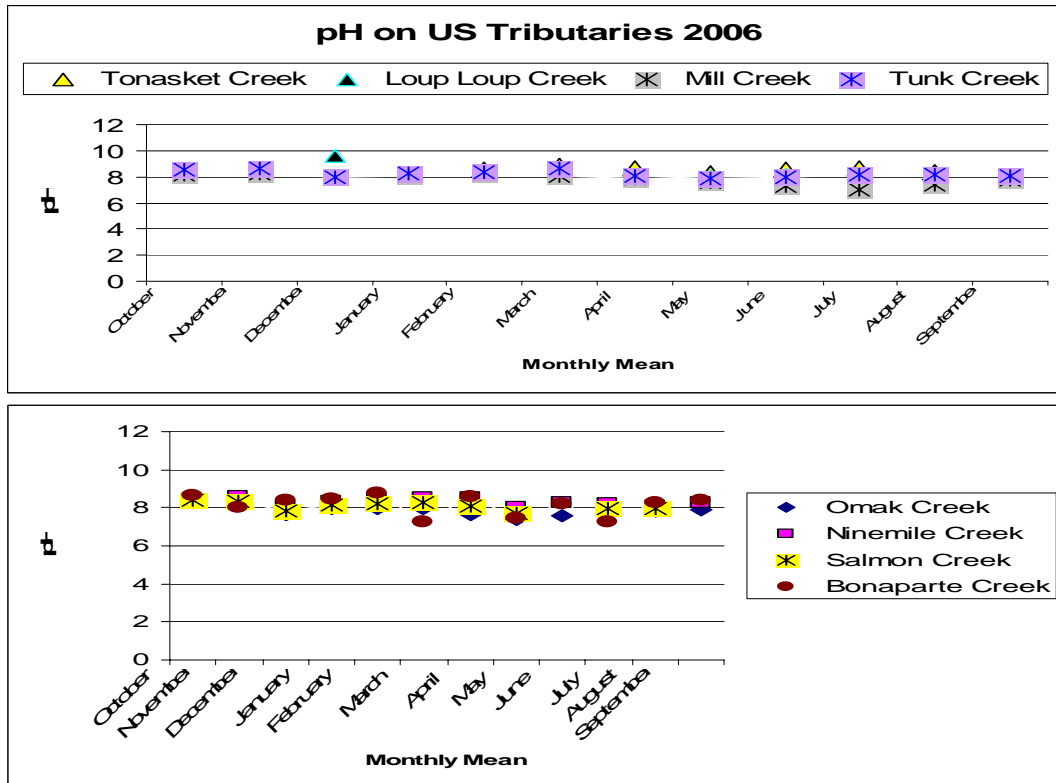


Figure 26. Mean monthly pH values for 8 tributary sub watersheds within the Okanogan River basin derived from data collected by the Colville Tribes during 2006.

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 27) and temperature can exceed 20°C (Figure 36) 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 et al. 1982, Burrows 1964). The literature shows the minimum lethal level for ammonia, NH_3 , for rainbow trout is 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 WDOE 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-Main-stem Status and Trend

In 2006, the highest recorded values of ammonia-nitrogen occurred in October for the Okanogan River (0.032 mg/L) and for the Similkameen River (0.040 mg/L). However, during the cold water months much less of the unionized form that is toxic to fish is present. During the warmer water months from June through September both historically and in 2006 all readings were less than 0.015mg/L which is well below any levels considered harmful to salmonids (Figure 27). Historically, ammonia readings along the Okanogan and Similkameen rivers have shown very minor variation at all sites and over time. The reason for the increased level of ammonia-nitrogen in October of 2006 is unknown but levels are still below those that would represent a negative impact to salmonid fish species (Figure 27). The most common reading during all the hot summer months since 1994 is 0.01 or less and this represents the lowest reading possible given the methodology employed by WDOE therefore the actual values are likely to be less. After analyzing data on this indicator for 12-years at the WDOE sites ammonia levels have been well below any levels that would have any

biological impact, this brings into question the value of continued monitoring for this indicator.

We conducted a trend analysis on the mean annual values for ammonia and found that over the last 12 years the Similkameen River had remained definitively stable (Figure 28). However, data was more varied for the Okanogan River especially near Oroville, WA where at first glance it would appear that a trend existed; statistics show that no discernible trend existed. At the Malott site on the Okanogan River a marginally detectable declining trend does exist with ammonia levels declining at a very slow rate of -0.002 mg/L/yr . With a trend toward lower levels and because current levels are well below those that would have any impact on salmonids continued monitoring of this indicator for salmonids is of questionable value.

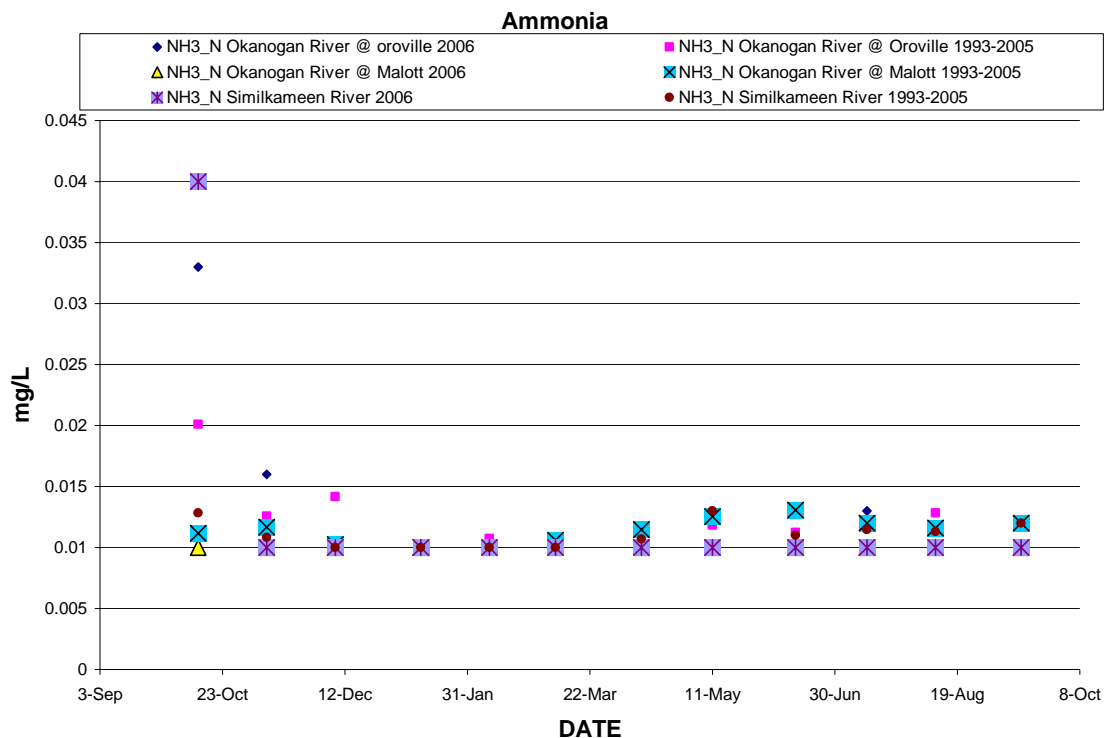


Figure 27. Status data collected in 2006 for Ammonia-nitrogen compared to the historical average from 1993 to 2005 at WDOE sites along the Okanogan River near the town of Malott, and Oroville, WA and the Similkameen River near Oroville, WA.

Ammonia (NH₃_N) 12 Year Trend in the Okanogan and Similkameen Rivers

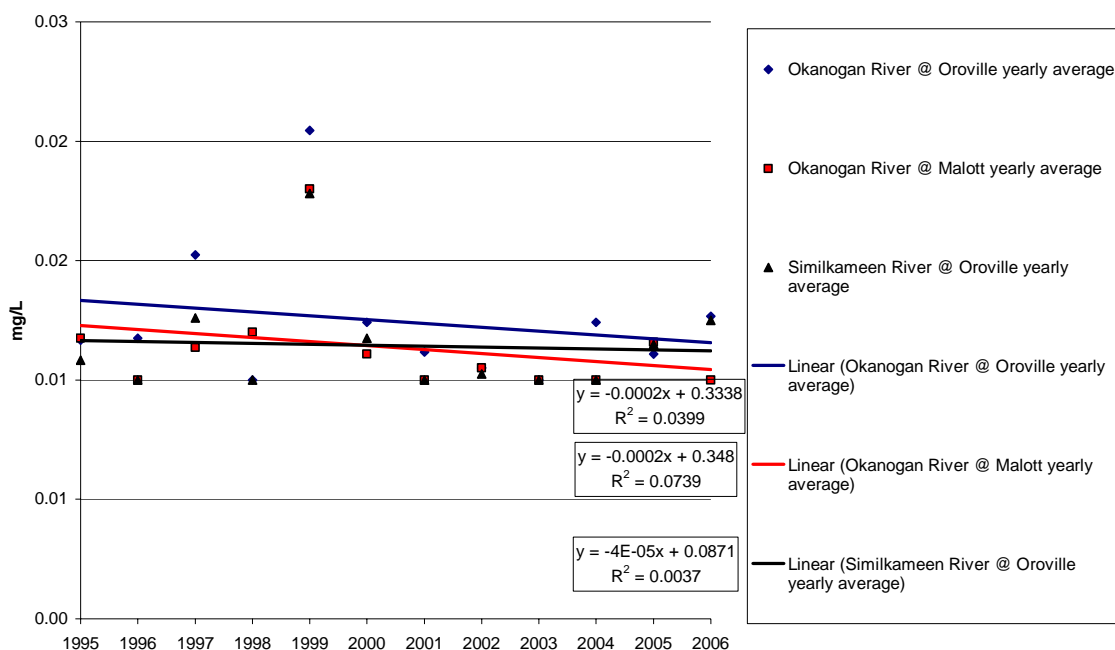


Figure 28. Mean annual trend data for Ammonia (NH₃_N) over the 12 year period from 1995 to 2006 for WDOE sites located on the Okanogan River and Similkameen Rivers.

Nitrogen and Phosphorus

Total nitrogen is measured by WDOE at sites along the Okanogan and Similkameen rivers and consists of both Nitrite (NO₂), and Nitrate (NO₃). Nitrogen is an oxidation product of mainly ammonia in aquatic systems and the primary source of these nutrients is from erosion, fish waste, other biological processes, 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 (HNO₂). Along the Okanogan River, 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 fish 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 fish growth by 50% due to increased algal growth. 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 constrained by the limiting nutrient.

In the Okanogan basin, we have phosphorous levels that are occasionally up to twice as high as nitrogen levels and N: P ratios remain well below the threshold of 10:1 during all times of the year (Figure 29-32). Nitrogen is always limiting in the Okanogan and Similkameen rivers 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 on salmonids.

Nitrogen and Phosphorus-Main-stem Status and Trend

The status of nitrite as measured by WDOE is consistently from 2 to 10 times below any potentially harmful level and has been since 1993. However, the measurements taken at WDOE sites include both nitrite and nitrate so direct measurement of this indicator is not possible and the specific proportion of each can only be estimated at present. Specific nitrite levels are likely 4 to 20 times below the levels currently monitored (Figure 29). Peak nitrogen nutrient loads on the Okanogan River in January likely result from salmon carcass decay. The magnitude of nitrogen levels in 2006 on the Okanogan and Similkameen rivers were up to five times less than average nitrogen levels from 1993-2005 (Figure 29). Between sites the highest readings both historically (0.095 mg/L) and in 2006 (0.067 mg/L) occurred at the Okanogan River site near Malott with the lowest reading for all sites in 2006 being 0.01 mg/L.

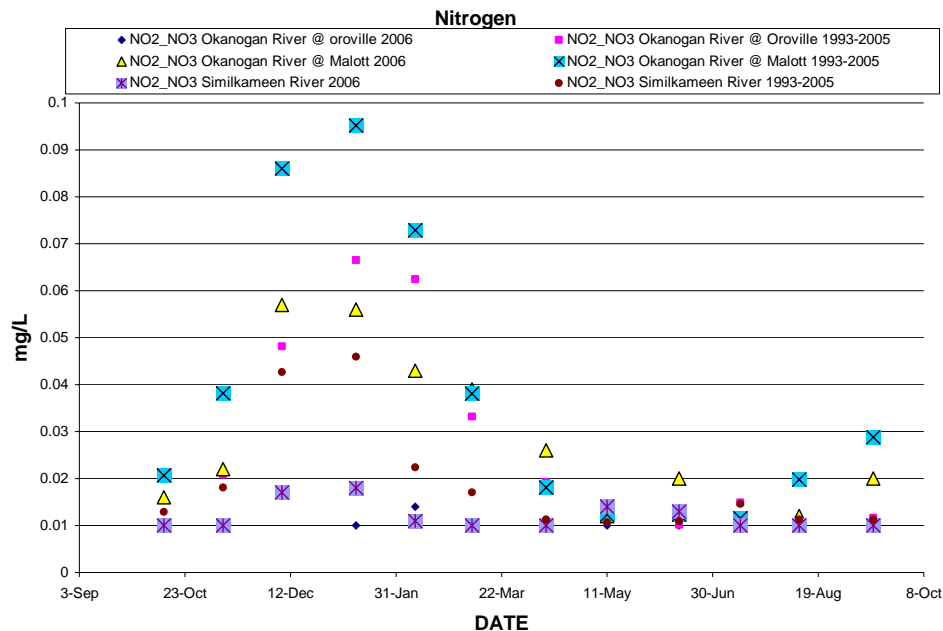


Figure 29. Status data for total nitrogen (nitrate + nitrite) comparing 2006 to the historical average readings from 1993 to 2005 collected at WDOE sites located along the Okanogan River near the town of Malott, and Oroville, WA and the Similkameen River near Oroville, WA.

Although not limiting, phosphorous levels have been measured at the WDOE sites over the last 12 years of interest (Figure 30). Peak phosphorous nutrient loads typically occur from April through June as water runs off upland areas during the spring. The magnitude of phosphorous levels in 2006 on the Okanogan and Similkameen rivers were approximately half the average phosphorous levels recorded from 1993-2005 (Figure 29). Between sites the highest reading both historically and in 2006 occurred at the Okanogan River site near Malott with the exception during the peak runoff period when the highest values (0.0923 mg/L) were recorded at the Similkameen River site. The lowest readings (0.0023 mg/L) occurred at the Similkameen River site during most of the year except during peak runoff when the lowest phosphorous readings (0.0071 mg/L) were recorded at the Okanogan River site near Oroville.

We found that in the last 12 years mean annual nitrogen values for all sites were trending slightly downward (Figure 31). The Okanogan River at Malott showed the greatest rate of decline at -0.0015 mg/L/yr. Mean annual phosphorous levels throughout the Okanogan subbasin are trending slightly downward with the highest rate of change (-0.003 mg/L/yr) occurring on the Similkameen River (Figure 32). The reduction in phosphorous levels is likely related to changes in land use practices such as reduced use of fertilizers. Over the past 12 years the ratio of N: P has moved toward a more nitrogen limiting system. Causative mechanisms for changes in nitrogen levels are currently not well understood.

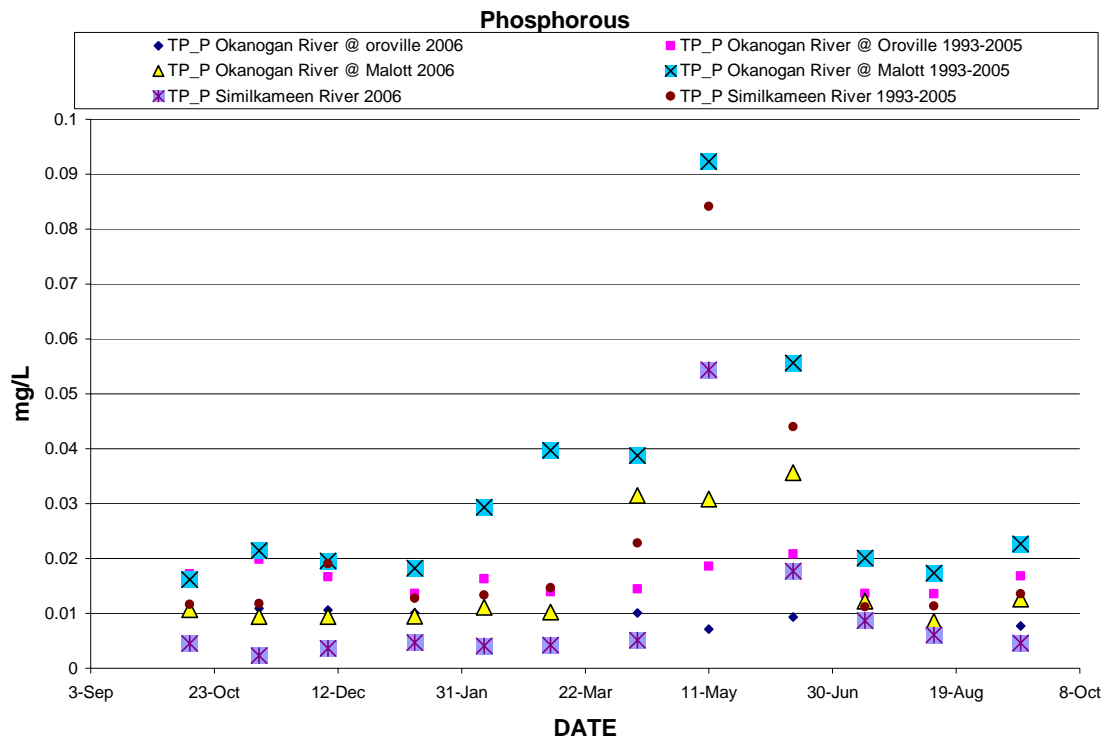


Figure 30. Status data for total phosphorous comparing 2006 to the historical average readings from 1993 to 2005 collected at WDOE sites located along the Okanogan River near the town of Malott, and Oroville, WA and the Similkameen River near Oroville, WA.

Nitrogen (NO₂_NO₃) 12 Year Trend in the Okanogan and Similkameen Rivers

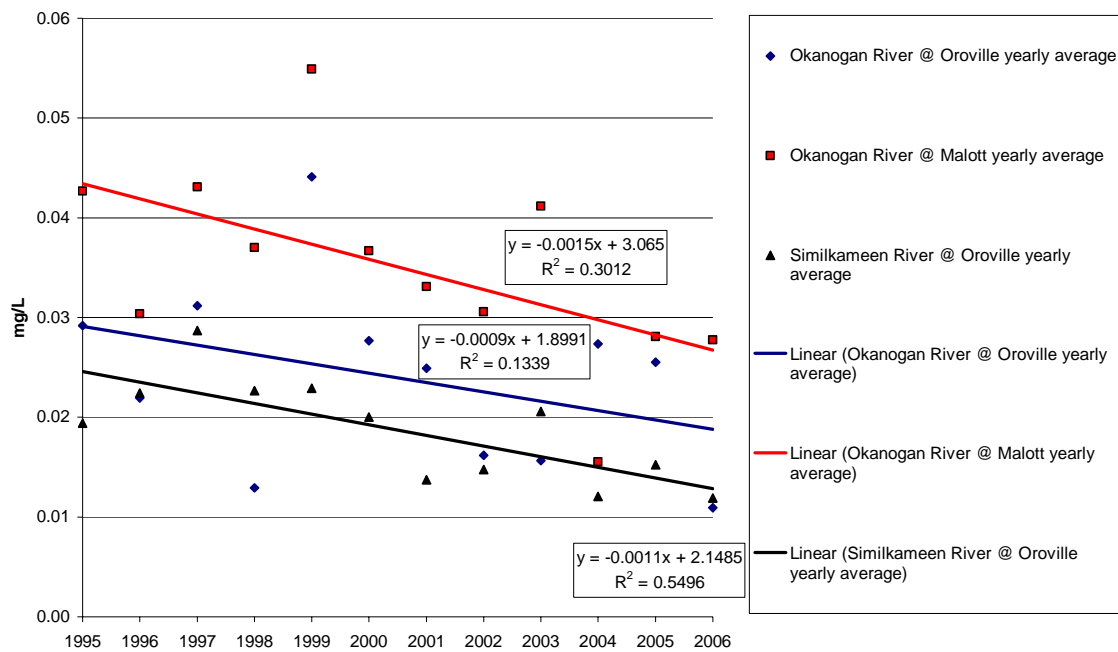


Figure 31. Mean annual total nitrogen (NO₂_NO₃) trend during the 12 year period from 1995 to 2006 collected from the Okanogan and Similkameen rivers.

Phosphorous (TP_P) trend in the Okanogan and Similkameen Rivers

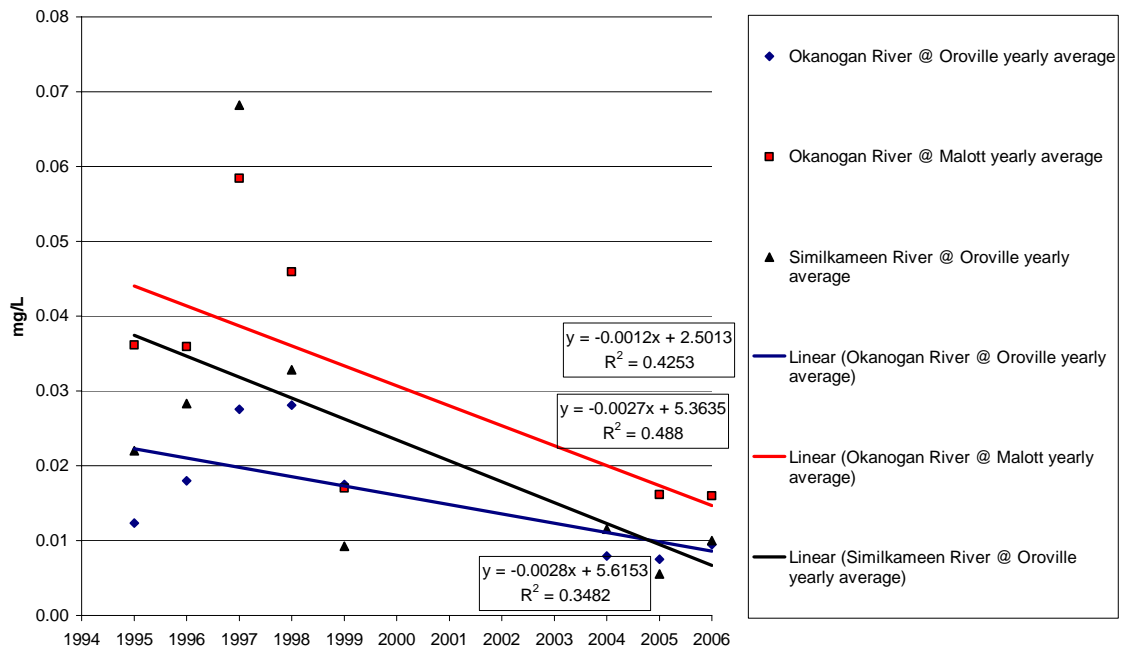


Figure 32. Mean annual total phosphorous (TP_P) trend during the 12 year period from 1995 to 2006 collected from the Okanogan and Similkameen rivers.

Conductivity

Specific conductance in water is directly related to total ionic concentrations and to a much smaller degree this indicator is modified by 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 $\mu\text{S}/\text{cm}$), freshwater typically has conductivity ratings from 50 $\mu\text{S}/\text{cm}$ to 1,500 $\mu\text{S}/\text{cm}$, and seawater is typically 500 times more conductive (Reynolds 1996). *“Conductivity has been shown to have an effect on fish production, however, it's important to remember that these are only correlations (i.e., they do not demonstrate cause and effect). It is more than likely, both fish production and conductivity vary directly with some other covariate or covariates that would more directly explain these effects on fish production”* (Tracy Hillman personal communication). Water conductivity is the most important environmental factor that impacts electrofishing. Extremely low conductivity such as below 20 $\mu\text{S}/\text{cm}$ results in electro fishing devices being unable to cause involuntary muscle contractions but this can be remedied with the addition of sodium chloride. High conductivities such as above 1,500 $\mu\text{S}/\text{cm}$ typically exceed the capacity of most electrofishing power sources (Reynolds 1996). NOAA Fisheries recommends not using electrofishing devices for collecting salmonids at conductivities above 350 $\mu\text{S}/\text{cm}$ due to increasing concerns over potentially harmful side effects.

Conductivity-Main-stem Status and Trend

In 2006 readings on the Okanogan River at Malott, WA varied from 110 $\mu\text{S}/\text{cm}$ in June to 339 $\mu\text{S}/\text{cm}$ in September (Figure 33) and these readings were slightly higher than the 12-year moving average. The Similkameen River near Oroville, WA, consistently had lower conductivity than the Okanogan River and readings in 2006 were slightly lower than the averages for the period from 1993 through 2005 (Figure 33). In 2006, the lowest conductivity reading was 80 $\mu\text{S}/\text{cm}$ in June at the Similkameen site and the highest reading was 339 $\mu\text{S}/\text{cm}$ in September at the Okanogan River site near Malott. During the spring runoff period (April through June) ionic concentrations become diluted especially on the Similkameen River and the Okanogan River downstream of its confluence resulting in lower conductivity during this period. The regulation of flow at Zosel Dam minimizes changes in conductivity on the Okanogan River near Oroville. Conductivity levels recorded at main-stem monitoring sites are unlikely to have any impact on salmon or steelhead survival or production.

The mean annual conductivity trend of the Okanogan River site located near Oroville, WA showed increasing conductivity levels over the last 12-years at a rate of 4.33 $\mu\text{S}/\text{cm}/\text{yr}$. The cause for these increased ionic concentrations is likely tied to the reduction in discharge documented earlier but direct causal mechanisms remain unknown (Figure 34). The Similkameen River has had very stable specific conductance readings over the last 12 years. The Okanogan River near Malott, WA appears to be intermediate between the other two forks and shows a slightly increasing trend. It is unlikely that the levels documented and rates of change in conductivity throughout the Okanogan River subbasin will have any meaningful impact on salmonid survival or production.

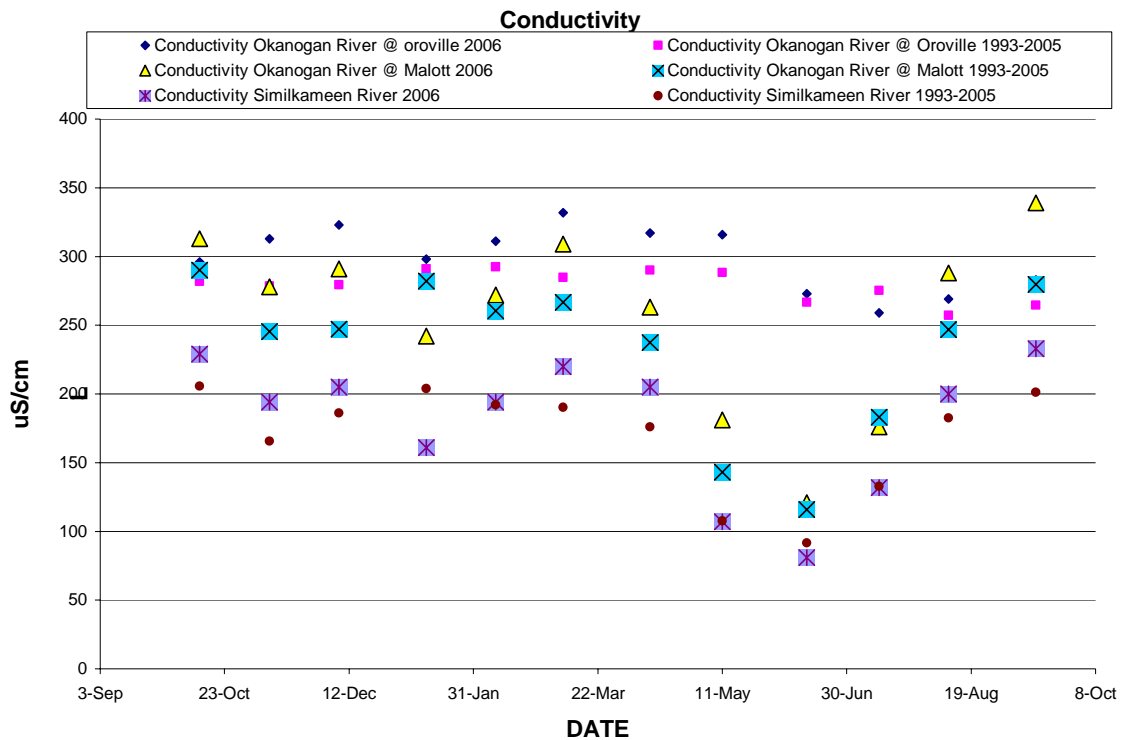


Figure 33. Specific conductivity levels in 2006 compared to the historic average from 1993 to 2005 at WDOE sites along the Okanogan and Similkameen rivers.

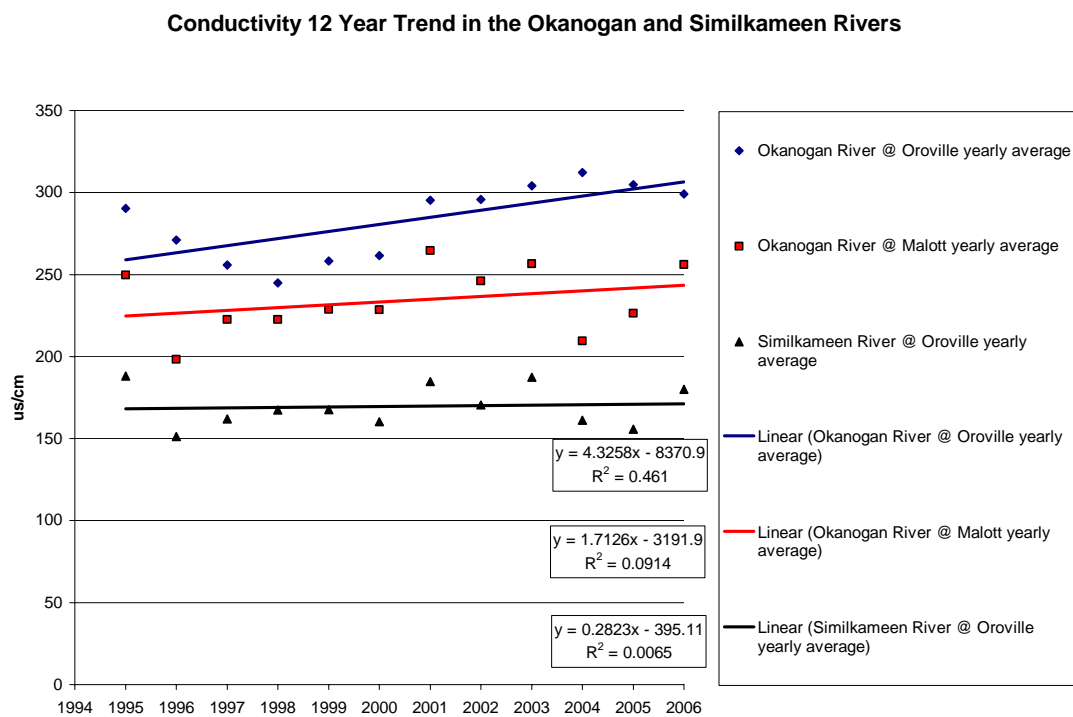


Figure 34. Mean annual data for conductivity trends during the last 12 years from 1995 to 2006 for WDOE sites located along the Okanogan and Similkameen rivers.

Conductivity-Tributary Status

We collected additional conductivity data at OBMEP tributary sites located throughout the Okanogan River basin in 2006 (Figure 35). Tributaries to the Okanogan River showed a great deal of variability in specific conductivity readings. The lowest reading was 50 μ S/cm at Bonaparte Creek in December. The highest reading was 960 μ S/cm at Tonasket Creek in April. The pattern in the data showed that most tributaries peaked in February and March and had their lowest levels in June.

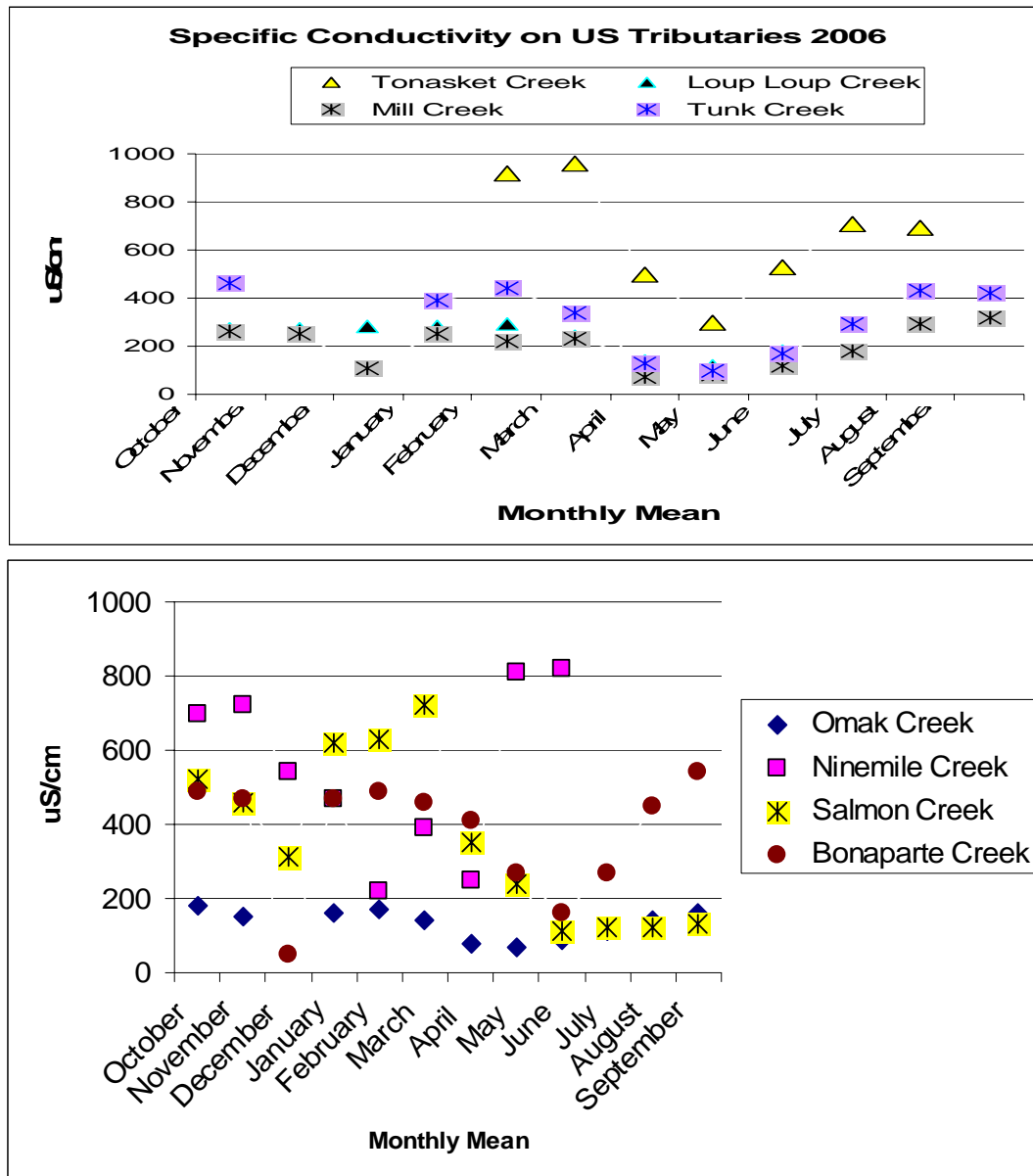


Figure 35. Mean monthly specific conductivity values for 8 tributary sub watersheds within the Okanogan River basin derived from data collected by the Colville Tribes during 2006.

Temperature

Temperature data was collected by the Colville Tribes Fish and Wildlife Department near the Town of Malott, WA on the Okanogan River using Onset temperature data loggers that recorded mean temperature data once every hour from 1995 through 2004. However, data loggers were removed each winter to avoid damage therefore little data exists from the end of January to the middle of March. Starting in 2005 the OBMEP project provided funding to enhance the USGS stream gauging station to include real-time temperature data collection and these data are collected once every 15-minutes year round (<http://waterdata.usgs.gov/nwis/uv?12439500>). For our analysis we averaged all hourly or 15-minute data into mean daily average temperatures as this is the most commonly used measure of temperature reported in the research literature. A comprehensive temperature document will be completed in 2008 that will analyze real-time, hourly temperature readings collected by the USGS, Environment Canada and the Colville Tribes from many sites throughout the Okanogan River basin.

Salmonids exhibit avoidance behavior for waters that are warmer than 20°C while temperatures above 21°C are known to be stressful to most salmonids and this occurs in most years. Salmonids will begin to delay migration into rivers once temperatures reach 21°C and OBMEP video data suggests that migration will be completely halted once temperatures exceed 24°C. Direct mortality begins to occur at temperatures above 25°C (Jenkins and Burkhead 1993).

In the Okanogan River subbasin summer migrants can encounter a condition termed “The Similkameen Trap”. This trap is set-up when rapidly warming waters exiting Canada in the upper Okanogan River reach 24°C prior to the Similkameen River. Because fish try to avoid these warm water conditions the fish that enter the Okanogan River prior to the thermal barrier occurring in the Lower Okanogan River below Malott, WA become “trapped” above the confluence with the upper Okanogan and Similkameen Rivers. Early arriving migrants are more susceptible to becoming trapped and in some years high pre-spawn mortality has occurred to both Chinook and sockeye salmon. Pre-spawn mortality typically occurs when fish are trapped for extended periods or during periods of very warm water temperatures on the Similkameen River below Enloe Dam. Fish that arrive later and remain in the Columbia River until such time as temperature conditions favor migration in September (Figure 36) typically avoid any negative effects of the Similkameen Trap.

Temperature-Main-stem Status and Trend

The historical data from 1995 to 2005 indicates that lower water temperatures likely occur during the months of December through February and high summer water temperatures occur from late June to early September. During 2006, temperatures of 0°C were recorded through most of the month of December followed by rapid warming in March and June. Water temperatures exceeded 22°C starting on June 27th and continued above this point until the end of July. In 2006, the Okanogan River at Malott had a peak mean daily temperature on 7/25/2006 of 27.7 °C. In 2006, average daily temperatures exceeded 25°C for eight days in July at the Malott site. Temperatures hovered around 22°C until August 27th when the

temperatures declined below this threshold for good (Figure 36). Mild summer air temperatures throughout the months of August and September likely resulted from major forest fires that burned locally throughout this period. The fires produced dense smoke clouds that blocked the sun's rays and reduced air temperatures and thermal inputs.

We were able to construct a 10 year trend for temperature for the Okanogan River site located at Malott, WA (Figure 37). In order to develop this trend requires struggling with several issues; 1) Defining a period that is biologically important to salmonids, 2) Determining the magnitude of the indicator of biological significance; and 3) how to most transparently present the trend information. To do this we looked at many possible alternatives. We chose to focus on the delayed migration of adult salmon that occurs when temperatures exceed 22°C. This has been a well documented problem in the Okanogan subbasin for many years (Hyatt et al. 2003). As the salmon experience more days of delayed migration the probability that they will successfully spawn is reduced.

Over the last 10 years delays in migration have increased at a rate of 1.82 days per year due to increased warm water temperatures. Increases in water temperature can be linked to many anthropogenic activities such as building reservoirs that release only warm surface water during summer months, reduced stream sinuosity and riparian shading, reduced cold water inputs from spring development and diversion of coldwater tributaries, and climate change brought on by fossil fuel burning and other industrial waste products. Increasing water temperatures within the Okanogan River watershed represent the single most limiting factor facing salmonids in main-stem habitats. Tributary habitats are more limited by a lack of water and both indicators represent critical items for monitoring habitats related to salmonids today and into the foreseeable future.

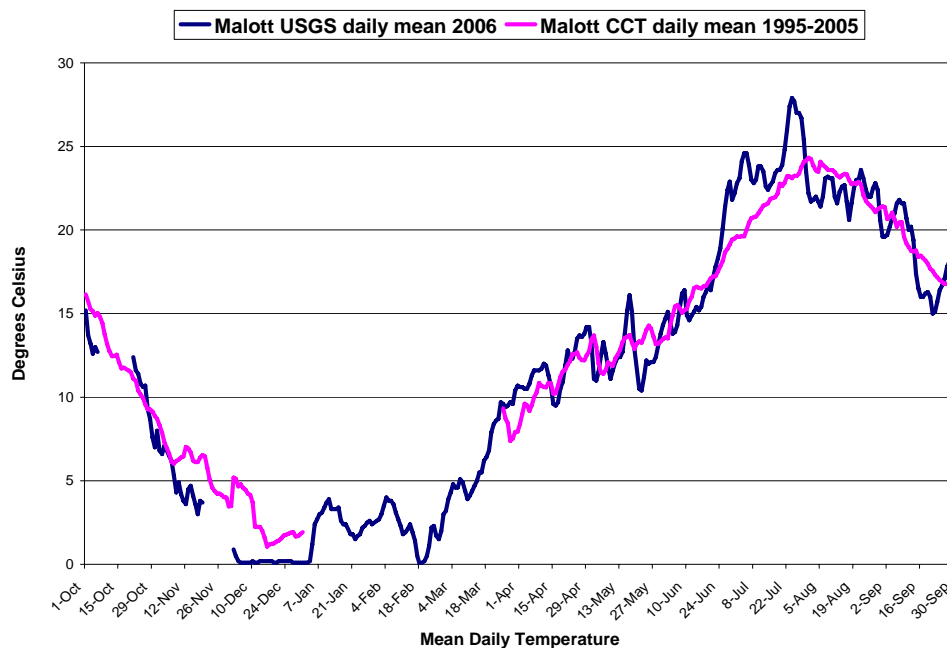


Figure 36: Mean daily temperature data comparing the historic average from 1995 through 2005 to 2006 on the Okanogan River near the town of Malott, WA. Missing data in 2006 is from equipment malfunctions.

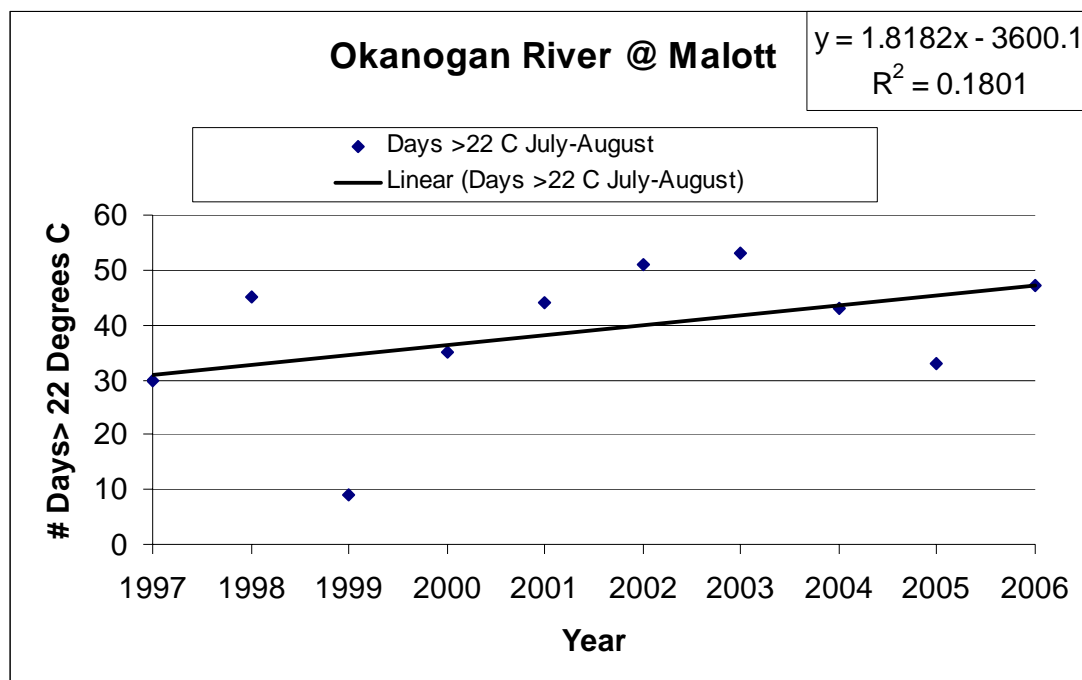


Figure 37: The number of days that migration is delayed into the Okanogan River over the last 10 years assuming migration becomes delayed at 22 degrees Celsius.

Conclusions

The OBMEP staff compiled data collected by the USGS, WDOE and Environment Canada in addition to collecting their own data using Eureka Manta water quality probes. Results from compiled data were more consistent and reliable than the data collected with the water quality probes. The water quality probes were not as maintenance free as we had hoped. During initial data collection we relied on calibrating the probes once every few months. We noticed there was a need for more calibration due to inaccurate readings. In the future we would recommend that we collect water quality samples and have them analyzed at a water quality lab for the best data results. If that option is deemed cost prohibitive we recommend a more rigorous calibration schedule so the readings we do get from the probes are more accurate and reliable. Regardless of these and other technological glitches, the water quality data presented in this report represents the best available information related to salmonid survival and productivity for the Okanogan River basin to date.

Monitoring results showed peak discharge in United States tributaries and Okanogan main-stem sites in 2006 to be higher than average peak flows from previous years sampled. 2006 was an abundant water year. In the Similkameen River, 2006 discharge was nearly twice as high when compared to the average discharge from the previous four years. Peak flows in 2006 were a month earlier (May) than average peak flows. All 12-year trends for the main stem Okanogan and Similkameen had what appeared to be a slightly decreasing trend. The greatest decrease over 12 years was on the Okanogan River at Malott. This decreasing trend in discharge is not beneficial for salmonid production and efforts to reverse this trend should be strongly encouraged.

Dissolved oxygen levels were within the low end of acceptable limits for healthy salmonid reproduction, hatching and rearing. We found that for the past 12 years dissolved oxygen levels have been on a slightly downward trend during summer/fall Chinook egg incubation. Trends in decreasing dissolved oxygen levels are consistent with trends in increasing temperature and are therefore likely covariates.

Turbidity levels were only a concern on the Similkameen and some of the Okanogan River tributaries, as they reached 70-90 NTUs during spring runoff. This had the potential of reducing primary productivity but also may act as a catalyst for smolt out-migration. The Okanogan River site at Malott and the sampling site on the Similkameen River at Oroville had a marginally detectable decreasing 12 year trend in turbidity. However, these data were highly variable and appear to be influenced by the magnitude of spring runoff.

The pH values lack much fluctuation between space and over time which indicates that the Okanogan River basin has excellent buffering characteristics that protect it from fluctuating pH levels. The 12 year trends for pH indicate that levels are remaining stable along the entire Okanogan River. However, within the Similkameen drainage dramatic annual changes in the mean pH values have occurred resulting in a declining trend for pH.

Ammonia, nitrogen and phosphorous levels on the mainstem Okanogan and Similkameen Rivers were all within acceptable values for healthy salmonid populations. After assembling 12-years of status data for this indicator at WDOE sites ammonia levels have been well below any levels of biological importance to salmonids, this brings into question the value of continued monitoring for this indicator within this watershed. Over the past 12 years the ratio of N: P has moved toward a more nitrogen limiting system.

Conductivity levels were similar on the mainstem Okanogan and Similkameen when comparing the historic 12 year averages versus the data for 2006. We had uncertainty about high readings that exceeded 800 $\mu\text{S}/\text{cm}$ for Ninemile Creek during May and June and readings over 900 $\mu\text{S}/\text{cm}$ for Tonasket Creek which occurred in March and April. Both of these creeks are near the border of Washington and Canada and appear to contain higher levels of inorganic compounds than other creeks throughout the basin but the exact cause for these high readings remains unknown. However, it is unlikely that the levels documented and rates of change in conductivity throughout the Okanogan River subbasin will have any meaningful impact on salmonid survival or production.

Temperature is one of the main limiting factors for salmonid production in the Okanogan River basin. Temperature on the mainstem Okanogan River in 2006 peaked at over 25°C at Malott in July and August for eight days. Temperatures similar to these are normal during the warm summer months and salmonids have adapted to avoid these temperatures by waiting in the Columbia River until temperatures cool in early September. Trends indicate that adult salmon are being increasingly delayed when attempting to migrate into the Okanogan River due to increasing water temperatures. Future water quality monitoring efforts in the Okanogan River Basin should focus on temperature and discharge, as they are found to be the main limiting factors for salmonid health in the basin.

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**Appendix B-2007 OKANOGAN BASIN
SNORKEL SURVEYS**

**2007 OKANOGAN BASIN
SNORKEL SURVEYS**

Performance Period: March 1, 2007 – February 29, 2008

BPA Project # 200302200

Prepared by

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Prepared for

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Bonneville Power Administration
Division of Fish and Wildlife
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March 2008

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Abstract

The Colville Tribes' Fish and Wildlife Department conducted snorkel surveys in established EMAP sites throughout the Okanogan basin as part of the Okanogan Basin Monitoring and Evaluation Program. In 2007, snorkel surveys were conducted along the main stem Okanogan River in Canada and associated tributary streams within both the United States and Canada. Eleven different species of fish were identified. The most abundant families of fish observed were Salmonidae and Cyprinidae, and the most abundant species were steelhead/rainbow trout (*Oncorhynchus mykiss*). The majority of juvenile *O. mykiss* were found in Okanogan River tributaries accessible to returning adults. Bonaparte Creek had the highest density of juvenile *O. mykiss* in the United States and Inkaneep Creek had the highest density in Canada. A very low number of juvenile *O. mykiss* were counted within main stem Okanogan River sites in Canada. No snorkeling was performed in main stem sites within the United States. There were consistent numbers of juvenile *O. Mykiss* across years at annual U.S. tributary sites. These numbers reinforce that coldwater tributaries are vital to the survival of steelhead in the Okanogan basin. An effort to preserve, reestablish and allow access to cold water tributaries for steelhead, in the U.S. and Canada is warranted.

Introduction

The Okanogan River currently represents the northern extreme for the distribution of anadromous fish in the entire Columbia River basin. The confluence with the Columbia River is located in north central Washington State, but 70% of the Okanogan River watershed is located in Canada. Due to an extremely low gradient, high summer water temperatures and high turbidity, the Okanogan River differs greatly from traditional conditions most people consider ideal for anadromous fish production. Returning fish must traverse nine major hydroelectric dams and several smaller impediments. Many tributary streams have been diverted in part or whole to support the local agrarian economy. In spite of all this, a healthy stock of summer Chinook, and the most robust stock of sockeye salmon remaining in the Columbia River basin call the Okanogan River home. The Okanogan River is like two rivers in one: the United States (US) portion of the river is strongly influenced by the Similkameen River, which provides most of the water and sediment from a flashy, snowmelt-driven watershed; while the Okanogan River above the Similkameen confluence provides a lesser quantity of warmer water from a stable, clear, lake-drained watershed.

For many years, spawning and rearing information related to anadromous fish in the Okanogan basin had more to do with professional opinion than actual data. The use of Salmon Creek, Omak Creek, and the upper Similkameen River by steelhead was noted in a National Marine Fisheries Service Document (Fulton, 1970). In Canada, it is likely that historically steelhead, chinook, sockeye, and coho spawned in tributaries south of Okanogan Lake (Rae 2005). In fact, the Okanogan Nation's traditional name for Shingle Creek literally translates as "place where steelhead spawn" (Rae 2005). Two streams, Inkaneep and Vaseux, currently have accessible habitat for steelhead and Chinook salmon. Spawning areas were identified upstream from Lake Osoyoos (WDW 1993) and large rainbow trout were identified in an Okanogan Lake creel survey from the 1920's (Shepard 1992). However, distribution of steelhead and Chinook in the Canadian portion of the Okanogan River basin remains largely unknown (Rae 2005). The State of Washington considers steelhead from the Okanogan and Methow Rivers to be a composite stock, so little information specifically related to the Okanogan River basin exists (WDF 1993).

Chapman et al. 1994, clearly links spawning activity of summer steelhead with juvenile densities. Density independent factors related to habitat, water quality, climate, and geology set the potential upper limit for juvenile production while density dependent functions such as predation, disease, and competition keep the population from achieving this upper limit (Poff and Ward 1989). Although snorkel surveys have occurred throughout the Wenatchee and Methow basins for the purposes of research studies over the years (Griffith and Hillman 1986, Hillman and Chapman 1989, Mullan et al. 1992), no effort has yet been made to compile and analyze data for providing information about changes in juvenile steelhead densities over time.

"We believe that numbers of adult steelhead in the mid-Columbia basin increase as the abundance of juveniles (seeding levels) increase until an upper limit, i.e. carrying capacity, is reached".

Chapman et al. 1994

Most literary references related to juvenile summer steelhead abundance and distribution throughout the Okanogan basin are personal opinions, such as *"In as much as riffle and*

cascade habitat is lacking in the Okanogan River, and because of warm summer temperatures and high sediment levels, we would expect to see few steelhead rearing in the main stem, this is probably also true in the lower reaches of the Similkameen River” (Chapman et al 1994). No statements about rearing capacity or juvenile densities could be found for tributaries to the Okanogan River. Although these opinions may prove to be true, they are not currently supported by empirical evidence.

In an attempt to improve the understanding of the Okanogan River basin, the Okanogan Basin Monitoring and Evaluation Program (OBMEP) collects empirical data to address a number of management questions. The snorkeling part of this program attempts to monitor the egg to parr portion of the life cycle for anadromous fish native to the Okanogan Basin. Juvenile fish abundance and densities are also used as the response variable for evaluating habitat changes over time. Juvenile summer steelhead are the focal species because they require extended rearing time in freshwater habitats, are commonly found throughout the Okanogan basin and because they are federally listed as endangered. Information on both abundance and distribution are important to fishery managers, planners, and decision makers. Non-anadromous fish distributions, abundance, and species composition are also collected but considered secondary and used only as relative abundance indicators.

Methods

A probabilistic sampling design was used to randomly select sites from a sampling universe which included all accessible habitats for anadromous fish in the United States and Canadian portions of the Okanogan River watershed. Annual panel sites are sampled yearly, while rotating panel sites are sampled once every 5 years (Figures 1 & 2).

Snorkel surveys occurred within two weeks of the OBMEP physical habitat surveys. Four main stem Okanogan River and 12 small-tributary sites were surveyed in Canada. Eighteen tributary sites within the United States were also surveyed. However, no main stem Okanogan River sites in the United States were snorkeled due to funding cuts that occurred in 2007. Tributary snorkel surveys were performed by a single snorkeler moving upstream through the length of the reach. Sites observed to be dewatered during the physical habitat surveys were not snorkeled and considered to represent zero fish.

Survey reaches were snorkeled using protocols developed from the Upper Columbia strategies (Hillman 2006) and methodologies refined for OBMEP (Arterburn et al. 2005a). Fish were identified to species if possible, to family if needed and lastly into non-salmonid and salmonid groups when necessary to reduce the number of unidentified fish in the sample. Each fish was grouped into 1 of 3 size categories:

- less than 100mm (0+ age fish)
- between 100 and 300mm (1+ and 2+ age fish)
- greater than 300mm (3+ age fish)

Sampling on small tributary streams in the United States was conducted between July 23, 2007 and October 5, 2007. Sampling in Canada started on July 5, 2007 and finished on September 5, 2007.

For this document the results are organized by; 1) country, 2) tributary or sub-watershed, and 3) main stem reach. The results are also compiled graphically to show spatial locations of observations. Analysis consisted of compiling results to determine total fish observed, juvenile *O. mykiss* identified, adult *O. mykiss* detected, and the dominant species seen in each reach. Densities were calculated for *O. mykiss* and total fish observed per square kilometer. The density values are the number of fish observed divided by the area observed by the snorkeler which was calculated as the product of visual distance (which was assumed to be the average wetted width if the whole channel was visible), and the reach length of each site surveyed.

US Snorkel Survey Sites 2007

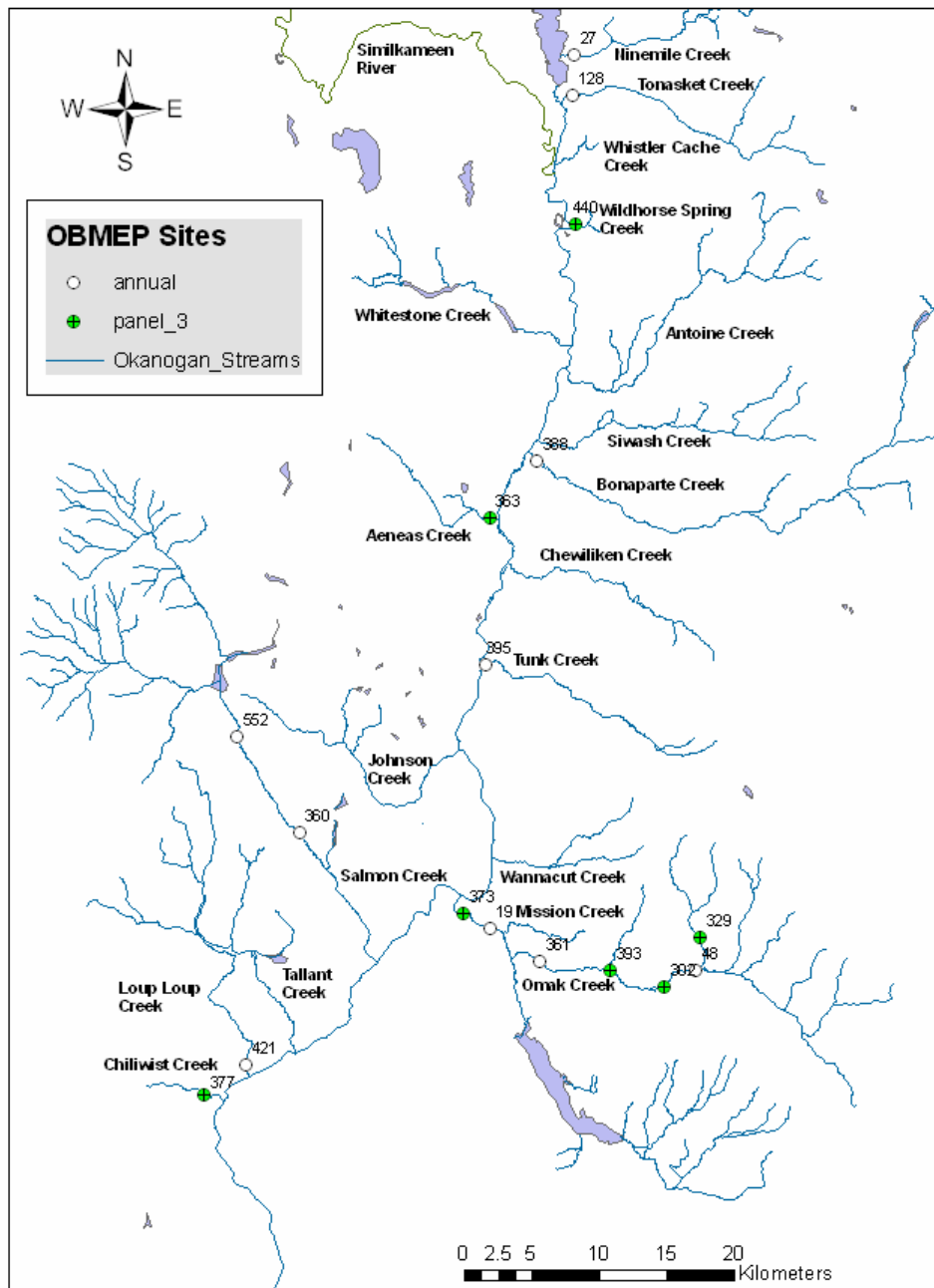


Figure 1: The location of United States snorkel sites monitored by OBMEP in 2007.

Canada Snorkel Survey Sites 2007

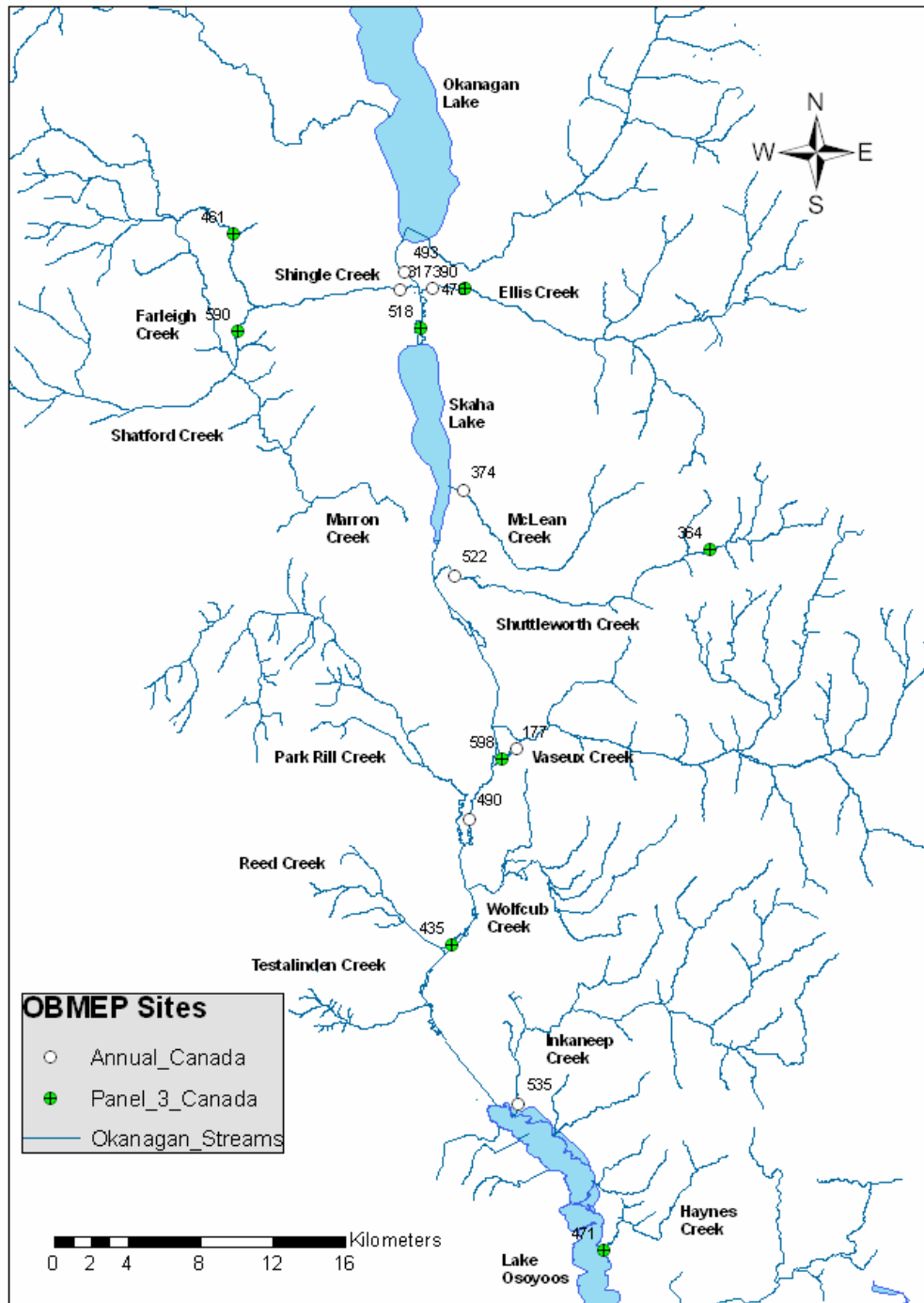


Figure 2: The location of United States snorkel sites monitored by OBMEP in 2007.

Results and Discussion

Species Richness

All fish species observed by OBMEP field crews during snorkeling efforts since inception of the program are presented in Table 1. The salmonid species observed in 2005, 2006, and 2007 were similar with the exception of westslope cutthroat trout which were documented in Aeneas Creek. Westslope cutthroat trout are thought to be native to the Wenatchee, Entiat, and Methow Rivers but the widespread stocking of nonnative cutthroat and rainbow trout make it impossible to identify the origin of these fish positively (Behnke 1992). Cutthroat trout populations in the Okanogan basin do not typically exist in areas accessible by redband trout or steelhead; therefore documented barriers to anadromous fish (Arterburn et al. 2007b) have helped sustain these disjunct populations.

The total number of species observed in 2007 was eight. This number of species was substantially less than the number of species observed in 2006 (18) and 2005 (15). The reduction in species observed was due to elimination of snorkel surveys in main stem portions of the United States due to funding cuts. Main stem habitats typically contain a greater species richness than tributary habitats. Tributary habitats support mostly cold-water species from the families Salmonidae, Catostomidae, and Cottidae. However, the main stem habitats can be inhabited by, at least, limited quantities of any species listed in Table 1.

Total *Oncorhynchus mykiss* observed

In 2007, a total of 1,507 juvenile and 8 adult *O. mykiss* were observed at all sites within the Okanogan River basin. A total of 3 juvenile and 1 adult *O. mykiss* were counted at main stem Okanogan River sites located within Canada. An additional 1,504 juvenile and 7 adult *O. mykiss* were identified in tributary sites. The highest numbers of juvenile *O. mykiss* were observed in Vaseux Creek, followed by Inkaneep Creek, and Bonaparte Creek.

The number of juvenile *O. mykiss* observed in 2007 were compared to the number of redds observed for several perennial reaches in Bonaparte, Omak and Ninemile creeks (Table 2). Correlations between redd density and juvenile *O. mykiss* were recognized in Bonaparte, Omak and Ninemile creeks. Juvenile *O. mykiss* densities were lower at common sites in 2007 when compared to the 4 year average with the exception of sites located on Bonaparte and Inkaneep Creeks (Table 3). Reduction in juvenile *O. mykiss* is likely attributed to decreased flow in these selected tributaries during 2007 (Figure 3).

Table 1: Fish species observed during snorkel surveys in the Okanogan River Watershed in the summer of 2005, 2006 and 2007.

Species Observed	Observed in 2005	Observed in 2006	Observed in 2007
Sockeye Salmon <i>Oncorhynchus nerka</i>	X	X	X
Chinook Salmon <i>Oncorhynchus tshawytscha</i>	X	X	
Summer Steelhead <i>Oncorhynchus mykiss</i>	X	X	X
Cutthroat Trout <i>Oncorhynchus clarki lewisi</i>			X
Brook Trout <i>Salvelinus fontinalis</i>	X	X	X
Mountain Whitefish <i>Prosopium williamsoni</i>	X	X	X
Bridgelip Sucker <i>Catostomus columbianus</i>	X	X	X
Yellow Perch <i>Perca flavescens</i>	X	X	
Redside Shiner <i>Richardsonius balteatus</i>	X	X	
Northern Pikeminnow <i>Ptychocheilus oregonensis</i>	X	X	
Common Carp <i>Cyprinus carpio</i>	X	X	
Smallmouth Bass <i>Micropterus dolomieu</i>	X	X	
Largemouth Bass <i>Micropterus salmoides</i>	X	X	
Pumpkinseed <i>Lepomis gibbosus</i>	X	X	
Largescale Sucker <i>Catostomus macrocheilus Girard</i>		X	
Channel Catfish <i>Ictalurus punctatus</i>		X	
White Crappie <i>Pomoxis annularis</i>		X	
Peamouth <i>Mylocheilus caurinus</i>		X	
Bluegill <i>Lepomis macrochirus</i>		X	
Shorthead Sculpin <i>Cottus confusus</i>	X		X
Black Bullhead <i>Ameiurus melas</i>	X		X

Table 2: Descriptions of reference reaches used for comparing the number of juvenile *O. mykiss* observed by snorkel surveys, number of fish/ha and number of redds documented in redd surveys (Arterburn et al. 2007).

Reference Reaches	River Mile	Total Reach length (KM)	OBMEP Snorkel sites	Juvenile <i>O. mykiss</i>	Area in Hectares	Juvenile <i>O. mykiss</i> Density(fish/ha)	# of Redds
Tunk Creek TU1	0-0.2	0.32	395	0	0.01	0	NA
Bonaparte Creek-B1	0-1.6	2.57	388	220	0.02	9389	70
Ninemile Creek-N1	0-1.72	2.77	27	15	0.02	653	3
Tonasket Creek-TO1	0-3.5	5.63	128	2	0.01	198	6
Omak Creek Lower	0-6.2	10	19, 373	157	0.13	1208	47
Omak Creek Upper	6.2-21.5	24.6	361, 393, 48, 302	192	0.43	447	2
Salmon Creek	4.3-22.3	18	360, 552	211	0.22	959	NA
Stapaloop Creek	1.5-1.6	0.15	329	40	0.03	1333	0
Loup Loup Creek	0-2.1	3.3	421	0	0	0	6
Wanacut Creek	0-1	1.6	NA	0	0.02	0	1
Aeneas Creek	0.5-0.6	0.15	363	21	0.21	102	NA
Wild Horse Spring Creek	0.2-0.3	0.15	440	0	0.01	0	7
Okanagan River-Canada 1	136.6-151.6	24.1	435, 490	1	2.24	0.4	0
Okanagan River-Canada 2	151.6-170.2	30	518, 493	2	2.7	0.7	NA
Haynes Creek	0.2- 0.3	0.15	471	0	0.01	0	0
McLean Creek	0.55-0.65	0.15	374	178	0.03	5307	NA
Inkaneep Creek	0-1.8	2.9	535	295	0.07	4358	2
Vaseux Creek	0.36-3.0	4.9	177, 598	643	0.42	1531	0
Shuttleworth Creek	0-3.2	5.1	522, 538	25	0.2	125	0
Shingle Creek	0-0.7 & 8.3-8.4	0.3	317,461	39	0.12	325	NA

Shatford Creek	1.2-1.3	0.15	590	117	0.07	1789	NA
Ellis Creek	0-1.8	0.3	390,470	12	0.11	110	NA

NA=Not Surveyed

Table 3: Comparison of the juvenile *O. mykiss* densities (fish/ha) across years (2004-2007) at select sites and the 4 year averages for each site.

OBMEP-site	2004	2005	2006	2007	4-year average
388-Bonaparte Creek	5790	3630	2720	9389	5382
19-Omak Creek	390	3590	2560	1065	1901
48-Omak Creek	850	1160	820	695	881
360-Salmon Creek	1040	1960	150	931	1020
27-Ninemile Creek	1020	1560	3720	653	1738
535-Inkaneep Creek	300	1530	1070	4358	1814

Table 4: Average relative juvenile abundance (# of fish/site) at annual sites across years

Location	2004	2005	2006	2007
Okanogan River	N/D	0.3	0	N/D
Similkameen River	N/D	0	2	N/D
U.S. Tributaries	93.2	87.7	86.4	90.6
Canada	5	6.9	11.1	85

United States snorkel observations by sub-watershed

Loup Loup Creek included only Site 421 which is located below Loup Loup falls; the terminus for anadromous fish (Arterburn et al. 2007). This reach was dry and therefore had no fish.

Wanacut Creek included one reference site located below the falls identified as the terminus for anadromous fish (Arterburn et al. 2007). No fish were identified during the snorkel survey.

Tunk Creek included site 395 located below Tunk Falls which is the terminus for anadromous fish (Arterburn et al. 2007). Site 395 was dry at the time of snorkeling except for a few small pools of water. No fish were identified during the snorkel survey.

Aeneas Creek (Figure 4) included Site 363 located above the barrier to anadromous fish (Arterburn et al. 2007). Twenty one juvenile *O. mykiss*, 8 westslope cutthroat trout and 159 eastern brook trout were identified. The density of juvenile *O. mykiss* was 102/ha and the total fish density was 920 fish/ha.

Bonaparte Creek (Figure 4) included site 388 and was dominated by *O. mykiss* (220 juvenile and 0 adult). The density of juvenile *O. mykiss* was 9,389/ha. The density observed at this site was much higher than previous years (Table 3) and was considered an abundant year for steelhead spawning (Arterburn et al. 2007a). Other fish species observed in 2007

were bridgelip suckers (63) and eastern brook trout (135). The total fish density for all species at this site was 18,050 fish/ha.

Wild Horse Spring Creek (Figure 4) included Site 440, located below the terminus for anadromy (Arterburn et al. 2007). No fish were observed during the snorkel survey. However, juvenile *O. mykiss* were identified in spot surveys throughout the watershed in 2006 and 2007.

Stapaloop Creek (Figure 5) included Site 329 and was dominated by *O. mykiss* (40 juvenile and 0 adults). The density of juvenile *O. mykiss* was 1333/ha in 2007. Other fish observed included 7 eastern brook trout.

Omak Creek (Figure 5: sites 19, 373, 361, 393, 48 & 302) was divided into two reaches: 1) Omak Lower, from the confluence with the Okanogan River upstream to Mission Falls (RM 0 to 6.2), containing EMAP sites 19 and 373, Omak Upper, from Mission Falls upstream to Trail Creek (RM 6.2 to 21.5), containing EMAP sites 361, 393, 48, and 302. The dominant species at all sites, in both reaches, except one, was *O. mykiss* which represented 74% of all fish observed in Omak Creek during 2007 surveys.

Omak Lower (Figure 5: sites 19 & 373) 157 juvenile *O. mykiss* were observed, this represents and a combined average juvenile *O. mykiss* density of 1208/ha. The densities of *O. mykiss* increased as you progressed upstream toward Mission Falls. The average fish density for all species at these sites was 1450-fish/ha. The second most abundant fish were bridgelip suckers, making up 6% of the fish observed. Site 19 has been surveyed since 2004. The average juvenile *O. mykiss* density at this site was 1065/ha, which was less than the previous two years but greater than 2004 (Table 3).

Omak Upper (Figure 5: sites 361, 393, 48 & 302). Mission Falls is considered the current terminus for anadromous fish (Arterburn et al. 2007), although a steelhead redd was located upstream of the falls in 2001. Habitat modifications were made to these falls during 2006 in order to aid fish passage. During redd surveys in the spring of 2007 two redds were observed within the falls but no redds were observed above Mission Falls (Arterburn et al 2007a) therefore, fish observed above the falls are considered resident. A total of 192 juvenile rainbow trout were observed at these sites in 2007. The juvenile rainbow trout densities ranged from 750-fish/ha at site 302 to 280-fish/ha at site 393 where the dominant species was eastern brook trout. The average fish density for all juvenile *O. mykiss* at these sites was 510/ha. Site 48 has been surveyed since 2004. The average juvenile *O. mykiss* density at this site was 695/ha, which was less than the previous three years (Table 3). One factor that may contribute to the reduction in fish production at this site is the increasing amounts of fine sediment. Increases of the volume of fine sediment within residual pools (V^*) which has increased nearly 100% from 2000 to 2005 (Chris Fisher-Colville Tribes unpublished data). Although rehabilitation efforts have been underway since 2000 to address sediment issues resulting from timber harvest activities and high road densities in the upper reaches of this watershed. The measurable benefits from such headwater activities will not be realized for decades as sediment transport is a slow process (Waters 1995).

Salmon Creek (Figure 6: sites 360 & 552) both of these sites are upstream of the Okanogan Irrigation District diversion dam. Since this dam diverts 100 percent of the flow in Salmon Creek, access is denied to anadromous fish; therefore, we considered all *O. mykiss* to be resident. A total of 211 juvenile and 2 adult *O. mykiss* were observed at these sites in 2007. The juvenile *O. mykiss* densities ranged from 931/ha at site 360 to 1,013/ha at site 552. The dominant species at both sites was *O. mykiss* and comprised 71% of all fish observed. The average fish density for all *O. mykiss* at these sites was 959-fish/ha. The average fish density for all species at these sites was 1400-fish/ha. Site 360 at RM 7.6, has been surveyed since 2004. The average juvenile *O. mykiss* density was more than 2006 but less than 2005 and 2004 (Table 3).

Tonasket Creek (Figure 7, site 128), Two juvenile *O. mykiss* were observed at site 128. The density of juvenile *O. mykiss* was 198/ha. This section of the creek usually goes dry during the mid-summer. Tonasket Creek has been disconnected from the Okanogan River due to lack of flow in most years, during and shortly after spring run-off. In 2007, 6-steelhead redds and two steelhead adults were observed (Arterburn et al 2007a).

Ninemile Creek (Figure 7, site 27), during 2007, 15 juvenile *O. mykiss* and 2 eastern brook trout were observed at this site. The juvenile *O. mykiss* density was 653/ha. Since 2004 the average juvenile *O. mykiss* density at this site was less than the previous three years (Table 3). We attribute this to lack of access for adult spawners to the creek at the mouth in 2007 due to low flow(Kistler, pers. obs. 2007).

The map displays the Okanogan River watershed with several creeks labeled: Wildhorse Spring Creek, Mosquito Creek, Whitestone Creek, Antoine Creek, Siwash Creek, Bonaparte Creek, Aeneas Creek, and Wildhorse Creek. Snorkel sites are marked with symbols: a white circle for 'annual' and a green circle with a cross for 'panel_3'. Callout boxes provide 2007 fish catch data for specific sites. A legend identifies the symbols and stream types. A scale bar at the bottom indicates distances up to 8 kilometers.

2007 Snorkel Site Data:

Site	2007 # of fish	2007 Density fish/ha	2007 Juvenile O. Mykiss	2007 Adult O. Mykiss	2007 Total Fish
Wildhorse Spring Creek (panel_3)	0	0	0	0	0
Antoine Creek (annual)	25	-	-	-	-
Siwash Creek (annual)	368	-	-	-	-
Bonaparte Creek (panel_3)	220	9,389	0	0	418
Bonaparte Creek (annual)	364	-	-	-	-
Aeneas Creek (panel_3)	21	102	0	0	168
Whitestone Creek (panel_3)	363	-	-	-	-

75

Omak and Stapaloop Creek

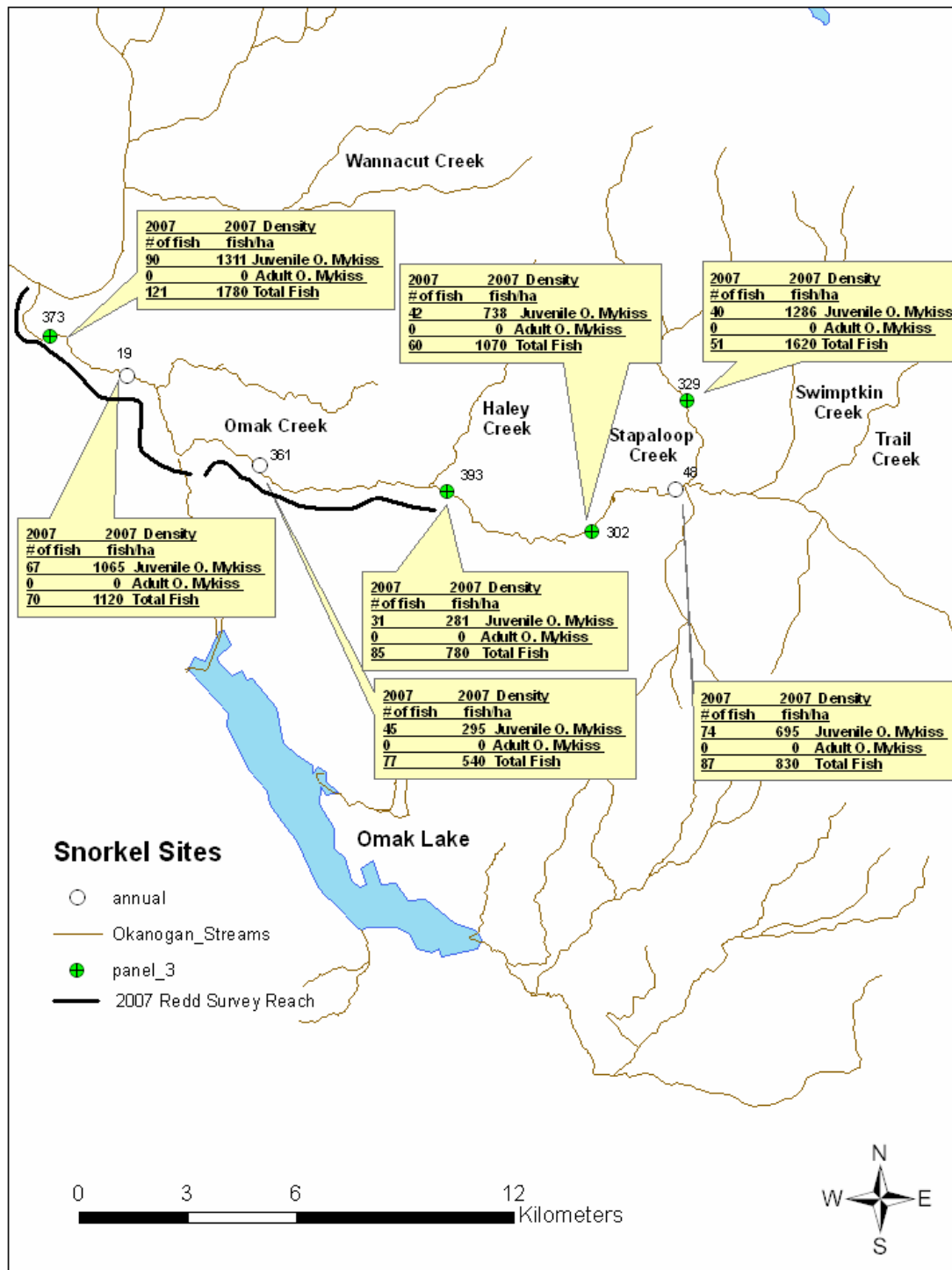


Figure 5: Snorkel survey observations for Omak and Stapaloop Creek.

Salmon Creek

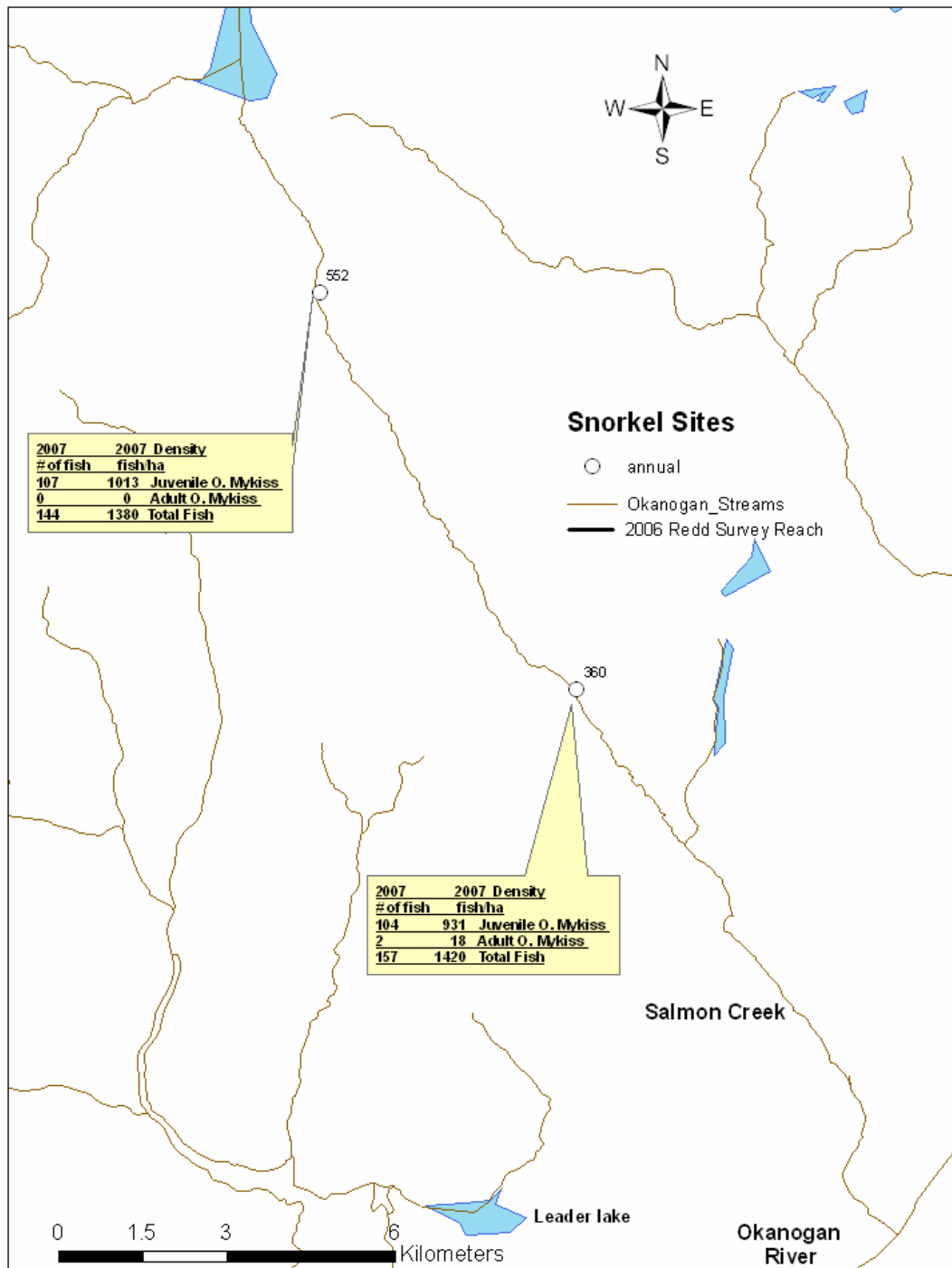


Figure 6: Snorkel survey observations for Salmon Creek (all sites are located above the OID diversion).

Ninemile and Tonasket Creek

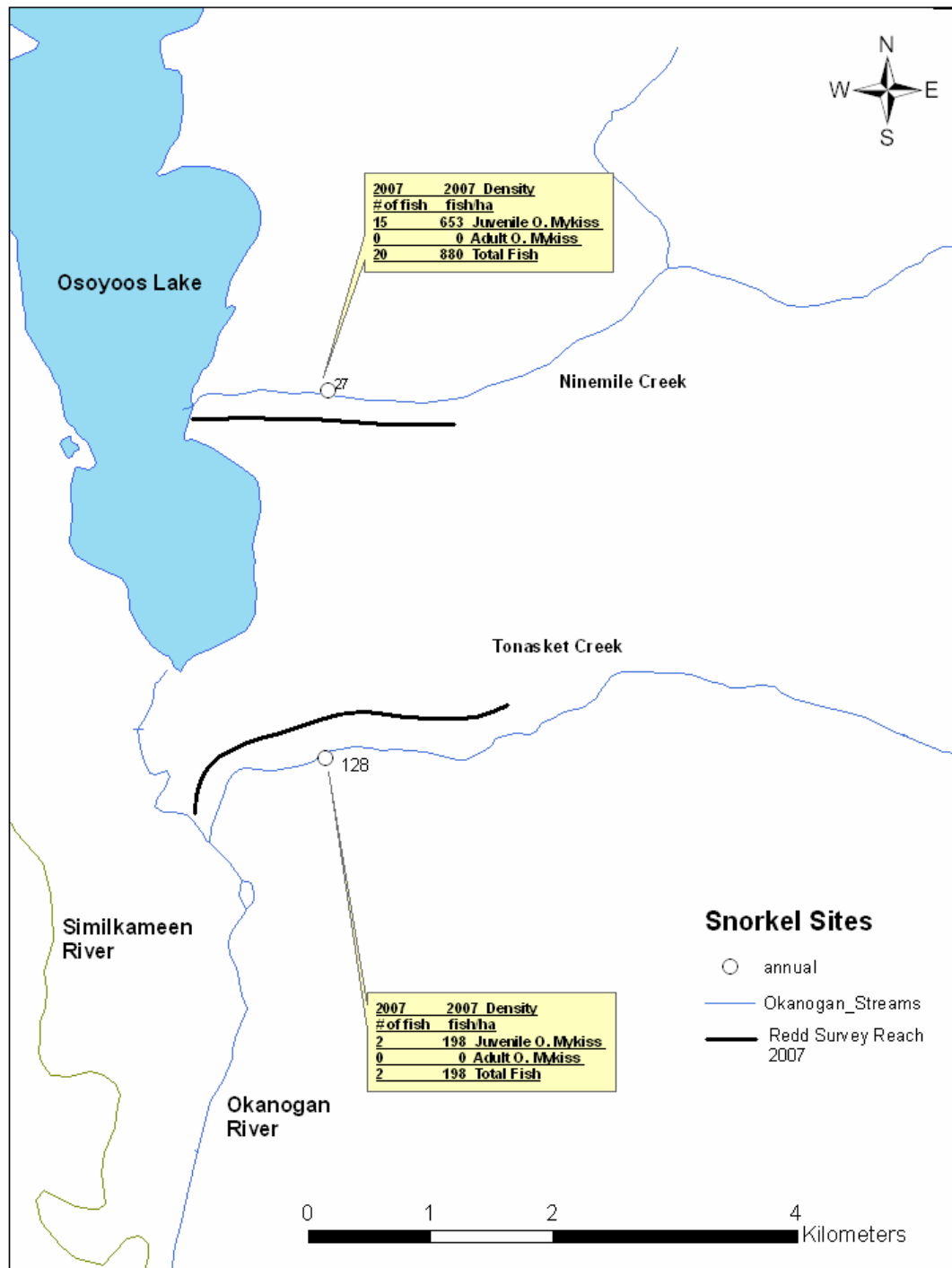


Figure 7: The location of snorkel reaches and fish observed in Nine mile and Tonasket Creeks during 2007.

Snorkel observations by sub-watershed in Canada

Snorkel sites located in Canada were surveyed by the natural resource staff of the Okanagan Nation Alliance. There were three juvenile and one adult *O. mykiss* observed in the main stem Okanagan River and 1,309 juvenile and five adult *O. mykiss* observed in the tributaries in Canada. Inkaneep Creek (site 535); Vaseux Creek (177, 598), McLean Creek (374), Shingle Creek (590 and 461), Shatford Creek (590), Shuttleworth Creek (522, 364) and Ellis Creek (470) all had juvenile *O. mykiss* present. However, only Inkaneep Creek and Vaseux Creek are regularly accessible to anadromous salmonids. Juvenile *O. mykiss* detected at sites 535, 177 and 598 have the potential to be steelhead progeny while *O. mykiss* at the other tributary sites are most likely offspring from resident rainbow trout.

Canada Reach 1 (Figure 8: site 490 and 435) includes the segment of the main stem Okanagan River in Canada from the United States/Canadian border to McIntyre Dam (1-juvenile and 0-adult *O. mykiss* observed). The dominant fish species were minnows assumed to be from the Cyprinidae family. These fish comprised 62% of all fish observed. The average fish densities observed at these sites were 20-fish/ha and 0.4 juvenile *O. mykiss* per hectare.

Haynes Creek site 471 was snorkeled but no fish were observed at this site. The lack of any fish observed in this creek for 2005, 2006 and 2007 and the fact that the creek only flows intermittently, indicates that this is poor habitat for salmonids and fish in general. Data collected to date from Haynes Creek supports that this creek is not utilized by anadromous fish and therefore this annual site will be switched with one of the panel sites on McLean Creek.

Inkaneeep Creek (Figure 8: site 535) the dominant species observed at these sites were juvenile *O. mykiss* with 295 being observed. Juvenile *O. mykiss* density was 4,358/ha. The only other fish observed at these sites were three unidentified cyprinids. This site has been surveyed since 2004. The average juvenile *O. mykiss* density in 2007 at this site was much higher than 2004-2006 (Table 3). Currently, this creek is believed to produce more summer steelhead than any other stream in the Canadian portion of the Okanagan basin accessible to anadromous fish.

Vaseux Creek (Figure 8: site 177 and 598) both of these sites were below the barrier to anadromous fish and therefore all fish observed are considered steelhead. A total of 643 juvenile *O. mykiss* were observed at these sites in 2007, although 27 of them were dead at site 598 due to dewatering. The juvenile *O. mykiss* density was 1848/ha at site 598 and 1036/ha at site 177. The only other fish observed at these sites were 209 minnows. Total fish densities observed were 2,390-fish/ha at site 598 and 1,520-fish/ha at site 177. Although this creek has great potential to produce juvenile *O. mykiss* water quantity issues greatly limit consistent fish production (Kistler and Arterburn 2007).

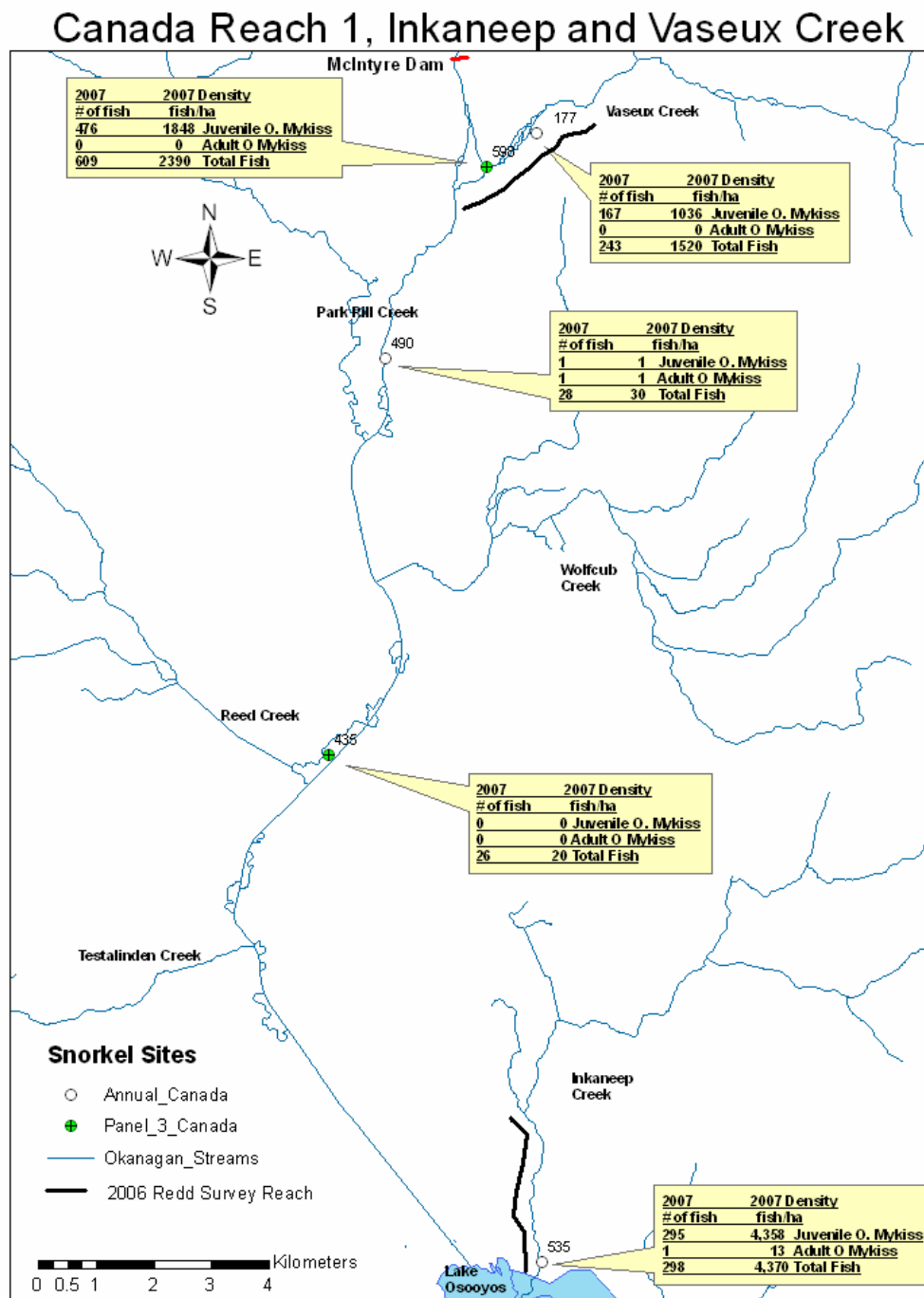


Figure 8: Snorkel site location and fish observed for Vaseux Creek, Inkaneeep Creek and the segment of the main stem Okanagan River in Canada from the 49th Parallel upstream to McIntyre Dam.

All fish observed at the following sites are considered resident fish due to anadromous fish blockage at McIntyre Dam on the Okanagan main stem.

Canada Reach 2 (Figure 9: sites 518 and 493) represents the segment of the main stem Okanagan River in Canada from McIntyre Dam to Okanagan Lake. Two juvenile *O. mykiss* were observed at site 493 with a fish density of 0.7-fish/ha. Individuals of the Cyprinidae family were most abundant within this reach. These fish made-up 30% of the fish observed at these sites with a total average fish density at these two sites of 30 fish/ha.

Shuttleworth Creek (Figure 9: site 522 and 364) site 522 had 25 juvenile *O. mykiss* observed with a density of 253/ha. Site 364 had no juvenile *O. mykiss*, however 22 eastern brook trout were observed resulting in a fish density of 573 fish/ha. Other fish observed at site 522 were 18 cyprinids. The average density for all fish at these two sites was 590 fish/ha.

McLean Creek (Figure 9: site 374) had 178 resident, juvenile *O. mykiss* observed with a density of 5307/ha. No other fish were observed. This creek has excellent potential for steelhead rearing, based on the number of fish observed at this site, once barriers to fish passage at both McIntyre and Skaha dam are removed.

Ellis Creek (Figure 8: site 470) only one site out of two sites surveyed for habitat parameters (site 470) was surveyed. 1 adult *O. mykiss* and 12 juvenile *O. mykiss* were observed along with 45 minnows from the family Cyprinidae. Juvenile *O. mykiss* density was 110/ha and the total fish density was 570 fish/ha.

Shingle Creek (Figure 9: site 317 and 461) 39 juvenile *O. mykiss* were observed at site 461 and no juvenile *O. mykiss* were observed at site 317. Sixty-one cyprinids and 10 juvenile sockeye (*Oncorhynchus nerka*) were observed at site 317 and were the only other species observed at either site. Density of juvenile *O. mykiss* was 325-fish/ha at site 461. The average density within both reaches was 830 fish/ha.

Shatford Creek (Figure 9: site 590) 4 adult and 117 juvenile *O. mykiss* were observed along with 61 eastern brook trout. Density of juvenile *O. mykiss* was 1789 fish/ha. Total fish density at this site was 2810 fish/ha.

Canada Reach 2, Shuttleworth, McLean, Ellis, Shingle and Shatford Creeks

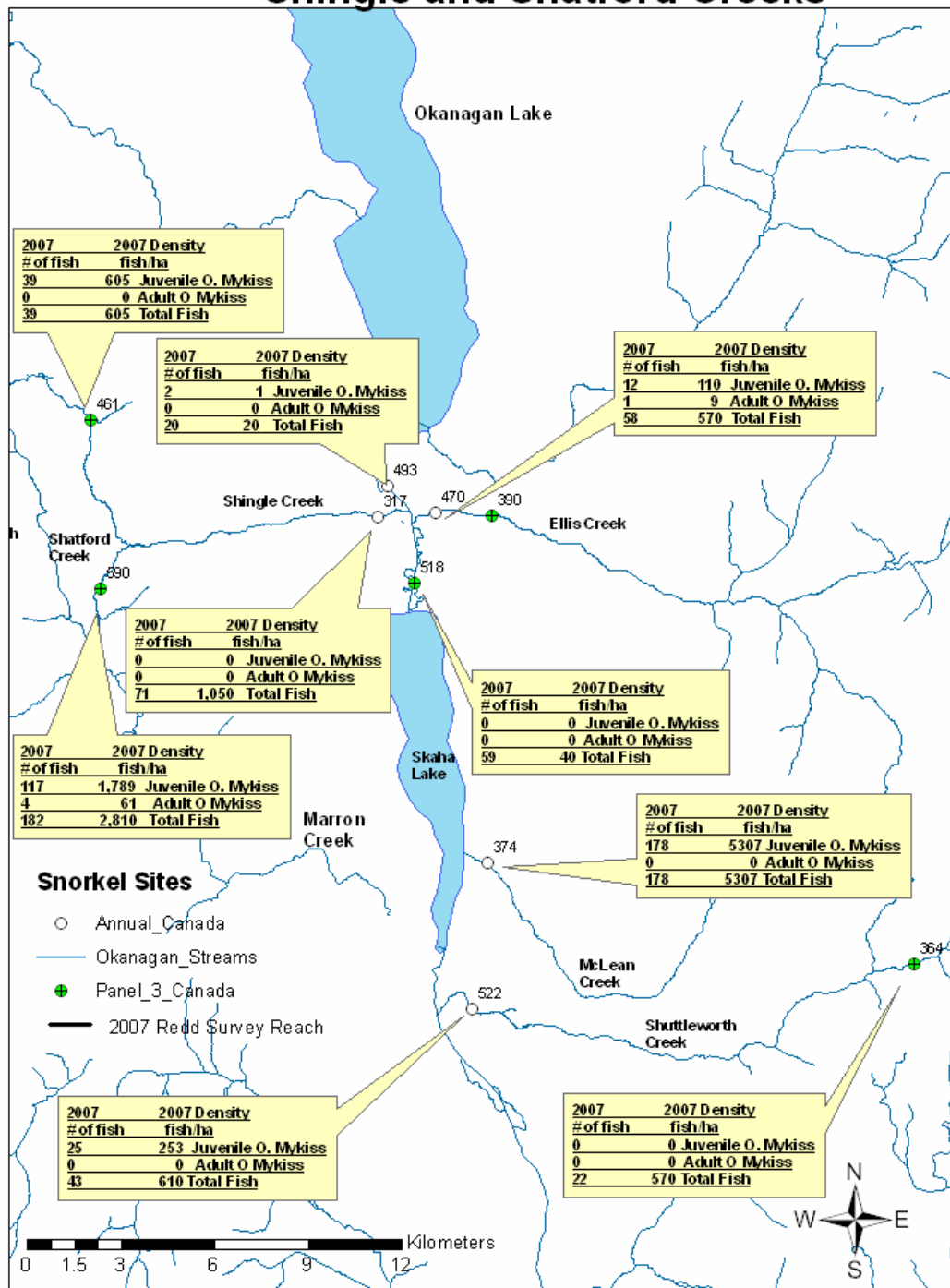


Figure 9: The location of snorkel sites and fish observed in Shuttleworth, McLean, Ellis, Shingle and Shatford Creeks along with the segment of the main stem Okanagan River in Canada from McIntyre Dam to Okanagan Lake.

Conclusions

Coldwater tributaries are vital to the survival of steelhead in the Okanogan basin. There was a large increase in juvenile *O. mykiss* abundance in Bonaparte, Vaseux, and Inkaneep creeks in 2007 when compared to previous year's surveys. Increased numbers of juvenile steelhead in Bonaparte Creek were likely due to an increase in the number of adult steelhead that utilized this creek. High Okanogan River discharge in the spring of 2007 allowed increased access to Bonaparte creek (Arterburn et al 2007a). Secondly, discharge was the lowest recorded (0.5 cfs) while conducting the snorkel survey, which likely caused the fish to be more concentrated elevating densities. In Inkaneep and Vaseux Creek the additional complication of a more seasoned field crew, resulted in vastly increased numbers of juvenile steelhead. Additional years of monitoring and more cross training between the Colville Tribes and the Okanogan Nation Alliance will reduce potential inconsistencies and improve future results.

There has been a high degree of inter-annual variation within snorkel sites (Table 3). Correlations have been investigated to explain this:

- First, the number of redds, summer steelhead spawners and redd densities (redds/km) were compared to juvenile *O. mykiss* density
- Second, if a creek had below average flow in a given year would more juvenile *O. mykiss* be observed due to a reduction in the amount of available habitat.
- Third, *O. mykiss* density was compared to the daily, mean and minimum flow of the year previous to the snorkel survey.
- Fourth, did summer steelhead smolt releases in Omak Creek, due to residualization, increase the density of juvenile *O. mykiss* observed during snorkel surveys.
- Finally, daily mean maximum discharge and years of above average discharge was compared to density of juvenile *O. mykiss*. The expectation was that elevated discharge would disperse or flush more juvenile *O. mykiss* resulting in a reduction in density.

Many factors play a role in the variation in numbers of juvenile *O. Mykiss* detected during snorkel surveys. None of the above proved to be exactly correlated to explain this variation. Juvenile *O. Mykiss* numbers per annual site were consistent across years in the US tributaries, Similkameen and Okanogan Rivers (Table 4). Numbers were not consistent in the Canadian tributaries and that could be explained by the fact that; only one site was surveyed in 2004, and a different survey methodology was used in 2005 and 2006. 2007 data in Canadian tributaries was comparable to US tributaries from 2004-2007.

In some small, cold water tributaries we found that limiting surveys to a small reach may have a high likelihood of missing fish, resulting in a poor estimate of production. No juvenile *O. Mykiss* were observed in Wanacut or Wildhorse Spring Creek at survey sites in 2007. However on spot surveys in Wild Horse Spring Creek we did observe juvenile *O.*

Mykiss. In years to come we will attempt to survey the entire section of creek accessible to anadromous fish in order to get a more accurate number of juvenile fish in these creeks.

In Canada, based upon snorkel surveys, summer steelhead densities exceeded (Inkaneep Creek, 441) or were similar (Vaseux Creek, 105, 187) to tributaries of the Okanogan River where summer steelhead are established (Omak Creek, 121). The densities of *O. mykiss* in selected tributaries in Canada may be conservative, as several numbers of fish were identified as “unknown” and may have been *O. mykiss*. Even so, the numbers of juvenile *O. mykiss* are considerable. Numerous potential habitat rehabilitation projects, such as screening diversions, removing barriers and increasing discharge, could increase substantially the densities of juvenile *O. mykiss*.

Once passage is provided at McIntyre Dam, projected in 2009, Shuttleworth Creek will be accessible to summer steelhead. Based upon habitat and barrier surveys, Shuttleworth Creek provides 3+ miles of potential spawning and rearing habitat. McLean, Shingle, Shatford and Ellis Creeks are upriver of McIntyre Dam and of Skaha Lake Dam. Physical habitat data reflect these creeks have potential to support steelhead spawning and rearing. In addition, further refinement of selected snorkeling sites and seasoning of staff will result in a collection of reputable data which will be the premise for future projects directed at accelerating the recovery of a historically-abundant species.

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**Appendix C- OKANOGAN BASIN
SPRING SPAWNER REPORT FOR 2007**

**OKANOGAN BASIN
SPRING SPAWNER REPORT FOR 2007**



CCT/AF-2007-6

September 2007

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OKANOGAN BASIN SPRING SPAWNER REPORT FOR 2007

Performance Period: March 1, 2007 – February 28, 2008

CCT Account # 315807

BPA Project # 200302200

Prepared by

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Prepared for

U.S. Department of Energy
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Division of Fish and Wildlife
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September 2007

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Abstract

The Okanogan Basin Monitoring and Evaluation Program collected data related to spring spawning anadromous salmonid stocks across the entire Okanogan River basin. Data were collected using redd surveys, traps, underwater video, and PIT-tag technology then summarized and analyzed using simple estimate models. From these efforts we estimated that 1,266 summer steelhead spawned in the Okanogan River basin and constructed 552 redds; 152 of these fish were of natural origin. Of these, 121 summer steelhead, including 29 of natural origin, created an estimated 70 redds in the Canadian portion of the Okanogan basin. We estimated summer steelhead spawner escapement into each sub-watershed along with the number from natural origin and the number and density of redds. We documented redd desiccation in Loup Loup Creek, habitat utilization in Salmon Creek as a result of a new water lease program, and 10 spring Chinook returning to Omak Creek. High water through most of the redd survey period resulted in development of new modeling techniques and allowed us to survey additional tributaries including the observation of summer steelhead spawning in Wanacut Creek. These 2007 data provide additional support that redd surveys conducted within the United States are well founded and provide essential information for tracking the recovery of listed summer steelhead. Conversely, redd surveys do not appear to be the best approach for enumerating steelhead spawners or their distribution within Canada. We also identified that spawning distributions within the Okanogan River basin vary widely and stocking location may play an overriding role in this variability.

Introduction

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) was created in March of 2004 to conduct basin-wide monitoring for anadromous fish in the Okanogan River basin. The OBMEP project is funded by the Bonneville Power Administration (BPA project # 200302200) to fill data gaps particularly associated with endangered summer steelhead through implementation of scientifically rigorous, long-term status and trend monitoring of habitat, water quality, and biological indicators. OBMEP uses protocols derived from the Upper Columbia Strategy (Hillman 2006) that recommends one of the following: a) a complete redd census, if possible, or; b), an annual count of the number of redds within already-established index areas, or; c) an annual count of redds in randomly-selected reaches chosen using the EMAP design. By following the Upper Columbia Strategies we maintain coordination and compatibility with other monitoring and evaluation efforts in the Upper Columbia ESU, located in the Wenatchee, Entiat, Methow, Okanogan and main stem Columbia rivers above Priest Rapids Dam (Figure 1).

In 2005, a complete census of all main stem habitats was conducted within the U.S. for the first time. Several large areas contained no redds and were designated as unlikely to ever have suitable habitat for spawning to occur. Eliminating these areas from future surveys reduces cost without the loss of any biologically important data. A few other areas such as Tunk and Ninemile creeks have limited access due to a lack of land owner permission. Historic redd survey data collected by the Colville Tribes also provided important information used to establish reference reaches on Omak Creek. Collectively, several recommendations were made in 2005 that we first applied in 2006 and maintained in 2007. One such recommendation was limiting our main stem redd surveys to discharges less than 3,000 CFS due to poor visibility.

This is the third year of steelhead redd surveys conducted by the Colville Tribes in the Okanogan Basin. The 2005 report contained an extensive literature review of historic spawning information related to the Okanogan River basin (Arterburn et al. 2005). This document builds upon previously reported information. Previous annual survey reports can be accessed through our web-site at: <http://nrd.colvilletribes.com/obmep/Reports.htm>

Methods

Steelhead redd surveys were conducted in the Okanogan River and Similkameen River drainages, along the main stems and in all accessible tributaries downstream of identified anadromous fish migration barriers (Arterburn et al. 2007a, Walsh and Long 2006). Designated main stem and tributary survey reaches have been defined and can be viewed in Table 1. These survey reaches encompass all known spawning habitat currently available in the United States portion of the Okanogan River basin (except parts of Tunk and Ninemile creeks) and are also include the majority of the annual and rotating panel EMAP habitat sites (Figure 2). The area of the Okanogan below the Chiliwist Creek confluence are subject to inundation from the Columbia River (Wells Pool/Lake Pateros) and therefore lacks the appropriate velocity and substrate needed for summer steelhead to spawn. We do not consider this area spawning habitat and therefore have eliminated it from any surveys or estimates.

Redd surveys were planned along the main stem Okanogan River between April 3 and May 1, 2007, and were to be conducted up to three times during the spawning period provided discharge levels in Okanogan River were below 3,000 cfs. However, discharge levels remained above 3,000 cfs for most of the redd survey period in 2007 which limited our surveys to the single reach from Zosel Dam downstream to the confluence with the Similkameen River. In this reach, flows are regulated by Zosel Dam and water flowing out of Osoyoos Lake remains clear under even high discharge conditions. Multiple-pass redd surveys of tributary habitats were conducted between April 16 and June 16. In Omak Creek, three surveys were conducted at established index areas, one extending 2 km upstream from the mouth of Omak Creek, the other between the lower-end of OBMEP Site 19 upstream to Mission Falls. Above Mission Falls, reaches were surveyed once during the post peak period using the downstream extent of the randomly selected EMAP sites upstream for 1 km.

All steelhead redd surveys were conducted, and redds verified, by at least two Colville Tribal fisheries staff members trained in the application of the OBMEP redd survey methodology (Arterburn et al. 2007b). Main stem surveys were conducted by rafts. Tributary spawning areas were surveyed by foot. All island sections or other main stem areas that could not be floated due to limited access and/or obstacles (e.g. wood debris, braided channels, and diversions) were also surveyed by foot. Raft surveys were conducted by a minimum of two people using two, 1-man, 10' Skookum Steelheader model catarafts.

Redds were marked by GPS and surveyor flagging tied to bushes or trees on the stream-bank adjacent to the area where redds were observed. Individual flags were marked with the survey date, direction and distance from the redd/s, consecutive flag number, total number of redds represented by the flag, and surveyor initials. The same information was captured electronically by entering it into a Trimble GeoExplorer XT data logger. The color of the flagging was changed for each survey. Incomplete redds or test pits were not flagged and not counted. On subsequent surveys, all redds were counted and every attempt made to locate all flags from previous surveys. We noted missing flags by a gap in the numbering sequence. If a flag was found to be missing, the surveyor re-flagged redds based on the previously collected GPS location and information. Re-flagged redds were not counted as new redds.

GPS data and other information collected during field surveys were recorded on Trimble units and downloaded into GPS Pathfinder Office® after every survey. The GIS data were reviewed and spatially corrected to accurately display coordinates in a map format. Escapement calculations were made for each main stem reach, sub watershed and the entire Okanogan River population. We employed the method currently used by WDFW in the Upper Columbia Basin to extrapolate escapement estimates using the sex ratio of broodstock collected randomly over the run (Andrew Murdoch, WDFW, Pers. Comm.). For example, if the sex ratio of a random sample of the run is 1.5:1.0, the expansion factor for the run would be 2.5 fish/redd. This method is used for all supplemented stocks within the Upper Columbia Basin. We expanded this method by incorporating sex ratio data generated from the Omak Creek and Bonaparte Creek weirs in addition to using the sex ratio calculated from fish collected at Wells Dam. Both the total number of redds and spawning escapement were reported to the nearest whole number.

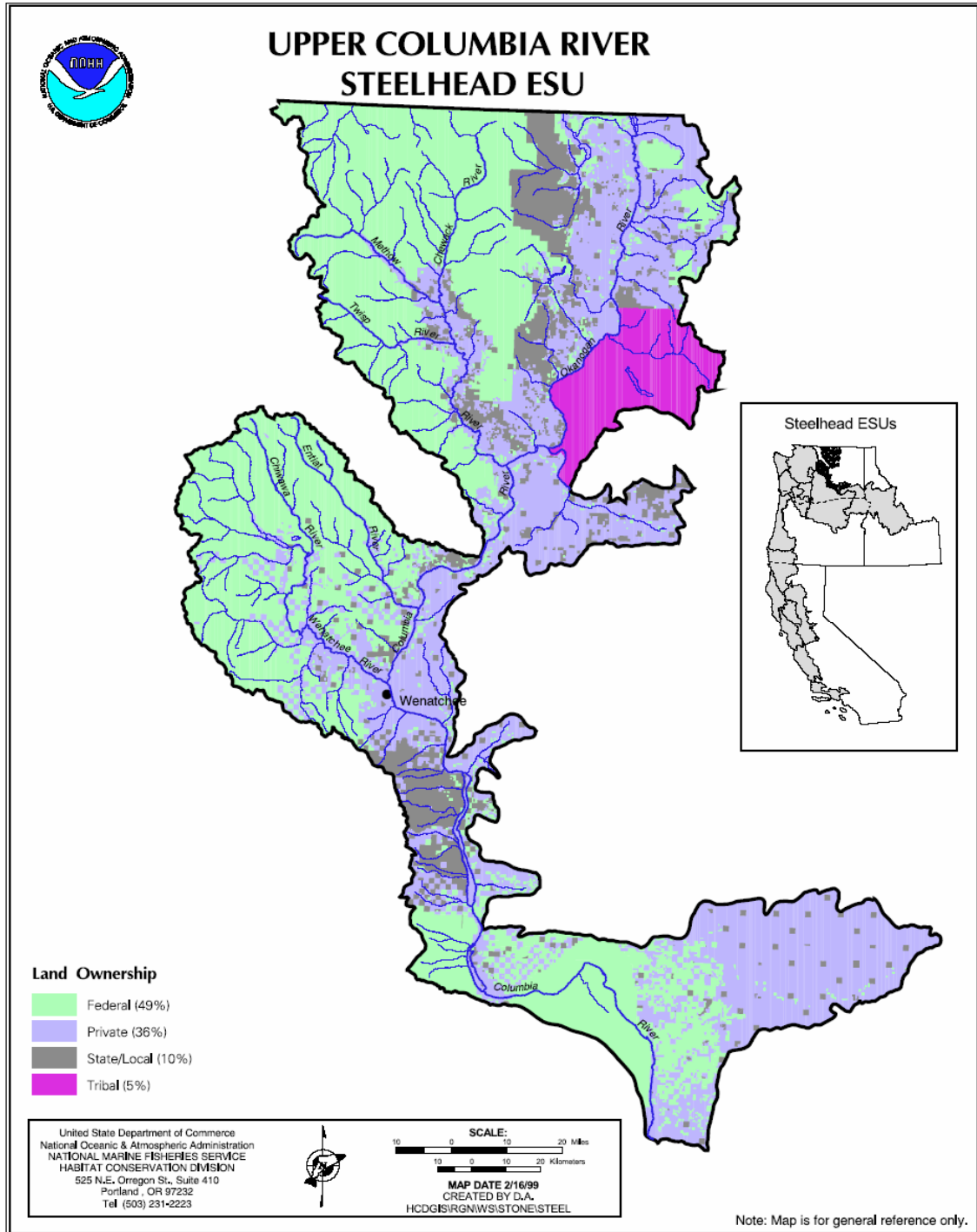


Figure 1: The Upper Columbia River summer steelhead Evolutionarily Significant Unit showing land ownership. *Map courtesy of NMFS-HCD*

Table 1. Designated redd survey reaches with location description and reach length in kilometers used in the Okanogan Basin Monitoring and Evaluation Program.

Redd Survey Reaches	Location Description	Reach length(km)
S1	Similkameen/Okanogan Confluence(0) to Enloe Dam (14.6)	14.6
O1	Okanogan River south of Chiliwist Creek(23.7) to Loup Loup Creek(26.7)	3.0
O2	Okanogan River at Salmon Creek(41.4) to the Office(52.3)	10.9
O3	Okanogan River at the office(52.3) to Riverside(66.1)	13.8
O4	Okanogan River at Riverside(66.1) to Janis Bridge(84.6)	18.5
O5	Okanogan River at Janis Bridge(84.6) to Tonasket park(91.4)	6.8
O6	Okanogan River at Horseshoe Lake(112.4) to Confluence with Similkameen River(119.5)	7.1
O7	Okanogan River at confluence(119.5) to Zosel Dam(127.0)	7.5
TU1	Tunk Creek @Okanogan River Confluence (0) to High water mark (0.2)	0.2
B1	Bonaparte Creek/Okanogan River confluence (0) to Bonaparte Falls (1.6)	1.6
N1	Ninemile Creek from Okanogan River confluence(0) to Eder land (1.7) Maximum potential (4.3 km)	1.7
TO1	Tonasket Creek/Okanogan River Confluence(0) to Tonasket Falls (3.5)	3.5
A1	Antoine Creek/Okanogan River Confluence(0) to Antoine Barrier (1.3)	1.3
L1	Loup Loup Creek/Okanogan River Confluence to Loup Loup Falls (3.3)	3.3
WS1	Wildhorse Spring Creek/Okanogan River Confluence to Barrier (1.1)	1.1
WC1	Whistler Cache Creek/Okanogan River Confluence to Barrier (0.7)	0.7
OM1	Omak Creek/Okanogan River Confluence(0) to Omak Lake Rd. Bridge (2.0)	2
OM2	EMAP site 19 Lower (5.3) to Mission Falls (9.0)	3.7
OM48	EMAP site 48 Lower (25) to River Kilometer (26)	1
OM393	EMAP site 393 Lower 16.7) to River Kilometer (17.7)	1
OM361	Above Mission Falls (9.5) to EMAP site 345 (13.3)	3.8
OM302	River Kilometer (21.5) to EMAP site 302 lower (22.5)	1
SC1	Confluence with the Okanogan (0) to OID Diversion (7.2)	7.2

Annual and Panel Map

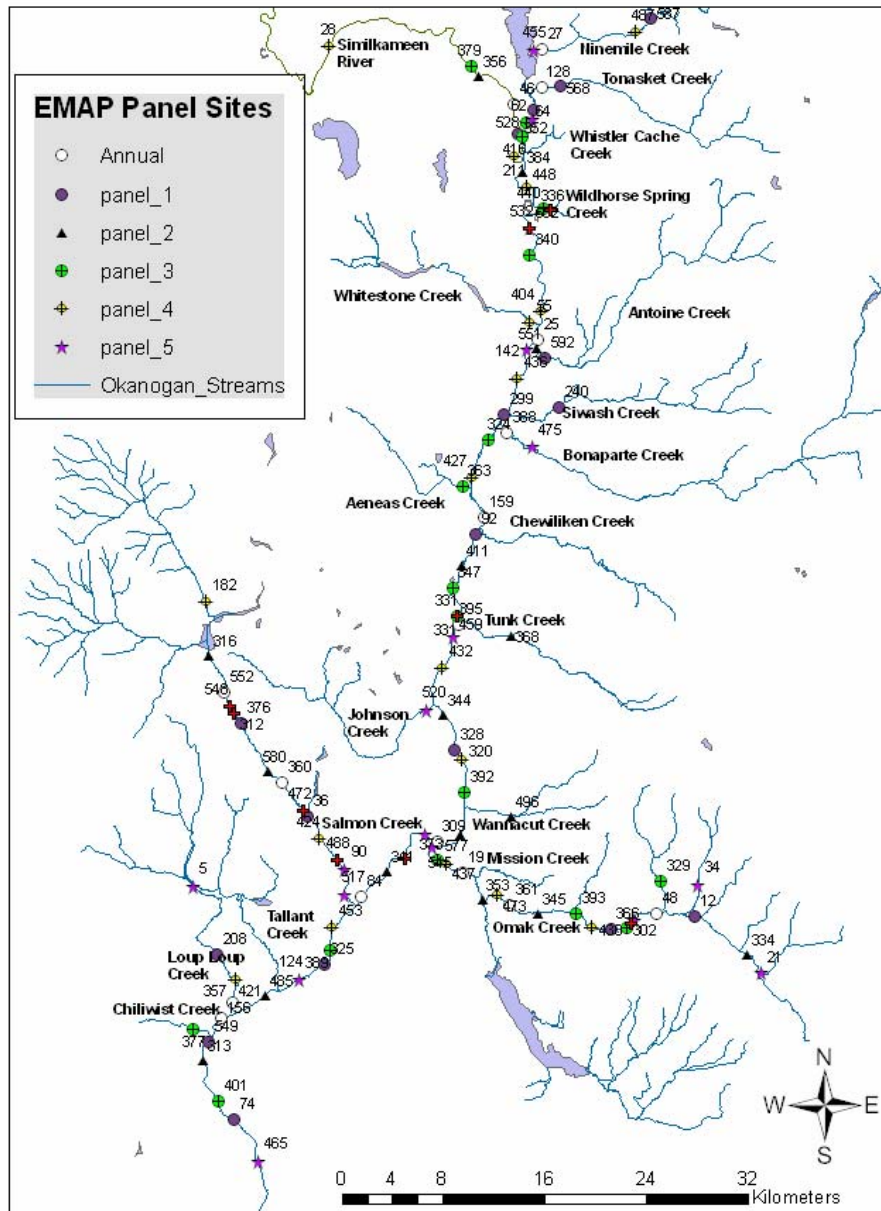


Figure 2: Probabilistic sampling design was used to select EMAP sites from a sampling universe that included all accessible habitats for anadromous fish in the United States portion of the Okanogan River Watershed. Annual sites are sampled annually and panel sites (1-5) are sampled once every 5 years on a rotating basis.

Total redd estimates, in combination with spawner escapement where data exists (Omak Creek weir, Bonaparte Creek weir, and Zosel Dam counts), can be used to estimate total escapement with a high level of accuracy. Estimating redds in tributaries where landowner permission could not be granted represents a more difficult problem. The only way to expand estimates to the entire creek is to multiply the density of redds per km of stream in the sampled area by the remaining length of stream accessible by summer steelhead; this method was only needed for Ninemile and Salmon creeks.

Sex ratio data can be used to provide estimates of total spawner escapement for the reach, watershed or sub-watershed. The sex ratio was determined by counting and sexing all adult fish returning to Wells Dam, the Omak Creek and Bonaparte Creek weirs. The ratio of males to females is used for representative streams. Main stem habitats use Wells values, medium-sized tributaries use the sex ratio from the Omak Creek weir, and small streams use the sex ratio from the Bonaparte Creek weir, assuming that each female will produce one redd.

During the spring of 2007, high discharges did not allow us to survey the majority of main stem Okanogan River reaches. Therefore, we needed to estimate main stem redd numbers and distribution. In order to accomplish this we used two methods. First, we surveyed the reach from below Zosel Dam to the confluence of the Similkameen River (Reach O7). To estimate other reaches of the Okanogan River we determined the proportion of redds observed in this reach during the 2005 and 2006 redd surveys. This proportion was then applied to the other reaches along the Okanogan and Similkameen Rivers to estimate total main stem redd abundance. As a check-and-balance we also calculated escapement estimates using the WDFW Okanogan River escapement estimate (WDFW –unpublished data) which apportions summer steelhead to both the Methow and Okanogan rivers and accounts for all known recreational harvest. The WDFW escapement estimate was used as a starting point to subtract known information related to tributary redd surveys, weir counts, and escapement into Canada. The number of redds was then calculated by estimating redds/reach based upon historic patterns of redd distribution.

Results and Discussion

Sex ratios

In 2007, 390 adult summer steelhead were sexed at Wells Dam, including 163-males and 227-females, for a sex ratio of 1.72 steelhead per redd (Charlie Snow, WDFW Pers. Comm.). At the Omak Creek trap, 97 adult summer steelhead consisting of 53-males and 44-females were collected. This makes a 1.2:1 male to female ratio and a *number of fish per redd* of 2.2 that will be applied to Omak Creek and other moderate-sized tributaries such as Salmon and Loup Loup creeks. On Bonaparte Creek, 164 summer steelhead were enumerated, of which 107 were male and 57 female, resulting in a sex ratio of 2.88. We assumed that other small tributaries had a similar sex ratio to Bonaparte Creek.

Percent wild

Trap and dam counts provide the basis for determining the natal origin of summer steelhead in the Okanogan River basin. In 2007, WDFW estimated the number of wild summer steelhead that passed above Wells Dam at 552 or 8.27% of the total escapement. These values were based upon Wells Dam fish counts, scale analysis, hatchery releases, and stray rates estimated for Wells Hatchery (Charlie Snow, WDFW Pers. Comm.). The proportion of these fish assigned to the Okanogan River was 116 or 9.22% of the Okanogan River population. This percentage was applied to all main stem Okanogan reaches. We estimated the number and percent wild for summer steelhead that spawned in Omak Creek as 13 and 13.4% of the total summer steelhead collected at the Omak Creek trap. Estimates for Bonaparte Creek were 21 or 12.8% of the steelhead collected at the Bonaparte Creek trap and was based upon the presence or absence of adipose fins and PIT-tags. At Zosel Dam, video images of the presence or absence of adipose fins were used to determine origin with 32 wild fish being counted, resulting in 21.77% of the run passing upriver of Zosel Dam being classified as natural origin. Three of these wild fish were apportioned to Tonasket and Ninemile creeks. The remaining 29 wild steelhead or 23.69% were assumed to be destined for spawning habitat in Canada. The estimated total number of wild summer steelhead spawning in the Okanogan River subbasin was 152 or 12.01% of the total summer steelhead escapement in 2007.

Okanogan River and Similkameen River Main Stem

Discharge rates in 2007 in no way approximated normal, other than in the total amount of water that passed throughout the spring. Flows were five times the historic high flows during early April and remained higher than the historic mean until almost June (Figure 3). Extremely high flows prevented conducting redd surveys in the main stem Okanogan River below the confluence of the Similkameen River.

The Okanogan River was divided into seven segments for analysis. These segments were based on access points and included reaches on the Similkameen River. All reaches were located upstream of the Wells Pool influence that is commonly agreed to be at the confluence of Chiliwist Creek and the Okanogan River. Data collected in 2005 and 2006 were used as reference for main stem reach survey timing. In 2005, when flows on the main stem exceeded 3,000 cfs, visibility was too poor to continue with main stem redd surveys (Arterburn et al. 2005). Therefore, we had planned to begin main stem redd surveys April 1, 2007. However, due to extremely rare runoff conditions, discharge remained greater than 3,000 cfs and poor visibility conditions compromised our ability to conduct main stem surveys in reaches other than O7 (Figure 3). We estimated redds along the main stem Okanogan River in 2007 based on information we could collect in 2007 from reach O7 and past survey data from 2005 and 2006. Because elevated discharge compromised our ability to do most of our scheduled main stem redd surveys, we focused our efforts on expanded redd surveys in the tributaries.

To estimate redds based upon one survey reach we first had to determine the historic proportion of redds for each of the main stem reaches. To do this we summed the number of redds counted from surveys conducted in 2005 and 2006 for each reach and divided this value by the total number of main stem redds observed to get a proportion of historic redds. We were able to complete redd surveys in reach O7 (150 redds) and the historic proportion of redds for this reach was estimated at 37.69%. By dividing the number of redds observed in 2007 by the historic proportion we estimated the total number of redds we should have observed along all main stem reaches at 398. This value was then multiplied by the historic proportion of the estimated reaches to compute the number of redds for each main stem reach. The estimated number of redds was multiplied by the sex-ratio from Wells Dam to estimate the number of spawners that these redds would represent. Because these estimates were based upon redd surveys on reach O7; to address inter-annual variability, our assumption was that the other reaches of the main stem would be equally impacted by visibility and runoff conditions. However, the clear water coming out of Zosel Dam made us question this a-priori assertion. The results from this effort are presented in Table 2 and compared to an alternative method used to QA/QC our results.

In the past, OBMEP redd surveys were used to estimate the number of spawners in the Okanogan River. Our spawner estimates have been compared to spawner escapement estimates developed by WDFW as part of our quality control efforts and our estimates have shown good correlation in both 2005 and 2006. Over concerns that our earlier method of estimating main stem redds would result in a biased estimate of spawners, we decided to calculate the number of redds from the WDFW spawner escapement estimate for comparison. This approach starts with the number of fish counted at Wells Dam (6,674) from the DART web site <http://www.cbr.washington.edu/dart/adult.html>. Harvested fish are subtracted from this number and a split percentage is used to partition summer steelhead into the Methow River (79%) and Okanogan River (21%) values to estimate escapement (Bob Jateff, WDFW, Pers. Comm.). Using this method, the number of summer steelhead entering the Okanogan River was estimated at 1,258. Data from traps, video chambers, and tributary redd surveys were subtracted from 1,258 resulting in 418 adult spawners that were unaccounted. These unaccounted spawners plus the 258 spawners estimated from the redd surveys in reach O7 were distributed across the main stem reaches using the proportions that were developed by using our 2005 and 2006 redd surveys. The results from both methods were within three adult (395, 398, Table 2). Since the results were comparable we used the values from the a-priori approach to conduct the remaining analysis.

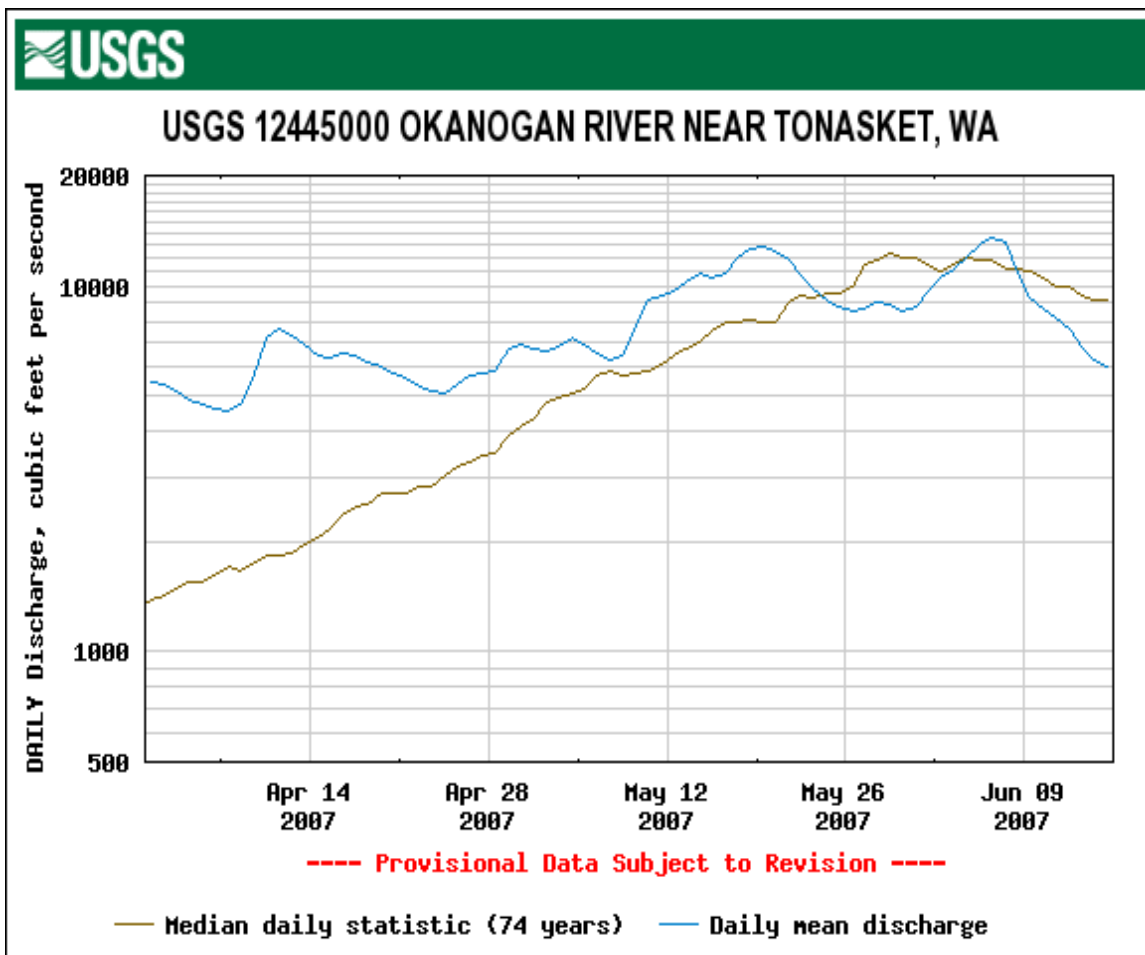


Figure 3: Okanogan River discharge for the period between April 1 and June 15, 2007. The 74-year historic average is also plotted on the graph for reference (<http://waterdata.usgs.gov/wa/nwis/uv?12445000>).

Okanogan River Reach O7 was surveyed three times in 2007 and a total of 150 summer steelhead redds were identified: April 3 (13 redds); April 17 (71 redds); and May 1 (66 redds). The majority of redds were observed between Zosel Dam and the Cross Channel in 2007, which is similar to results in 2006 (Figure 4). During peak spawning, numerous summer steelhead were observed constructing or near redds. We estimated that the number of summer steelhead spawning in this reach was 258 and 24 were of natural origin. We calculated a redd density of 34.4 redds per km in this reach.

The timing of summer steelhead redd construction in 2005 progressed from the lower river northward with peak activity around the middle of April in the main stem reaches. In 2006, redd construction timing did not follow a specific pattern and varied by location from early to late April. In 2007, redd construction timing in Reach O7 was very similar to 2006 with most redds created in early- to mid-April and fewer redds observed during the late April survey. Reach O7 did continue to attract many spawning adult summer steelhead, particularly between Zosel Dam and the Cross Channel above Driscoll Island. Where habitats were conducive, steelhead built redds in close proximity to one another, especially in pool tail-out areas and at the heads of mid-channel islands.

Table 2: Comparison of number of redds estimated using two different methodologies. The 2007 Reach O7 estimate applied the historic proportions of redds observed to the data collected in 2007 in the O7 reach. The Wells Dam estimated redd count begins with the WDFW predicted adult spawner escapement and subtracts all known adult spawner estimates from redd surveys, trap data, and video data collected in 2007. The remaining fish were then apportioned amongst the main stem reaches based upon historic distributions, then divided by the sex ratio for Wells Dam in order to estimate the number of redds in each reach. The number of redds observed during steelhead redd surveys in 2005 and 2006, with reference reach length, description, and designation for these observations are also presented. Values coded by * are estimated values

Reference Reaches	Description (river-KM)	Reach length (KM)	2005 (redd count)	2006 (redd count)	2007 Reach O7 (*Estimated redd count)	2007 Wells Dam (*Estimated redd count)
O1	Okanogan River south of Chiliwist Creek(23.7) to Salmon Creek(41.4)	28.5	17	0	9*	9*
O2	Okanogan River @ Salmon Creek(41.4) to CCT Office(52.3)	10.9	56	4	31*	30*
O3	Okanogan River @ CCT Office(52.3) to Riverside(66.1)	13.8	8	2	5*	5*
O4	Okanogan River @ Riverside(66.1) to Janis Bridge(84.6)	18.5	58	11	35*	35*
O5	Okanogan River @ Janis Bridge(84.6) to Mouth of Siwash Creek(93.8)	14.8	65	39	53*	52*
O6	Okanogan River @ Mouth of Siwash Creek(93.8) to Confluence of the Similkameen River(119.5)	41.4	19	1	10*	10*
O7	Okanogan River at Confluence of the Similkameen(119.5) to Zosel Dam(127.0)	7.5	141	153	150	150
S1	Similkameen River @ Okanogan confluence(0) to Enloe Dam (14.6)	23.5	106	100	105*	104*
Total	Okanogan River		470	310	398	395

Redd Survey Reach 07-2007

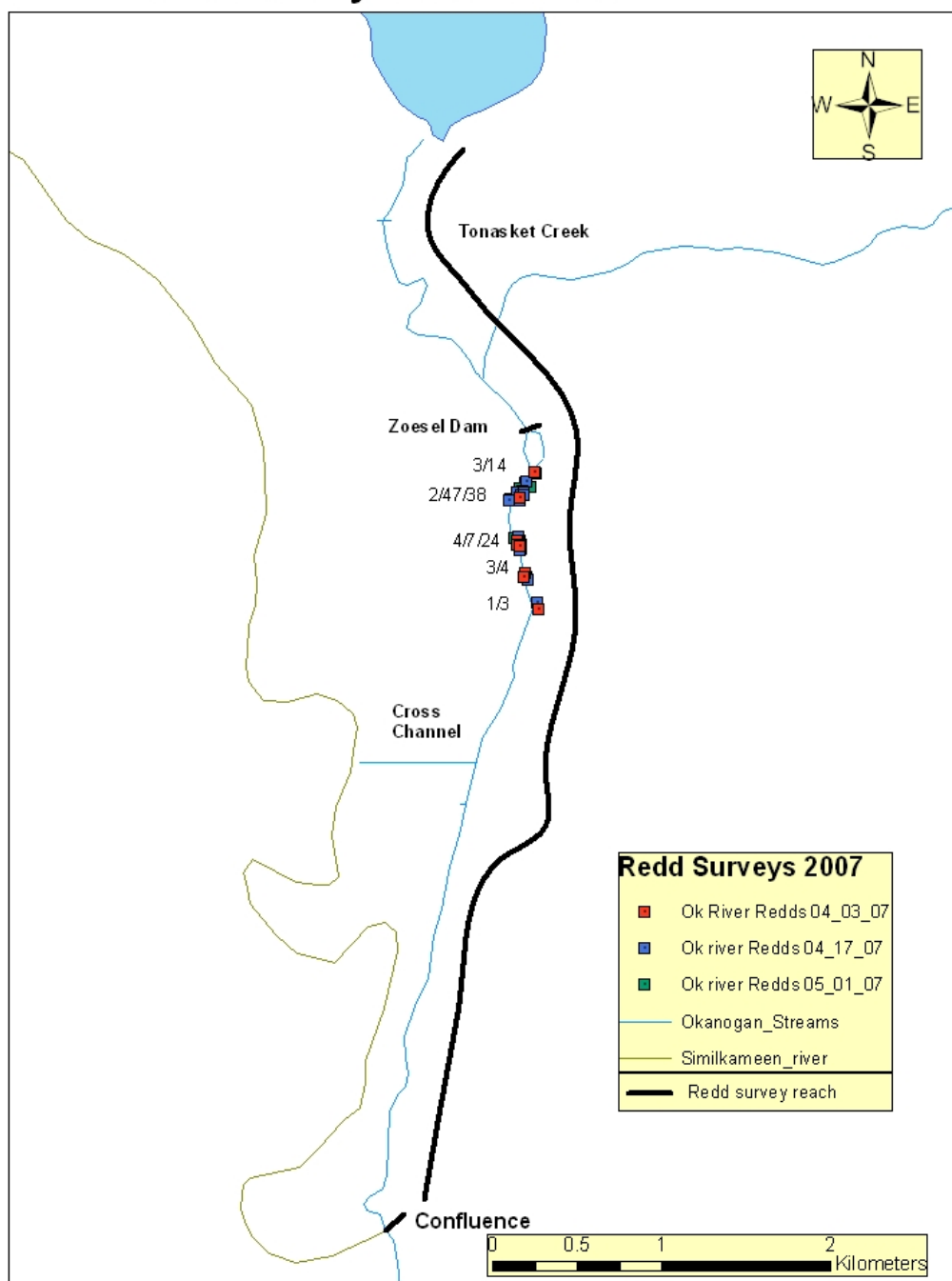


Figure 4: Redd distribution observed in 2007 for Okanogan River Reach O7 from Zoesel Dam downstream to the confluence with the Similkameen River.

Tributary redd surveys in the Okanogan River basin

Tributary habitats were originally planned for survey during the first week of June. However, high water in the Okanogan River provided an opportunity to conduct multiple-pass redd surveys over an extended area beginning April 16 with final surveys completed on June 11, 2007. Tributary runoff during 2007 was moderated by cool, dry weather throughout the period that allowed the slightly above average snowpack to melt in an orderly manner. This provided excellent conditions for multiple redd surveys in most tributaries throughout the survey timeframe.

In 2007, most tributary streams reached peak discharge by mid-March and steadily decreased throughout the spawning period. A normal hydrograph consists of an ascending limb in March and April then peaking in mid- to late-May. The almost complete lack of spring precipitation resulted locally in a very controlled runoff in the tributary streams (Table 3). Elevated discharge in the Okanogan River provided unimpeded access into most tributaries, as indicated by 156 steelhead entering Bonaparte Creek. However, minimal precipitation resulted in diminished discharges from most tributaries and limited spawner distribution (Figure 5).

Table 3: Precipitation totals measured by the National Weather Service at Omak Airport <http://www.crh.noaa.gov/product.php?site=NWS&issuedby=OMK&product=CLM&format=CI&version=6&glossary=0>

Month	Inches of precipitation in 2007	Inches of precipitation in 2006	Inches of precipitation on Average
March	0.08	0.81	1.00
April	0.06	0.89	1.00
May	0.74	1.35	1.08
Total	0.88	3.05	3.08

Each tributary of the Okanogan River represents a unique data set; therefore the results of each tributary are described individually.

Ninemile Creek

Lack of access to private lands has been an ongoing problem on Ninemile Creek. No exhaustive survey of fish passage barriers has been possible due to an uncooperative landowner. However, the Colville Tribes Fish and Wildlife Department's personnel have incrementally documented migration barriers within this watershed (Arterburn et al. 2007). We have verified that anadromous fish have access to a minimum of 1.7 km (lower extent of private lands) and a maximum of 4.3 km (impassable falls) of spawning and rearing habitat. Surveys uncovered one impediment at river kilometer 1.3 and this blockage could be a complete barrier during low water years such as 2005 and 2007 (Figure 5). Extrapolating redd surveys is limited to the maximum habitat available but this evaluation is subject to change as additional habitat information is gained. Within the lower 1.7 km, two redds were identified on April 18, 2007 and one on May 2, 2007 (Figure 6). No redds or summer steelhead were observed during the final survey on May 16, 2007. Escapement was

estimated between 9 and 22 summer steelhead with a density of 1.76 redds/km. However, it is suspected that our lower estimate is more representative due to lack of sufficient flows which likely limited access. If we assume escapement into Ninemile Creek was 9 summer steelhead then one of these fish was likely of natural origin.

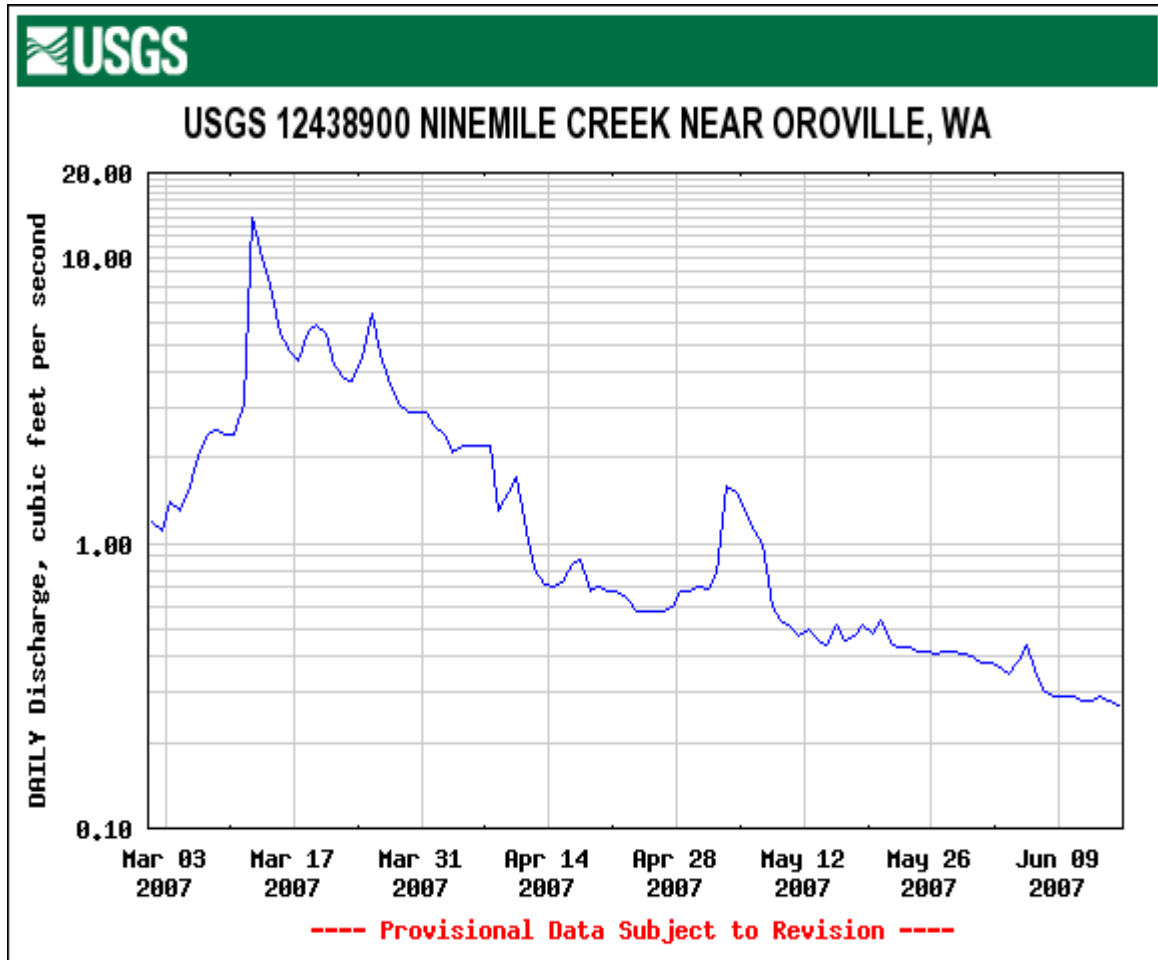


Figure 5: Discharge graph for Ninemile Creek. Flows below 1.0 cfs make it extremely difficult for adult steelhead to migrate through or spawn in this stream.

Tonasket Creek

Tonasket Creek had good flows throughout the steelhead spawning season in 2007. The barrier to upstream migration is a natural falls at river km 3.5 (Arterburn et al. 2007). Only during the second survey were redds observed. Six redds were observed on April 27, 2007 (Figure 6). The escapement for Tonasket Creek was estimated at 17 summer steelhead with a density of 4.86 redds/km. From these estimates, we predict that 2 wild steelhead returned to Tonasket Creek in 2007.

Ninemile(N1)and Tonasket Creek(T1) Redds 2007

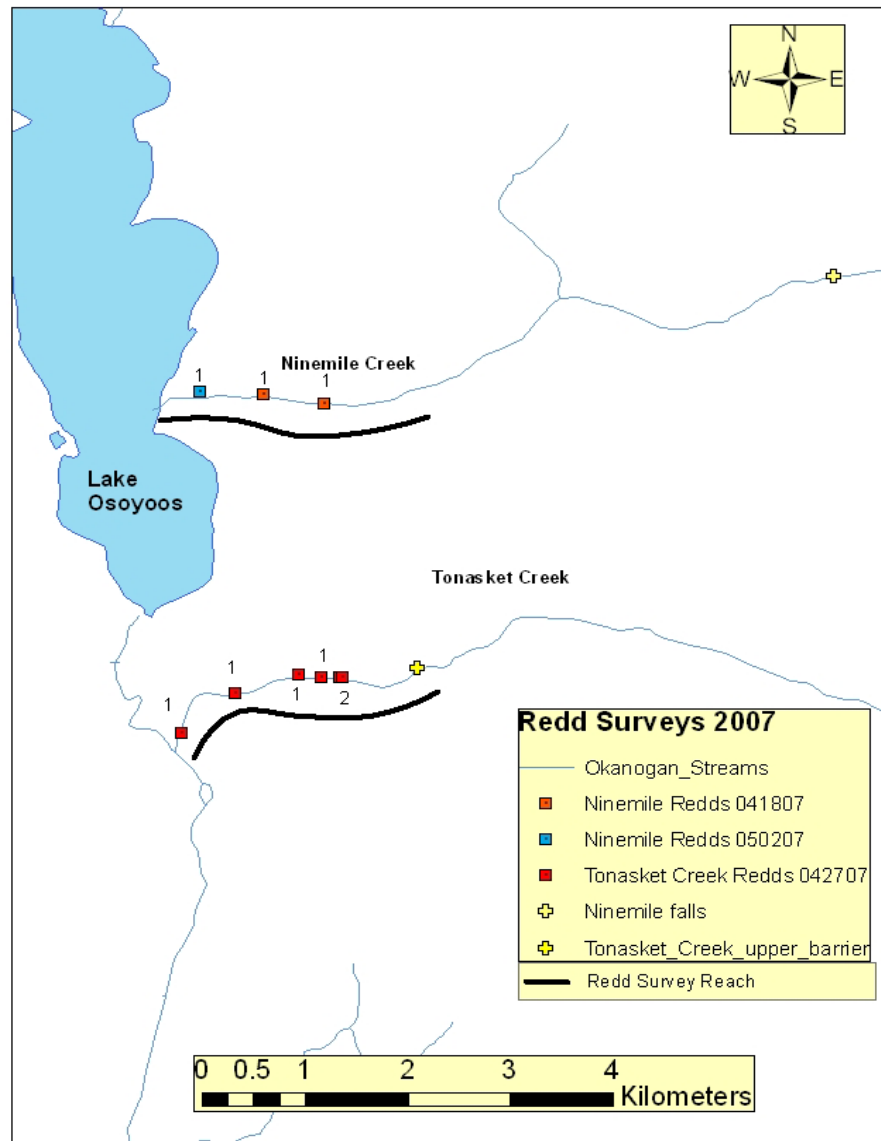


Figure 6: Redd distribution observed in 2007 for Ninemile and Tonasket Creek in the accessible lower portions of each creek.

Wildhorse Spring Creek

Wildhorse Spring Creek had been inaccessible prior to 2006 due to a large beaver dam located near the confluence with the Okanogan River. However, high flows in 2006 dislodged this dam. With the barrier removed summer steelhead began colonizing these habitats. In 2006 three redds were observed by OBMEP crews and verified by WDFW biologists. Again in 2007, steelhead redds were observed within the 1.1 km of available habitat. One adult steelhead was observed on April 8, 2007, and no redds or fish were observed on April 23, 2007. Seven redds were observed during a survey conducted on May 24, 2007 (Figure 7). Some uncertainty does exist regarding these redds as the substrate size

was smaller than usual for summer steelhead and the size of observed redds were also smaller than one would typically equate with summer steelhead for all redds observed. At adult traps on Omak and Bonaparte creeks, several small steelhead were captured during 2007. Also, the close proximity of redds suggests that more than one redd may have been constructed by one fish, or may have been “test pits”. Using our a-priori methodology we would estimate these redds to represent 20 spawning adults at a density of 6.4 redds/km. However, due to some uncertainty related to these redds, a minimum estimate would be 12 adults using the Wells Dam sex ratio. Natural-origin steelhead predictions would range between 2 and 3 fish. Based upon channel dimensions, size of substrate, and no adult steelhead observed during surveys, the lower number of adults is likely more accurate. .

Whistler Cache Creek

During 2007, field crews attempted to do three redd surveys but the creek was dry so no redds were observed. After doing redd surveys in 2006 during which water was present in this stream and attempting them again in 2007. We believe that this stream does not have any spawning potential for summer steelhead (Figure 7). Therefore, no further spawning surveys are planned along this creek.

Antoine Creek

Antoine Creek typically has perennial discharge but had limited discharge for adult passage throughout the 2007 steelhead spawning season. Although we surveyed the stream on April 11, April 24, and May 14, we did not observe any summer steelhead adults nor redds. The barrier to upstream migration has been located at river kilometer 1.3 where a bedrock feature and irrigation diversion exists (Arterburn et al. 2007). Therefore, escapement was zero in 2007. Snorkel surveys have identified multiple year-classes of both brook and rainbow trout indicating that some rearing habitat does exist (Kistler et al. 2006, Kistler and Arterburn 2007). However, in most years the mouth of this tributary is difficult for adult fish to navigate. Redd surveys conducted during 2007 indicate the need for modifying the confluence area to ensure access during typical flow conditions. In addition, hatchery supplementation of locally-adapted hatchery steelhead smolts would “seed” the available habitat in this creek resulting in an increased likelihood that adults would return to this stream to spawn.

Wildhorse Spring Creek Redds 2007

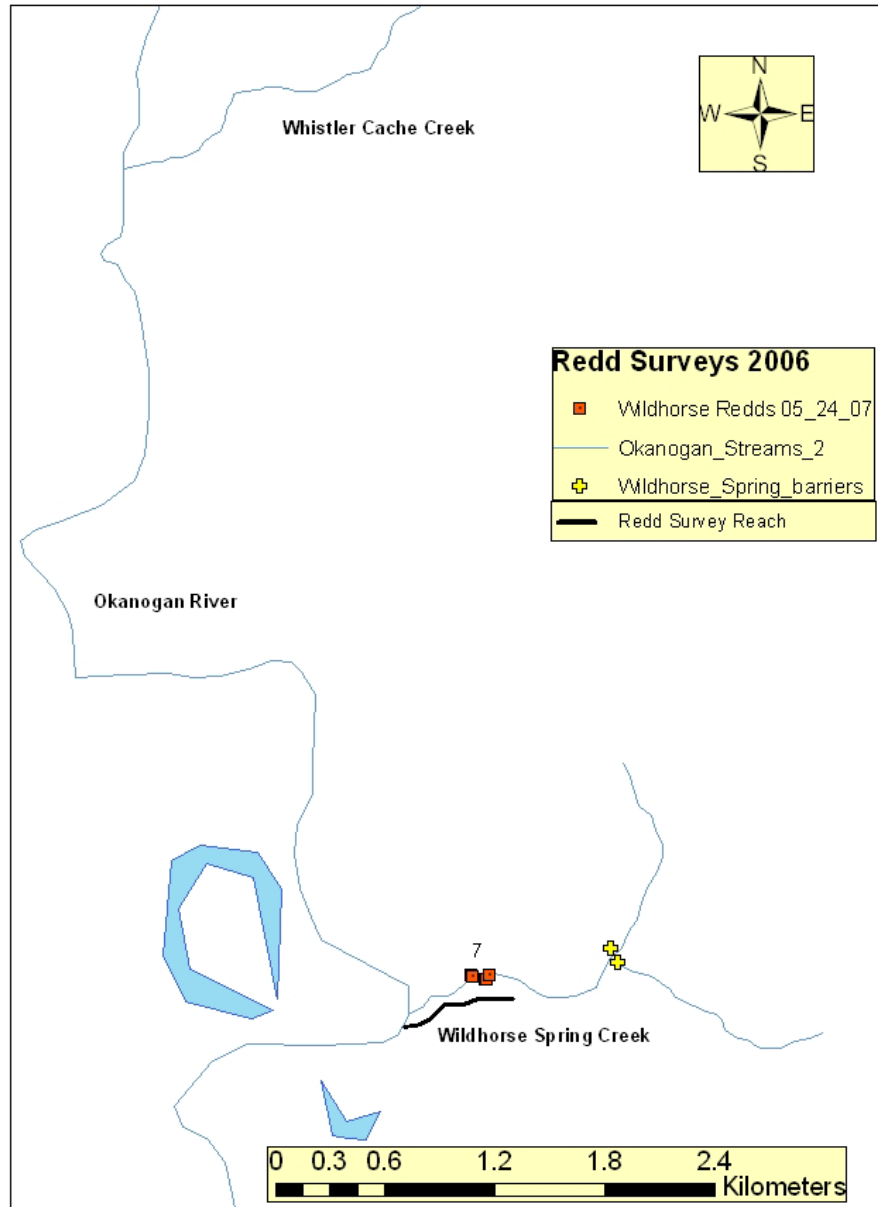


Figure 7: The location of redds within the Whistler Cache Creek and Wildhorse Spring Creek sub-watersheds in 2007.

Bonaparte Creek

In 2007, a picket weir trap was installed on March 28. We captured 164 summer steelhead, including 57 females, and 107 males and 21 being of natural origin. Since this trap was considered impassable, redd surveys to generate spawner estimates were not necessary above the trap. Furthermore redd surveys during 2005, and 2006 exhibited an even distribution throughout the 2.2 kilometers of accessible habitat (Arterburn et al. 2005, Arterburn and

Kistler 2006, Arterburn et al. 2007). Redd surveys downstream of the weir were not conducted until July 31 due to elevated water height on the Okanogan River which precluded streambed observations. Although obscure, 13 summer steelhead redds were identified below the trap site (Figure 8). Based upon the sex ratio generated from the trap data, an estimated 37 summer steelhead spawned downstream of the trap site. Of the fish enumerated at the trap, 12.8% were of natural origin. An additional 5 fish of natural-origin spawned downstream of the trap site. Redd density was calculated at 32.27/km which is the highest density since 2005 when a density of 41.88/km was observed (Arterburn et al. 2005). The total number of spawners was 204, of which 26 were of natural origin. Due to the abundance of adult steelhead returning to Bonaparte Creek, and the limited spawning and rearing habitat, Bonaparte Creek should be seriously considered as a future site for locally adapted broodstock collection.

Tunk Creek

Adult summer steelhead may have entered the lower portion of Tunk Creek and spawned successfully. However, as access is not permitted by the landowner from the confluence upstream to the base of Tunk Falls, our redd surveys have always been limited to the area within the high-water mark of the Okanogan River. In 2007, high water along the Okanogan River made it impossible to survey for redds even within the lowest reach of Tunk Creek as has occurred in past years. Previous redd surveys identified 4 redds in 2005 and 1 redd in 2006 within the lower 0.2km of Tunk Creek. These observations were extrapolated into adult escapement estimates of 7 to 46 summer steelhead in 2005 and 2 to 7 summer steelhead in 2006 (Arterburn et al., 2005; Arterburn and Kistler 2006). Because only a very limited area of Tunk Creek is accessible for redd surveys it is hard to hypothesize about cause and effect relationships. Because we have only minimal data for Tunk Creek, our 2007 escapement estimate must remain unknown.

Wanacut Creek

Although this creek has a sizeable watershed (roughly 22,000 acres), data is scarce primarily due to discontinuous surface flow within the lower 1 kilometer. During 2006, a falls was documented at river kilometer 2.64 defining the extent of accessible habitat by anadromous salmonids (Arterburn et al. 2007). During the spring of 2007, Swimptkin Canyon, Pothole Canyon, and Wanacut creeks were all flowing and accessible by summer steelhead. All three creeks were surveyed on April 12 and April 19, 2007, but no redds were observed. However by April 25, both Swimptkin and Pothole Canyon creeks had stopped flowing. Wanacut Creek was still flowing; one redd and one adult summer steelhead were observed (Figure 9). A final survey was conducted on Wanacut Creek on May 15, 2007, and documented no additional redds or adult fish. Redd densities were estimated at 0.38 redds/km and we estimated that 3 adult summer steelhead spawned in Wanacut Creek but none were of natural origin. This stream should be considered for supplemental stocking from a locally-adapted hatchery program to encourage greater adult returns.

Bonaparte Creek Redds-2007

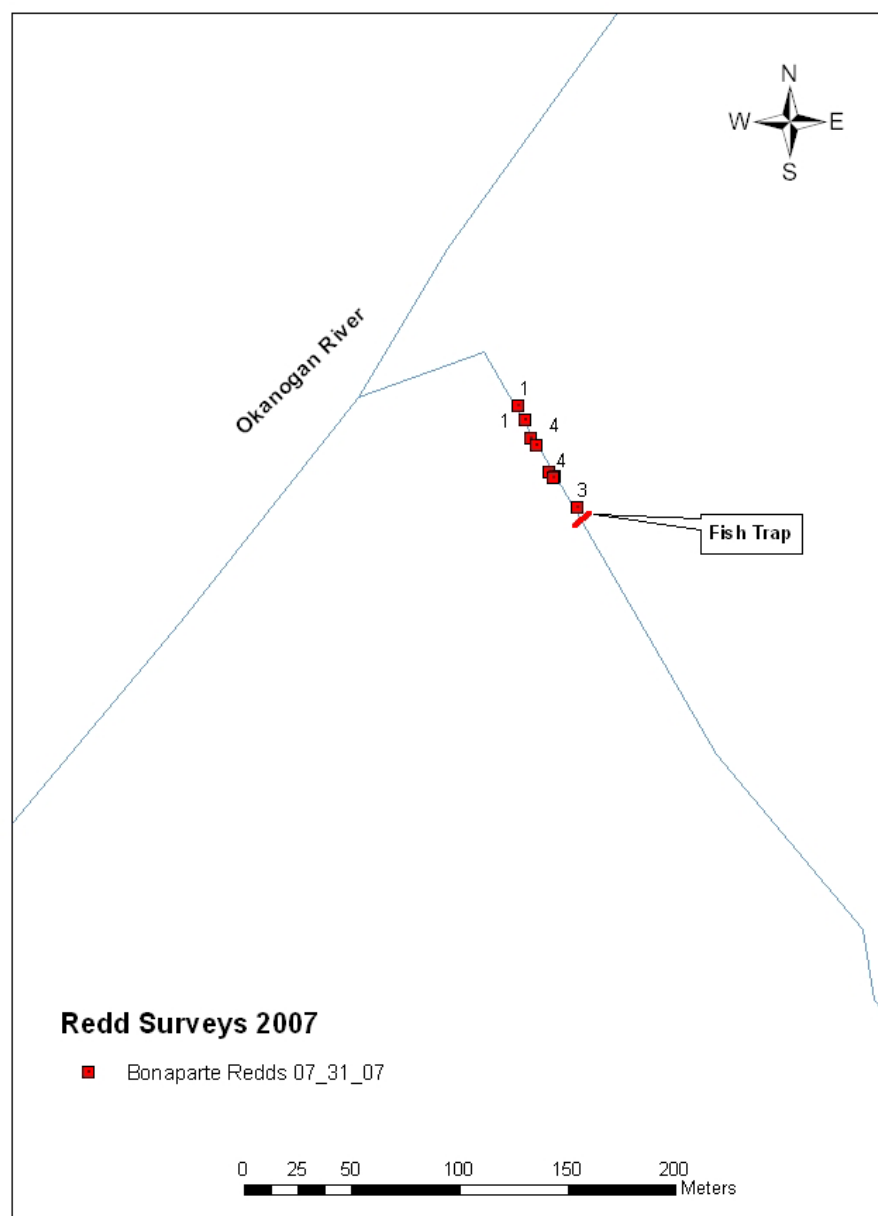


Figure 8: Steelhead redd distribution in Bonaparte Creek during 2007 from the confluence with the Okanogan River upstream to the picket weir trap.

Wanacut Creek Redds 2007

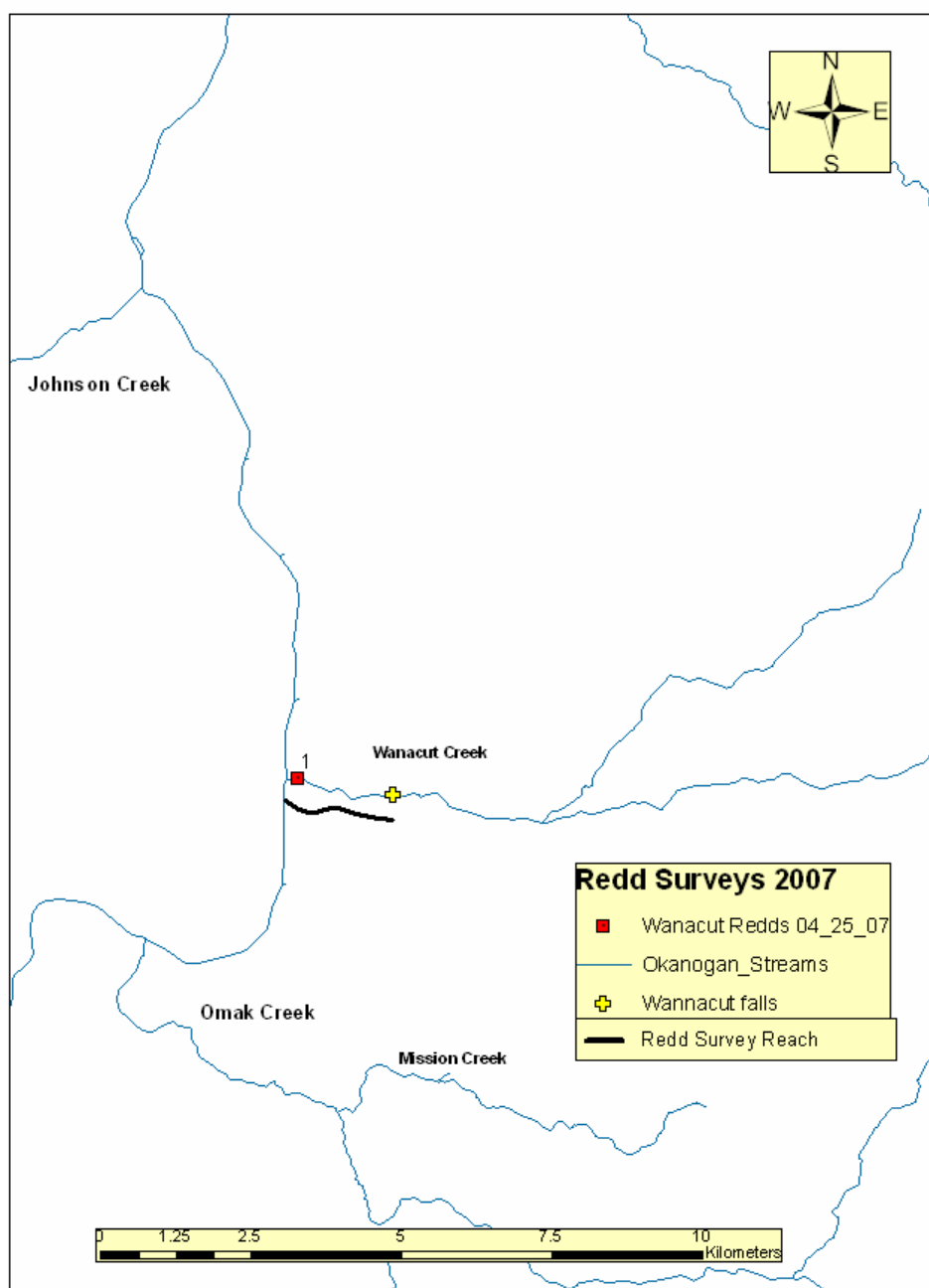


Figure 9: Steelhead redd distribution in Wanacut Creek during 2007 from the confluence with the Okanogan River upstream to the falls.

Omak Creek

At the trap on Omak Creek, 10 adult spring Chinook salmon and 97 adult summer steelhead were captured during 2007. The summer steelhead trapped included 53 males and 44 females, including 13 of natural origin. A total of 25 redds were observed downstream of the trap during our survey on June 1, 2007 (Figure 10).

Nine kilometers of spawning habitat are accessible in Omak Creek below Mission Falls and an additional 22 kilometers are available upstream. However, Mission Falls is considered a significant impediment to fish passage. Three redd surveys were conducted in the lower 9 km on April 16, April 30 and June 1, 2007. A total of 24 redds were identified including 2 within the lowermost reach below Mission Falls (Figure 10). Upstream of Mission Falls, redd surveys were conducted on May 30 (lowermost reach of Stapaloop Creek) and June 13 when reaches OM48 and OM334 were surveyed. No redds were identified during surveys above Mission Falls.

Based upon the number of redds downstream of the trap and the number of fish captured at the Omak Creek weir, we estimated that 153 adult summer steelhead, of which 20 were of natural origin, spawned in Omak Creek during the spring of 2007. The density of redds downstream of Mission Falls was estimated at 7.73 redds/km, which is the highest density since 2005. Recent efforts to provide fish passage at Mission Falls do not appear to have expanded the spawning distribution. However, redds have been observed within the falls near recently installed passage structures. Due to the previous investments and the amount of potential habitat available upstream of Mission Falls, investigations to augment passage should continue. As efforts to address passage at Mission Falls continue, so should redd surveys as a means of evaluating the effectiveness of improvement efforts.

Salmon Creek

Historically, Salmon Creek has been diverted for irrigation purposes. The resulting dry stream channel extends from the OID diversion dam located at river kilometer 7.2 to the confluence with the Okanogan River. Occasionally, uncontrolled spills have occurred downstream of the OID's diversion dam. These releases, usually occurred after summer steelhead spawning (mid-May to June), and resulted in a torrent of water being released that is conducive for neither adult passage nor spawning. However, summer steelhead passage flows were evaluated during a controlled release of 25 cfs from April 1 through April 14, 2003. During this 2 week period, 6 redds were constructed within the lower reach of Salmon Creek (Fisher and Arterburn 2003).

As a result of these passage evaluation studies, a long-term water lease was negotiated between the Colville Tribes and the Okanogan Irrigation District (OID) which provided sufficient water for a smolt release in 2007. In the future, this agreement will provide water sufficient for both the adult and smolt steelhead to migrate through the lower 7.2km of Salmon Creek once the channel configuration is modified. The OID controlled releases began on April 29, 2007 according to an agreed upon varied release schedule (Table 4).

Omak Creek Redd Surveys 2007

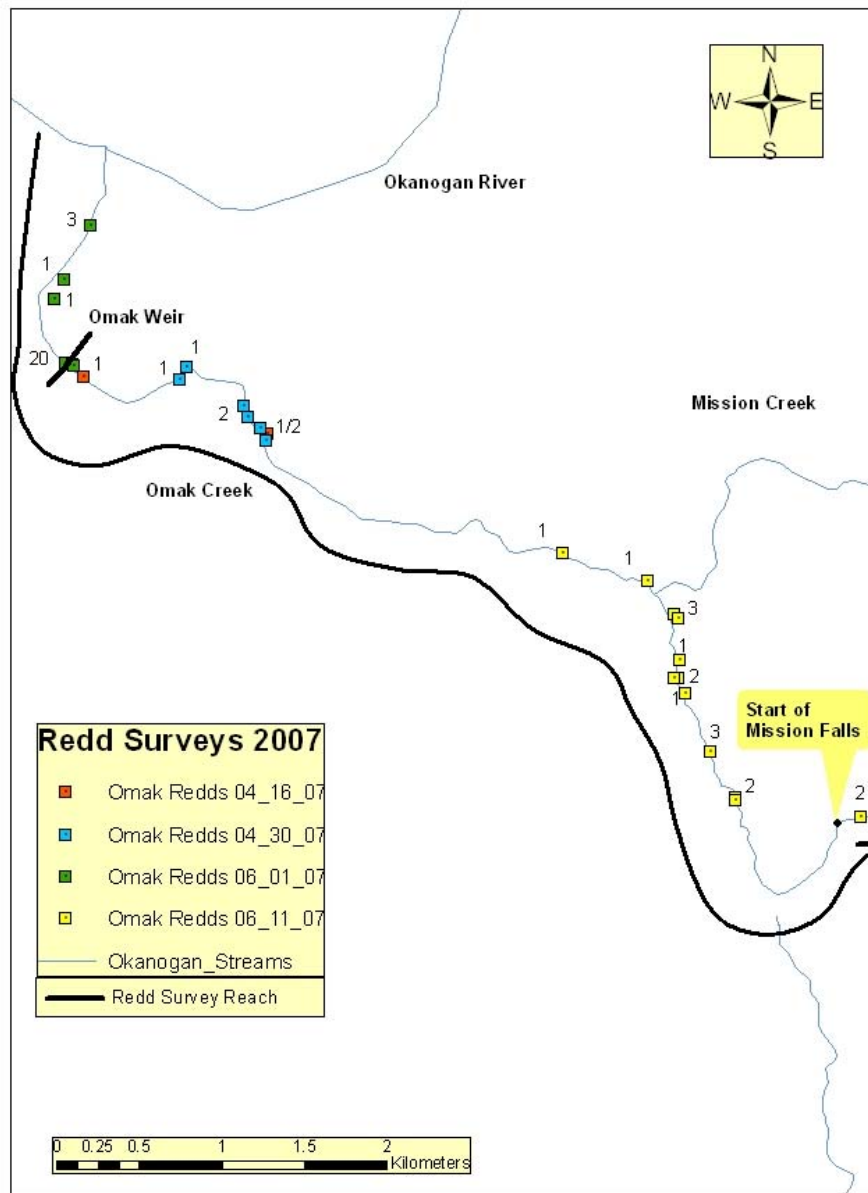


Figure 10: Omak Creek steelhead redd distribution downstream of Mission Falls in 2007.

A redd survey was conducted on June 4, 2007, shortly after flows were reduced downstream of the OID diversion. Redd surveys upstream of this point were limited due to lack of landowner permission. The fishway at the OID diversion would provide an excellent location to enumerate adult fish using a removable video counting station or trap. Six redds were identified during this survey downstream of the OID diversion (Figure 11). However, it is unknown how many fish, if any, migrated above this point. A minimum number of spawners from these redds is estimated at 13 of which two would have been of natural origin. These redds result in a redd density of 0.63/km. Expanding the observed redds to include all habitat downstream of Conconully Dam results in an estimated 21 redds, or 46 summer steelhead, of

which 6 would be of natural origin. Because there are no known passage impediments, the estimate for all available habitats is likely more representative of the number of adults that utilized Salmon Creek during 2007.

Enumeration of spawners using Salmon Creek would be much improved with the addition of a video counting station or removable trap, custom-designed to fit the fish ladder at the OID diversion. Dramatic increases in steelhead production are anticipated due to the water lease agreement signed between the Colville Tribes and OID. By synchronizing water releases to coincide with adult steelhead migration timing, more redds will be constructed near areas with excellent rearing habitat.

Table 4. Varied water release schedule for the OID diversion dam on Salmon Creek. (Start/end date and exact discharge may vary, depending upon survey of channel and success of smolt out migration). Conversion: 1.98 acre-foot = 1 cfs for 24 hours.

DATE	Flow (cfs)	Volume (acre-feet)
April 29	5	9.9
April 30	5	9.9
May 1	5	9.9
May 2	10	19.8
May 3	10	19.8
May 4	10	19.8
May 5	10	19.8
May 6	20	39.6
May 7	20	39.6
May 8	30	59.4
May 9	30	59.4
May 10	20	39.6
May 11	20	39.6
May 12	10	19.8
May 13	10	19.8
May 14	30	59.4
May 15	30	59.4
May 16	30	59.4
May 17	20	39.6
May 18	10	19.8
May 19	10	19.8
May 20	5	9.9
May 21	5	9.9
May 22	5	9.9
TOTAL		712.8

Salmon Creek Redds 2007

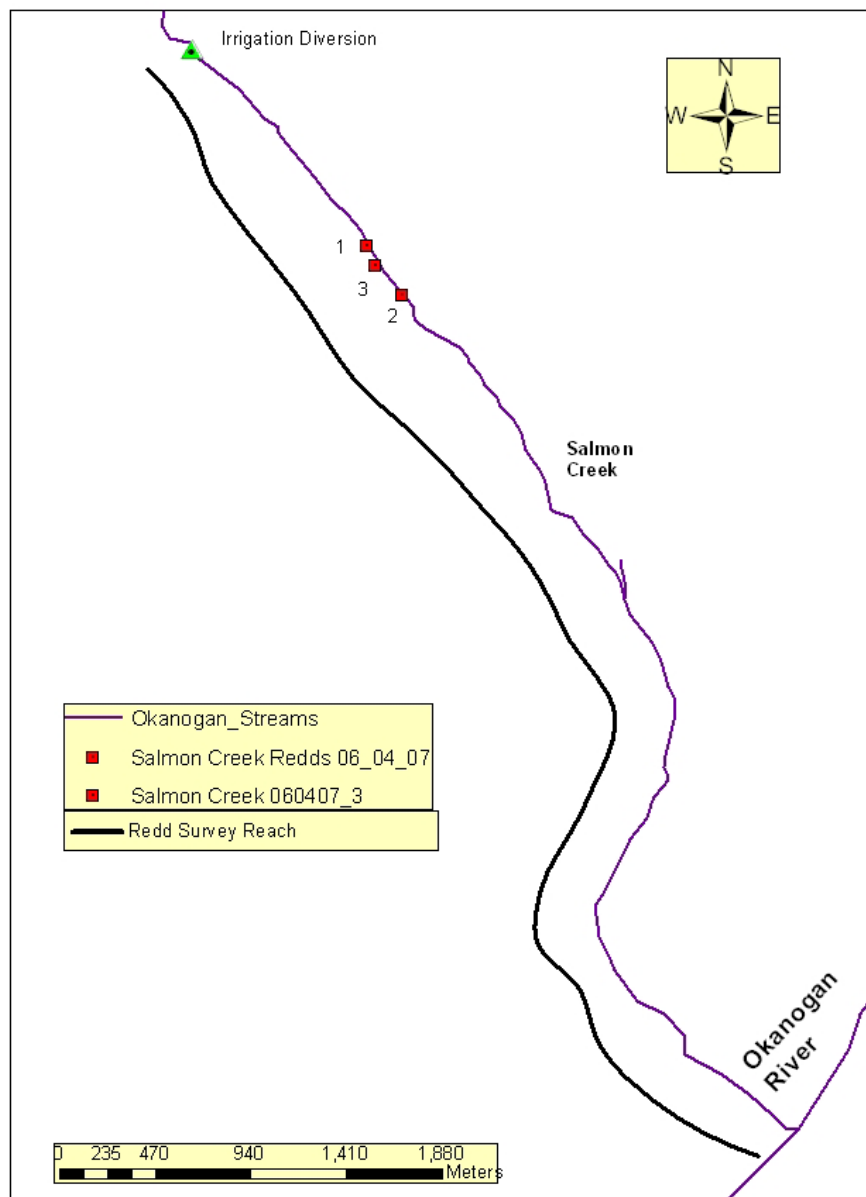


Figure 11: Steelhead redd distribution in Salmon Creek downstream of the Okanogan Irrigation District's diversion dam during 2007.

Loup Loup Creek

Loup Loup Creek was initially surveyed for redds on April 6, 2007, but no redds were observed. A second survey was conducted on April 20. During the second survey, one adult steelhead and three redds were identified. The Helensdale irrigation diversion was closed during all redd surveys and effectively created a migration barrier (Figure 12). However, the entire L1 reach from the Okanogan River confluence to Loup Loup Falls (3.3km) contained water during the first two surveys (Figure 12).

During our final survey on May 29, 2007, an additional 5 redds were observed (Figure 12). However, the reach downstream of the irrigation diversion dam for approximately 0.2km, where the most up-stream redds had previously been documented, was dewatered. The lack of water in the channel resulted in mortalities of post-emergent steelhead fry as well as other ages and species of fish (Figures 13 and 14). The reach from the irrigation return-flow channel downstream to Highway 7 still had minimal overland flow.

The observed redds represented approximately 18 summer steelhead, of which 2 would have been from natural origin. A redd density of 2.42 redds per kilometer was estimated for the accessible reach of Loup Loup Creek. Redd densities would likely increase substantially if perennial flows were reestablished, passage impediments were removed (culverts), and steelhead were supplemented using locally-adapted hatchery stocks. Steelhead redd surveys should continue in Loup Loup Creek to provide baseline information, and document the effectiveness of habitat rehabilitation projects, once implemented.

Other small United States Tributaries

As part of an ongoing effort to explore the more remote parts of the Okanogan subbasin, several small tributaries were surveyed in 2007. Redd counts were conducted on Chiliwist Creek, located south of Malott, on April 26; Elgin Creek, at the north end of Okanogan, on May 3; Fish Hatchery Creek, located at the southern end of Omak, on May 4; and Aeneas Creek, located south of Tonasket, on May 17. Access into these tributaries is typically limited due to alluvial fans and the high, vertical banks of the Okanogan River channel at their confluences. In 2007, due to the high water levels of the Okanogan River, these tributary confluences were inundated improving access for anadromous fish. All four of these small streams are spring fed and represent better rearing than spawning habitats. No redds or adult summer steelhead were observed during any of our surveys.

Although classified as a perennial waterbody, Elgin Creek was deemed inaccessible to steelhead due to a small falls identified near the confluence. Fish Hatchery Creek was also inaccessible to steelhead due to an undersized culvert and settling pond near the confluence with the Okanogan River. Chiliwist Creek, even when the Okanogan River is high enough to allow access, has minimal spawning potential for steelhead due to its narrow width (1.75m average) and limited discharge (typically less than 1 cfs). These conditions allow even small amounts of debris to impede both juvenile and adult steelhead passage. Aeneas Creek has very minimal spawning habitat due to elevated alkali levels and a compacted, "cement-like"

substrate. Aeneas Creek could however, provide juvenile rearing habitat in the lower 0.5 km of the creek. Spawning habitat could be augmented by regularly depositing optimum size gravel and installing log structures to increase down-welling sites.

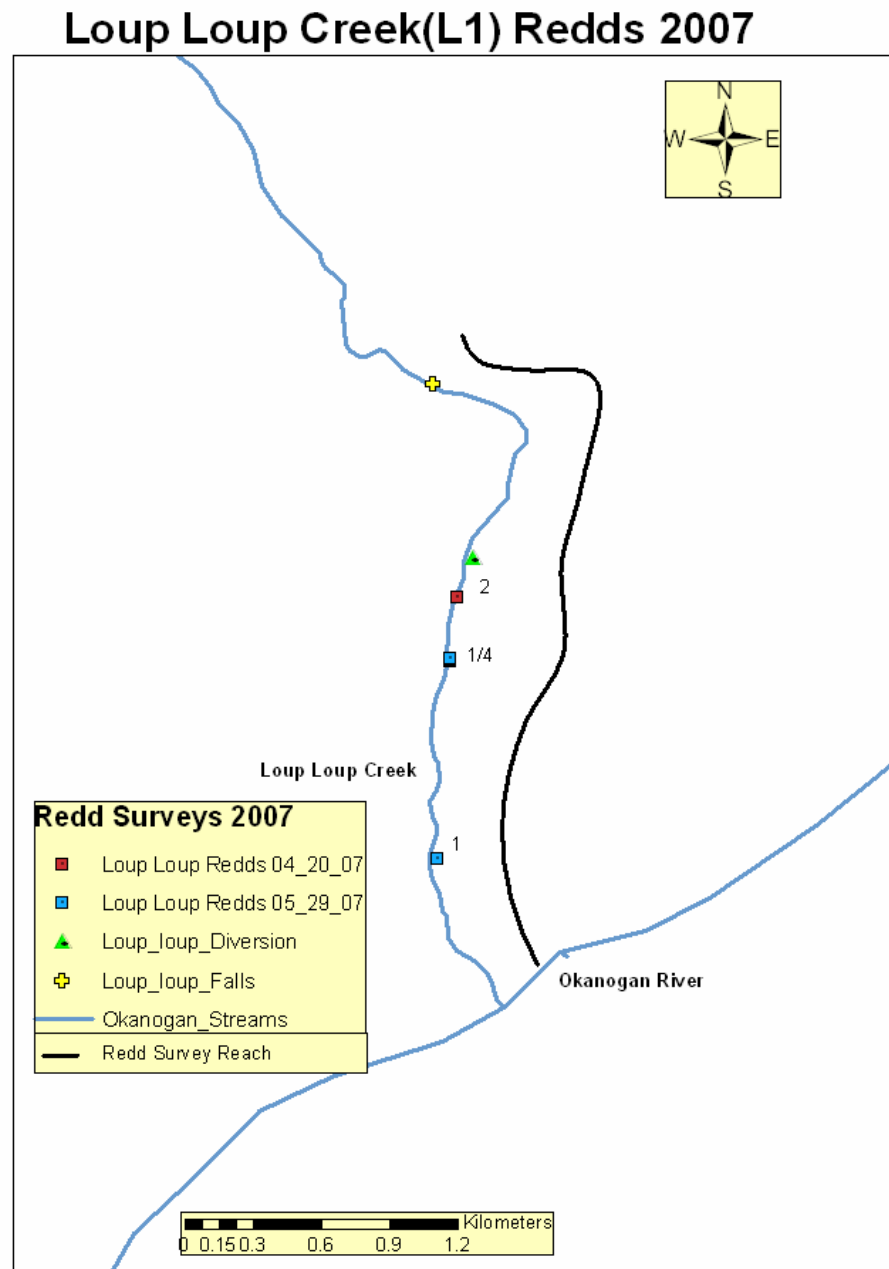


Figure 12: Steelhead redd distribution in Loup Loup Creek during 2007. The falls represent the natural upstream limit for anadromous fish.



Figure 13: Left: Summer steelhead redd first observed during a survey conducted on April 20 became desiccated due to flow diversion on Loup Loup Creek on May 29. Right: Close-up of alevins removed from the redd showing that development was close to that of a swim-up fry.



Figure 14: Multiple age-class mortalities of brook trout and rainbow trout observed during redd surveys conducted on Loup Loup Creek on May 29, 2007, showing multiple age classes of brook and rainbow trout that were killed by dewatering when an irrigation diversion dam, located at river kilometer 2.13 was closed..

Escapement into Canada

Since 2005, redd surveys have been conducted in Canada to compliment survey data collected in the United States. Although OBMEP data are very promising in the United States, results haven't been as impressive in Canada; a different method may be necessary to accurately calculate steelhead escapement into Canada. With the completion of the Zosel Dam counting station in 2006, a more accurate enumeration of summer steelhead entering Canada is possible. Therefore, OBMEP will utilize video counts at Zosel Dam, rather than redd surveys, to quantify the number of steelhead spawners entering Canada.

Calculating the number of spawners entering Canada is not as simple as counting the number of summer steelhead passing Zosel Dam (Table 5). The number of spawners that enter Ninemile (9) and Tonasket creeks (17), must be subtracted. These two creeks are located

above Zosel Dam but south of the international border. In 2007, 147 summer steelhead were counted at Zosel Dam. Twenty six were estimated as destined for United States tributaries. Therefore, 121 summer steelhead were expected to spawn in the Canadian portion of the Okanagan Basin. Of the summer steelhead destined for Canada, an estimated 29 were naturally-produced; 23.7% of the total escapement.

Table 5. The number of spawning summer steelhead that passed Zosel Dam by month in 2007. Adipose-present fish are considered Wild; adipose-clipped fish are considered Hatchery.

Month	Number of Hatchery Adults	Number of Wild Adults	Total
March	23	11	34
April	73	5	78
May	19	16	35
Total	115	32	147

Canadian Distribution

Spawner surveys in Canada have resulted in only a limited number of redds being observed over the last few years. This year was no exception as redd surveys conducted by the Okanagan Nation Alliance (ONA) between May 1 and June 19, 2007, indicate that redds were observed only in Inkaneep Creek, and only one fish seen in Vaseux Creek.(Figure 15). However, video counts at Zosel Dam, and trap catches on Inkaneep Creek in 2006, indicate a much greater number of adult summer steelhead entering Canada than accounted for by redd surveys. It seems unreliable to estimate spawner abundance using redd survey data collected in Canada, therefore estimates of adult escapement will be based upon Zosel Dam counts and trap counts, if installed. Spawner distribution estimates will be extrapolated from data collected from the three locations where summer steelhead redds have been observed during past redd surveys, and using historical redd survey and trap data.

From redd survey data collected in 2005, 2006, and 2007, the 2006 Inkaneep trap data (Long et al. 2006), fish observations in 2005 (Walsh and Long 2006), and anecdotal information compiled from local fisherman, we estimated 80% of summer steelhead entering Canada are destined for Inkaneep Creek. Approximately 17% appear to enter Vaseux Creek and 3% spawn along the main stem Okanagan River upstream of Osoyoos Lake. Using these percentages in conjunction with our previous estimated escapement into Canada would result in an estimated escapement of 97 summer steelhead spawners into Inkaneep Creek of which 23 would be of natural origin. We estimated that 21 steelhead spawned in Vaseux Creek, of which 5 would be of natural origin. Only 3 adult steelhead are estimated to have spawned in the main stem Okanagan River above Osoyoos Lake, including 1 fish that was likely of natural origin.

Inkaneep and Vaseux Creeks

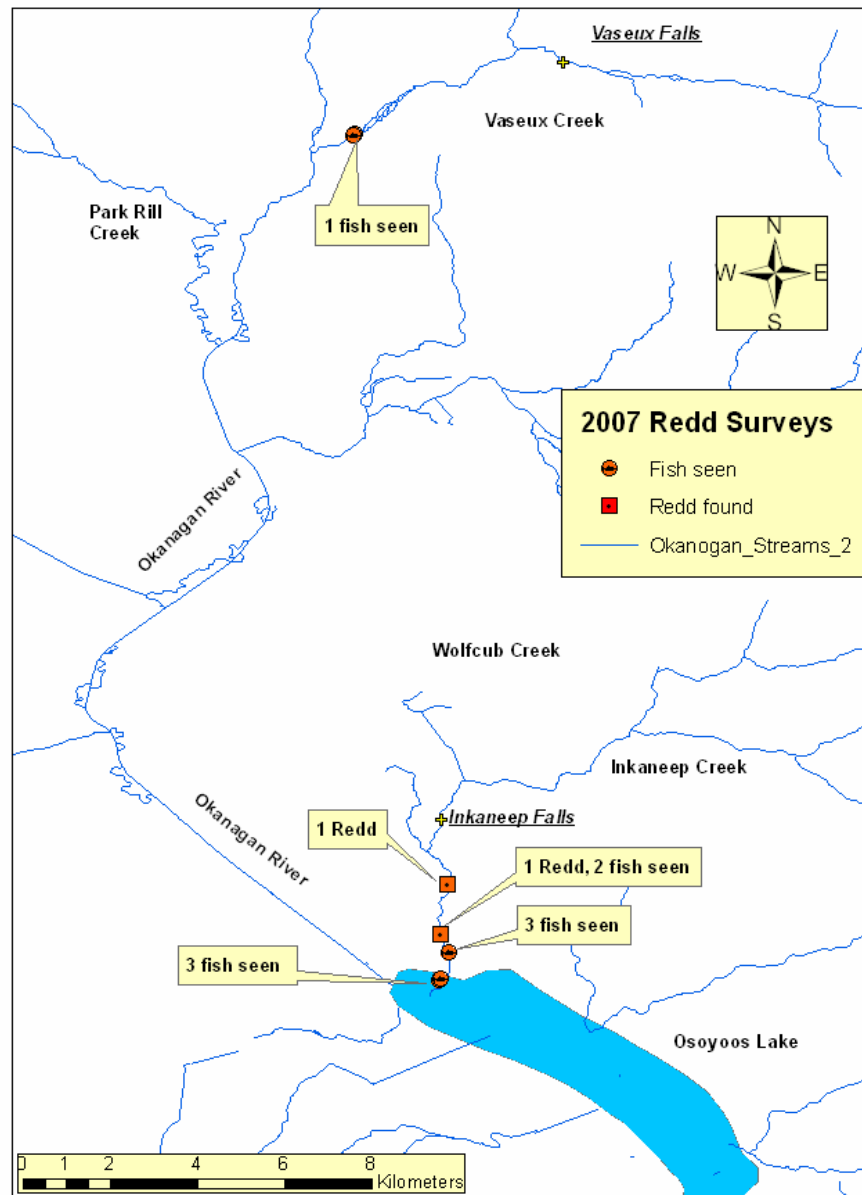


Figure 15: Steelhead and steelhead redds observed downstream of McIntyre Dam by the Okanagan Nation Alliance in the spring of 2007 using OBMEP survey protocols.

Bringing it all together

Summer steelhead were recently relisted as “endangered” under the Endangered Species Act in the Upper Columbia River Evolutionary Significant Unit. Detailed, percent-wild information for 2007 has already been presented in this document and the mean value represents the best available information. High and low estimates represent the full range of possible values. The total escapement estimate for Okanogan River summer steelhead spawners in 2007 was between 1,234 and 1,280 (Table 6). These estimates are consistent with WDFW estimates derived from Wells Dam passage counts modified by subtracting harvest take information. WDFW estimated total spawner escapement into the Okanogan River Basin at 1,258 summer steelhead (Bob Jateff, WDFW, Pers. Comm.). All necessary information has been presented in order to provide a more accurate estimate of adult steelhead escapement and origin in the Okanogan Basin (Table 7).

A summary of the best available counts and estimates for each reach or sub-watershed throughout the Okanogan River basin is presented in Table 8. Our surveys indicate that main stem spawning is common throughout the Okanogan River but is more heavily focused in the northern portion of the Okanogan and lower Similkameen rivers. The lack of redds in the main stem Okanogan River in Canada is surprising as considerable, high-quality habitat exists. Within the United States portion of the basin, most hatchery steelhead are scatter-planted at various locations along the Okanogan and Similkameen rivers; no hatchery stocking occurs in Canada. Therefore, it is highly likely that redd distributions are heavily influenced by the stocking locations used by Washington Department of Fish and Wildlife. Summer steelhead that spawn in tributary habitats of the Okanogan River are more likely to find suitable environmental conditions and rearing habitats than those spawning in the main stem. If more summer steelhead were stocked into Okanogan basin tributaries, the chances of these tributaries contributing to recovery efforts would be greatly enhanced.

Table 6: Between year comparison of combined hatchery- and natural-origin summer steelhead for the Okanogan River. In 2005 and 2006, only low and high estimates were provided so that a simple arithmetic mean was computed for both years. The OBMEP estimate for 2007 was based on best available information provided in this document and presented in Table 8.

Okanogan River summer steelhead spawner population trend data				
Year	WDFW escapement estimate	OBMEP redd Survey estimate		
		Low	Mean	High
2005	1,322	1,147	1,315	1,482
2006	811	779	855	930
2007	1,258	1,234	1266*	1,280

* based upon all available information this is the best possible estimate

Table 7: Natural origin summer steelhead estimates since 2005 for the Okanogan River. The 2005 and 2006 estimates were calculated by multiplying the average wild percent for the Okanogan River from various sources, such as trap and dam counts with data from Table 6. The WDFW estimate is based upon Wells Dam counts and scale analysis. The OBMEP estimate for 2007 was based on best available information provided in this document and presented in Table 8.

Okanogan River wild summer steelhead spawner population trend data				
Year	WDFW escapement estimate	OBMEP redd Survey estimate		
		Low	Mean	High
2005	N/A	143	164	185
2006	132	127	139	151
2007	116	148	152*	155

* based upon all available information this is the best possible estimate

Table 8 - Redd counts and spawner counts for each sub-watershed or counting location along with the estimated number of naturally produced summer steelhead represented by each in 2007. The grand total for the entire Okanogan River population is presented with subtotals for tributary and main stem habitat types in the United States and Canada.

Category	Description/location	2007		
		Spawners	Redd count	# wild
US Tributary	Spawners into Omak Weir	97		13
US Tributary	Spawners below Omak Weir	55	25	7
US Tributary	Spawners into Bonaparte weir	167		21
US Tributary	Spawners below Bonaparte weir	37	13	5
US Tributary	Spawners observed at Zosel Dam	147		32
US Tributary	Spawners into Salmon Creek	46	21	6
US Tributary	Spawners into Wanacut Creek	3	1	0
US Tributary	Spawners into Loup Loup Creek	18	8	2
US Tributary	Spawners into Antoine Creek	0	0	0
US Tributary	Spawners into Tonasket Creek	17	6	2
US Tributary	Spawners to Ninemile Creek	9	3	1
US Tributary	Spawners into Tunk Creek	N/D	N/D	N/A
US Tributary	Spawners into Wildhorse Creek	12	7	2
US Tributary	Spawners into Aeneas Creek	0	0	0
US Tributary	Spawners into Whiskey Cache Creek	0	0	0
US Tributary	Spawners into Chiliwist Creek	0	0	0
US Tributary	Spawners into Elgin Creek	0	0	0
US Tributary	Spawners into Fish Hatchery Creek	0	0	0
US Tributary	Spawners into Pothole Canyon Creek	0	0	0
US Tributary	Spawners into Swimptkin Canyon Creek	0	0	0
Canada Tributary	Spawners into Inkaneep Creek	97	56	23
Canada Tributary	Spawners into Vaseux Creek	21	12	5
US Main stem	Spawners into reach O1	15	9	1
US Main stem	Spawners into reach O2	53	31	5
US Main stem	Spawners into reach O3	9	5	1
US Main stem	Spawners into reach O4	61	35	6
US Main stem	Spawners into reach O5	91	53	8
US Main stem	Spawners into reach O6	18	10	2
US Main stem	Spawners into reach O7	258	150	24
US Main stem	Spawners into reach SI	181	105	17
Canada Main stem	Spawners into Canadian main stem	3	2	1
Subtotals	Adult escapement into US Main stem	684	398	63
Subtotals	Adult escapement into US Tributaries	461	84	60
Subtotals	Adult Escapement into Canada	121	70	29
Grand total		1,266	552	152

Conclusions

Steelhead spawner data clearly show that redd surveys throughout the United States portion of the Okanogan River Basin are possible in both tributary and main stem habitats and the distribution of spawning can be effectively quantified. Baseline information for spawning habitat distribution, spawn timing, and spawner escapement have been determined, but additional, annual data are necessary to strengthen the body of information for use in trend analysis. High quality spawning Okanogan River basin also allow for accurate estimates of redd production and spawner escapements even in years when environmental conditions prevent collection of adequate field data. Spring spawner data provides a reliable estimate of adult escapement and slightly less reliable estimate of origin for returning adults. Dependable and reliable estimates such as these are critical for tracking recovery of endangered upper Columbia summer steelhead within the Okanogan River basin.

The use of picket weir traps, video counting chambers, radio telemetry, or simple estimate models have produced more dependable data in Canada than redd surveys alone. Less than 30 redds in total have been identified in 3 years. Therefore the ONA and Colville Tribes need to consult with the upper Columbia Regional Technical Team, Pacific Northwest Aquatic Monitoring Partnership, Columbia System wide Monitoring and Evaluation Project, and Bilateral Okanogan Basin Technical Working Group on how best to collect summer steelhead spawner distribution and escapement estimates. The highly dynamic nature and flashy discharges of streams in southern British Columbia make this a difficult location for conducting redd surveys. Spawner distribution data collected during 2007 is capable of providing a dependable escapement estimate for the U.S. portion of the Okanogan River sub-basin and should continue unabated while the proper approach for assessing changes in steelhead distribution over time are debated for the portion of the basin located within Canada.

Annual variations in redd distribution can be profound for small tributaries within the Okanogan River basin. Changes in spawner distributions are primarily driven by four factors:

- 1) The discharge and elevation of the Okanogan River;
- 2) The discharge of the tributary streams;
- 3) The timing of runoff that alters the shape of the hydrograph, and most importantly;
- 4) The stocking location of hatchery smolts.

The first three items are largely part of the natural environmental conditions present in the basin, although they can be altered dramatically by such things as dam releases, irrigation withdrawals, and climate change. These items are inherently difficult for fisheries managers to address. However, the choice of juvenile stocking locations is well within the jurisdiction of fisheries managers to change or modify for the benefit of a given stock. Within the Okanogan River basin more effort should be given toward developing locally-adapted summer steelhead broodstocks and stocking into tributary habitats that provide the most suitable environmental and rearing conditions.

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Appendix D- PROTOCOL DOCUMENT: STEPS FOR TRANSLATING AND ENTERING DATA INTO THE MICROSOFT ACCESS OKANOAN BASIN MONITORING AND EVALUATION PROJECT (OBMEP) DATABASE

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1.0 INTRODUCTION

1.1 Project Background

Since May 2006, Summit Environmental Consultants Ltd. has been working with the Colville Confederated Tribes (CCT) Fish and Wildlife Department to develop a fully-functional Microsoft Access database designed and constructed for the Okanogan Basin Monitoring and Evaluation Program (OBMEP). The OBMEP project includes many sampling efforts (data collected and managed by the CCT), specifically snorkel surveys, trap surveys, video surveys, habitat surveys, redd surveys, water chemistry analyses, and hourly river water temperature measurements. In addition to these sampling efforts, the CCT also manages data collected by other agencies such as: the Wells Dam Fish Passage data; the Department of Ecology (DOE) water quality, temperature and flow data; the United States Geological Survey (USGS) temperature and flow data; and the Environment Canada flow and temperature data. The purpose of this document is to provide step-by-step protocols for translating the database components downloaded from hand-held Trimble units or the internet into the pre-designed OBMEP Microsoft Access database.

The approach used in writing these protocols is to provide a technician that potentially may not be experienced with data handling with the tools required to handle data in Microsoft Excel, Microsoft Word and Microsoft Access. Common database terms used in this document are defined in the glossary located at the end of this document (Section 19.0).

1.2 Project Objectives

The general objective of this task is to develop step-by-step protocols for translating data from various file types (e.g., Trimble units, internet downloaded files) into the OBMEP Microsoft Access database.

Specific objectives of this project are to:

- Review the original data files;
- Modify the original OBMEP database design, if necessary to accommodate these data and operate efficiently;
- Develop preliminary protocols and electronic data entry forms (if applicable) for review by CCT staff;
- Conduct iterative discussions with CCT staff to simplify procedures, modify the design of the original files (if appropriate) and enhance the design of the OBMEP database; and
- Develop a final data transfer protocol document and OBMEP database design.

1.3 Data Entry vs. Translation

There are two ways to enter data. The first way is to manually enter the data using pre-designed electronic entry forms that comprise the applicable fields and relationships from various tables in the database. Using these forms will ensure that all data remains relational.

However, this way of entering data can be very time consuming. Data not collected electronically (i.e., recorded on paper) should be entered into the database using Microsoft Access entry forms.

The second way is to translate data already stored in electronic format is through Excel templates. This way is much more efficient but it is very easy for the database user to make mistakes when entering data this way (not keeping the fields consistent, omitting data types, etc.). Therefore, a thorough quality assurance/quality control (QA/QC) analysis (see Section 17.0) should be performed once the data has been imported to ensure the data remained relational and that data quality was maintained. For mass amounts of data, the use of Excel templates is recommended instead of entry forms as it is much more efficient.

1.4 Entry forms in the Database

Entry forms have been created for the redd data, the snorkel data, the trap data, and the video data. These forms are located in the OBMEP database under the Forms tab (prefix “ENTRYFORM” for sorting purposes). The forms with the prefix “SubEntryForm” are sub forms incorporated into complete data entry forms. The sub entry forms have not been designed for independent use and exist only as components of the complete data entry forms.

1.5 Document Layout and Appendices

The next sections of this document provide protocols for various translating data from specific database components into the OBMEP database. Hints and extra notes are provided in the text boxes for additional help. The sections are as follows:

- Habitat data (collected by CCT staff using Trimble units; Section 4.0);
- Wells Dam Fish passage data (downloaded from the internet; Section 5.0);
- DOE water quality data (downloaded from the internet; Section 6.0);
- DOE hourly temperature data (downloaded from the internet; Section 7.0);
- Eureka water quality data (collected by CCT staff; Section 8.0);
- BoxCar hourly temperature data (collected by CCT staff; Section 9.0);
- DOE flow data (downloaded from the internet; Section 10.0);
- USGS flow and daily temperature data (downloaded from the internet; Section 11.0);
- Environment Canada flow and temperature data (downloaded from the internet; Section 12.0);
- Redd Survey data (collected by CCT staff; Section 13.0);
- Snorkel data (collected by CCT staff; Section 14.0);
- Trap data (collected by CCT staff; Section 15.0); and
- Video data (collected by CCT staff; Section 16.0).

Following this group of sections is a section on quality assurance/quality control (QA/QC; Section 17.0), a section describing how to create simple queries (Section 18.0), and finally a glossary (Section 19.0).

Appendix A (on CD) consists of the various Microsoft Excel (TEMPLATES) that accompany each of the database component sections. When working with a specific database component, open the associated template for quick reference. The templates are as follows:

- 9 habitat templates (HIGHLIGHTED TEMPLATES.xls, HIGHLIGHTING, MASTER SAMPLE.xls, CANOPY.xls, CHANNEL.xls, HUMAN.xls, LGWOOD.xls, RIPARIAN.xls, SUBSTRATE.xls);
- Fish passage template (5.0 FISH PASSAGE TEMPLATE.xls);
- DOE water quality template (6.0 DOE WQ TEMPLATE.xls);
- DOE temperature template (7.0 DOE TEMP TEMPLATE.xls);
- Eureka water quality template (8.0 EUREKA WQ TEMPLATE.xls);
- Boxcar temperature template (9.0 BOXCAR TEMP TEMPLATE - OLD DESIGN.xls and 9.0 BOXCAR TEMP TEMPLATE - NEW DESIGN.xls);
- DOE flow template (10.0 DOE FLOW TEMPLATE.xls);
- USGS flow and temperature template (11.0 USGS FLOW TEMP TEMPLATE.xls);
- Environment Canada flow template (12.0 EC FLOW TEMPLATE); and
- Redd survey template (13.0 RED SURVEY TEMPLATE).

Appendix B (also on CD) consists of the current database (April 30, 2007 version).

2.0 METHODS

2.1 Review the Original Data Files

Summit reviewed the original data files to identify database fields, key variables and field types. Unique queries were run on each field to determine the range of data that are collected, and to review the arrangement of fields and tables. The results of these queries were used to identify design modifications that will make the database run more efficiently.

2.2 Modify the Database Design

The original OBMEP database design (received in July 2006) has been modified to resemble a fully-functional relational database. These modifications include addition of lookup tables and lookup fields that enforce referential integrity of the data, as well as indexing fields which will allow queries to run more efficiently. To facilitate data entry into the database, pre-designed entry forms and/or Excel templates can be used by users familiar with the database design.

2.3 Develop Preliminary Protocols and Entry Forms

Protocols were developed for the database components downloaded from Trimble units or from the internet. The simplest way to translate data from an electronic vertical spreadsheet into a horizontal database format is to complete the translation in Microsoft Excel. Using the following protocols in conjunction with the Microsoft Excel templates, it is easy to trace your steps if questions or problems arise.

On the other hand, the simplest way to enter data that is manually collected in the field (i.e., writing down observations onto field sheets) is through the use of user-friendly entry forms pre-designed in the database.

2.4 Conduct Iterative Discussions

CCT staff has reviewed previous versions of this protocol document and through iterative discussions, Summit has identified additional modifications to the database design, and revisions to these protocols.

2.5 Develop Final Protocol Document and Database Design

Summit has prepared this protocol document and completed design modifications to the original database design. Summit will continue to provide ongoing support for future translations and for developing queries to analyse data stored in the fully-functional OBMEP database.

3.0 DATABASE DESIGN

The database design was developed in Microsoft Access (MS Access) 2003 version. The database design can be saved in earlier versions; however some of the features may not function properly in the earlier versions. MS Access databases are particularly flexible as the component database tables can be easily exported to other database applications, such as Microsoft Excel (.xls file) and Borland Paradox (.dbf file). In addition, MS Access is widely used and is often the software of choice for beginner and intermediate database users. Many of the database software systems that are designed to handle enormous quantities of data (e.g., Oracle) use MS Access as the user-interface software. Furthermore, in using MS Access, all information can be managed from a single database file (i.e., .mdb file).

The database is a relational database (i.e., the database consists of several tables that are linked together to facilitate retrieval of data in a wide variety of ways). The main advantage of a relational database is that queries, reports, and forms can be created to display information from several tables at once.

4.0 HABITAT DATA PROTOCOL

The habitat component of the database has been assembled using six separate data types (prefix ptbl), and the design is based on relationships linking each of the tables to the MASTER SAMPLE table and various lookup tables (prefix lkp). The six data types are as follows:

1. Canopy;
2. Channel;
3. Human Influence;
4. Large Wood;
5. Riparian; and
6. Substrate.

A preliminary form has been created that provides a useful tool to get comfortable with the design and how these data behave in the relational database. To open this form, under Objects (on the left-hand side of the Database window), click Forms and double click on the “HABITAT DATA FORM”.


The following instructions outline the basic steps required to translate data from the Trimble unit output (hints and extra notes are provided in the text boxes for additional help):

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent HABITAT data download by date”.

4.1 Getting Started

1. Export Trimble data in pathfinder office as a sample Microsoft Access .mdb set up file. Save this and then export data to a new Microsoft Excel worksheet.
2. Insert a new column at the beginning of the worksheet and count the records consecutively starting from one greater than the last SAMPLEID in the MASTER SAMPLE table in the database. Name the header of this column “SAMPLEID”.

Note: This SAMPLEID is specific to each record and is how the database links itself to the other data types. It is critical that this column be retained and remains relational when splitting up the data.

3. Open the HIGHLIGHTING workbook (Excel file), Select the entire color coded “highlighting” worksheet and then click the Format Painter button  on the Standard toolbar. Then click on the entire Trimble worksheet. This will highlight the Trimble worksheet with the same colors as the TEMPLATE.

Hint: If you don't see the Standard toolbar, on the View menu, point to Toolbars, and then click Standard.

4. Hold down the Ctrl key and select the individual **blue** columns by clicking with the mouse on the header of each column. Then Copy, and Paste these columns into 7 separate worksheets from your original worksheet that was formatted by the painter (MASTER SAMPLE, CANOPY, RIPARIAN, LGWOOD, HUMAN, CHANNEL, SUBSTRATE). Look at example worksheets (see HIGHLIGHTED TEMPLATES.xls) and copy appropriate colors into appropriate worksheets from your data. For example, MASTER SAMPLE should be **blue** and **yellow**; CANOPY is **blue** and **green**, etc.).

Hint: To Copy, and Paste, click Edit – Copy to copy the information, and then click to where you want to paste the information and click Edit – Paste.

4.2 Translation

The next step is what we term “Translation” of data. This is the process of re-arranging vertical spreadsheets to relational horizontal database tables. The following steps will walk you through how to translate data from each worksheet into the applicable database tables. Examples for each data type are provided in individual workbooks in the TEMPLATES directory. Open the applicable example (template) when translating data for quick reference. Copy each of the highlighted worksheets individually and paste into a new worksheet in a new workbook. Once you have pasted the highlighted worksheet into the workbook, you can remove the highlighting if you find it confusing.

Note: Save each workbook (file) as a new file to keep yourself organized. Organization is very important during this process so that steps can be followed or traced back if data questions or problems arise.

4.2.1 Master Sample

1. Copy the first row from the TEMPLATE worksheet in the MASTER SAMPLE file (workbook) and paste into your MASTER SAMPLE worksheet.
2. The field CREW will need to be split into CREWMEMBER1, CREWMEMBER2, etc. Use just the initials for each CREWMEMBER (as listed in the lkp_CREW in the database).

Note: To copy just the data (and not the headers), select the rows by selecting and dragging the mouse down the rows you would like to select (e.g., 2 through 12).

3. Fill in the DATA_COLLECTED field with Yes or No and the BIOEVENT field with the word HABITAT.

4. The TRANSECT_HAB data that we want to store in the database are the “Transect A” format. If any of the entries have an “X”, need to enter “SIDE” into the CHANN_SIDE field and change these data to reflect the appropriate transect (without the “X” designation). For all other records enter CHANNEL into the CHANN_SIDE field.
5. Format the DATE_START field by selecting the column, then click Format – Cells. Under the Number tab, choose Date and select the 7th option on the pull-down list (14-Mar-98).
6. Format the TIME_START field by selecting the column, then click Format – Cells. The database is formatted to store time data in the 24 hour clock, so then click Format – Cells. Under the Number tab, choose Time and select the 4th option on the pull-down list (13:30:55).

4.2.2 Canopy

The 6 **green** columns (vertically displayed data) will become two horizontal columns (TRANSDIR and DENSIMETER). The procedure is detailed in the following steps (you can follow examples of these steps in the CANOPY template: TRANSLATE1, TRANSLATE2, etc.):

1. Insert a column before each DENS column.
2. Copy and Paste the formulas from the CANOPY template into each new column. Make sure the formulas line up with the last SAMPLEID. The formulas are “=cell in the adjacent column to the right” in the header row, and then “=cell above in the same column” for the rest of the column where data exist in the adjacent column. Examples of these formulas are highlighted in **orange** and **yellow**. Each column should have an **orange** cell header and each row that has data should have a corresponding **yellow** cell.
3. Select the entire worksheet, then Copy and Paste Special as Values (see hint below) to convert the formulas to values.

Hint: To Paste as Values, click Edit – Copy, then click Edit – Paste Special and choose Values. Remember to keep the entire worksheet highlighted for both the Copy and Paste as Values.

Note: The reason for the Paste as Values step is to change the cells from a formula to an actual value.

4. Cut (i.e., move) each set of DENS columns (newly created column and DENS data column) and Paste underneath the first set.

Hint: An easy way to select data in an Excel spreadsheet is to use the key pad. By holding the Shift key, while using the arrow keys you can select multiple cells one by one. By holding both the Ctrl key and the Shift key you can select a group of cells that contain data. The Shift key will automatically select to where there is a break in data. Therefore:

1. Click on the DENS header for the second set;
2. Hold the Shift Key and arrow over to the column just before the DENS header for the third set;
3. While continuing to hold the Shift key, also hold the Ctrl key and press arrow down to select entire set;

5. Copy and Paste the SAMPLEID and TRANSECT_HAB columns so that they repeat themselves for each set. Delete the repeated headers, so that the headers are only in the first row.
6. Copy the first row from TEMPLATE worksheet in the CANOPY template and paste copied cells into the first row of your CANOPY worksheet.

4.2.3 Riparian

The first 20 columns are either Right Bank or Left Bank (contain the following fields: CP_VEG, CP_BIGTREE, CP_SMTREE, US_VEG, US_WOOD, US_NONWOOD, GC_WOOD, GC_NONWOOD, GC_LWD, and GC_BARE). The first 10 columns in the Trimble data are Right Bank and the next 10 are Left Bank.

1. Insert one column just after the HAB TRANSECT _ data.
2. Cut and Paste these data from LB columns underneath the RB columns. Fill the cells in the new column accordingly with either LB or RB. I have highlighted this column in **yellow**.
3. Copy and Paste the SAMPLEID and TRANSECT_HAB columns so that they repeat themselves for both sets. Delete the repeated headers and any empty cells, so that the headers are only in the first row.
4. Copy the first row from the TEMPLATE worksheet in the RIPARIAN file (workbook) and paste into your RIPARIAN worksheet.

4.2.4 Large Wood

Copy the header from the TEMPLATE worksheet in the LARGE WOOD workbook and paste copied cells into the first row of your LARGE WOOD worksheet.

4.2.5 Human Influence

The procedure for these data is nearly the same as the RIPARIAN, except there are 26 columns (contains the following fields: HU_WALL, HU_BLDG, HU_RIVACC,

HU_PVMT, HU_PIPE, HU_TRASH, HU_CLEAR, HU_CROP, HU_PSTR, HU_LOG, HU_MINACT, HU_DIVERT, UNSTABB, and COMMENTS). The first 13 columns are LB and the next 13 are RB. It is important to note that with the HUMAN INFLUENCE data are reverse from the RIPARIAN (i.e., the LB is the first set and the RB is the last set). Also, there are no data for Transect K, so you can delete this row before translating.

1. Insert one column just after the HAB_ TRANSECT data.
2. Cut and Paste these data from RB columns underneath the LB columns. Fill the cells in the new column accordingly with either RB or LB. I have highlighted this column in **yellow**.
3. Copy and Paste the SAMPLEID and TRANSECT_HAB columns so that they repeat themselves for both sets. Delete the repeated headers and any empty rows, so that the headers are only in the first row. Then copy the header from the TEMPLATE worksheet in the HUMAN INFLUENCE workbook and insert the copied cells into the first row of your HUMAN INFLUENCE worksheet.
4. Combine the COMMENTS1 and COMMENTS2 fields (located at far right hand side of Trimble data (Columns AC and AD)).

4.2.6 Channel

Many fields require translation (similar to the CANOPY data but a bit more complex). These 78 vertically displayed columns will be translated into six (6) horizontal columns (GRADIENT, BAR_WIDTH, THAL_DEPTH, HAB_TYPE, FINES, SCHAN, BACW, and COMMENT). As above, you can follow examples of the translating steps in the numbered worksheets in the TEMPLATE workbook:

1. Copy columns D through CE and Paste into a new worksheet. Then insert a column just before the BAR_WIDTH header for each set (1 through 9) and before the WET_WIDTH(0). I have highlighted this column in maroon. Add the header STA_NUM for each of the inserted columns and add the appropriate STA_NUM (1 through 9) for all entries down the column.
2. Cut (i.e., move) each set of columns (starting at the second set) and Paste underneath the first set. See the hint above for an easy way to select data in an Excel worksheet using the key pad.
3. Make sure the headers match (the headers are mostly in the same order for each set except for sets 0 and 5 have WETTED_WIDTH, BANKFULL_WIDTH, BANKFULL_HEIGHT, and GRADIENT (slope). I have highlighted sets 0 and 5 in **aqua**. Data for sets 1 through 4 and 6 through 9 needs to be moved to the right to match the headers. To do this select data in columns B through E, click Insert – Cells, and choose Shift cells right. The set 5 data need to be switched (move the WETTED WIDTH, etc. from columns H to L and Insert into Column B.

Hint: To check that you have done this correctly, select the first row of the dataset and Choose Data – Filter – Auto Filter. Then by clicking on the pull-down list for each column, you will get a unique list of data in that column. Particular attention should be given to Column G, the BAR_WIDTH column. The items in the pull-down list should be limited to numbers and BAR_WIDTH headers.

4. TRANSECT_HAB) into the left side of these data (Insert Columns) and match up. In the example, there are no channel data for Transect K, so delete this entry.
5. Copy and Paste data from these blue columns so that they repeat themselves for each dataset. Delete the repeated headers, so that the headers are only in the first row.
6. Copy the first row from the TEMPLATE worksheet in the CHANNEL workbook and paste into the first row of your CHANNEL worksheet.
7. For the fields that have blank cells for sets 0-4 and 6-9, Find and Replace <blank> with -999. Finally, scroll through the comment field and enter any applicable information into the Cascade/Falls fields (CA_FA_HT, CA_FA_LN, and CA_FA_GRAD).

4.2.7 Substrate

This dataset is a lot like the CHANNEL and CANOPY data in that several fields require translation. The 30 vertically displayed columns will be translated into six (6) horizontal columns (STANUM, POSITION, DEPTH, SIZECLASS, EMBED_PCT, and COMMENT). As above, you can follow examples of the translating steps in the numbered worksheets in the TEMPLATE workbook:

1. Insert a column just before the DEPTH header for each set (i.e., Column D, Column H, etc). Then, as with the CANOPY data, Copy and Paste the formulas from the TEMPLATE workbook into each new column. Make sure the formulas line up with the last SAMPLEID. The formulas are “=cell in the adjacent column to the right” in the header row, and then “=cell above in the same column” for the rest of the column where data exist in the adjacent column. Examples of these formulas are highlighted in orange and yellow. Each column should have an orange cell header and each row that has data should have a corresponding yellow cell.
2. Select the entire worksheet, then Copy and Paste as Values to convert the formulas to values.

Hint: To Paste as Values, click Edit – Copy, then click Edit – Paste Special and choose Values. Remember to keep the entire worksheet highlighted for both the Copy and Paste as Values.

Note: The reason for the Paste as Values step is to change the cells from a formula to an actual value.

3. Cut (i.e., move) each set of columns (starting at the second set) and Paste underneath the first set. See the hint above for an easy way to select data in an Excel worksheet using the key pad.
4. Copy and Paste the SAMPLEID and TRANSECT_HAB columns so that they repeat themselves for each set. Delete the repeated headers, so that the headers are only in the first row.
5. Insert one column next to the descriptor column (Column D) and Copy and Paste these data so that there are duplicates.
6. In the first Column (Column D), Find and Replace (Replace All) “*_” with <nothing> and then run again finding “(m)*” and also replacing (Replace All) with <nothing>. In the second column (Column E), Find and Replace (Replace All) “DEPTH*” with <nothing>, and then run again finding “F” and also replacing with <nothing>.

Hint: The most efficient way to complete the Find and Replace is to select the column and click Edit – Find, then press the Options button and Choose “Match entire cell contents”. Then you can Find and Replace. Use Replace All.

7. Copy the first row from the TEMPLATE worksheet in the SUBSTRATE workbook and paste into the first row of your SUBSTRATE worksheet.
8. Find and Replace (Replace All) the following:
 - a. POSITIONS field, as follows: Position on transect. L= Left bankfull stage; LC=left of center; C=center; RC=right of center; R=right bankfull stage.

4.3 Importing the Worksheets into the Database

The next step is to import each of the translated files into the database. The TEMPLATES use the same field names of the database, Microsoft Access will automatically recognize the fields. If the TEMPLATES are not used, you will need to make the field relationships explicit when appending. The following procedure details how to import the translated files into the database, using the TEMPLATES as described above:

Note: Make sure all of the Headers in your seven worksheets are the same as the headers in the example workbooks

1. Open the database in Microsoft Access.
2. Click File – Get External Data – Import and browse to the file that contains the translated data you wish to append to the database.

Hint: The browse “import” window defaults to Files of Type “Microsoft Office Access”. To change to Excel files, click the pull-down list beside Files of Type and select “Microsoft Excel”.

3. The Import Spreadsheet Wizard will prompt you to do the following:
 - a. Select a worksheet - choose the worksheet that has the final translation (with the TEMPLATE headers). Click Next.
 - b. Tick the First Row Contains Column Headings checkbox. You will likely get the popup box that says: “The first row contains some data that can not be used for valid Access field names. In these cases, the wizard will automatically assign valid field names”. Click OK, and then Click Next.
 - c. Choose the In a New Table selection. Click Next.
 - d. Click Next again.
 - e. Choose the No Primary Key selection. Click Next.
 - f. Rename the file as the data type and add the date/time and person translating if you like. It is very important to remain organized here. Click Finish.
 - g. The popup box saying Finished importing file, click OK.
4. Repeat the above step (Step #3a-g) until all 7 files (MASTER SAMPLE, CANOPY, CHANNEL, HUMAN, LGWOOD, RIPARIAN and SUBSTRATE) are imported into the database.
5. The next step is to append these tables to the appropriate database tables. Use the following procedure to create the queries to accomplish this step:
 - a. Under Objects (on the left-hand side of the Database window), click Queries.
 - b. Click New (top of the Database window).
 - c. In the New Query window select Design View, then OK.
 - d. In the Show Table window, select the table you want to append to the database, and then click Add). Then press the Close button in the Show Table window.
 - e. Add all of the appropriately named fields (i.e., SAMPLEID, TRANSECT_HAB, etc and not the Field1, Field2) to the design grid. To do this, drag the field from the field list to a column in the design grid, or double-click the field name in the field list (to remove a field from the design grid, click the column selector to highlight the column, and then press the Delete key).
 - f. View the results of the query by clicking the Run button (exclamation mark icon) on the toolbar, or select Datasheet View from the View menu.
 - g. Make the query an **Append Query** by clicking Query – Append Query, then in the Append window, select the database table you want to add your data to (i.e., if you are adding RIPARIAN data, choose the tbl_HAB_RIPARIAN table. Where the fields match, the program will automatically select the fields to append to.

<p>Note: All of the fields should match if you have used the template headers appropriately and if you have selected the right tables to append from and append to.</p>

6. Once you have confirmed that the append query will occur correctly, click the Run button (exclamation mark icon) on the toolbar and these data will append to the existing records.

5.0 FISH PASSAGE DATA PROTOCOL

5.1 Downloading Data into Excel

Data are downloaded from the *Columbia River DART (Data Access in Real Time)* data for Adult Salmonid Passage at Wells (data since 1977). The following procedure details how to download these data into Microsoft Excel:

1. Via the internet, navigate to the following website:
<http://www.cbr.washington.edu/dart/adult.html>
2. From the pull-down list, select WEL-Wells [1977] and the year you wish to download. Click Begin Run.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent FISH PASSAGE data downloaded by date”.

3. In the window that opens data (still in Microsoft Internet Explorer), Click File – Save As (or Page – Save As) to save a copy of the file for your records (save as a txt file). Name the file something useful (for example *DART WELLS 2006.txt*).
4. Copy the headers and data table and paste into an empty Excel worksheet. Do not include the summary data at the bottom of the table.
5. Select the Column A of the worksheet and Click Data – Text to Columns.
6. Convert Text to Columns Wizard.
 - a. Step 1 of 3: Select Fixed Width, click Next.
 - b. Step 2 of 3: Move the column separators to properly encase data in individual columns, click Next.
 - c. Step 3 of 3: Select the Mo/Da/Year column and under Column Data Format, Select “Date” and choose MDY from the pull-down list, and click Finish.
7. Select the entire worksheet and Find and Replace comma (“,”) with <nothing>. Click Replace All.

5.2 Translation

5.2.1 Master Sample

1. Delete the columns with the 10yr average data (Columns E, G, I, L, and N). Therefore, should only keep the following columns: Proj; Mo/Da/Year; ChRun; Chin; JChin; Sthd; SthdW; Sock; Coho; JCoho; Bull Tr; Lmpry; TempC. Also delete the second row (has “-----“ in each cell). Your worksheet should look like the template worksheet named “comma delimited”.
2. Insert a new column at the beginning of the worksheet and count the records consecutively starting from one greater than the last SAMPLEID in the MASTER SAMPLE table in the database. Name the header of this column “SAMPLEID”. Your worksheet should look like the template worksheet MS-TRANSLATE2.

3. Copy and Paste the SAMPLEID, Proj, Mo/Da/Yr, ChRun and TempC columns into a new worksheet. Your worksheet should look like the template worksheet MS-TRANSLATE3. Name this worksheet MASTER SAMPLE to keep yourself organized. Copy the first row from the MASTERSAMPLE TEMPLATE worksheet in the FISH PASSAGE TEMPLATE workbook and paste copied cells into the first row of your MASTER SAMPLE worksheet.
4. In this worksheet, select the SITEID column and Find and Replace WEL with WELLS.
5. Format the DATE_START field by selecting the column, then click Format – Cells. Under the Number tab, choose Date and select the 7th option on the pull-down list (14-Mar-98).
6. In the RUN column, Find and Replace (Replace All) “Su” with SUMMER. Then run two more times finding “Sp” and replace (Replace All) with SPRING, and finding “Fa” and replace with FALL.

Hint: The most efficient way to complete the Find and Replace is to select the column and click Edit – Find, then press the Options button and Choose “Match entire cell contents”. Then you can Find and Replace. Use Replace All.

5.2.2 Fish Passage

As with the Habitat Data, the next step is translation. The 10 fish species columns (vertically displayed data) will become two horizontal columns (SPECIES and COUNT). The procedure is detailed in the following steps (you can follow examples of these steps in the TEMPLATE workbook: TRANSLATE1, TRANSLATE2, etc.):

1. Copy the “comma delimited” sheet into a new worksheet. Name this worksheet FISH PASSAGE to keep yourself organized. Then insert a column before each SPECIES column (starting with Chin) and delete the temperature column. The first three columns contain the “MASTER SAMPLE information” (Proj, Mo/Da/Yr, and ChRun).
2. Copy and Paste the formulas from the FISH PASSAGE TEMPLATE.xls workbook (TRANSLATE2 worksheet) into each new column. Make sure the formulas line up with the last SAMPLEID. The formulas are “=cell in the adjacent column to the right” in the header row, and then “=cell above in the same column” for the rest of the column where data exist in the adjacent column. Examples of these formulas are highlighted in orange and yellow. Each column should have an orange cell header and each row that has data should have a corresponding yellow cell. Your worksheet should look like the template worksheet FP-TRANSLATE2.

3. Select the entire worksheet, then Copy and Paste Special as Values (see hint below) to convert the formulas to values.

Hint: To Paste as Values, click Edit – Copy, then click Edit – Paste Special and choose Values. Remember to keep the entire worksheet highlighted for both the Copy and Paste as Values.

4. Cut (i.e., move) each set of SPECIES columns (newly created column and COUNT data column) and Paste underneath the first set. Rename Column E to SPECIES and Column F to COUNT. Your worksheet should look like the template worksheet FP-TRANSLATE4.

Hint: An easy way to select data in an Excel spreadsheet is to use the key pad. By holding the Shift key, while using the arrow keys you can select multiple cells one by one. By holding both the Ctrl key and the Shift key you can select a group of cells that contain data. The Shift key will automatically select to where there is a break in data. Therefore:

1. Click on the SPECIES header (e.g., Chin, JChin) for the second set;
2. Hold the Shift Key and arrow over to the column just before the next SPECIES header for the third set;
3. While continuing to hold the Shift key, also hold the Ctrl key and press arrow down to select entire set;
4. Now Cut this selection (Edit-Cut or Ctrl X);
5. Press Ctrl-Home to arrive at cell A1;
6. Press Ctrl-down (↓) to arrive at the end of the data in that column;
7. Press the down arrow once more to arrive at the next empty row underneath the data;
8. Now Paste data (Edit-Paste or Ctrl P).
9. Repeat for sets 2 through 10.

5. Then Copy and Paste the SAMPLEID, Proj, Mo/Day/Year, and CHRun data so that they repeat themselves for each set. This data is highlighted as yellow/green/red in the FP-TRANSLATE5 worksheet for further clarification. Delete the repeated headers that may have been copied for each set. The headers should only exist in the first row. Your worksheet should look like the template worksheet FP-TRANSLATE5.
6. Copy the first row from FISH PASSAGE TEMPLATE worksheet in the FISH PASSAGE TEMPLATE workbook and paste copied cells into the first row of your FISH PASSAGE worksheet. Note there are two extra columns, LIFESTAGE and WILD_HATCH (see next step).
7. Add a data filter on the first row (i.e., the headers).

Hint: To add a data filter, select the row you want to filter. Click Data – Filter – Auto Filter. This adds pull-down lists for each header in the row. To show all data, Select “(All)” from the pull-down list.

- a. Filter for “JChin” and Add JUVENILE in the LIFESTAGE field for each record. Do the same for “JCoho”.
- b. Filter for “Chin” and Add ADULT in the LIFESTAGE field for each record. Do the same for “Coho”.
- c. Filter for “Sthd” and Add HATCHERY in the WILD_HATCH field for each record. Filter for “SthdW” and Add WILD in the WILD HATCH field.
- d. In the SPECIES column, Find and Replace (Replace All) for the following names:
 1. Chin – Chinook.
 2. JChin – Chinook.
 3. SthdW – Steelhead.
 4. Sthd – Steelhead.
 5. Sock – Sockeye.
 6. JCoho – Coho.
 7. Bull Tr – Trout Bull.
 8. Lmpy – Lamprey.

5.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3.

6.0 DOE WATER QUALITY DATA PROTOCOL

Data are downloaded from the **Department of Ecology River and Stream Flow Monitoring in the Water Resource Inventory Area (WRIA) 49, Okanogan**. The OBMEP database retains data for the three “long-term stations” located in WRIA 49, as follows:

1. 49A070 – Okanogan R @ Malott;
2. 49A190 – Okanogan R @ Oroville; and
3. 49B070 – Similkameen R @ Oroville.

In addition to these “long-term stations”, the OBMEP database also retains data from shorter term stations in the Okanogan River, such as:

4. 49A090 – Okanogan River @ Okanogan;
5. 49A110 – Okanogan River @ Omak; and
6. 49A130 – Okanogan River @ Riverside.

6.1 Downloading Data

The following procedure details how to download these data into Microsoft Excel:

1. Via the internet, navigate to the following website:
<http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=notes&scrolly=0&wria=49&sta=first>.
2. Click on the station of interest.
3. Click on the “finalized data” tab to display data from the most recent year available.
4. There are two ways to download the data, as follows:
 - a. Simplest option – horizontal format. This is the simplest option for incorporating into the database because it is downloaded in database (vertical) format. However, you are downloading the entire dataset and will need to filter out the recent data only, for the 3 stations of interest.
 - i. At the bottom of the page, click on the “[All project data for WRIA 49](#)” link.
 - ii. Click “Save to File” in the File Download window.
 - iii. Browse to an appropriate location to save the file, Click Save, Then Close.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent WQ data downloaded by date”.

Hint: To add a data filter, select the row you want to filter. Click Data – Filter – Auto Filter. This adds pull-down lists for each header in the row. To show all data, Select “(All)” from the pull-down list.

- b. Vertical (crosstab) format. This option only retrieves the year of interest (so you don't need to filter out the data), but it is downloaded in crosstab format. Data in this format requires translation (re-arranging the vertical spreadsheet to relational horizontal database tables) before it can be incorporated into the database.
 - i. Under the "conventional parameters" data, Click on the "save the above table to file" button.
 - ii. Click "Save to File" in the File Download window.
 - iii. Browse to an appropriate location to save the file, Click Save, Then Close.
 - iv. Repeat steps 4 through 6 for the "metals" data.

6.2 Translation

6.2.1 Converting the Downloaded Data into Excel Format

The following steps only pertain to data downloaded in horizontal format (see Section 6.1 above, Option 4a.). If you decide to download the data in vertical form (Option 4b.), you will need to translate the data by following steps similar to the fish passage translation (Section 5.2.2). The specific details for this translation are not included in this document.

1. Open the downloaded "49.zip" file by double clicking through Windows Explorer.
2. If you are using the Evaluation Version of Winzip, Unzip the file by selecting "Use Evaluation Version". Then click the Extract button, choose an appropriate location to store the extracted file and click Extract. If you have other unzipping software, follow the step-by-step prompts to extract the file. The extracted file is automatically named "49.txt".
3. Open Microsoft Excel (Start – All Programs – Microsoft Excel or double click the icon on your desktop).
4. Click File – Open.
5. Using the "Files of type" pull-down list in the Open window, Select "All Files (*.*)".
6. Navigate to the 49.txt file, Select and Click Open.
7. The Text Import Wizard will automatically appear:
 - a. Step 1 of 3 – Choose Delimited, Click Next.
 - b. Step 2 of 3 – Check Tab, Click Next.
 - c. Step 3 of 3 – Select each field and Select General under Column Data Format, except for the "Date" field, choose Date M/D/Y. Click Finish.

8. Click File – Save As. In the Save As window, select Microsoft Excel 5.0/95 Workbook from the Save As Type pull-down list, browse to an appropriate location and click Save. Name the file something useful (for example 49A070_2007.xls).

Note: A window will pop up that says, “...xls may contain features that are not compatible with Microsoft Excel 5.0/95 Workbook. Do you want to keep the workbook in this format? Click Yes.

6.2.2 Filtering Data in Excel

1. Add a data filter on the first row (i.e., the headers).

Hint: To add a data filter, select the row you want to filter. Click Data – Filter – Auto Filter. This adds pull-down lists for each header in the row. To show all data, Select “(All)” from the pull-down list.

2. In the “date” column, Click the pull-down arrow (dates will be automatically sorted chronologically). Decide which date is the beginning of these data you would like to incorporate (for example 1/3/2005).

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent WQ data downloaded by date”.

3. Choose (Custom...) in the pull-down list and in the Custom AutoFilter window, choose “is greater than or equal to” in the pull-down list and type in the beginning date (e.g., 1/3/2005).
4. Once filtered, a good check of the stations is to Click the pull-down arrow of the station column and a unique list will appear. You should only see a list of the desired stations. If there are stations you do not wish to incorporate, filter and delete.
5. Keeping the filter on, Select the entire workbook and Click Edit – Copy.
6. Open a new worksheet and Click Edit – Paste. Rename the worksheet to WATER QUALITY CHEMISTRY.

6.2.3 Customizing Data to Match the Database Design

1. Format the date by selecting the column, then click Format – Cells. Under the Number tab, choose Date and select the 7th option on the pull-down list (14-Mar-98).

2. In the parameter column, Find and Replace (Replace All) “FC” with FECAL_COL. Then finding “TURB” and replace (Replace All) with TURBIDITY.
3. As with the previous protocols, these data must be split into two tables, MASTER SAMPLE and WQ CHEMISTRY (see TEMPLATES in the DOE WQ TEMPLATE).
 - a. Master Sample
 - i. Select the First three columns (station, date and time) and Copy into a new worksheet.
 - ii. Click Data – Filter – Advanced Filter.
 - iii. In the Advanced Filter window, under Action, Choose “Copy to another location”.
 - iv. In the same window, click the right hand selector in the “Copy to” box and select a cell in the first row of the worksheet (beside the existing data, for example Column E).
 - v. Check the “Unique records only” checkbox.
 - vi. Click OK.
 - vii. Delete the first four columns of this worksheet so that only the unique records show.
 - viii. Insert a new column at the beginning of the worksheet and count the records consecutively starting from one greater than the last SAMPLEID in the MASTER SAMPLE table in the database. Name the header of this column “SAMPLEID”.
 - ix. Enter two new headers, BIOEVENT and AGENCY after the last column and enter WATER QUALITY and DOE, respectively in these columns for each record.
 - x. Copy the first row from MASTER SAMPLE template in the DOE WQ TEMPLATE workbook and paste copied cells into the first row of your active worksheet.
 - b. Water Quality Chemistry - Copy the first row from WQ CHEMISTRY template in the DOE WQ TEMPLATE workbook and paste copied cells into the first row of your active worksheet.

6.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3. It is important to remember with chemistry results, often analyses are performed in different ways. For example, less than detection limit results are sometimes treated as zeros, sometimes as the real value and sometimes as half the detection limit. A new field (termed VALUE_CALC) will be created prior to analyses to ensure data are treated appropriately. It is not efficient to update this field as you import data, rather to update as part of the database audit conducted prior to analyses.

7.0 DOE HOURLY TEMPERATURE DATA PROTOCOL

As with the DOE Water Quality (Section 6.0), a portion of the DOE hourly temperature data are also downloaded from the **Department of Ecology River and Stream Flow Monitoring in the Water Resource Inventory Area (WRIA) 49, Okanogan**. In particular, this website contains hourly temperature data for the same three “long-term stations” located in WRIA 49, as follows:

- 49A070 – Okanogan R @ Malott (July 27, 2005 to September 30, 2005);
- 49A190 – Okanogan R @ Oroville (June 6, 2001 to September 20, 2005); and
- 49B070 – Similkameen R @ Oroville (June 6, 2001 to August 31, 2003).

In addition to these sites, DOE has also provided Microsoft Excel files for three additional stations, as follows:

- 49F070 – Bonaparte Creek (September 9, 2002 to January 10, 2006);
- 49C100 – Omak Creek (September 24, 2003 to January 11, 2006); and
- 49E080 – Tunk Creek (August 29, 2002 to January 11, 2006).

This file also contains data for station 49B070 – Similkameen River (continued from download above, September 24, 2003 to January 10, 2006).

The following procedure relates to data available from the website only. It is also important to note that temperature data are not stored in relational tables (i.e., ptbl_Master_Sample and a temp table). This is because temperature data contain one value for each station, day and time hourly). Temperature data are stored in one “side” table, named atbl_HOURLYTEMP (note prefix change to atbl).

7.1 Downloading Data

The following procedure details how to download data for the three “long-term stations” into Microsoft Excel:

1. Via the internet, navigate to the following website:
<http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=notes&scrollly=0&wria=49&sta=first>.
2. Click on the station of interest.
3. Click on the “temperature” tab to display data from the most recent year available.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent TEMP data downloaded by date”.

4. At the bottom of the data, Click on the link, *Data in tabbed-delimited text file (all years)*: [tmp49A070.zip](#) (note the last six characters is the specific station name).
5. Click Save in the File Download window.

6. Browse to an appropriate location to save the file, Click Save, Then Close.

7.2 Translation

7.2.1

Converting Downloaded Data into Excel Format

The following steps only pertain to data available on the website. Incorporation of additional Microsoft Excel files provided by DOE will follow a similar protocol, but the specific details are not included in this document.

1. Open the downloaded “tmp49A070.zip” file by double clicking through Windows Explorer.
2. If you are using the Evaluation Version of Winzip, Unzip the file by selecting “Use Evaluation Version”. Then click the Extract button, choose an appropriate location to store the extracted file and click Extract. If you have other unzipping software, follow the step-by-step prompts to extract the file. The extracted file is automatically named “tmp49A070.txt”.
3. Through review of these files, it is apparent that the values in the txt is slightly disjointed (i.e., the records do not match up perfectly). The best way to fix this is to perform a Delete – Shift Cells Up in Microsoft Excel. Open Microsoft Excel (Start – All Programs – Microsoft Excel or double click the icon on your desktop, if available).
 - a. Click File – Open.
 - b. Using the “Files of type” pull-down list in the Open window, Select “All Files (*.*)”.
 - c. Navigate to each station tmp#####.txt file, Select and Click Open.
 - d. The Text Import Wizard will automatically appear:
 - i. Step 1 of 3 – Choose Fixed Width, Click Next.
 - ii. Step 2 of 3 – You may need to add a break line at this step. Scroll through the dataset at this step to locate the best spot for a break line. Click Next.
 - iii. Step 3 of 3 – Select Each field and Select General under Column Data Format, except for the “Date” field, choose Date Y/M/D. Click Finish.
 - e. As mentioned above, the data may be disjointed and will have extra blank cells where data needs to be manually shifted to match it up correctly. Note that blank cells do not necessarily mean that the data is mismatched (may indicate “no data”, but if the data is mismatched in your table, the easiest way to find where the data starts being mismatched is to filter and review where blank cells occur. To filter the data, follow these steps:
 - i. Select the first row of the dataset (contain the headers), Choose Data – Filter – Auto Filter.
 - ii. In each column, Click the pull-down list and select “(Blanks)”. If there are blanks, follow the procedure in Step f. If there are not any blanks, skip Step f and continue with the protocol.
 - f. This procedure will shift blank cells to correct mismatched data (if applicable)
 - i. In the Trip column, Click the pull-down arrow and select “(Blanks)”.

- ii. Select the Trip, Station, Date and Time cells for all filtered records (all blanks for the rows highlighted in blue – denoting the filter) and Click Edit – “Go To...”.
- iii. When the Go To window appears, Click on the “Special...” button.
- iv. Select the “Visible cells only” option.
- v. Click Edit –Delete – Shift Cells Up.

Hint: To show all data, Select “(All)” from the pull-down list.

4. These data include all records available for all years. As the historical records already exist in the database, filter out only the records for your desired dates (for example, the most recent year):
 - a. Select the first row of the dataset (contains the headers), Choose Data – Filter – Auto Filter.
 - b. In the “date” column, Click the pull-down arrow (dates will be automatically sorted chronologically). Decide which date is the beginning of these data you would like to incorporate (for example 1/3/2005).
 - c. Choose (Custom...) in the pull-down list and in the Custom AutoFilter window, choose “is greater than or equal to” in the pull-down list and type in the beginning date (e.g., 1/3/2005).
 - d. Keeping the filter on, Select the entire workbook and Click Edit – Copy.
 - e. Open a new worksheet and Click Edit – Paste.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent TEMP data downloaded by date”.

5. Repeat the above steps for each desired station (i.e., 49A190 and 49B070). Stack each dataset into one file and complete the next steps on all three stations at the same time.
6. Click File – Save As. In the Save As window, select Microsoft Excel 5.0/95 Workbook from the Save As Type pull-down list, browse to an appropriate location and click Save. Name the file something useful (for example 49A070_2007.xls).

Note: A window will pop up that says, “...xls may contain features that are not compatible with Microsoft Excel 5.0/95 Workbook. Do you want to keep the workbook in this format? Click Yes.

7.2.2 Customizing Data to Match the Database Design

You can follow examples of these steps in the DOE TEMP TEMPLATE workbook: TRANSLATE1, TRANSLATE2, etc.):

1. Copy the first row from TEMPLATE in the DOE TEMP TEMPLATE workbook and paste copied cells into the first row of your active worksheet.

2. Format the date by selecting the column, then click Format – Cells. Under the Number tab, choose Date and select the 7th option on the pull-down list (14-Mar-98).
3. Format the TIME_START field by selecting the column, then click Format – Cells. The database is formatted to store time data in the 24 hour clock, so then click Format – Cells. Under the Number tab, choose Time and select the 4th option on the pull-down list (13:30:55).
4. Enter DOE into the AGENCY column for each record.
5. Add “DOE-“ to each SITE_ID so that it matches with the lkp_SITES table. Find “49A070” and Replace All “DOE-49A070”. Do the same for 49A190 and 49B070.

7.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3.

8.0 EUREKA WATER QUALITY DATA PROTOCOL

The CCT collects the following water quality parameters for 35 stations:

- Temperature;
- Specific Conductivity;
- Dissolved Oxygen (mg/L and %);
- pH;
- Turbidity; and
- Salinity.

The following procedure outlines the steps to translate the data from the csv (Comma delimited) file into the database.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent WQ data downloaded by date”.

8.1 Downloading Data into Excel

1. Open Microsoft Excel (Start – All Programs – Microsoft Excel or double click the icon on your desktop).
2. Click File – Open.
3. Using the “Files of type” pull-down list in the Open window, Select “All Files (*.*)”.
4. Navigate to the csv file, Select and Click Open.
5. Click File – Save As. In the Save As window, select Microsoft Excel 5.0/95 Workbook from the Save As Type pull-down list, browse to an appropriate location and click Save. Name the file something useful (for example *OBMEP-551_Jan2007.xls*).

Note: A window will pop up that says, “...xls may contain features that are not compatible with Microsoft Excel 5.0/95 Workbook. Do you want to keep the workbook in this format? Click Yes.

8.2 Translation

8.2.1 Master Sample

1. The first two columns contain the “MASTER SAMPLE information (DATE, and TIME). Insert a new column at the beginning of the worksheet and count the records consecutively starting from one greater than the last SAMPLEID in the MASTER SAMPLE table in the database. Name the header of this column “SAMPLEID”.

2. Copy and Paste the SAMPLEID, DATE and TIME columns into a separate worksheet. Name this worksheet MASTER SAMPLE to keep yourself organized. Copy the first row from the MASTER SAMPLE TEMPLATE worksheet in the EUREKA WQ workbook and insert the copied cells into the first row of your MASTER SAMPLE worksheet.
3. In this worksheet, Enter the appropriate SITEID into all records (use lkp_SITES to identify the appropriate SITEID, for example “OBMEP-###”)

8.2.2 Water Quality

As with the Fish Passage Data (Section 5.0), the next step is translation. The 11 parameter columns (vertically displayed data) will become four horizontal columns (DATE, TIME, PARAMETER and CONC). The procedure is detailed in the following steps (you can follow examples of these steps in the EUREKA WQ TEMPLATE workbook: TRANSLATE1, TRANSLATE2, etc.):

1. Copy the original worksheet into a new worksheet and name the worksheet WQ CHEM to keep yourself organized. Delete the last two columns (Bat V V and Circulator). Then insert a column before each parameter column (Temperature, Sp. Cond, DO mg/L, pH, Turbid, Salinity, and DO). The first two columns contain the “MASTER SAMPLE” information (DATE, and TIME) and therefore you do not need to insert a column before these columns.
2. Copy and Paste the formulas (entire column) from the EUREKA EQ TEMPLATE.xls workbook (TRANSLATE2 worksheet) into each new column. Make sure the formulas line up with the last SAMPLEID. The formulas are “=<cell in the adjacent column to the right>” in the header row, and then “=cell above in the same column” for the rest of the column where data exist in the adjacent column. Examples of these formulas are highlighted in orange and yellow. Each column should have an orange cell header and each row that has data should have a corresponding yellow cell.
3. Select the entire worksheet, then Copy and Paste Special as Values (see hint below) to convert the formulas to values.

Hint: To Paste as Values, click Edit – Copy, then click Edit – Paste Special and choose Values. Remember to keep the entire worksheet highlighted for both the Copy and Paste as Values.

Note: The reason for the Paste as Values step is to change the cells from a formula to an actual value.

4. Cut (i.e., move) each set of parameter (e.g., temperature, DO, pH, etc.) columns (newly created column and CONC data column) and Paste underneath the first set. Compare the TRANSLATE3 and TRANSLATE4 worksheets to get an idea of what this step means.

Hint: An easy way to select data in an Excel spreadsheet is to use the key pad. By holding the Shift key, while using the arrow keys you can select multiple cells one by one. By holding both the Ctrl key and the Shift key you can select a group of cells that contain data. The Shift key will automatically select to where there is a break in data. Therefore:

1. Click on the parameter header (e.g., temp, DO, pH) for the second set;

5. Copy and Paste the SAMPLEID column so that it repeats itself for each set. Delete the repeated headers, so that the headers are only in the first row.
6. Copy the first row from WQ CHEM TEMPLATE worksheet in the EUREKA WQ TEMPLATE workbook and paste copied cells into your WQ CHEM worksheet into the first row.
7. In the parameter column (i.e., now termed CHEMCODE), Find and Replace (Replace All) for the following names (use lkp_CHEMDICT to identify the appropriate CHEMCODE, for example “TEMP”):
 - a. Temperature °C – TEMP.
 - b. Sp.Cond ms/cm – SP_COND.
 - c. DO mg/L - DO_MGL.
 - d. pH – PH.
 - e. Turbid NTU – TURBIDITY.
 - f. Salinity PSS – SALINITY.
 - g. DO % - DO_PERCENT.

Note: The easiest way to do this is to copy the original chemical name in the spreadsheet (e.g., Temperature °C), Then Click Edit-Find and in the “Find What:” box, Enter “Ctrl-V” (this is the key code for “paste”) and then in the “Replace With:” box, type the appropriate CHEMCODE (e.g., TEMP).

8. In the AGENCY column add CCT for all records.

8.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3. It is important to remember with chemistry results, often analyses are performed in different ways. For example, less than detection limit results are sometimes treated as zeros, sometimes as the real value and sometimes as half the detection limit. A new field (termed VALUE_CALC) will be created prior to analyses to ensure data are treated appropriately. It is not efficient to update this field as you import data, rather to update as part of the database audit conducted prior to analyses.

9.0 BOXCAR HOURLY TEMPERATURE DATA PROTOCOL

Boxcar temperature data are collected by CCT staff. The CCT is currently redeveloping the design of how data are collected by temperature probes, however the probes using the old design will continue to collect data until the batteries die. As the batteries are replaced, the new design will be adopted. For purposes of this document, there are two protocols (Section 9.1), one for the old design and one for the new design (Section 9.2) and associated TEMPLATE workbooks.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent TEMP data downloaded by date”.

9.1 Old Design

1. Open Microsoft Excel (Start – All Programs – Microsoft Excel or double click the icon on your desktop, if available).
 - a. Click File – Open.
 - b. Using the “Files of type” pull-down list in the Open window, Select “All Files (*.*)”.
 - c. Navigate to the data file (downloaded from the temperature probe, for example “360 Salmon Creek 2006.txt”, Select and Click Open.
 - d. The Text Import Wizard will automatically appear:
 - i. Step 1 of 3 – Choose Delimited, Click Next.
 - ii. Step 2 of 3 – Check Tab **and** Check Space, Click Next.
 - iii. Step 3 of 3 – Select the Date field and Select Date MDY Column Data Format; Select Time and Select Text; Select Temperature and Select General. Click Finish.
2. Click File – Save As. In the Save As window, select Microsoft Excel 5.0/95 Workbook from the Save As Type pull-down list, browse to an appropriate location and click Save. Name the file something useful (for example *360 Salmon Creek 2006.xls*).

Note: A window will pop up that says, “...xls may contain features that are not compatible with Microsoft Excel 5.0/95 Workbook. Do you want to keep the workbook in this format? Click Yes.

3. Copy the first row from TEMPLATE in the “BOXCAR TEMP TEMPLATE – OLD DESIGN” workbook and paste copied cells into your active worksheet (replacing the headers in the first row of your worksheet).
4. Format the date by selecting the column, then click Format – Cells. Under the Number tab, choose Date and select the 7th option on the pull-down list (14-Mar-98).
6. Format the TIME field by selecting the column, then click Format – Cells. The database is formatted to store time data in the 24 hour clock, so then click Format – Cells. Under the Number tab, choose Time and select the 4th option on the pull-down list (13:30:55).

7. Enter the appropriate SITEID into all records (use lkp_SITES to identify the appropriate SITEID, for example “OBMEP-360”)
8. Enter BOXCAR into the AGENCY column for each record.
9. Enter “BOXCAR DATA” into the SOURCE column for each record.

9.2 New Design

9.2.1

Converting the Data into Excel Format

1. Export the desired file into Excel format using Hoboware software.
2. Open Microsoft Excel (Start – All Programs – Microsoft Excel or double click the icon on your desktop, if available).
 - a. Click File – Open.
 - b. Using the “Files of type” pull-down list in the Open window, Select “All Files (*.*)”.
 - c. Navigate to the data file (downloaded from the temperature probe, for example “1065639.csv”, Select and Click Open.
3. Click File – Save As. In the Save As window, select Microsoft Excel 5.0/95 Workbook from the Save As Type pull-down list, browse to an appropriate location and click Save. Name the file something useful (for example *360 Salmon Creek 2006.xls*).

Note: A window will pop up that says, “...xls may contain features that are not compatible with Microsoft Excel 5.0/95 Workbook. Do you want to keep the workbook in this format? Click Yes.

9.2.2

Customizing Data to Match the Database Design

You can follow examples of these steps in the “BOXCAR TEMP TEMPLATE – NEW DESIGN” workbook: TRANSLATE1, TRANSLATE2, etc.):

1. Delete the first row (contains the Plot Title: #####) and delete the first column (has consecutive #s). Delete the last four columns (Batt, V; Coupler Detached; Couple Attached; and End of File). Delete last row of data. Insert a column after Time, GMT-08:00.
2. Copy and Paste the data in the Time Column (Column A) into the adjacent blank Column (Column B). Expand the B column to show all the data, by dragging the column separator to the right.

Note: You do not need to format these columns separately for Date and Time. Access will automatically treat the data appropriately when this data is appended to the existing tables in the database,

3. Copy the first row from TEMPLATE in the “BOXCAR TEMP TEMPLATE – OLD DESIGN” workbook and paste copied cells into your active worksheet (replacing the existing headers in your active worksheet).
4. Enter the appropriate SITEID into all records (use lkp_SITES to identify the appropriate SITEID, for example “OBMEP-360”).
5. Enter BOXCAR into the AGENCY column for each record.
6. Enter “BOXCAR DATA” into the SOURCE column for each record.

9.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3.

10.0 DOE FLOW DATA PROTOCOL

As with the DOE Water Quality (Section 6.0) and the hourly temperature data (Section 7.0), the flow data (this section) are also downloaded from the **Department of Ecology River and Stream Flow Monitoring in the Water Resource Inventory Area (WRIA) 49, Okanagan**. In particular, this website contains flow data (historical data include monthly, more recent data are collected daily) for thirteen stations located in WRIA 49. The OBMEP database captures eight of these stations.

Flow data are measured monthly or daily at the following four stations (see Section 10.1):

- 49B070 – Similkameen R @ Oroville;
- 49C100 – Omak Creek near St. Mary’s Mission;
- 49F070 – Bonaparte Creek @ Tonasket; and
- 49E080 – Tunk Creek near Riverside.

Flow data are measured irregularly and infrequently at the following four stations (see Section 10.2):

- 49D080 – Johnson Creek @ Riverside;
- 49G060 – Antoine Creek near mouth;
- 49H080 – Tonasket Creek near Oroville; and
- 49J060 – Ninemile Creek near Oroville.

The data downloaded from the website for each of these station groups is different and the protocols are addressed separately in this document (Section 10.1 – Frequently collected flow data, and Section 10.2 – Randomly collected flow data).

As above with the temperature data (Sections 7.0 and 9.0), flow data are also not stored in relational tables (i.e., ptbl_Master_Sample and a flow table). All flow data are stored in one “side” table, named atbl_FLOW.

10.1 Frequently Collected Flow Data

10.1.1 Downloading Data into Excel

The following procedure details how to download data for the seven stations into Microsoft Excel:

1. Via the internet, navigate to the following website:
<https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?wria=49>.
2. Click on the station of interest.
3. Scroll to the bottom of the page and click on the “mean daily table” link for the most recent water-year.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent FLOW data download by date”.

4. In the window that opens data (still in Microsoft Internet Explorer), Click File – Save As (or Page – Save As) to save a copy of the file for your records (save as a txt file). Name the file something useful (for example *49B070_2006.txt*).
5. Close this window and Open the txt file in Microsoft Word.
6. In the txt file, Click Edit - Select All, then Click Edit – Replace... In the Find What window put “~” and in the Replace With window put “X” and Click Replace All. Note: the reason we do this step now is because Microsoft Excel does not recognize “~”. We will delete the “X” at a later step. It is important that the “X” is put in so that the data will line up correctly in the following steps.
7. If applicable, Find and Replace “?” with “X” as well.
8. Copy the headers and data table and paste into an empty Excel worksheet.
9. Select Column A for the entire dataset and Click Data – Text to Columns.
10. Convert Text to Columns Wizard.
 - a. Step 1 of 3: Select Fixed Width, click Next.
 - b. Step 2 of 3: Move the column separators to properly encase these data in individual columns, click Next.

Note: To delete a column separator, point the cursor to it and Double-click.

- c. Step 3 of 3: Click Finish.
11. Select rows 2 to 33 of the worksheet and Find and Replace each qualifier (“U”, “A”, “I”, “B”, “T”, “J”, “[“, “]”, and “X”) with <nothing>. Click Replace All. Qualifiers are not retained in the database.

10.1.2 Translation

As with the Eureka Water Quality Data (Section 8.0), the next step is translation. The 12 month columns (vertically displayed data) will become two horizontal columns (DATE and FLOW). The procedure is detailed in the following steps (you can follow examples of these steps in the TEMPLATE workbook: TRANSLATE1, TRANSLATE2, etc.):

1. Delete the second row (blank). Then insert a column before each month column. Delete the last column (Day) as this is a repeat of the first column.
2. Copy and Paste the formulas (entire column) from the DOE FLOW TEMPLATE.xls workbook (TRANSLATE2 worksheet) into each new column. Make sure the formulas line up with the last SAMPLEID. The formulas are “=cell in the adjacent column to the right” in the header row, and then “=cell above in the same column” for

the rest of the column where data exist in the adjacent column. Examples of these formulas are highlighted in orange and yellow. Each column should have an orange cell header and each row that has data should have a corresponding yellow cell.

3. Select the entire worksheet, then Copy and Paste Special as Values (see hint below) to convert the formulas to values.

Hint: To Paste as Values, click Edit – Copy, then click Edit – Paste Special and choose Values. Remember to keep the entire worksheet highlighted for both the Copy and Paste as Values.

Note: The reason for the Paste as Values step is to change the cells from a formula to an actual value.

4. Cut (i.e., move) each set of MONTH and FLOW columns and Paste underneath the first set.
5. Copy and Paste the DAY column (for example 1 through 31) so that it repeats itself for each set. Delete the repeated headers, so that the headers are only in the first row.
6. Copy and Paste headers from TRANSLATE6 to your worksheet Row #1.

Hint: An easy way to select data in an Excel spreadsheet is to use the key pad. By holding the Shift key, while using the arrow keys you can select multiple cells one by one. By holding both the Ctrl key and the Shift key you can select a group of cells that contain data. The Shift key will automatically select to where there is a break in data. Therefore:

1. Click on the month header for the second set.
2. Hold the Shift Key and arrow over to the column just before the next month header for the third set.
3. While continuing to hold the Shift key, also hold the Ctrl key and press arrow down to select entire set.
4. Now Cut this selection (Edit-Cut or Ctrl X).
5. Press Ctrl-Home to arrive at cell A1.
6. Press Ctrl-down to arrive at the end of the data in that column.
7. Press the down arrow once more to arrive at the next empty row underneath the data.
8. Now Paste data (Edit-Paste or Ctrl P).
9. Repeat for sets 2 through 10.

7. Enter the year of these data (example '05 or '06) into the **orange** highlighted cells. Copy and Paste the formulas from the DATE column in the TRANSLATE6 worksheet (highlighted in **yellow**). This will format the date to fit the database design (e.g., 14-May-06). This is a *concatenate* function.
8. Select the DATE column, then Copy and Paste Special as Values (see hint above, after #3) to convert the formulas to values. Delete the cell containing the year.
9. Copy the first row from TEMPLATE worksheet into the first row of your data. Under AGENCY, enter DOE for each record. Under SITEID, enter the station number that corresponds with SITEIDs in the lkp_SITES table (e.g., DOE-49B070).
10. Filter the FLOW column for blanks and delete these records.

Hint: To add a data filter, select the row you want to filter. Click Data – Filter – Auto Filter. This adds pull-down lists for each header in the row. To show all data, Select “(All)” from the pull-down list.

10.2 Randomly Collected Flow Data

10.2.1 Downloading Data into Excel

The following procedure details how to download data for the seven stations into Microsoft Excel:

1. Via the internet, navigate to the following website:
<https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?wria=49>.
2. Click on the station of interest.
3. Scroll to the bottom of the page and click on the “mean daily table” link for the most recent water-year.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent FLOW data download by date”.

4. In the window that opens data (still in Microsoft Internet Explorer), Click File – Save As (or Page – Save As) to save a copy of the file for your records (save as a txt file). Name the file something useful (for example *49B070_2006.txt*).
5. Close this window and Open the txt file in Microsoft Word.
6. Copy only the headers and data table and paste into an empty Excel worksheet.
7. Select Column A for the entire dataset and Click Data – Text to Columns.
8. Convert Text to Columns Wizard.

- d. Step 1 of 3: Select Fixed Width, click Next.
- e. Step 2 of 3: Move the column separators to properly encase these data in individual columns, click Next.
- f. Step 3 of 3: Click Finish.

10.2.2 Translation

1. Delete row 2
2. Cut date data in Column A and paste under the header in column D
3. Cut time data in column B and paste under the header in column E
4. Select the date column(column D) and right click-format cells and select the 7th option (14-Mar-01)
5. Copy the first row from TEMPLATE worksheet and paste copied cells into the first row of your data (replacing the existing headers in your active worksheet). Under AGENCY, enter DOE for each record. Under SITEID, enter the station number that corresponds with SITEIDs in the lkp_SITES table (e.g., DOE-49B070).

10.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3.

11.0 USGS TEMPERATURE AND FLOW DATA PROTOCOL

The temperature and flow data are downloaded from the **USGS National Water Information System** website. The website contains data for **1,486,615 sites**. The OBMEP database retains data for three stations, as follows:

- USGS-12439500;
- USGS-12445000; and
- USGS-12447200.

Historical water chemistry data are available for these three stations and has been incorporated into the OBMEP database. Since these data are not continually collected, a protocol for incorporation is not required. If collection and water quality testing for these stations starts again in the future, a protocol for incorporation should be developed.

11.1 Downloading Data into Excel

The following procedure details how to download these data into Microsoft Excel:

1. Via the internet, navigate to the following website:
<http://nwis.waterdata.usgs.gov/nwis/uv?12439500>.

Note: The above website contains data for station USGS-12439500. Therefore, to navigate to the other two stations, use the following websites, respectively:

<http://nwis.waterdata.usgs.gov/nwis/uv?12445000>; and

<http://nwis.waterdata.usgs.gov/nwis/uv?124347200>.

2. In the box “Available data for this site”, choose “Time series: Real time data”.
3. Scroll down the page until you see the heading:
Additional Data and Information.--Station [data inventory](#) and [annual data report](#).”, Click [data inventory](#).
4. In the “AVAILABLE DATA” box Click Time Series: Daily Data.
5. Scroll down the page until you see the table with the following headings, “Available Parameters; Period of Record; Output format; and Begin date and End date”.
6. Under Available Parameters, there are five choices with check boxes beside them. Put check marks in the discharge and temperature boxes. If additional boxes are checked, click on the check mark to uncheck them.
7. In the Output Format section of the box, Select the tab-separated option.
8. Add the desired dates in Date start and Date end (day after the last date in the OBMEP database to today’s date). The Period of Record shows the dates that each data type is available.

Hint: To query the database for the last date already incorporated in the database, Double Click on the queries “CCTqry_Recent TEMP data downloaded by date” and “CCTqry_Recent FLOW data downloaded by date”.

9. Click GO.
10. In the window that opens that data (still in Microsoft Internet Explorer), Click File – Save As (or Page – Save As) to save a copy of the file for your records (save as a txt file). Name the file something useful (for example *1243950.txt*).
11. Close this window and open each of the txt files.
12. Copy the headers and data table from each text file and Paste into an empty Excel worksheet (one worksheet for each station).
13. Delete the second row (contains 5s, 15s, 16s, 14s)
14. The desired data for the database are in columns A (agency), B (station), C (date), D (flow), and J (mean daily temp). Delete the unnecessary columns.
15. Combine the desired data from all three stations into one worksheet and translate all together.

11.2 Translation

Because temp and flow data are separate from the relational components of the database, the translation is quite simple. The dataset will be split into two tables, atbl_HOURLYTEMPS and atbl_FLOW. The procedure is detailed in the following steps (an example is provided in the USGS FLOW TEMP TEMPLATE workbook):

1. Columns A, B, C and D make up the atbl_FLOW table. Copy these 4 columns into an empty worksheet and copy the first row from FLOW TEMPLATE worksheet into the first row of your data.
2. Columns A, B, C and E make up the atbl_HOURLYTEMPS table. Copy these 4 columns into an empty worksheet and copy the first row from TEMP TEMPLATE worksheet into the first row of your data.
3. For both worksheets, Find and Replace All in the SITEID field, 12439500 with USGS-12439500; 12445000 with USGS-12445000; and 12447200 with USGS-12447200.

11.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3.

12.0 ENVIRONMENT CANADA FLOW and TEMPERATURE DATA PROTOCOL

Flow data are downloaded from the **Environment Canada Water Survey Real-Time Hydrometric Data** website. The OBMEP database currently retains data for only one station, OKANAGAN RIVER NEAR OLIVER (08NM085). However, new data are currently being collected for additional stations in Vaseux Creek, Inkaneep Creek and Shuttleworth Creek. Temperature data will also be available on this website in the future and downloading and translation will follow a similar protocol as outlined below.

12.1 Downloading Data into Excel

The following procedure details how to download these data into Microsoft Excel:

1. Via the internet, navigate to the following website:
<http://scitech.pyr.ec.gc.ca/waterweb/SelectProvince.asp?lang=0>
2. Under “Please select a province”, Select British Columbia and Click GO.
3. Using the mouse, select the station on the map that you want to download.
4. In the Data Category window, Select HISTORIC and Click GO.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent FLOW data download by date”.

5. Scroll down to the Archived Hydrometric Data Report:
 - a. In the Report Type window, select DAILY.
 - b. In the Report Output Type, select DATE-DATA FORMAT (CSV).
 - c. Click Obtain Report.
6. Click [Click here to download the file.](#) Click Open.
7. A window will open the dataset (looks like an Excel worksheet but is still in Windows Explorer)
8. Click File – Save As. In the Save As window, select Microsoft Excel 5.0/95 Workbook from the Save As Type pull-down list, browse to an appropriate location and click Save. Name the file something useful (for example *08NM085 - 2007.xls*).

Note: A window will pop up that says, “...xls may contain features that are not compatible with Microsoft Excel 5.0/95 Workbook. Do you want to keep the workbook in this format? Click Yes.

9. Close this window and open the .xls file.

12.2 Translation

1. The values are stored as cubic meters per second and need to be converted to cubic feet per second for consistency in the database. To convert these values, multiply each value by 35.31. Use the Formula in Column F “=[cell]*35.31 and drag down for the entire dataset.

Note: This conversion was adopted from *Hydrologic Units & Conversions*
<http://www.srh.noaa.gov/wgrfc/convert.html>.

2. Select the entire worksheet, then Copy and Paste Special as Values (see hint below) to convert the formulas to values.

Hint: To Paste as Values, click Edit – Copy, then click Edit – Paste Special and choose Values. Remember to keep the entire worksheet highlighted for both the Copy and Paste as Values.

3. Delete the second row (empty).
4. Copy the first row from TEMPLATE worksheet into the first row of your data. Under AGENCY, enter ENVIRONMENT CANADA for each record (Paste over the existing headers).
5. Format the DATE field by selecting the column, then click Format – Cells. Under the Number tab, choose Date and select the 7th option on the pull-down list (14-Mar-98).

12.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3.

13.0 REDD SURVEY DATA PROTOCOL AND ENTRY FORM

The redd survey data are collected by CCT staff in trimble units. The following sections provide two ways to incorporate the data into the database, either by following the protocol for translation once downloaded into excel (Section 13.1), or by entering using the electronic entry form in the database (Section 13.2).

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent REDD data downloaded by date”.

13.1 Protocol

The following procedure outlines the steps to translate the data from the Microsoft Excel (xls) file into the database.

1. Export Trimble data in pathfinder office as OBMEP shapefile (.dbf). Save this file and then export data to a new Microsoft Excel worksheet. Name this file something useful (for example, creek and date of survey).
2. Open Microsoft Excel (Start – All Programs – Microsoft Excel or double click the icon on your desktop, if available).
3. Click File – Open.
4. Navigate to the data file (downloaded from the Trimble Unit, for example “Redd_Sur.xls”, Select and Click Open.
5. Copy the entire worksheet into two duplicate separate worksheets. Name one MASTER SAMPLE and name the other REDD.

13.1.1 Master Sample

The following procedure pertains to the worksheet you just created called MASTER SAMPLE.

1. Insert two columns at the beginning of the file.
2. Copy the first row from the MASTER SAMPLE TEMPLATE and paste copied cells into the first row of your active worksheet (replacing the headers in the first row of your worksheet).
3. Enter the appropriate SITEID into all records (use lkp_SITES to identify the appropriate SITEID, for example “OBMEP-####”)
4. Copy and Paste the columns with the headers into a new worksheet. In the example TEMPLATE workbook (TRANSLATE1 MASTERSAMPLE worksheet) these columns are highlighted in green).
5. Filter the dataset for the unique records. To do this, use the following procedure:
 - a. Select all columns and Click Data – Filter – Advanced Filter.

- b. In the Advanced Filter window, under Action, Choose “Copy to another location”.
 - c. In the same window, click the right hand selector in the “Copy to” box and select a cell in the same worksheet that is below the data (for example, cell A20).
 - d. Check the “Unique records only” checkbox.
 - e. Click OK.
6. Copy and Paste the unique records (and headers) into a new worksheet. You may have to manually delete repeated records. For example, in the sample data provided in the TEMPLATE, the two bottom records have the same MASTER SAMPLE data as the top record. In this case, the final worksheet should only have one record.
 7. Name this worksheet MASTER SAMPLE UNIQUE to keep yourself organized. This is the worksheet that will be imported into the database in Section 13.1.3.
 8. In the SAMPLEID column, count the unique records consecutively starting from one greater than the last SAMPLEID in the MASTER SAMPLE table in the database.
 9. In the BIOEVENT column, enter REDD into all records.

13.1.2 Redd

The following procedure pertains to the REDD worksheet only (created above).

1. Insert one column at the beginning of the file.
2. Copy the first row from the REDD TEMPLATE and paste copied cells into the first row of your active worksheet (replacing the headers in the first row of your worksheet).
3. Copy and Paste the columns with the headers into a new worksheet. In the example TEMPLATE workbook (TRANSLATE1 REDD worksheet) these columns are highlighted in pink.
4. In the SAMPLEID column, enter the appropriate SAMPLEID (as per the MASTER SAMPLE TABLE). For example, in the sample data provided in the template the three records will all have a SAMPLEID of 1.
5. Scan the data for missing entries and fill in as appropriate. For example, in the sample data provided in the template the flag color was only entered for the first records. All three records should have had “red” entered as well.

13.1.3 Importing the Worksheets into the Database

Follow the same steps as outlined in Section 4.3.

13.2 Entry Form

As mentioned above, another option to enter data is to use the electronic entry forms in the database. To open the pre-designed entry forms, Under Objects (on the left-hand side of the Database window), click Forms. The names of the pre-designed form will be displayed in the Database window. Each of these entry forms has the prefix “ENTRYFORM” for sorting purposes.

Double click on the entry form of interest (ENTRYFORM REDDDATA). A box will appear asking for the Data Type. For the Redd data, enter REDD. Once in the form, you can press the Tab key to scroll through the fields. The field descriptor appears in the bottom left hand corner of the screen.

To scroll through the records, click the arrow keys at the bottom of the form. To enter a new record, click the arrow key with the asterisk and a new blank record will open. Database users must be forewarned that all changes to the database are permanent and cannot be reversed (e.g., deleting a record, updating information in a cell, etc.). Because of this, care must be taken when working with the data directly in the entry forms.

Here is an example of the entry form for the Redd Survey Data:

Microsoft Access - [ptbl_MASTER_SAMPLE]

File Edit View Insert Format Records Tools Window Help

Type a question for help

MS Sans Serif 8 B I U

SAMPLEID (Autonumber) 16095

BIOEVENT: REDD

SITEID OKANRT1

CREWMEMBER1 JA DATE (dd-mm-yy) 21-Feb-07 WEATHER Partly Cloudy

CREWMEMBER2 KK WATERTEMP (C): 15 COMMENTS

CREWMEMBER3 TE VIS_DIST_START (m) 3

CREWMEMBER4 VIS_DIST_END (m) 2

CREWMEMBER5

SubEntryForm REDD DATA

	FLAGCOLOR:	FLAGNO:	NO_REDDS:	AD_PRE:	AD_NOTP:	AD_UNK:	MAX_DEPTH:	DIR:	DIST:	LAT_DD:	LONG_DD:
▶	RED	1	2	0	0	0	3	N	25	48.40582382	-119.500306487
	RED	2	3	1	0	2	0	E	30	48.405799935	-119.500305582
	RED	3	5	0	2	0	3	W	15	48.40577902	-119.500306196
*		0	0	0	0	0	0		0	0	0

Record: 1 of 1

Biological Sampling Event ID

NUM

14.0 SNORKEL DATA ENTRY FORM

See the text in Section 13.2 (Redd Data) for instructions on how to use the entry forms.

Hint: To query the database for the last date already incorporated in the database, Double Click on the query “CCTqry_Recent REDD data downloaded by date”.

(EL):

Microsoft Access - [ENTRYFORM SNORKELDATA : Form]

File Edit View Insert Format Records Tools Window Help

Tahoma 8 B I U

SAMPLEID (Autonumber): 201

BIOEVENT: SNORKEL

SITE_ID: 08MEP-360 DATE (dd-mm-yy): 13-Oct-06

AVG_WIDTH: 5.57 START_TIME (24 hr): 10:50 WATER_TEMP_START (F): 44 WEATHER: Sunny

END_TIME (24 hr): 12:08 WATER_TEMP_END (F): 44

VIS_DIST (in feet): 5.57

VIS_QUAL (Poor; Fair; Good; Unknown): GOOD

COMMENTS: Very cold water likely counts are biased low

CREWMEMBER1: JA

CREWMEMBER2: TE

CREWMEMBER3:

CREWMEMBER4:

CREWMEMBERS:

SubEntryForm SNORKEL_DATA

TRANSECT	SPECIES	SIZE_CLASS	NUM_FISH
C-D	Rainbow	100-300mm	3
C-D	Rainbow	<100mm	2
E-F	Rainbow	>300mm	1
E-F	Rainbow	100-300mm	1
F-G	Rainbow	<100mm	1
G-H	Rainbow	100-300mm	8
G-H	Rainbow	>300mm	1
G-H	Trout Brook	100-300mm	22
G-H	Trout Brook	>300mm	6
H-I	Trout Brook	100-300mm	2
H-I	Rainbow	100-300mm	1
I-J	Trout Brook	<100mm	1
I-J	Rainbow	100-300mm	2
J-K	Rainbow	100-300mm	1
G-H	Cottid Unknown	<100mm	1

Add New Record

Record: 2 of 101

Site ID as provided by 01_SITE, '08MEP-' plus 3-digit Site Number.

NUM

15.0 TRAP DATA ENTRY FORM

See the text in Section 13.2 (Redd Data) for instructions on how to use the entry forms. Here is an example of the entry form (ENTRYFORM TRAPDATA) for the Trap Data (for the Data Type, enter TRAP):

Microsoft Access - [ENTRYFORM TRAPDATA : Form]

File Edit View Insert Format Records Tools Window Help Type a question for help

Tahoma 8 B I U

SITENAME: Okanogan River Trap RPM: 8.5 CREWMEMBER1: EB SAMPLEID (Autonumber)
 TIME_START (24 hr): 0:30 DATE_START (dd-mmm-yy): 10-May-06 CALCULATE JULIANDATE 130 CREWMEMBER2: FJ 20
 TIME_END (24 hr): 2:10 DATE_END (dd-mmm-yy): 10-May-06 CREWMEMBER3: CREWMEMBER4: CREWMEMBER5: Add New Record
 Trap Size: 8 FOOT WEATHER: cold, clear and no wind
 Fishing Position (1 or 2): 1
 Redeploy Start Time (24 hr): 3:00 BIOEVENT: TRAP
 Redeploy RPM: TRAP NOTES: Cleaned trap. Flow increased DATA COLLECTED? ☒

Salmonids

	SPECIES:	LIFESTAGE:	COUNT:	MORTALITIES:	AD_CLIP:
▶	Chinook	SMOLT	23	0	Yes
	Sockeye	JUVENILE	37	2	No
	Steelhead	SMOLT	6	0	Yes
*			0	0	

SUM: 68

[Open Form to Enter Individual Fish Data](#)

Non-Salmonids

	SPECIES	COUNT	MORTALITIES
▶		0	0

Number of Marked (i.e., dyed) and Recaptured Salmonids

	SPECIES	TOTALNO_MARKED	TOTALNO_RECAP
▶	Steelhead		1
*			

Record: 19 of 185
 SiteName (lkp_SITES, sorted by Traps) NUM

16.0 VIDEO DATA ENTRY FORM

See the text in Section 13.2 (Redd Data) for instructions on how to use the entry forms. Here is an example of the entry form for the Video Data (for the Data Type, enter VIDEO):

Microsoft Access - [ENTRYFORM VIDEODATA : Form]

File Edit View Insert Format Records Tools Window Help

Tahoma 8 B I U

SiteName: **OBMEP-ZOSEL** Date Started at the Site (dd-mmm-yy): Hard Drive No: 1 Date Removed from the Site (dd-mmm-yy): Comments: SAMPLEID (Autonumber): 7 **BIOEVENT:VIDEO**

INDIVIDUAL FISH OBSERVANCES

Observance Date (dd-mmm-yy): 05-Oct-05 Primary Mark: Unmarked
 Time (hour: 0-23): 0 Secondary Mark:
 Camera No (2 digit): 3 Sex:
 Fish Species: Chinook QUANTITY: 1 Has this motion clip been archived?
 Direction Migrating:
 Notes: Camera 1 becomes Camera 3 on later
 Reviewed By: QAQC By: Date Reviewed: Date QAQC: Enter Today's Date for QAQC
 TIMESTAMP 10/5/2005 0
 Use this Record Selector for Each Fish Observed During a Review Session: Add New Fish Observation

MAINTENANCE (for each HD set in the field)

Enter Today's Date
 Time (hour: 0-23):
 HardDr Motion % (.xx): 30.00%
 Timelapse Amount Free: 99349
 Motion Amount Free: 55058
 Notes:
 Refresh Calculations
 % Motion Free 73%
 % Time Lapse 57%
 Use this Record Selector for Daily Maintenance:
 Record: 1 of 1

Record: 1 of 21

STATUS (lists each date and camera for each site and harddrive)

Camera	Date_Start	# MD Clips Reviewed	Visibility White; Near	Visibility Black; Near	Visibility White; Far	Visibility Black; Far	Video	LIGHT_ON
3	05-Oct-05	488						✓
3	06-Oct-05	10682						✓
3	07-Oct-05	234						✓
*	0							

Add New Video Review Session

Web links: [Lake Osvoos daily mean lake level](#) [Okanogan River at Oroville discharge and temperature data](#)

Use this Record Selector for Each Video Review Session:
 Record: 7 of 33
 Site (lkp_SITE) NUM

17.0 QUALITY ASSURANCE/QUALITY CONTROL

It is important to understand how data quality is maintained through standardized QA/QC procedures. Following importing into the database, all records and tables should be audited. This auditing process involves analyses of outliers (e.g., to identify potential inconsistencies with units) and completeness (e.g., to identify missing samples or missing data); and, checking sample identification numbers (e.g., to ensure that data were not duplicated).

In general, auditing the database includes the following analyses:

- Check all parent-to-child (one-to-many) relationships to ensure the relationships are working appropriately;
- Perform unique queries on all fields to identify outliers;
- Perform min-max queries on all fields to identify outliers; and
- Perform duplicate queries to check for duplicate entries.

Any suspicious values should be checked against original documentation. Any changes that are made manually as a result of the checking should be double-checked by a second auditor.

18.0 CREATING SIMPLE QUERIES

The following instructions outline the basic steps required to create a select query, in query Design View.

1. Under **Objects** (on the left-hand side of the Database window), click **Queries**.
2. Click **New** (top of the Database window).
3. In the **New Query** window select **Design View**, then **OK**.
4. Select data you want to work with by adding the tables or queries that contain data of interest (in the Show Table window, select tables and/or queries, then **Add**). Once you have added the tables you are interested in querying, press the **Close** button in the Show Table window.
5. The query is completed by filling in the design grid, as follows:
 - a. To add a field to the design grid, drag the field from the field list to a column in the design grid, or double-click the field name in the field list (to remove a field from the design grid, click the column selector to highlight the column, and then press the **Delete** key);
 - b. To sort records in the query results, click in the **Sort** cell for the field you want to sort, click the arrow, and then select a sort order from the pull-down list (e.g., ascending);
 - c. To limit the records that you see in the query's results, specify criteria in the **Criteria** row for one or more fields (e.g., to include only Kokanee enter “*Kokanee*”); and,
 - d. To perform calculations on the values in a field, click **Totals** on the toolbar (Sum icon; or select **Totals** from the **View** menu) to display the **Total** row in the design grid, click the arrow, and then select a function by using the pull-down list (e.g., sum, average, etc.).
6. View the results of the query by clicking the **Run** button (exclamation mark icon) on the toolbar, or select **Datasheet View** from the **View** menu.

For more information on queries refer to the MS Office Access Help under the **Help** menu.

19.0 GLOSSARY

Column Component	Horizontal column in a spreadsheet (e.g., A, B, C). The habitat data are a component of several database components that ultimately make up the OBMEP database design. Examples of other database components are the Snorkel data, the Trap data and the Video data.
Data type	The habitat data are split into 6 data types (CANOPY, CHANNEL, LGWOOD, RIPARIAN, SUBSTRATE, and HUMAN). The SAMPLEID for each data type links to the MASTER SAMPLE table.
Highlight	Color coding cells with data.
Row	Vertical row in a spreadsheet (e.g., 1, 2, 3).
Select	Selecting multiple cells using the mouse or keypad
Template	The template worksheets contain the headers as named in the OBMEP database, but are in the same columns as the Trimble output design. Using these templates will simplify importing data into the OBMEP database.
Translation	This is the process of re-arranging vertical spreadsheet to relational horizontal database tables.
Workbook	A Microsoft Excel file that contains multiple worksheets.
Worksheet	A single spreadsheet contained in a Microsoft Excel workbook.