Upper Deschutes Watershed Council
Water Quality Monitoring Program

Water Quality Monitoring Program
Summary of Activities 2006

Upper Deschutes and Little Deschutes Subbasins, Oregon

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Upper Deschutes Watershed Council
Bend, Oregon: December 2006

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Attachments

1.0 The UDWC Water Quality Monitoring Program

The UDWC Water Quality Monitoring Program (WQ Monitoring Program) was initiated in 2001 as a result of the *USGS Framework for Regional, Coordinated Monitoring in the Middle and Upper Deschutes River Basin, 2000* (USGS Framework). A coalition of local, state, and federal partners (partners) comprise a Water Quality Committee (WQ Committee) that guides the WQ Monitoring Program. The WQ Monitoring Program and the WQ Committee have worked together since 2001 on water quality and quantity issues within the Upper Deschutes and Little Deschutes Subbasins.

Currently, the WQ Monitoring Program is crossing jurisdictional boundaries and establishing an understanding of regional conditions based on the Upper Deschutes and Little Deschutes Subbasin boundaries. By increasing our understanding of baseline conditions, the program is providing the capacity to relate water quality changes to resource management activities. The following are the UDWC Program focal services:

- *Coordinating regional monitoring*
  By collaborating with a network of community, local, state, and federal partners active in water quality monitoring, our program is preventing duplication of efforts, promoting the use of standard methods and protocols, and providing monitoring to fill gaps.

- *Compiling and analyzing regional data*
  Our program compiles data obtained from all water quality monitoring efforts of community, local, state, and federal partners across the Upper Deschutes and Little Deschutes Subbasin. This data is loaded into one regional database therefore enabling watershed based analyses that crosses jurisdictional boundaries.

- *Extending outreach & education*
  An increased understanding of the waters within the subbasins is starting to emerge due to the efforts of our program. This understanding is shared with the community via newspaper articles, group presentations, and community events. In addition, this understanding is passed to resource managers therefore promoting better decisions and project designs that help conserve, protect, and enhance our watersheds.

- *Providing technical assistance*
  The technical assistance being provided by our program is ensuring high quality data that is useful and compatible. Various standard methods and protocols for the subbasins have been evaluated and summarized by our program into one source document that serves as a tool for all monitoring efforts. In addition, training our partners in the application of methodologies and protocols for water quality monitoring is increasing the monitoring capacity of the region and increasing the quality of collected data.

2.0 Projects 2006

In order to relate water quality changes to resource management activities, six projects function together to comprise the WQ Monitoring Program. These projects and their accomplishments in 2006 are as follows:

1. *Regional Temperature Monitoring Project (2001 – current)*
   Under this project, continuous temperature monitoring is accomplished in the subbasins. Monitoring is targeted to capture the diurnal, seasonal, and annual variations in temperature that occur during the summer season (June 1 – September 30). In 2006, the continued use of vandal resistant deployment setups designed to collect data appropriately under changing flow conditions were utilized to place equipment into the field resulting in a decrease in the occurrences of equipment vandalization and an increase in the quantity of quality data.

2. *City of Bend Ambient Water Quality Monitoring Project (2004 – 2009)*
   In order to support the City of Bend Stormwater Management Plan, technical assistance has been provided by our program to the City of Bend in an effort to evaluate the Deschutes River waters as they flow through the Urban Growth Boundary (UGB). Innovative methodology and protocols for deploying advanced water quality monitoring equipment are continuing to be used. These vandal resistant deployment setups are designed to collect data appropriately under changing flow conditions resulting in zero occurrences of equipment vandalization and an increase in the quantity of quality data.

3. *Whychus Creek Watershed Project (2006 - 2007)*
   By continuously monitoring parameters that are related to known or expected changes, effectiveness monitoring for the Deschutes River Conservancy (DRC) in-stream flow restoration efforts will be accomplished. The water quality monitoring provided by our program allows for analyses of streamflow and water quality conditions in order to help optimize restoration flow targets to balance with economic resources. Insights gained increase the ability of the DRC to cost effectively provide in-stream flow restoration in the Deschutes Basin.

4. *Volunteer Monitoring Project (2004 – current)*
   By utilizing community volunteers to support the Regional Temperature Monitoring Project, a collaborative relationship between local communities and agencies is formed. Volunteer action increases local understanding of regional prioirty issues, restoration efforts, and state/federal laws and regulations. In 2006, trained volunteers collected continuous temperature data in the Tumalo Creek watershed. Trained volunteers include the community, land owners, Central Oregon Community College, Oregon State University students, the Central Oregon Fly Fishers Association, and Wolftree. In 2006, the project offered the trained volunteers opportunities to monitor in Whychus Creek, Tumalo Creek, Paulina Creek, and the Deschutes River watersheds.

5. *OSU Undergraduate Internship (2005 – 2010)*
   The OSU Intern increases the capacity of regional coordinated monitoring while providing a challenging, learning opportunity that increases hands on experiences and prepares the participating intern for a career in natural resources. The Internship supports the Regional Temperature Monitoring Project via monitoring approximately 20 stations within the Upper Deschutes and Little Deschutes Subbasins. In addition, the OSU Intern provides coordination for the Volunteer Monitoring Project.

6. *Regional Database Project (2001 – current)*
   Water quality data has been collected over the past 14 years by multiple partners. This data is compiled, graded for quality, and entered into a regional database for the Upper Deschutes and Little Deschutes Subbasins. Data is shared with partners and for evaluations of project effectiveness to improve water quality and is instrumental in the Oregon Department of Environmental Quality (ODEQ) assessments of stream health. In 2006, implementation of the US Environmental Protection Agency storage and retrieval database (STORET) (access at www.epa.gov/storet/) was tested to provide online access to water quality data; All continuous temperature data 2004 is available online.

3.0 Outputs 2006

3.1 Strategic Plans 2006

The UDWC Program and the WQ Committee have worked to identify appropriate questions and monitoring approaches for each watershed that will result in better data, decision making, and projects. The following strategic plans for 2006 were developed to guide the program and are attached (**Attachment A**):

1. *Water Quality Committee Memorandum of Understanding 2006 – 2011*

2. *Water Quality Monitoring Program Quality Assurance Project Plan 2006*

3.2 Water Quality Monitoring Technical Summaries 2006

The 2006 water quality monitoring season began in April 2006 and concluded in October 2006. Technical summaries for the 2006 monitoring season were completed in December of 2006. The following technical summaries for 2006 are attached (**Attachment B**):

1. *Lake Creek Restoration Project Effectiveness Monitoring Summary 2006*

2. *Deschutes River Temperature Summary 2004 - 2006*

3. *Deschutes River Temperature Summary 2004 - 2006 presentation*

3.2 Outreach and Education 2006

In 2006, multiple presentations were extended that detail technical summaries, share insights and lessons learned, and provide technical assistance. The following select presentations are attached (**Attachment C**):

1. *Restoration effectiveness monitoring in priority watersheds of the Deschutes Basin 2006; poster*

2. *Adaptive Management 2006: National Fish and Wildlife Foundation Water Transactions Program*

3. *Riverfest; Discover Alder Springs 2006*

4. *Riverfest; Wonders of Whychus 2006*

5. *Central Oregon Community College; Monitoring Water Quality of Deschutes Watersheds 2006*

6. *Rimrock Expeditionary Alternative Learning Middle School (REALMS) 2006*

In addition to the outreach and education that occurs via the OSU Undergraduate Internship, the Volunteer Monitoring Project, the WQ Committee, and community presentations, the WQ Monitoring Program participated in several other events including Salmonwatch on the Metolius 2006, Wolftree on the Metolius 2006, and Hugh Hartman Charter Middle School presentation 2006. During this outreach and education students from central Oregon participated in outdoor educational workshops about water quality in local watersheds.

4.0 Newsworthy Events 2006

The WQ Monitoring Program Water Quality Specialist provides technical assistance to local city councilors, groundwater/stormwater managers, and organizations focused on water quality. In 2006, the Water Quality Specialist participation was documented under the following postings:

1. *The Watershed and Aquatic Habitat Effectiveness Monitoring Workshop 4/2006,* sponsored by the Oregon Watershed Enhancement Board and the Independent Multidisciplinary Science Team, poster presenter, panel participant, and elected speaker for water quality workgroup.

2. *Network of Oregon Watershed Council Newsletter Summer 2006;* article Water Quality Monitoring in the Upper Deschutes.

3. *Sisters low on space for waste; City may use Whychus Creek, Bend Bulletin 7/20/2006*, quoted opinion regarding the release of treated effluent into Whychus Creek.

5.0 Summary Statistics 2006

The Upper Deschutes and Little Deschutes Subbasin includes 18 watersheds totaling over 2 million acres of land and over 1800 river miles. The UDWC facilitates 199 historic stations across the subbasins.

- In 2006, 96 stations were coordinated by our program and monitored by various partners:
  - 52 stations — United States Forest Service
  - 37 stations — UDWC Water Quality Monitoring Program (Including: 6 volunteer stations and 12 City of Bend stations)
  - 5 stations — ODEQ ambient monitoring stations
  - 3 stations — Bureau of Land Management
  - 1 station — Pacific General Electric

- Of the 96 stations:
  - 93 were monitored for continuous temperature
  - 17 stations were monitored for:
    - Dissolved oxygen
    - Percent saturation
    - pH
    - Specific conductance
    - Total dissolved solids
    - Turbidity
    - Nutrients
    - Chlorophyll-*a*
    - *Escherichia coli*
  - 9 stations were monitored for:
    - Dissolved oxygen
    - Percent saturation
    - pH
    - Specific conductance
    - Turbidity
  - 7 stations were monitored with continuous multiparameter monitoring sondes that measured:
    - Dissolved oxygen
    - Percent saturation
    - pH
    - Specific conductance
    - Total dissolved solids
    - Turbidity (four stations only)

1. *Water Quality Committee Memorandum of Understanding 2006 - 2011*
2. *Water Quality Monitoring Program Quality Assurance Project Plan 2006*

1. *Lake Creek Restoration Project Effectiveness Monitoring Summary 2006*
2. *Deschutes River Temperature Summary 2004 - 2006*
3. *Deschutes River Temperature Summary 2004 - 2006 presentation*

1. *Restoration effectiveness monitoring in priority watersheds of the Deschutes Basin 2006; poster*
2. *Adaptive Management 2006: National Fish and Wildlife Foundation Water Transactions Program*
3. *Riverfest; Discover Alder Springs 2006*
4. *Riverfest; Wonders of Whychus 2006*
5. *Central Oregon Community College; Monitoring Water Quality of Deschutes Watersheds 2006*
6. *Rimrock Expeditionary Alternative Learning Middle School (REALMS) 2006*

Memorandum of Understanding

Between

Bureau of Land Management
City of Bend
Deschutes River Conservancy
Oregon Department of Environmental Quality
Oregon Water Resources Department
Oregon Department of Fish and Wildlife
Portland General Electric
Upper Deschutes Watershed Council
US Forest Service Deschutes National Forest
US Forest Service Ochoco National Forest

For

Water Quality Monitoring Program for the Upper Deschutes and Little Deschutes Subbasins

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This Memorandum of Understanding (MOU) is entered into between the Upper Deschutes Watershed Council (UDWC), the Deschutes River Conservancy, the City of Bend, Portland General Electric, the United States Department of Agriculture acting by and through its U.S. Forest Service; Deschutes National Forest and Ochoco National Forest, the United States Department of Interior acting by and through its Bureau of Land Management (BLM), the State of Oregon acting by and through its Oregon Department of Fish and Wildlife (ODFW), Oregon Water Resources Department (OWRD), and the Oregon Department of Environmental Quality (ODEQ), hereinafter jointly referred to as the "Parties."

I. OVERVIEW AND STATEMENT OF MUTUAL BENEFIT AND INTERESTS

The UDWC, Deschutes National Forest, Crooked River National Grassland, BLM, Bureau of Reclamation, ODEQ, OWRD, and the ODFW signed a MOU in 2001 and created a regionally coordinated Water Quality Monitoring Program (WQ Monitoring Program), for the Upper Deschutes River Basin. Since 2001, the UDWC has provided a Water Quality Specialist (WQS) to implement the WQ Monitoring Program, including field monitoring, coordination of partner groups, data compilation and reporting. The MOU that initiated this program expires in February 2006.

The partners in the WQ Monitoring Program agree that a regionally coordinated water quality monitoring program is critically important for the success of long-term water quality restoration efforts, and establishment of this MOU is important to support these continued efforts. A coordinated program increases the regional monitoring capacity, promotes consistent quality assurance and quality control procedures, enhances communication, leverages technical and financial resources, and ensures that the signatories work toward a common goal of water quality restoration in the Upper Deschutes and Little Deschutes Subbasins.

II. PURPOSE

The purpose of this MOU is to implement an integrated water quality monitoring program for the Upper Deschutes and Little Deschutes Subbasins.

III. PROVISIONS

A Water Quality Committee (Committee) shall be formed with one representative of each signatory of this MOU. The Committee shall serve in an advisory capacity to the UDWC WQS.

1. The Committee shall have the following roles:
   - i. Identifying critical monitoring needs and priorities
   - ii. Reviewing data evaluations, documents and technical reports
   - iii. Providing technical expertise to assist in the implementation of the WQ Monitoring Program; and
   - iv. Providing assistance with securing funding for the WQ Monitoring Program.

2. The Committee shall review and endorse the following:
   - i. Annual Monitoring Strategy that outlines activities of the WQ Monitoring Program for the upcoming monitoring season. The Annual Monitoring Strategy is to be prepared by the WQS; and
   - ii. Formal results and publications produced by the WQ Monitoring Program.

IV. AMENDMENTS

This MOU may be amended upon issuance of written amendment signed by all Parties prior to expiration.

V. TERMINATION

This MOU may be terminated by mutual written consent signed by all Parties; or by any Party upon written notice submitted to the other parties. Termination may occur at any time prior to the expiration of this MOU.

VI. PARTICIPATION IN OTHER ACTIVITIES

This MOU in no way restricts the Parties from participating in similar activities with other public or private agencies, organizations or individuals.

VII. NO FINANCIAL OBLIGATION

This MOU is neither a fiscal nor a funds obligation document.

IN WITNESS WHEREOF, the parties have executed this MOU through duly authorized officials as of the last date written below:

BUREAU OF LAND MANAGEMENT

_________________________ / / ______
Printed Name:
Title:

OREGON
DEPARTMENT OF FISH AND WILDLIFE

_________________________ / / ______
Printed Name:
Title:

CITY OF BEND

_________________________ / / ______
Printed Name:
Title:

UPPER DESCHUTES WATERSHED COUNCIL

_________________________ / / ______
Printed Name:
Title:

DESCHUTES RIVER CONSERVANCY

_________________________ / / ______
Printed Name:
Title:

UNITED STATES FOREST SERVICE
DESCHUTES NATIONAL FOREST

_________________________ / / ______
Printed Name:
Title:

OREGON
DEPARTMENT OF ENVIRONMENTAL QUALITY

_________________________ / / ______
Printed Name:
Title:

UNITED STATES FOREST SERVICE
OCHOCO NATIONAL FOREST

_________________________ / / ______
Printed Name:
Title:

OREGON
WATER RESOURCES DEPARTMENT

_________________________ / / ______
Printed Name:
Title:

PORTLAND GENERAL ELECTRIC

_________________________ / / ______
Printed Name:
Title:

Water Quality Committee Guiding Principles

Revised: 1/17/06

It has been decided by the Water Quality Committee that:

1. The Committee shall meet at least annually, but preferably on a more frequent basis as decided by the Committee.

   - Currently the Committee meets between 2:00 – 4:00 on the second Thursday of every odd month at the UDWC conference room.

   - Additional meetings are scheduled as needed.

2. The Committee shall select a chairperson on an annual basis who will be responsible for chairing the Committee meetings.

3. The Water Quality Specialist will develop the agenda for the Committee meetings.

4. Each signatory to this MOU shall have one vote on the Committee.

5. A quorum shall be defined as a minimum of 51% of the signatories of this MOU. A quorum is required for any formal decisions of the Committee.

6. The Committee shall strive to make decisions on a consensus basis. If consensus cannot be achieved, a 2/3 majority vote shall be required to pass formal decisions of the Committee.

QUALITY ASSURANCE PROJECT PLAN

2006

Project Name: Water Quality Monitoring Program

Partners:
Bureau of Land Management
Bureau of Reclamation
City of Bend
Oregon Department of Environmental Quality
Oregon Water Resources Department
Oregon Department of Fish and Wildlife
United States Forest Service
Upper Deschutes Watershed Council

QA Officer - State	Steve Hanson, Monitoring Specialist Oregon Department of Environmental Quality	Date
QA Officer - Subbasin	Bonnie Lamb, Natural Resource Specialist Oregon Department of Environmental Quality	Date
Project Director	Ryan Houston, Executive Director Upper Deschutes Watershed Council	Date
Project Manager	Lesley Jones, Water Quality Specialist Upper Deschutes Watershed Council	Date

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GROUP A. PROJECT MANAGEMENT

A3. Distribution List

The following is a partner distribution list:

- Bureau of Land Management
- Bureau of Reclamation
- City of Bend
- Oregon Department of Environmental Quality
- Oregon Water Resources Department
- Oregon Department of Fish and Wildlife
- United States Forest Service
- Upper Deschutes Watershed Council

This document is available upon request by contacting:

Upper Deschutes Watershed Council
700 NW Hill Street
Bend, OR 97701
541-382-6103

A4. Project Task / Organization

The Water Quality Monitoring Program (WQ Monitoring Program) was initiated in 2001 and is guided by the *USGS Framework for Regional, Coordinated Monitoring in the Middle and Upper Deschutes River Basin* (2000) (USGS Framework). A Water Quality Committee consisting of multiple partners provides direction to the Water Quality Specialist who implements the USGS Framework and facilitates the WQ Monitoring Program. The Water Quality Committee includes the following partners:

- Bureau of Land Management
- Bureau of Reclamation
- Oregon Department of Environmental Quality
- Oregon Water Resources Department
- Oregon Department of Fish and Wildlife
- United States Forest Service
- Upper Deschutes Watershed Council

The following is a list of all key personnel under the Water Quality Committee, their organizations, and contact information:

Table 1 Project Personnel

Name	Organization	Title	Contact Information
Michelle McSwain	Bureau of Land Management	Hydrologist	541-416-6877
Larry Zakrajsek	Bureau of Reclamation	Water and Land Specialist	541-389-6541 x230
Bonnie Lamb	Oregon Department of Environmental Quality	Natural Resource Specialist	541-388-6146 x239
Ted Wise	Oregon Department of Fish and Wildlife	Assistant District Fish Biologist	541-388-6363
Kyle Gorman	Oregon Water Resources Department	South Central Region Manager	541-388-6669
Marc Wilcox	United States Forest Service	Forest Hydrologist	541-383-5537
Ryan Houston	Upper Deschutes Watershed Council	Executive Director	541-382-6102
Lesley Jones	Upper Deschutes Watershed Council	Water Quality Specialist	541-383-6850

A5. Purpose Statement / Problem Definition / Background

Purpose Statement

The purpose of the WQ Monitoring Program is to provide baseline information to fill data gaps, evaluate water quality improvements associated with the instream flow restoration in the Upper Deschutes Subbasin, and support future TMDL implementation. The WQ Monitoring Program creates the foundation upon which our partners can develop effective, efficient water quality protection and management efforts.

Problem Definition

In the Upper Deschutes and Little Deschutes Subbasin there are more than 380 miles of waterways listed as impaired under Section 303(d) of the Clean Water Act. The listed impairments are displayed in **Table 3** and listed waterways are displayed on **Map 1**. Many factors contribute to water quality impairment across the subbasins, yet, according to the Upper Deschutes Subbasin Assessment 2003, stream dewatering from agricultural diversions has been identified as the single most important factor in poor water quality (UDWC, 2003b).

In order to address water qulaity impairment and since the early 1990's, local, state and federal partners have been working collaboratively to improve instream flows in key reaches of Tumalo Creek, Whychus Creek and the upper Deschutes River. The achieved flow restoration is provided in **Table 2**.

Table 2 Restored and Target Flows

	Pre-1990 Flow (cfs)	Current Flow (cfs)	Target Flow (cfs)
Upper Deschutes River middle reach	30	50	250
Whychus Creek (at Sisters)	0	7	20
Tumalo Creek (below irrigation diversion)	0	8	20

cfs = cubic feet per second

The flow restoration is focused on improving water quality, fish habitat and, ultimately, the removal of these reaches from the 303(d) list. Despite major improvements in flow over the past 10 years, there have not been focused monitoring efforts designed to specifically evalute the changes in water quality associated with instream flow restoration or upcoming TMDL implementation.

In order to address this need the Water Quality Committee drafted a Monitoring Strategy for 2006/2007. Under this strategy, the WQ Monitoring Program provides regional coordinated monitoring with set program goals that meet the objectives outlined in the USGS Framework. The main goals of the WQ Monitoring Program are to:

1. Provide baseline water quality conditions of parameters that are expected to change due to instream flow restoration and TMDL implementation;

2. Evaluate the targets for instream flow restoration;

3. Inform proactive restoration efforts by providing the data need to evaluate, model, and track restoration effectiveness; and

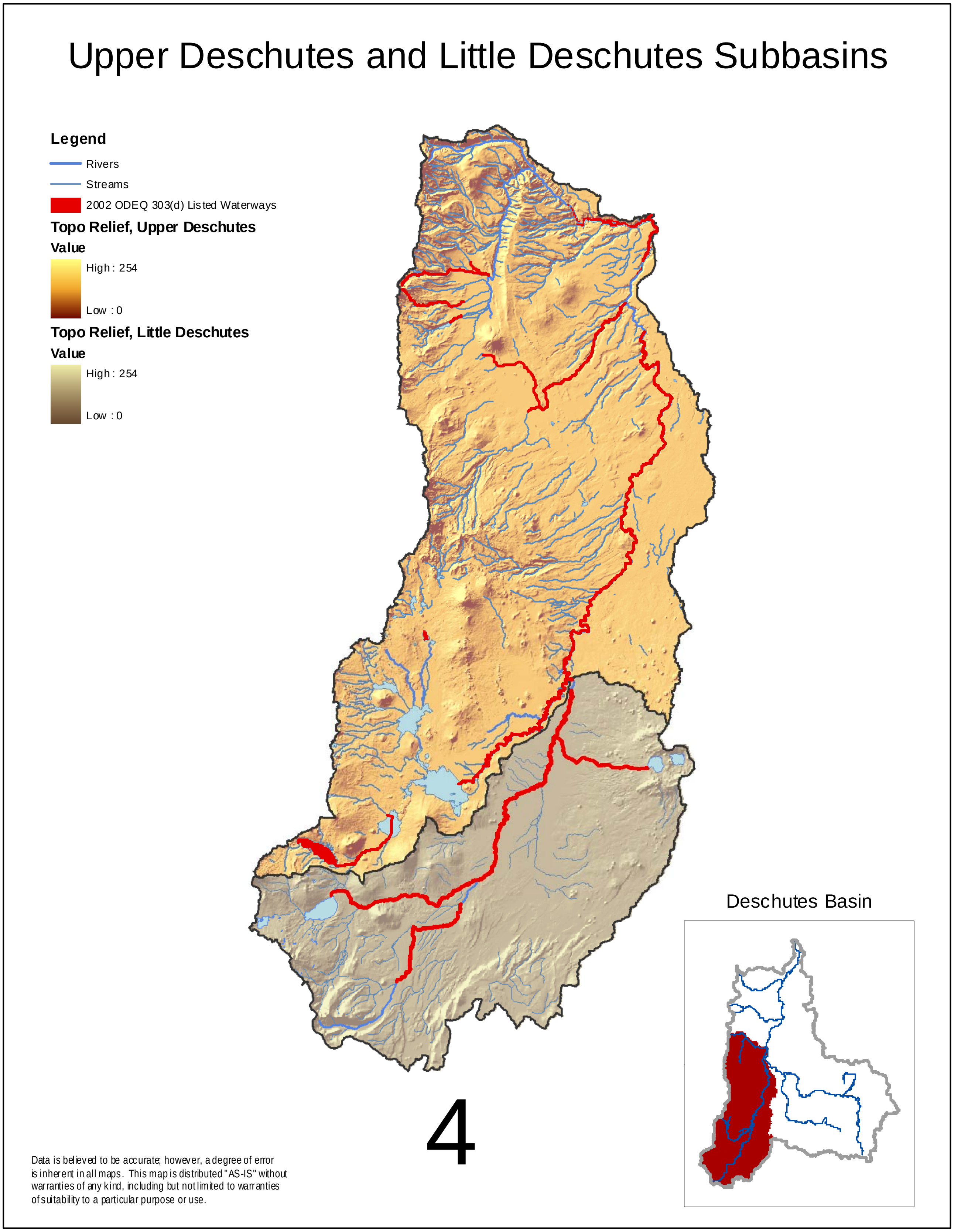
4. Support future TMDLs through monitoring implementation effectiveness and sharing data with the Oregon Department of Environmental Quality.

In 2006 / 2007, the WQ Monitoring Program will continue to implement the USGS Framework. Regional coordinated monitoring will be continued in the Upper Deschutes and Little Deschutes Subbasin and will target the Upper Deschutes River, Whychus Creek, and Tumalo Creek watersheds.

Table 3 303(d) Listed Waters per ODEQ 303(d) list 2002

Waterbody Name	River Mile	Parameter	Season	List Date
Upper Deschutes River watershed				
Deschutes River	0 to 46.4	pH	Summer	1998
Deschutes River	0 to 46.4	Temperature	September 1 - June 30	2002
Deschutes River	0 to 46.4	Temperature	Summer	1998
Deschutes River	46.4 to 99.8	Dissolved Oxygen	September 1 - June 30	1998
Deschutes River	46.4 to 99.8	pH	Winter/Spring/Fall	2002
Deschutes River	46.4 to 99.8	Temperature	September 1 - June 30	2002
Deschutes River	46.4 to 99.8	Temperature	Year Around	1998
Deschutes River	126.4 to 162.6	pH	Winter/Spring/Fall	2002
Deschutes River	126.4 to 162.6	pH	Summer	1998
Deschutes River	126.4 to 162.6	Temperature	September 1 - June 30	2002
Deschutes River	126.4 to 162.6	Temperature	Summer	1998
Deschutes River	162.6 to 168.2	pH	Summer	1998
Deschutes River	162.6 to 168.2	Temperature	Summer	2002
Deschutes River	162.6 to 168.2	Temperature	September 1 - June 30	2002
Deschutes River	168.2 to 189.4	Chlorophyll a	June 1 - September 30	2002
Deschutes River	168.2 to 189.4	Dissolved Oxygen	July 1 - August 31	2002
Deschutes River	168.2 to 189.4	Dissolved Oxygen	September 1 - June 30	1998
Deschutes River	168.2 to 189.4	Sedimentation	none stated	1998
Deschutes River	168.2 to 189.4	Temperature	September 1 - June 30	2002
Deschutes River	168.2 to 189.4	Turbidity	Spring/Summer	1998
Deschutes River	189.4 to 222.2	Turbidity	Spring/Summer	1998
Deschutes River	189.4 to 222.2	Dissolved Oxygen	September 1 - June 30	1998
Deschutes River	189.4 to 222.2	Sedimentation	none stated	1998
Lava Lake	0 to 0	Dissolved Oxygen	June 1 - September 30	2002
Odell Creek	0 to 11	Temperature	Summer	2002
Odell Creek	0 to 11	Temperature	September 1 - June 30	2002
Odell Lake/Odell Creek	11 to 16.3	pH	Summer	1998
Metolius River watershed				
Brush Creek	0 to 2	Temperature	Year Around	2002
Canyon Creek	0 to 11.4	Temperature	Year Around	2002
Crescent Creek	0 to 26.1	Temperature	Summer	1998
First Creek	3.6 to 12.1	Temperature	September 1 - June 30	2002
Lake Creek	0 to 1.5	Temperature	Summer	1998
Lake Creek	0 to 1.5	Temperature	Summer	1998
Whychus Creek watershed				
Indian Ford	0 to 11.2	Temperature	Summer	2002
Whychus Creek	0 to 1.6	Temperature	September 1 - June 30	2002
Whychus Creek	1.6 to 21	Temperature	Summer	2002
Whychus Creek	1.6 to 21	Temperature	September 1 - June 30	2002
Little Deschutes River watershed				
Little Deschutes River	0 to 54.1	Dissolved Oxygen	September 1 - June 30	2002
Little Deschutes River	0 to 54.1	Dissolved Oxygen	July 1 - August 31	2002
Little Deschutes River	54.1 to 78	Temperature	Summer	1998
Little Deschutes River	54.1 to 78	Temperature	September 1 - June 30	2002
Paulina Creek	0 to 13.2	Temperature	Summer	1998

Map 1 2002 ODEQ 303(d) Listed Waterways



Background

Upper Deschutes Subbasin

The Upper Deschutes Subbasin includes four study areas based on 5th field hydrologic unit boundaries and include the upper Deschutes watershed, Metolius River watershed, Whychus Creek watershed, and Tumalo Creek watershed (**Map 2**) (UDWC, 2003a,b,c).

Upper Deschutes watershed

The Deschutes River flows south from Little Lava Lake to Crane Prairie Reservoir, travels east through Wickiup Reservoir, north through Bend, and finally north to Lake Billy Chinook. The Upper Deschutes River is approximately 132 miles long, and contains three study areas based on 6th field hydrologic unit boundaries:

- Above Wickiup reach: The Deschutes River begins at the headwaters of Lava and Little Lava lakes at RM 253 then flows into Crane Prairie Reservoir, which is the first of two impoundments. The Deschutes River continues for two miles and flows into a second, larger impoundment Wickiup Reservoir.

- Upper Deschutes reach: From Wickiup Reservoir outlet at RM 222, the Deschutes River flows in a northerly direction to the end of this reach at RM 164 located at the North Canal Dam in the City of Bend. Main tributaries within the upper Deschutes reach include Fall River, Little Deschutes River, and Spring River.

- Middle Deschutes reach: From the North Canal Dam at RM 164, the Deschutes River flows in a northerly direction for approximately 44 miles to the inflow of Lake Billy Chinook at RM 120. There are two major tributaries along this reach: Tumalo Creek and Whychus Creek. Tumalo Creek is located at RM 160.2 and Whychus Creek is located at RM 123.

Metolius River Watershed

The Metolius River source is at the Head of the Metolius headwater springs, it flows north through Camp Sherman, around Green Ridge, and heads south east at approximately RM 20 until it flows into Lake Billy Chinook. The Metolius River is a major tributary of the Deschutes River, but due to the establishment of the Pelton Round Butte Dam Complex the Metolius River now flows into Lake Billy Chinook. The Metolius River is approximately 41 miles long.

Whychus Creek Watershed

The Whychus Creek source is springs and snow/glacial melt with a small amount from direct precipitation runoff. There are a series of springs along Whychus Creek that contribute a significant amount of flows to the mainstem. Major tributaries include Snow Creek, Pole Creek, and Indian Ford Creek. Pole Creek is usually completely diverted for irrigation purposes and so does not flow into Whychus Creek during the summer. During the summer months in most years, Indian Ford Creek does not contribute surface flows into Whychus Creek. Whychus Creek is approximately 39 miles long.

Tumalo Creek Watershed

The Tumalo Creek watershed source is primarily from springs and snowmelt originating in the snowpack of the western part of the watershed. Headwater tributaries include: South, Middle, and North Forks of Tumalo Creek. Major tributaries include Bridge Creek and Tumalo Lake Creek. Tumalo Creek is approximately 18 miles long.

Little Deschutes Subbasin

The Little Deschutes Subbasin contains one study area with seven watersheds based on 5th field hydrologic unit boundaries (**Map 2**). These watersheds include: Newbery, Little Deschutes, Long Prairie, Sellers, Walker Mountain, Upper Little Deschutes and Crescent. The Little Deschutes River headwaters tributaries include Clover Creek and Hemlock Creek. The river flows north from its headwaters approximately 97 miles to the Deschutes River. Major tributaries include Crescent Creek and Paulina Creek. The headwater of Crescent Creek is Crescent Lake, a natural lake that has been turned into a reservoir, and Crescent Creek has three tributaries: Cold Creek, Refrigerator Creek, and Big Marsh Creek. The headwater of Paulina Creek is Paulina Lake, another natural lake that has been converted into a reservoir, and Paulina Creek, although considered a tributary of the Little Deschutes River, does not have enough flow in most years to reach the river and dissipates into Paulina Prairie. (UDWC, 2002)

Upper Deschutes and Little Deschutes Subbasin Modifications

There are multiple modifications to the waterways of the subbasins that have the potential to affect water quality. On the Deschutes River, these features include two reservoirs, six diversions, two hydroelectric facilities, and four dams. On Tumalo Creek, these modifications include two diversions located at two dams. On Whychus Creek, these features include seven major diversions.

Deschutes River Modifications

Under natural conditions, the hydrology of the Deschutes River would be based on the inflow of groundwater and major tributaries. Because the Deschutes River is spring fed, the hydrologic regime would naturally be very stable and uniform as compared to fluctuations seen in surface runoff fed systems (USFS, 1996). Currently, conditions are modified as follows:

- Above Wickiup reach: From the cold headwater springs at Lava Lake, the Deschutes River flows through the warm, shallow, and wide Crain Prairie Reservoir. Next, the river flows into Wickiup Reservoir. Wickiup Reservoir regulates the flows downstream that are diverted and travel through several hundred miles of canals in order to meet agricultural needs of areas to the north. During the irrigation season from April to October, the upper Deschutes reach averages approximately 1200 cfs as water is released from Wickiup Reservoir. Conversely, during the storage season from November to March flows in the upper Deschutes reach below Wickiup Reservoir can drop to as little as 20 cfs.

- Upper Deschutes reach: From Wickiup Reservoir, the Deschutes River flows north towards the southern boundary of the City of Bend near the first diversion at Arnold Canal. After crossing into the city Urban Growth Boundary, an additional diversion is located at the Central Oregon Canal. During high flow years, excess water from the Central Oregon Canal is diverted to the Central Oregon Irrigation District Hydroelectric Plant and then returned to the river. Further downstream, near the Old Mill District, the Deschutes River meets Colorado Avenue Dam. Passing this dam, the Deschutes River flows into Mirror Pond, a 40-acre impoundment created by the Bend Hydroelectric Project Dam. Next, the Deschutes River reaches the Steidl Dam and Tumalo Irrigation District Bend Feed Canal. Finally, the Deschutes River meets the North Canal Dam, which diverts waters to three canals including North Unit Main Canal, North Canal, and Swalley Canal.

- Middle Deschutes reach: Due to the diversions in the upper Deschutes reach, the hydrology of the middle reach during the summer months consists of low flows downstream of the North Canal Dam located at RM 164. At river mile 160, Tumalo Creek contributes variable amounts of cfs depending on how much water is diverted from the creek by Tumalo Irrigation District. Flows remain low until the groundwater influences at RM 133 where a series of spring complexes starting near Lower Bridge add cool flow to the Deschutes River. Further downstream, Whychus Creek contributes approximately 100 cfs of cold water to the Deschutes River.

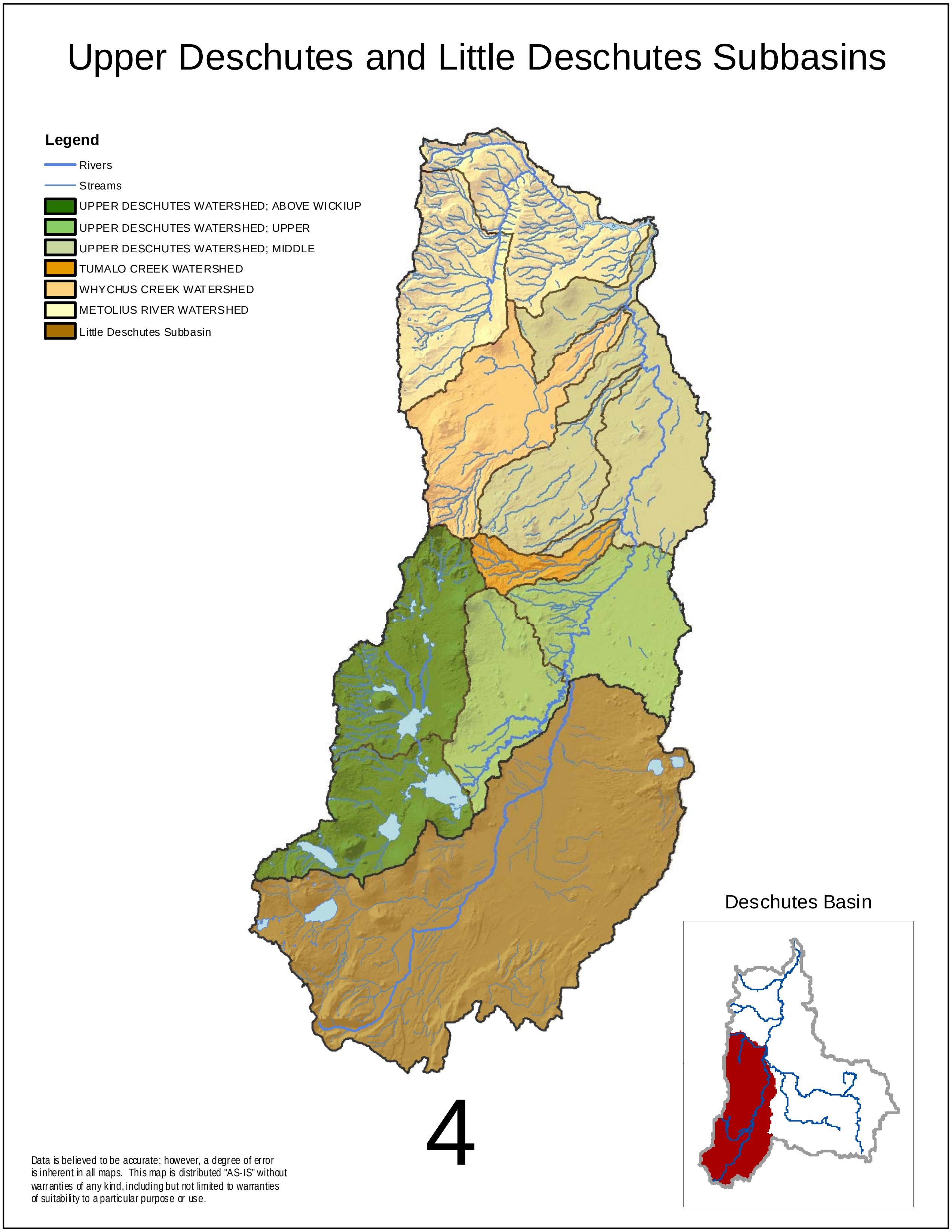
Tumalo Creek Modifications

Within Tumalo Creek watershed, a dam in combination with a diversion of municipal water supply from Bridge Creek occurs prior to its confluence with Tumalo Creek. Tumalo Creek is also obstructed by a dam and diverted by the Tumalo Feed Canal prior to its confluence with the Deschutes River.

Whychus Creek Modifications

The largest water diversion in the watershed is the Whychus Creek canal managed by Whychus Creek Irrigation District and located at RM 23.5. There are several other major diversions above the city of Sisters between the two gauges including: McCallister, Plainview, Lazy Z, Edgington, Sokol and Leithauser diversions.

Map 2 Study Areas



A6. Project Task Description

In order to meet the WQ Monitoring Program goals, six projects function together to accomplish regional coordinated monitoring:

1) *Regional Temperature Monitoring Project (2001 – current)*
   Under this project, continuous temperature monitoring is accomplished at 89 stations in the Upper Deschutes and Little Deschutes Subbasins. Monitoring is targeted to capture the diurnal, seasonal, and annual variations in temperature that occur during the summer season (June 1 – September 30).

2) *City of Bend Water Quality Monitoring Project (2004 – 2009)*
   Monitoring is designed to support the City of Bend Stormwater Management Plan and to provide an understanding of diurnal, seasonal, and annual variations in multiple parameters that are currently 303(d) listed. The UDWC trained the City of Bend to conduct monitoring on the Deschutes River and Tumalo Creek within the Urban Growth Boundary (UGB). Grab sampling and continuous temperature monitoring is conducted at twelve stations and continuous multiparameter monitoring is conducted at 5 stations. Monitoring occurs during one fall/winter/spring month and during the summer season (June 1 – September 30). The UDWC contributes data management and technical reporting.

3) *Whychus Creek Watershed Project (2006 - 2008)*
   By continuously monitoring parameters that are related to known or expected changes, effectiveness monitoring for the Deschutes River Conservancy (DRC) Water Acquisitions Program will be accomplished. Water quality monitoring will correlate streamflow and water quality conditions at ten stations within the watershed.

4) *Regional Database Project (2001 – current)*
   Water quality data has been collected over the past 14 years by multiple agencies. This data is compiled, graded for quality, and is entered into a comprehensive database for the Upper Deschutes and Little Deschutes Subbasins. Data is shared with partners and is instrumental in the ODEQ and USEPA watershed restoration objectives and partner project effectiveness evaluations. Implementation of the USEPA database STORET will be used to streamline the data submission process to ODEQ and will provide efficient and timely online access to water quality data.

5) *Volunteer Monitoring Project (2004 – current)*
   By utilizing community volunteers to support the Regional Temperature Monitoring Project, a collaborative relationship between local communities and agencies is formed. Volunteer action increases local understanding of regional prioirty issues, restoration efforts, and state/federal laws and regulations. Annually, trained volunteers provide approximately 300 hours towards monitoring 10 stations within the Upper Deschutes and Little Deschutes Subbasins.

6) *OSU Intern Project (2005 – 2010)*
   The OSU Intern increases the capacity of regional coordinated monitoring while providing a challenging, learning opportunity that increases hands on experiences and prepares the participating intern for a career in natural resources. The Internship supports the Regional Temperature Monitoring Project via monitoring approximately 20 stations within the Upper Deschutes and Little Deschutes Subbasins. In addition, the OSU Intern provides coordination for the Volunteer Monitoring Project.

The WQ Monitoring Program is designed to collect information at 90 stations in the Upper Deschutes and Little Deschutes Subbasins (**Table 4** and **Map 3**). The WQ Monitoring Program follows an annual timetable outlining coordination, pre-season preparation, monitoring season, post-season tasks, and reporting (**Table 6**).

There are multiple monitoring efforts across the Upper Deschutes and Little Deschutes that are coordinated by the UDWC Water Quality Monitoring Program. The UDWC partners, Water Quality Specialist, OSU Intern, and volunteers comprise a field crew that conducts monitoring. Monitoring consists of continuous temperature monitoring, grab samples, and continuous multiparameter monitoring. The City of Bend and the ODEQ both have additional monitoring not covered in this QAPP that can be referenced under the City of Bend QAPP and at the ODEQ website at http://www.deq.state.or.us/ (UDWC, 2005).

Continuous Temperature

Eighty nine stations are evaluated for continuous temperature monitoring. There are 24 stations located on the Deschutes River, six stations located on the Little Deschutes River, 4 stations located on Tumalo Creek, ten stations located on Whychus Creek, 3 stations located on the Metolius River, and 42 stations located on major tributaries across the subbasins. (**Map 4**)

Grab Samples

Grab sampling is conducted at 27 stations. There are 14 stations located on the Deschutes River two of which are utilized for split sampling (11 City of Bend, 3 ODEQ, 1 UDWC, and 1 PGE). There are 10 stations on Whychus Creek that are monitored by the UDWC, two stations on Tumalo Creek that are monitored by the City of Bend, and one station on the Little Deschutes River that is monitored by the ODEQ. (**Map 5**)

Continuous Multiparameter Monitoring

Eight continuous multiparameter monitoring stations collect data in the Upper Deschutes Subbasin. Five stations are operated by the City of Bend and include two sondes deployed at fixed monitoring stations and one sonde that roams through three monitoring stations. The UDWC operates three stations and includes two sondes that are used at two stations on Whychus Creek and one station on the Upper Deschutes River middle reach. Total, the Deschutes River has six and Whychus Creek has two continuous multiparameter monitoring stations. (**Map 6**)

Table 4 Monitoring Locations

	Station ID*	System	Location	CT	G	CMP
1	AC	Abbot Creek	1280 Rd crossing	X		
2	AC 001.00	Abbot Creek	Lower Rd 12	X		
3	BC 000.25	Brush Creek	Rd 12	X		
4	BMC	Big Marsh Creek	West ditch	X		
5	BMC 005.25	Big Marsh Creek	Rd 6020	X		
6	BMC 007.75	Big Marsh Creek	North end d/s ditches	X		
7	BMC 009.00	Big Marsh Creek	Mainstem u/s ditches	X		
8	BMC 013.25	Big Marsh Creek	South end of marsh	X		
9	CaC 001.75	Canyon Creek	Rd 12	X		
10	CaC 005.00	Canyon Creek	Rd 1230	X		
11	CC 001.25	Candle Creek	d/s 1290 bridge	X		
12	CC 004.00	Candle Creek	Jefferson trailhead	X		
13	CrC 003.00	Crescent Creek	Hwy 61 crossing	X		
14	CrC 030.75	Crescent Creek	u/s Rd 6015 (d/s dam)	X		
15	CrC 025.75	Crescent Creek	Lower end of private u/s Big Marsh Creek	X		
16	DR 120.00	Deschutes River	USGS gaging station u/s Lake Billy Chinook	X	X	
17	DR 123.00	Deschutes River	d/s Whychus Creek	X		
18	DR 123.25	Deschutes River	u/s Whychus Creek	X		
19	DR 127.75	Deschutes River	u/s Steelhead Falls	X		
20	DR 133.50	Deschutes River	u/s Lower Bridge	X	X	X
21	DR 146.00	Deschutes River	u/s Cline Falls State Park	X		
22	DR 158.50	Deschutes River	d/s end Tumalo State Park	X		
23	DR 160.00	Deschutes River	d/s Tumalo Boulder Field	X	X	X
24	DR 160.25	Deschutes River	u/s Tumalo Creek	X	X	X
25	DR 163.25	Deschutes River	Firerock footbridge	X	X	
26	DR 164.75	Deschutes River	u/s Riverhouse Hotel	X	X	X
27	DR 165.75	Deschutes River	First St. Rapids	X	X	
28	DR 166.75	Deschutes River	Drake Park Footbridge	X	X	X
29	DR 167.25	Deschutes River	Columbia Park Footbridge	X	X	
30	DR 168.00	Deschutes River	Columbia St. Bridge	X	X	
31	DR 169.00	Deschutes River	u/s end Mill Log Pond	X	X	
32	DR 172.00	Deschutes River	Southern UGB	X	X	X
33	DR 181.50	Deschutes River	Benham Falls Footbridge	X		
34	DR 191.75	Deschutes River	Harper Bridge	X	X	
35	DR 217.25	Deschutes River	Pringle Falls Experimental Station	X	X	
36	DR 237.50	Deschutes River	d/s Browns Crossing	X		
37	DR 243.75	Deschutes River	Cow camp	X		
38	DR 246.75	Deschutes River	d/s Deschutes bridge at pullout by mm 42	X		
39	DR 250.50	Deschutes River	d/s Little Lava Lake	X		
40	FR 001.25	Fall River	1.5 mile u/s mouth	X		
41	FiC 004.00	First Creek	FS Rd 12	X		
42	HC 000.25	Hemlock Creek	Mouth / Rd 5835	X		
43	JC 000.75	Jack Creek	1420 Rd	X		
44	JeC 002.00	Jefferson Creek	1290 bridge	X		
45	LC 002.50	Lake Creek	trail 99	X		
46	LDR 000.25	Little Deschutes River	Mouth	X		

	Station ID*	System	Location	CT	G	CMP
47	LDR 005.50	Little Deschutes River	Hwy 42, South Century Dr., Rd 2114		X	
48	LDR 026.75	Little Deschutes River	OWRD gauge La Pine	X		
49	LDR 057.75	Little Deschutes River	Rd 62 crossing	X		
50	LDR 067.00	Little Deschutes River	Off Rd 100 near Crescent	X		
51	LDR 078.50	Little Deschutes River	Rd 5825 at USFS property boundary (d/s of hwy 58)	X		
52	LDR 089.00	Little Deschutes River	Cow Camp	X		
53	LnC ?	Link Creek	?	X		
54	MR 030.25	Metolius River	Bridge 99	X		
55	MR 037.00	Metolius River	Gorge Campground	X		
56	MR 040.00	Metolius River	d/s tract C bridge	X		
57	OC	Odell Creek	d/s East Odell Creek camp	X		
58	OC 002.00	Odell Creek	4660 Rd Crossing	X		
59	OC 004.00	Odell Creek	d/s Maklaks	X		
60	OC 008.25	Odell Creek	Resort bridge	X		
61	OCt2 ?	Odell trib #2	Mouth of 1st left bank trib u/s Maklaks Creek	X		
62	PC 006.50	Paulina Creek	Rd 21 / USFS Boundary	X		
63	PC 015.75	Paulina Creek	d/s Paulina Lake outlet	X		
64	RoC 000.25	Roaring Creek	Rd 1260	X		
65	SC 000.25	Whychus Creek	Mouth	X	X	
66	SC 001.50	Whychus Creek	d/s Alder springs	X	X	
67	SC 003.00	Whychus Creek	u/s Alder springs	X	X	
68	SC 006.00	Whychus Creek	u/s Rd 6360	X	X	
69	SC ~ RM 10	Whychus Creek	Rim Rock Ranch	X	X	X
70	SC 018.25	Whychus Creek	d/s end DBLT property	X	X	
71	SC 019.50	Whychus Creek	d/s Camp Polk Bridge on DBLT property	X	X	
72	SC 024.25	Whychus Creek	City Park, d/s gauge	X	X	
73	SC 026.00	Whychus Creek	4606 Rd, footbridge	X	X	
74	SC 030.25	Whychus Creek	USGS gauge	X	X	X
75	SnC 000.25	Snow Creek	u/s confluence Deschutes River	X		
76	SnC 004.75	Snow Creek	Rd 4270 crossing	X		
77	SnC 006.25	Snow Creek	Headwater springs	X		
78	SoC	Soda Creek	d/s falls	X		
79	SoC 001.25	Soda Creek	d/s of Rd 46 aprox 1/4 mi at wire fence line	X		
80	SpC 001.00	Spruce Creek	Rd 5830	X		
81	StC 000.25	Street Creek	Rd 64 Crossing	X		
82	TC 000.25	Tumalo Creek	mouth	X	X	
83	TC 003.25	Tumalo Creek	d/s Tumalo Feed Canal gauge	X		
84	TC 007.50	Tumalo Creek	u/s 4606 Rd	X	X	
85	TC 014.50	Tumalo Creek	d/s Skyliner bridge	X		
86	TC 017.25	Tumalo Creek	d/s Bridge Creek	X		
87	TCSF 000.25	Tumalo Creek South Fork	Mouth	X		
88	TrC 000.75	Trapper Creek	u/s footbridge	X		
89	TtC 006.75	Trout Creek	1018 Rd, Whispering Pines camp	X		
90	TtC 008.25	Trout Creek	Rd 1018 upper crossing	X		

(CT) = Continuous Temperature Monitoring
(G) = Grab Samples
(CMP) = Continuous Multiple Parameter Monitoring
*System and river mile**
** USGS topography maps, NAD 85

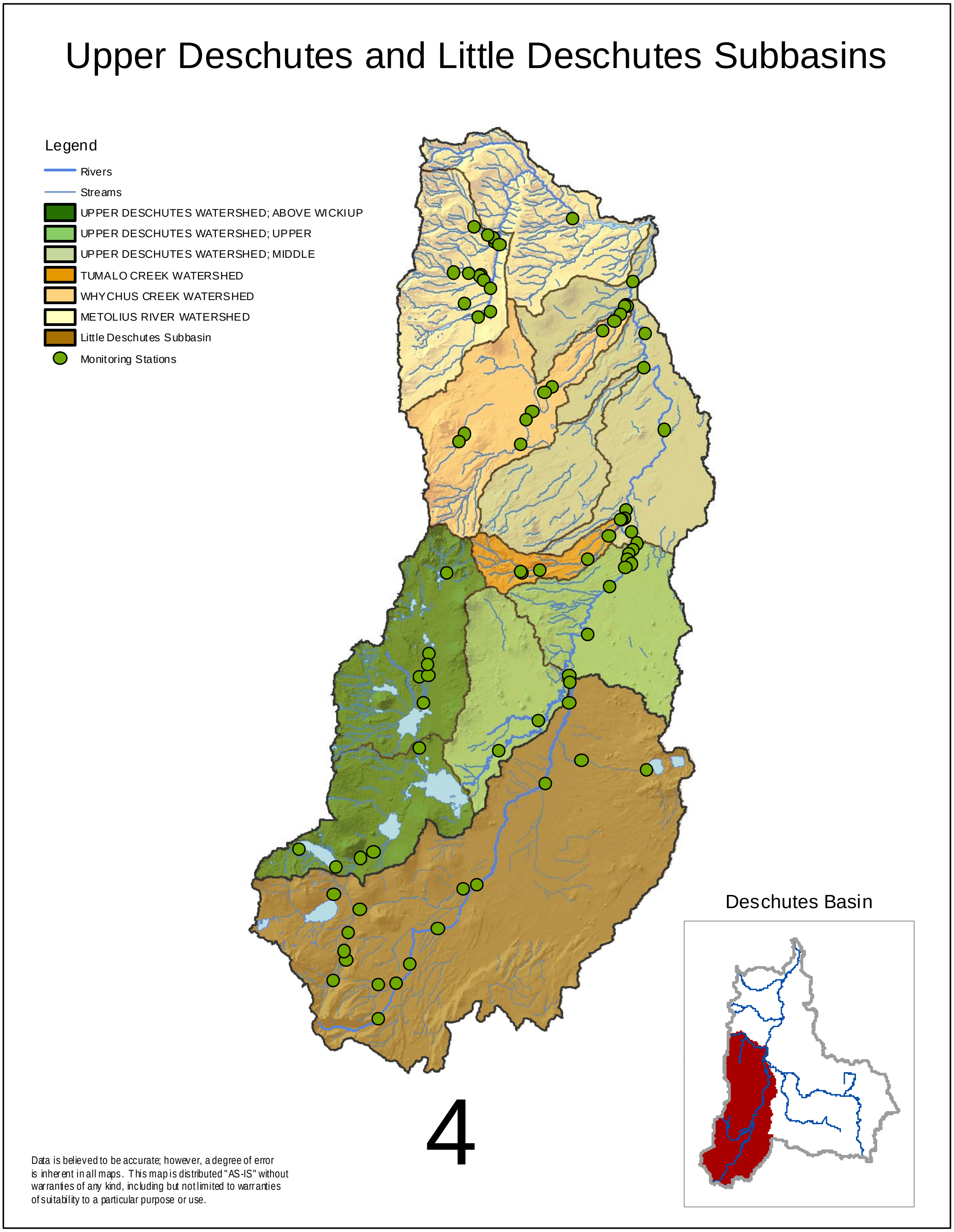
Table 5 Parameters

Monitoring	Parameters
Continuous Temperature (CT)	Continuous temperature
Grab samples (G)	pH
	Dissolved oxygen
	Percent saturation
	Specific Conductance and calculated TDS
	Turbidity
Continuous Multiparameter Monitoring (CM)	Continuous dissolved oxygen
	Continuous percent saturation
	Continuous pH
	Continuous Specific Conductance and calculated TDS

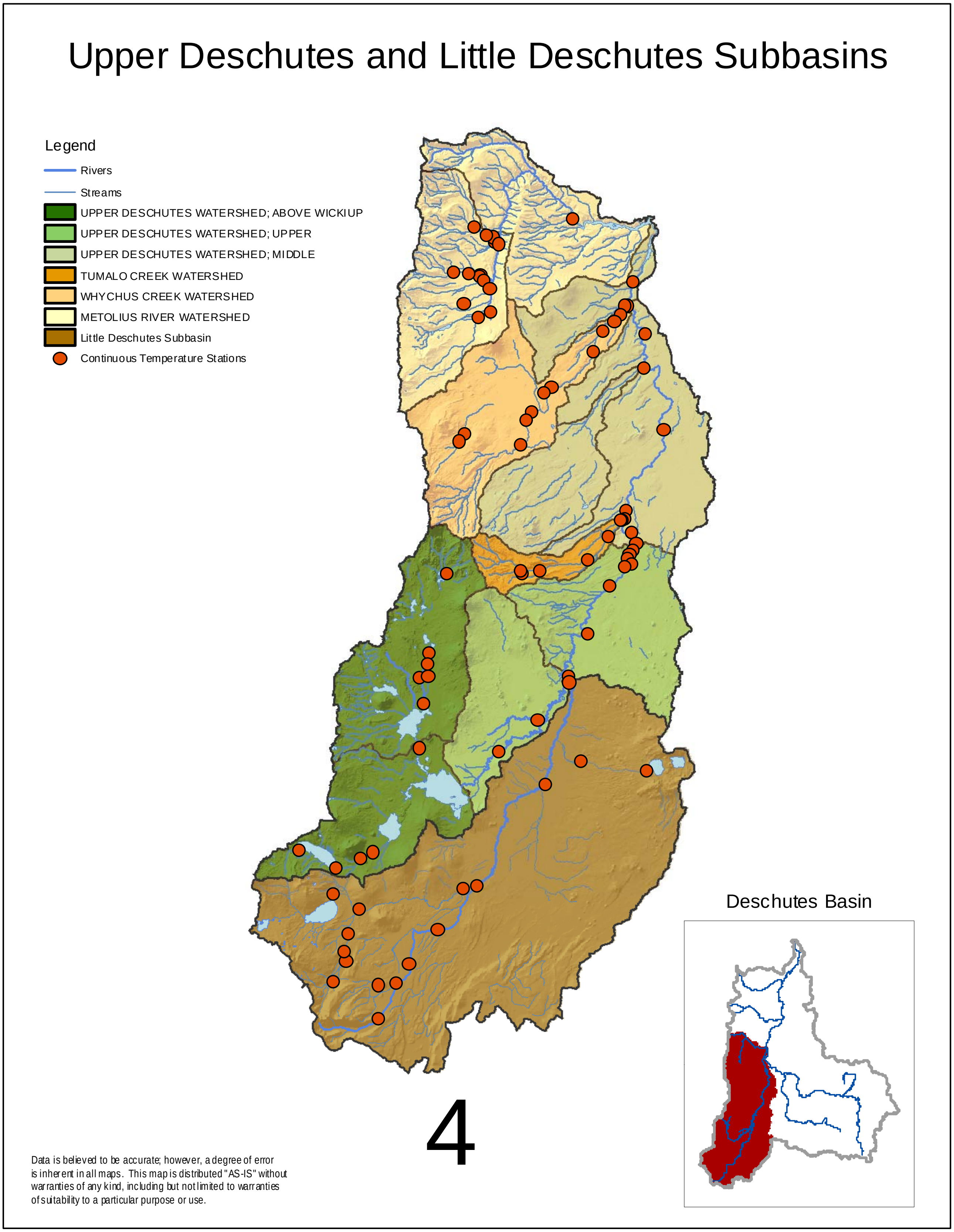
Table 6 Project Annual Timetable

Major Tasks	J	F	M	A	M	J	J	A	S	O	N	D
Monthly Coordination Meetings	X	X	X	X	X	X	X	X	X	X	X	X
Pre-season preparation (i.e.: supplies, equipment checks)	X	X	X									
Monitoring season		X		X	X	X	X	X	X	X		
Post-season tasks (i.e.: data management, equipment checks)										X	X	
Annual reporting	X										X	X

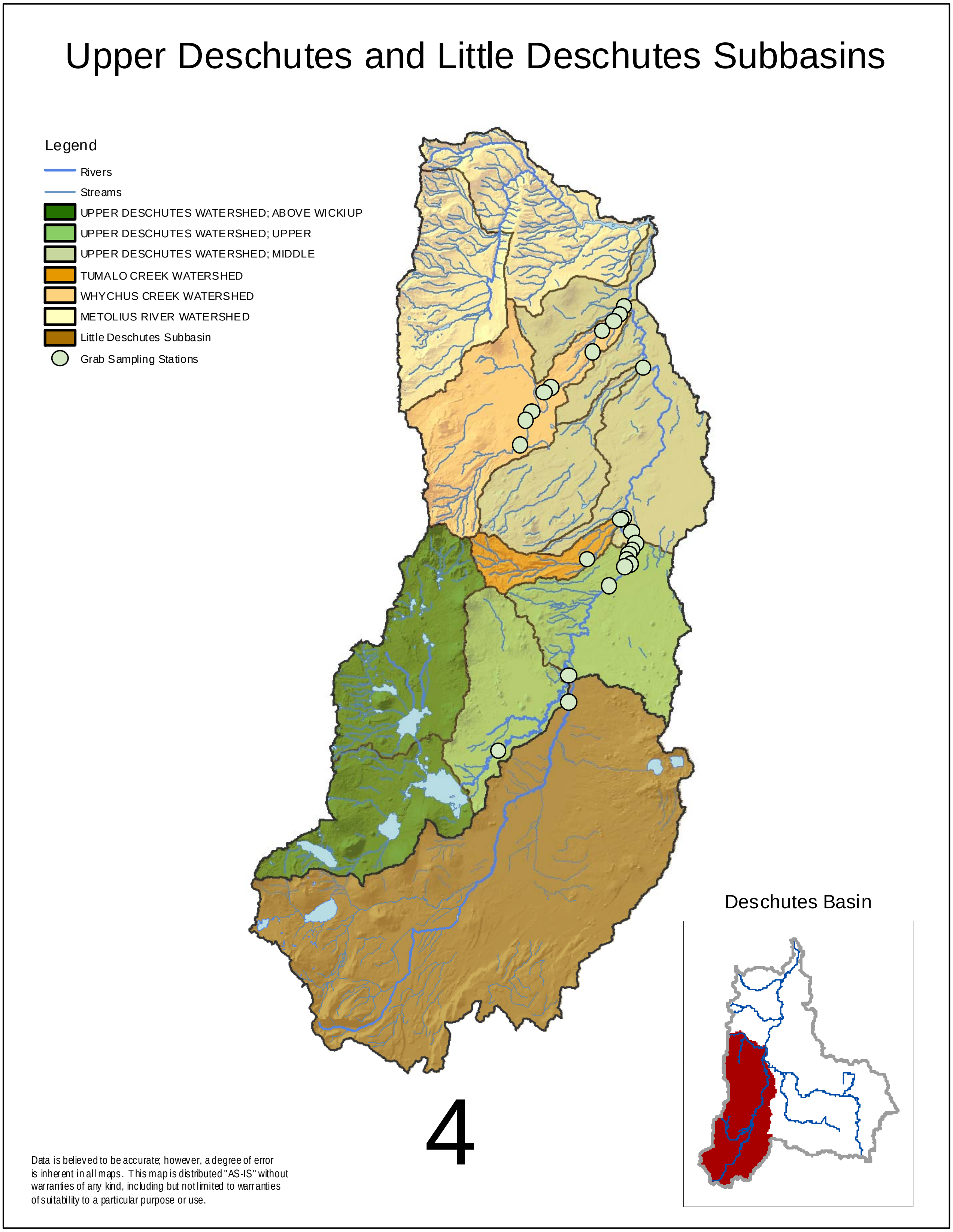
Map 3 Monitoring Station Locations



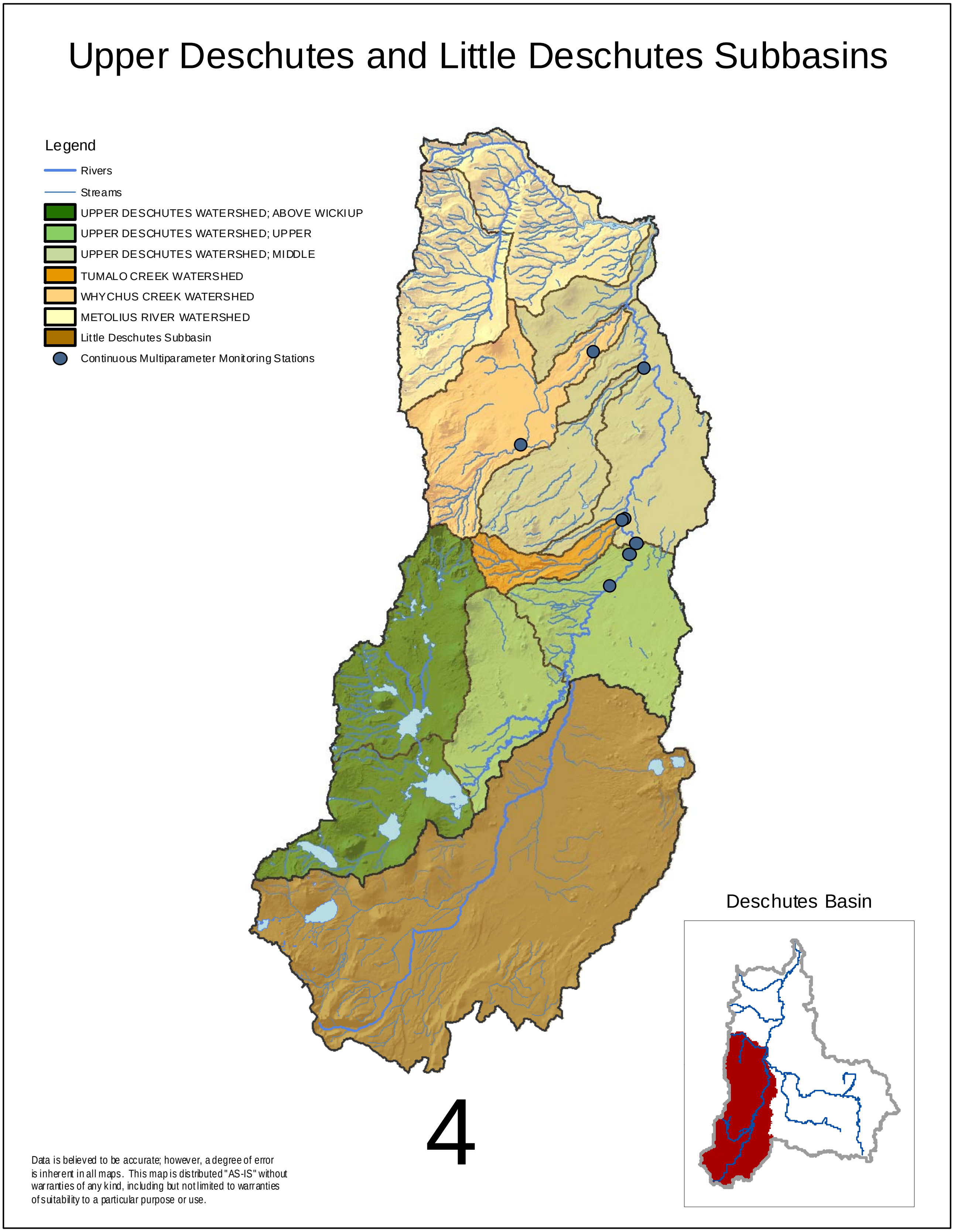
Map 4 Continuous Temperature Monitoring Stations



Map 5 Grab Sampling Stations



Map 6 Continuous Multiparameter Monitoring Stations



A7. Data Quality Objectives (DQO)

General Definitions

<u>Sampling day</u> – A one day event to collect samples at one or more stations.

<u>Sampling duration</u> – Length of study or deployment.

<u>Sampling event</u> – A one time grab or measurement representing a point in time.

<u>Sampling expedition</u> – A group of sampling days.

<u>Season</u> – Summer (June 1st – September 31st) or Fall/Winter/Spring (October 1st – May 31st).

DQO Definitions

DQO include precision, accuracy, measurement range, representativeness, comparability, and completeness. DQO are evaluated as described in the *UDWC Water Quality Monitoring Program SOP* section *4.6.1 DQO definitions*.

Continuous Temperature

The equipment for the continuous temperature monitoring was selected according to standards set forth by the ODEQ Data Quality Matrix for B quality data. Continuous temperature monitoring equipment and there capabilities are defined in (**Table 7**).

Table 7 Continuous Temperature DQO

Parameter	Equipment	Precision	Accuracy	Measurement Range
Continuous Temperature	Vemco Minilog 8-TR--5/+35	(+/- 0.2 C)	(+/- 0.5)	(-5 / +35 C)
Temperature audits	VWR NIST traceable thermometer	(+/- 0.001 C)	(+/- 0.05 C)	(-50 / 150 C)

Grab Samples

The equipment for grab sampling was selected according to standards set forth by the ODEQ Data Quality Matrix for B quality data. Grab sampling equipment and capabilities are defined in **Table 8**.

Table 8 Grab Sampling DQO

Parameter	Equipment	Precision	Accuracy	Measurement Range
Temperature	YSI 556 MPS	(0.01 C)	(+/-0.15 C)	(-5 / 45 C)
Dissolved oxygen	YSI 556 MPS	(+/- 0.01 mg/L)	(+/- 2% of reading)	(0 / 50 mg/L)
Percent saturation	YSI 556 MPS	(0.1% air sat)	(+/- 2% of reading)	(0 / 500%)
pH	YSI 556 MPS	(0.01 SU)	(+/- 0.2 SU)	(0 / 14 SU)
Specific conductance	YSI 556 MPS	(0.1 mS/cm)	(+/- 0.5% of reading)	(0 / 200 mS/cm)
Turbidity	Hach 2100P turbidimeter	(0.01 NTU)	(+/- 2% of reading)	(0 / 1000 NTU)

Continuous Multiparameter Monitoring

The equipment for continuous multiparameter monitoring was selected according to standards set forth by the ODEQ Data Quality Matrix for B quality data. Continuous multiparameter monitoring equipment and their capabilities are defined in **Table 9**.

Table 9 Continuous Multiparameter Monitoring DQO

Parameter	Equipment	Precision	Accuracy	Measurement Range
Continuous temperature	YSI 6920	(0.01 C)	(+/-0.15 C)	(-5 / 70 C)
Continuous dissolved oxygen	YSI 6920	(+/- 0.01 mg/L)	(+/- 2% of reading)	(0 / 50 mg/L)
Continuous percent saturation	YSI 6920	(0.1 %)	(+/- 2% of reading)	(0 / 500%)
Continuous pH	YSI 6920	(0.01 SU)	(+/- 0.2 SU)	(0 / 14 SU)
Continuous specific conductance	YSI 6920	(0.1 mS/cm)	(+/- 0.5% of reading)	(0 / 100 mS/cm)
Temperature audits	YSI 556 MPS	(0.01 C)	(+/-0.15 C)	(-5 / 45 C)
Dissolved oxygen audits	YSI 556 MPS	(+/- 0.01 mg/L)	(+/- 2% of reading)	(0 / 50 mg/L)
Percent saturation audits	YSI 556 MPS	(0.1% air sat)	(+/- 2% of reading)	(0 / 500%)
pH audits	YSI 556 MPS	(0.01 SU)	(+/- 0.2 SU)	(0 / 14 SU)
Specific conductance audits	YSI 556 MPS	(0.1 mS/cm)	(+/- 0.5% of reading)	(0 / 200 mS/cm)

A8. Qualifications / Certification

UDWC

The UDWC is a 501(c)3 nonprofit organization founded by landowners, ranchers, environmental interests, local citizens, and representatives from local governments and agencies. Board members are volunteers active in natural resource stewardship with the common commitment to working collaboratively toward watershed restoration. A four person staff manages the organization and oversees projects, and additional volunteers contribute time, expertise, and resources for specific projects and overall organizational efforts.

Executive Director

Ryan Houston, Executive Director, has a diverse background in natural resource management, habitat restoration and community-based environmental problem-solving. Before joining the UDWC in 2001, Ryan worked as a Senior Associate with Sycamore Associates, focusing on restoration and management of wetlands and endangered species. Ryan has previous experience working in riparian restoration for The Nature Conservancy, and as a research assistant at the Smithsonian Institution of Natural History. Ryan holds a M.S. in Ecology and Evolutionary Biology from the University of Arizona and a B.S. in Environmental Science, Policy and Management from the University of California, Berkeley.

Water Quality Specialist

Lesley Jones, Water Quality Specialist, has worked as an instructor and researcher of environmental science and chemistry since 1993. Lesley received a B.S. in cellular and molecular biology from Humboldt State University. While studying environmental toxicology at the University Nevada Reno, Lesley worked as a Graduate Research Assistant at the Desert Research Institute Northern Nevada Science Center and participated in a water quality program monitoring the Truckee River Watershed. More recently, Lesley held a Watershed Analyst position with the University of California at Davis where she designed and implemented a water quality program for the Upper Merced Watershed Council.

City of Bend Laboratory

The City Laboratory maintains accreditations and certifications by compliance with the relevant standards of operation, submission of acceptable performance evaluation test results, and undergoing periodic external audits by accrediting authorities. The laboratory is guided and evaluated by the following accrediting authorities:

- U.S. Environmental Protection Agency
- National Environmental Laboratory Accreditation Conference
- Oregon Environmental Laboratory Accreditation Program
- Oregon Department of Environmental Quality

A9. Documentation and Records

The following documents are housed at the UDWC:

- *Standard Methods for the Analysis of Water and Wastewater 20th Edition*
- the *Oregon Plan for Salmon and Watersheds Water Quality Monitoring Technical Guidebook 1999*
- *ODEQ Watershed Assessment Section Mode of Operations Manual 2004*
- the *UDWC Water Quality Monitoring Program SOP version 2004*

Documentation, records, and reports are managed as followed:

Continuous Temperature

- Calibration/maintenance records are kept in equipment notebooks maintained by and housed at the UDWC.
- Sampling Event Forms are completed for each station visit and housed at the UDWC in field notebooks (**Attachment A**).
- Information from the Sampling Event Forms and the pre/post deployment equipment checks are recorded onto Continuous Audit Logs (**Attachment C**).
- Measurements are recorded on the logger.
- The data is downloaded from the logger, graded for quality, and kept with the corresponding Continuous Audit Log.

Grab Samples

- Calibration/maintenance records are kept in equipment notebooks maintained by and housed at the UDWC.
- Sampling Event Forms are completed for each station visit and housed at the UDWC in field notebooks (**Attachment A**).
- Information from the Sampling Event Forms and the equipment check results are recorded onto a Grab Sampling Reporting Form (**Attachment B**).
- Measurements are recorded by Station ID into the handheld YSI 556 MPS. Turbidity is recorded onto the Sampling Event Form.
- The data is downloaded from the YSI 556 MPS, graded for quality, and kept with the corresponding Grab Sampling Reporting Form.

Continuous Multiparameter Monitoring

- Calibration/maintenance records are kept in equipment notebooks maintained by and housed at the UDWC.
- Sampling Event Forms are completed for each station visit and housed at the UDWC in field notebooks (**Attachment A**).
- Information from the Sampling Event Forms and the pre/post deployment equipment checks are recorded onto Continuous Audit Logs (**Attachment C**).
- Continuous data is recorded onto the deployed sonde.
- The data is downloaded from the sonde, graded for quality, and kept with the corresponding Continuous Audit Log.

Reference Attachment A. Sampling Event Form, Attachment B. Grab Sampling Reporting Form, Attachment C. Continuous Audit Log, and UDWC *Standard Operating Procedures; Field* section 4.0 Data Management for additional information regarding documentation and records.

GROUP B. DATA GENERATION AND ACQUISTION

B1. Sampling Process Design

Continuous Temperature

The continuous temperature monitoring sampling process design provides an understanding of daily and seasonal variations in temperature. Temperature is recorded hourly from April through October. This time period is selected in order to capture the changes that occur in the system as water is stored, released, impounded, and diverted and to capture the hottest time of the year.

Grab Samples

The grab sampling process design provides an understanding of baseline conditions across the system and is able to be compared to the continuous multiparameter monitoring data. Grab samples are collected monthly from April through October, and once during the fall/winter/spring (i.e.: February). These dates have been selected in order to capture baseline for parameters in the system as water is stored, released, impounded, and diverted and to capture the hottest time of the year.

Continuous Multiparameter Monitoring

The continuous multiparameter monitoring sampling process design provides an understanding of diurnal and seasonal variations in parameters and can be used as a reference for grab sample data. Continuous multiparameter monitoring is conducted on a planned schedule for each watershed:

> Whychus Creek watershed: in April (pre-irrigation season), July (hottest time of year), October (post-irrigation season), and once during the fall/winter/spring (i.e.: February).
>
> Upper Deschutes River watershed: in tandem with the City of Bend Ambient Water Quality Monitoring Project and to include summer and fall/winter/spring.

These dates have been selected in order to capture baseline for parameters in the system as water is stored, released, impounded, and diverted and to capture the hottest time of the year. These dates have also been selected to build upon existing monitoring efforts.

Three stations have been selected to help to track water quality changes in two watersheds as instream flow restoration occurs (**Table 2**):

- Whychus Creek Watershed: Two sondes will be deployed at fixed stations in order to capture water quality changes that are expected to occur due to the DRC Groundwater Exchange Project.

- Upper Deschutes Watershed; middle reach: One sonde will be deployed at a fixed station. This data will be collected in tandem with continuous multiparameter monitoring conducted under the City of Bend Ambient Water Quality Monitoring Project. The combined UDWC and City of Bend data can be used to establish a comprehensive baseline of water quality . This baseline can be used to begin to track changes in water quality that are expected to occur due to DRC instream flow restoration efforts.

B2. Sampling Methods Requirements

Table 10 displays a summary of the sampling methods including parameters, how the samples will be collected, equipment, sample preservation, and holding times. Samples are measured directly in-situ.

Reference attached UDWC *Standard Operating Procedures; Field* section 3.0 Field Collection Methods sub-section 3.2 Surface Water Sampling, section 5.0 Field Analytical Methods sub-section 5.x.5 Methods, and 6.0 Continuous Monitoring Methods sub-section 6.x.5 Methods for additional information regarding sampling methods requirements

Table 10 Summary of Sampling Methods

Monitoring	Parameter	Protocol	Equipment	Preservation	Storage	Holding Time
Continuous Temperature	Temperature	SOP*	Vemco Minilog 8-TR--5/+35	n/a	n/a	n/a
	Audits		VWR NIST traceable thermometer			
Grabs	Dissolved oxygen	SOP*	YSI 556 MPS	n/a	n/a	n/a
	Percent saturation		YSI 556 MPS	n/a	n/a	n/a
	pH		YSI 556 MPS	n/a	n/a	n/a
	Conductivity		YSI 556 MPS	n/a	n/a	n/a
	Turbidity		Hach 2100P	n/a	n/a	n/a
	Audits	SOP*	Winkler titration + reagents	n/a	n/a	n/a
			Orion 210A + pH buffers			
			YSI 30 + conductivity standards			
			StableCal Sealed Vial Fomazin			
Continuous Multiparameter Monitoring	Dissolved oxygen	SOP*	YSI 6920 sonde	n/a	n/a	n/a
	Percent saturation					
	pH					
	Conductivity					
	Audits		YSI 556 MPS			

SOP* = UDWC Standard Operating Procedures

B3. Sample Handling and Custody Requirements

For each grab sample collected, metadata is recorded on Sampling Event Forms to ensure accurate tracking and subsequent linkage of other data with the results of sample analyses. Sample information is recorded accurately, consistently, and legibly. Metadata include:

- Station ID
- Station description
- Date
- Time
- Surveyor
- Parameter
- QA/QC classification
- Comments

Surveyors compare information recorded on Sampling Event Forms for accuracy at the end of the day.

B4. Analytical Methods Requirements

Table 10 displays a summary of the analytical methods requirements including source of method and equipment needed. Samples are measured in-situ.

Reference attached UDWC *Standard Operating Procedures; Field* section 5.0 Field Analytical Methods sub-sections 5.x.5 Methods and 6.0 Continuous Monitoring Methods sub-sections 6.x.5 Methods for additional information regarding analytical methods requirements.

B5. Quality Control Requirements

Continuous Temperature

Sampling Duration - Continuous temperature: seven months; April through October.

Precision - In order to ensure sampling protocols are providing consistent results duplicate loggers are deployed at 10% of stations during the sampling duration. The precision is calculated by determining the *relative percent difference (RPD)* of the measurements collected by the duplicate loggers.

Accuracy - In order to ensure confidence in measurements, pre and post deployment accuracy checks comparing a standard reference material (true value) to a measurement of the reference material are used. In addition, monthly independent field audits comparing in-situ auditing equipment measurements (true value) to deployed continuous monitoring equipment measurements are performed.

Measurement Range - The ranges of reliable readings of equipment as specified by the manufacturer are compared to the *ODEQ Data Matrix 2004* to ensure applicability of equipment to measure in-situ conditions.

Representativeness - Data are collected in locations indicative of the waterbody. Well-mixed stations are selected to minimize the effects of variation.

Comparability - In order to ensure usefulness of the data collected, standard methodology as described in *Standard Methods for the Analysis of Water and Wastewater 20th Edition*, the *Oregon Plan for Salmon and Watersheds Water Quality Monitoring Technical Guidebook 1999*, *ODEQ Watershed Assessment Section Mode of Operations Manual 2004*, and the *UDWC Water Quality Monitoring Program SOP* are followed.

Completeness - The percent completeness of the sampling duration is calculated by evaluating the number of Grade A and B level data measurements against the total number of data measurements planned.

Grab Samples

Sampling Duration - Eight months; one fall/winter/spring month plus April through October.

- *Whychus Creek Watershed*
  - Four months
  - April, July, October, and one winter month
  - Scheduled to correspond to continuous multiparameter monitoring

- *Upper Deschutes River Watershed; Middle Reach*
  - In tandem with the City of Bend Ambient Water Quality Monitoring Project
  - To include summer and fall/winter/spring

Precision - In order to ensure sampling protocols are providing consistent results duplicate samples are collected at least once or at 10% of stations (whichever is greater) per monthly sampling expedition. The precision is calculated by determining the *relative percent difference (RPD)* of the duplicate samples.

Accuracy - In order to ensure confidence in measurements, blank samples are evaluated at least once or at 10% of stations (whichever is greater) per monthly sampling expedition.

Measurement Range - Laboratory methods are selected by evaluating the scope, range, and reporting limits of the methodology to ensure applicability of methods to measure in-situ conditions.

Representativeness - Samples are collected in locations indicative of the waterbody. Well-mixed waters are selected to minimize the effects of variation.

Comparability - In order to ensure usefulness of the data collected, standard methodology as described in *Standard Methods for the Analysis of Water and Wastewater 20th Edition*, the *Oregon Plan for Salmon and Watersheds Water Quality Monitoring Technical Guidebook 1999*, *ODEQ Watershed Assessment Section Mode of Operations Manual 2004*, and the *UDWC Water Quality Monitoring Program SOP* are followed.

Completeness - The percent completeness of the sampling duration is calculated by evaluating the number of usable or Grade A and B level data measurements against the total number of data measurements planned.

Continuous Multiparameter Monitoring

Sampling Duration

- *Whychus Creek Watershed*
  - Four deployments per year
  - April, July, October, and one winter month

- *Upper Deschutes River Watershed; Middle Reach*
  - In tandem with the City of Bend Ambient Water Quality Monitoring Project
  - To include summer and fall/winter/spring

Precision - In order to ensure sampling protocols are providing consistent results duplicate loggers are deployed at 10% of stations during the sampling duration. This will only apply if funds are available to provide equipment for duplicate loggers to be deployed. The precision is calculated by determining the *relative percent difference (RPD)* of the measurements collected by the duplicate loggers.

Accuracy - In order to ensure confidence in measurements, pre and post deployment accuracy checks comparing a standard reference material (true value) to a measurement of the reference material are used. In addition, an independent field audit comparing in-situ auditing equipment measurements (true value) to deployed continuous monitoring equipment measurements are performed.

Measurement Range - The ranges of reliable readings of equipment as specified by the manufacturer are compared to the *ODEQ Data Matrix 2004* to ensure applicability of equipment to measure in-situ conditions.

Representativeness - Data are collected in locations indicative of the waterbody. Well-mixed stations are selected to minimize the effects of variation. Deployment setups and sondes are cleaned and kept free of growth and debris during the sampling duration.

Comparability - In order to ensure usefulness of the data collected, standard methodology as described in *Standard Methods for the Analysis of Water and Wastewater 20th Edition*, the *Oregon Plan for Salmon and Watersheds Water Quality Monitoring Technical Guidebook 1999*, *ODEQ Watershed Assessment Section Mode of Operations Manual 2004*, and the *UDWC Water Quality Monitoring Program SOP* are followed.

Completeness - The percent completeness of the sampling duration is calculated by evaluating the number of Grade A and B level data measurements against the total number of data measurements planned.

Reference attached UDWC *Standard Operating Procedures; Field* section 3.0 Field Collection Methods sub-section 3.2.4 QC Sample Collection and section 4.0 Data Management sub-section 4.6 Data Quality for additional information regarding quality control requirements.

B6. Instrument / Equipment Testing, Inspection, and Maintenance Requirements

Continuous Temperature

Equipment utilized for continuous temperature monitoring is inspected according to standards set forth by the ODEQ Laboratory Division (**Table 11**).

Table 11 Continuous Temperature Equipment Testing, Inspection, and Maintenance Requirements

Equipment	Inspection Frequency	Type of Inspection
VWR NIST traceable thermometer	Annual accuracy check	Re-certification to NIST traceability standards
	Pre/post monitoring inspection	Operation of unit, cables, batteries

Grab Sampling

Equipment utilized for grab sampling is inspected according to standards set forth by the ODEQ Laboratory Division (**Table 12**).

Table 12 Grab Sampling Equipment Testing, Inspection, and Maintenance Requirements

Equipment	Inspection Frequency	Type of Inspection
YSI 556 MPS - temperature	Annual accuracy check	Re-certification to NIST traceability standards
	Pre/post monitoring inspection	Operation of unit, cables, batteries
YSI 556 MPS - dissolved oxygen	Pre/post monitoring accuracy check	Winkler titration
	Pre/post monitoring inspection	Operation of unit, cables, batteries, membrane
YSI 556 MPS - percent saturation	Pre/post monitoring accuracy check	Winkler titration
	Pre/post monitoring inspection	Operation of unit, cables, batteries, membrane
YSI 556 MPS - pH	Pre/post monitoring accuracy check	Orion 210A pH meter and buffers
	Pre/post monitoring inspection	Operation of unit, cables, batteries, probe
YSI 556 MPS - specific conductance	Pre/post monitoring accuracy check	YSI 30 and secondary standard
	Pre/post monitoring inspection	Operation of unit, cables, batteries
Hach 2100P turbidimeter	Quarterly calibrations	Hach StablCal formazin suspensions
	Pre/post monitoring accuracy check	Hach StablCal formazin suspensions
	Pre/post monitoring inspection	Operation of unit, batteries, sample vials

Continuous Multiparameter Monitoring

Equipment utilized for continuous multiparameter monitoring is inspected according to standards set forth by the ODEQ Laboratory Division (**Table 13**).

Table 13 Summer Intensive Equipment Testing, Inspection, and Maintenance Requirements

Equipment	Inspection Frequency	Type of Inspection
YSI 6920 sondes - temperature	Annual accuracy check	Re-certification to NIST traceability standards
	Pre/post monitoring inspection	Operation of unit, cables, batteries
YSI 6920 sondes - dissolved oxygen	Pre/post monitoring accuracy check	YSI 556 MPS
	Pre/post monitoring inspection	Operation of unit, cables, batteries, membrane
YSI 6920 sondes - percent saturation	Pre/post monitoring accuracy check	YSI 556 MPS
	Pre/post monitoring inspection	Operation of unit, cables, batteries, membrane
YSI 6920 sondes - pH	Pre/post monitoring accuracy check	YSI 556 MPS and buffers
	Pre/post monitoring inspection	Operation of unit, cables, batteries, probe
YSI 6920 sondes - specific conductance	Pre/post monitoring accuracy check	YSI 556 MPS and secondary standard
	Pre/post monitoring inspection	Operation of unit, cables, batteries

Reference attached UDWC *Standard Operating Procedures; Field* section 5.0 Field Analytical Methods sub-sections 5.x.4 Calibration and Standardization and section 6.0 Continuous Monitoring Methods sub-sections 6.x.4 Calibration Procedures for information regarding instrument / equipment testing, inspection, and maintenance requirements.

B7. Equipment Calibration and Frequency

Continuous Temperature

Equipment utilized for continuous temperature monitoring is calibrated according to frequencies set forth by the ODEQ Laboratory Division (**Table 14**).

Table 14 Continuous Temperature Monitoring Equipment Calibration and Frequency

Equipment	Calibration Frequency	Standard	WQS	City Lab	ODEQ Lab
VWR NIST traceable thermometer	Annual check	NIST certified thermometer at 5, 10, 15, 20, and 25 C			X
	When > 0.5 C difference		at factory		

Grab Samples

Equipment utilized for grab sampling is calibrated according to frequencies set forth by the ODEQ Laboratory Division (**Table 15**).

Table 15 Grab Sample Monitoring Equipment Calibration and Frequency

Equipment	Standard	Calibration Frequency	WQS	City* Lab	ODEQ Lab
YSI 556 MPS – temperature	NIST certified thermometer at 5, 10, 15, 20, and 25 C	Annual check		X	
		When > 0.5 C difference	to factory		
YSI 556 MPS – dissolved oxygen	Winkler titration of surface water	Pre/post monitoring check	X		
		When > 1.0 mg/L difference	X		
YSI 556 MPS – percent saturation	Winkler titration of surface water	Pre/post monitoring check	X		
		When > 1.0 mg/L difference	X		
YSI 556 MPS – pH	Orion 210A	Pre/post monitoring check	X		
		When > 0.1 SU of sample or buffer	X		
YSI 556 MPS – specific conductance	Primary NIST traceable standards	Annual calibration - conductivity		X	
	147 µmhos/cm secondary standard	Pre/post monitoring check	X		
		When > 7% difference	X		
YSI 30 – specific conductance	Primary NIST traceable standards	Annual calibration - conductivity			X
	NIST certified thermometer at 5, 10, 15, 20, and 25 C	Annual calibration - temperature			X
	147 µmhos/cm secondary standard	Pre/post monitoring check	X		
		When > 7% difference	X		
Hach 2100P turbidimeter	Hach StablCal formazin suspensions	Quarterly calibration	X		

*City of Bend Laboratory Division

Continuous Multiparameter Monitoring

Equipment utilized for Continuous Multiparameter Monitoring is calibrated according to frequencies set forth by the ODEQ Laboratory Division (**Table 16**).

Table 16 Continuous Multiparameter Monitoring Equipment Calibration and Frequency

Equipment	Standard	Calibration Frequency	WQS	City* Lab	ODEQ Lab
YSI 6920 sondes – temperature	NIST certified thermometer at 5, 10, 15, 20, and 25 C	Annual check		X	
		When > 0.5 C difference	to factory		
YSI 6920 sondes – dissolved oxygen	YSI 556 MPS and surface water	Pre/post monitoring check	X		
		When > 1.0 mg/L difference	X		
YSI 6920 sondes – percent saturation	YSI 556 MPS and surface water	Pre/post monitoring check	X		
		When > 1.0 mg/L difference	X		
YSI 6920 sondes – pH	YSI 556 MPS	Pre/post monitoring check	X		
	4, 7, 10 pH buffer	When > 0.1 SU of sample or buffer	X		
YSI 6920 sondes – specific conductance	YSI 556 MPS	Pre/post monitoring check	X		
	147 µmhos/cm secondary standard	When > 7% difference	X		

Reference attached UDWC *Standard Operating Procedures; Field* section 5.0 Field Analytical Methods sub-sections 5.x.4 Calibration and Standardization and section 6.0 Continuous Monitoring Methods sub-sections 6.x.4 Calibration Procedures for information regarding equipment calibration and frequency.

B8. Inspection and Acceptance Requirements for Supplies

Continuous Temperature

Auditing meters and field supplies are kept in a monitoring kit stored at the UDWC office. The Water Quality Specialist checks the contents of the kit and stocks as necessary. Supplies and inspections are outlined in **Table 17**.

Table 17 Continuous Temperature Monitoring Supplies and Inspection

Supply	Location	Inspection	Partner
Temperature monitoring kit	UDWC office	Blank Sampling Event Forms	Water Quality Specialist
		Sharpie	
		VWR NIST traceable thermometer	
		Batteries	
		Tools	
		Scissors	
		Duct tape	
		First aid kit	
		Waders and felts	

Grab Samples

All field equipment and supplies are kept in kits stored at the UDWC. Expiration dates for all supplies are clearly labeled. The Water Quality Specialist checks the contents of the kits and stocks as necessary. Supplies and inspections are outlined in **Table 18**.

Table 18 Grab Samples Supplies and Inspection

Supply	Location	Inspection	Partner
Grab sampling field kit - In-situ	UDWC	YSI 556 MPS	Water Quality Specialist
		Hach turbidimeter	
		Batteries	
		Tools	
		Waders and felts	

Continuous Multiparameter Monitoring

Auditing meters and calibration supplies are kept in kits stored at the UDWC office. Expiration dates for all supplies are clearly labeled. The Water Quality Specialist checks the contents of the kits and stocks as necessary. Supplies and inspections are outlined in **Table 19**.

Table 19 Continuous Multiparameter Supplies and Inspection

Supply	Location	Inspection	Partner
Sonde Auditing Kit	UDWC office	YSI 556 MPS	Water Quality Specialist
		Hach turbidimeter	
		Batteries	
		Scrub brushes	
		Tools	
		Waders and felts	
Calibration station	UDWC office	DO membranes	Water Quality Specialist
		4, 7, 10 pH buffers	
		Conductivity secondary standard	
		Distilled or deionized water	
		Disposal jug	
		Support stand	
		Batteries	
		Tools	
		Wipes, bench pads, latex gloves, and zip-lock bags	
Titration station	UDWC office	300 mL BOD bottles	Water Quality Specialist
		Manganous sulfate powder pillows	
		Alkaline iodide azide powder pillows	
		Sulfamic acid powder pillows	
		0.0250 N sodium thiosulfate, standardized solution	
		Pyrex 10 mL, 0.1 mL graduated, ground glass stopcock	
		Rubber bulb, tubing, 500 mL reservoir, and support stand	
		Magnetic stirrer and stir bar	
		250 mL graduated cylinder	
		500 mL Erlenmeyer flask	
		Transfer pipettes	
		disposal jug	
		Distilled or deionized water	
		Sharpie	
		Tools	
		Wipes, bench pads, latex gloves, and zip-lock bags	

Reference attached UDWC *Standard Operating Procedures; Field* section 5.0 Field Analytical Methods sub-sections 5.x.3 Equipment and Supplies and section 6.0 Continuous Monitoring Methods sub-sections 6.x.3 Equipment and Supplies for information regarding inspection / acceptance requirements for supplies.

B9. Data Acquisition Requirements

Terrain Navigator Pro software (USGS 7.5 minute series maps) and GPS technology are utilized to identify station locations and assign Station IDs. The Station ID consists of the system initials and a five digit river mile. In general, a station reach is 0.25 miles unless some influence such as a spring or tributary exists. River miles are assigned to the nearest 0.25 miles.

Flow data and solar radiation data are obtained from the Bureau of Reclamation and are used for evaluation and presentation of monitoring data.

- Flow data: http://www.usbr.gov/pn/hydromet/webhydarcread.html
- Solar radiation data: http://www.usbr.gov/pn/agrimet/agrimetmap/bewoda.html

The Oregon Administrative Rules and Water Quality Standards provide the criteria to evaluate the water quality data.

- http://www.deq.state.or.us/wq/wqrules/wqrules.htm

Reference attached UDWC *Standard Operating Procedures; Field* section 4.0 Data Management sub-sections 4.1 Station ID and 4.5 Regional Database for additional information regarding data acquisition requirements.

B10. Data Management

Data Management includes assigning Station ID, metadata recording, updating the regional database, grading data quality, and sharing data. Data management begins when the metadata is transferred to the Sampling Event Forms and ends when the graded data combined with all QA/QC data are verified as complete and accurate in the regional database.

The Water Quality Specialist, OSU Intern, and volunteers complete Sampling Event Forms. During data recording, the rules for significant figures are applied and the units of measurement are noted. Information from these forms is transferred into a regional database maintained by the Water Quality Specialist.

Reference attached UDWC *Standard Operating Procedures; Field* section 4.0 Data Management for information regarding data management.

GROUP C. ASSESSMENT AND OVERSIGHT

C1. Assessment and Response Actions

UDWC Water Quality Monitoring Program Performance

The UDWC Water Quality Monitoring Program is guided and evaluated by a Water Quality Committee and a coalition of partners who have worked to identify specific questions and appropriate approaches for each watershed towards the goal of acheiving quality data, decision making, and projects. Evaluation, mentorship, and technical assistance is provided to the Water Quality Specialist by the Water Quality Committee and other partners. These partners include:

- U.S. Forest Service
- Bureau of Land Management
- Bureau of Reclamation
- City of Bend
- Deschutes Basin Land Trust
- Deschutes Resources Conservancy
- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife
- Oregon Water Resources Department

City of Bend Laboratory Performance

The City Water Quality Laboratory has management personnel to ensure that there is the authority and resources needed to achieve accurate and reliable results obtained through the application of approved methodologies.

C2. Reports

The UDWC provides an annual report upon request. The report will discuss the methods, results, and an interpretation of the data within a regional context. Included will be data tables, summary statistics, graphics, and mapping. The report will also include recommendations for improving future monitoring, increasing data quality, and reducing costs. This report will be distributed for application towards future management decisions.

All quality data that is collected is stored in the regional database. Data within the regional database is submitted to the ODEQ for 303(d) listing and delisting purposes. The regional database is utilized for watershed based project effectiveness evaluations, evaluating regional conditions, and for presentations. Data and corresponding QA/QC is available upon request.

GROUP D. DATA VALIDATION AND USABILITY

D1. Data Review, Validation, and Verification Requirements

UDWC

The Water Quality Specialist downloads continuous temperature data, grab sampling data, and continuous multiparameter monitoring data, audits equipment, and grades data quality. The Water Quality Specialist compiles all graded A and B level data and enters the data into the regional database. Data quality is assessed according to the criteria set forth in the ODEQ Data Quality Matrix.

City of Bend

The City Water Quality Laboratory's general policy for data validation requires that all data generated be subjected to at least two levels of review before being released for reporting. The levels of review are as follows:

> <u>First Level</u>
> Bench-level review of analytical data against QA/QC policies, SOPs and predetermined performance criteria by the analyst responsible for conducting the analysis.
>
> <u>Second Level</u>
> Peer and/or supervisory review of the documentation from the analysis to confirm the observations of the original analyst, compliance with applicable policies and procedures and to confirm the absence of transcription errors. Second level reviewers may be peer analysts who have completed the necessary training to review the specific type of analytical data. The Laboratory Manager / QA Officer may also conduct the review. The original analyst may not perform second level review.

Reference attached UDWC *Standard Operating Procedures; Field* section 5.0 Field Analytical Methods sub-sections 5.x.6 Calculations and Data Reporting and section 6.0 Continuous Monitoring Methods sub-sections 6.x.6 Calculations and Data Reporting for information regarding data review, validation, and verification requirements.

D2. Validation and Verification Methods

In addition to these data management strategies, each type of monitoring (continuous temperature, grab, and continuous multiparameter monitoring) has its own set of data management strategies to verify high quality data.

Continuous Temperature

Pre/post monitoring equipment checks are performed and the precision of the equipment is evaluated against standards set forth in the ODEQ Data Quality Matrix. Each continuous temperature dataset is reviewed for nonsensical readings and time shifting.

Reference the UDWC *Standard Operating Procedures; Field* section 6.0 Continuous Monitoring Methods sub-sections 6.1.4 Calibration Procedures, 6.1.6 Calculations.

Grab Samples

Pre/post monitoring equipment checks are performed and the precision of the equipment is evaluated against standards set forth in the ODEQ Data Quality Matrix. Each grab sample result is reviewed for nonsensical readings.

Continuous Multiparameter Monitoring

Pre/post monitoring equipment checks are performed and the precision of the equipment is evaluated against standards set forth in the ODEQ Data Quality Matrix. Each continuous multiparameter dataset is reviewed for nonsensical readings and time shifting.

Reference the UDWC *Standard Operating Procedures; Field* section 6.0 Continuous Monitoring Methods sub-sections 6.2.4 Calibration Procedures, 6.2.6 Calculations and Reporting.

D3. Reconciliation with Data Quality Objectives

The ODEQ *Data Quality Matrix* is referenced for reconciling continuous temperature, grab sampling, and continuous multiparameter monitoring data with data quality objectives set forth by the state.

UDWC,2002. *Little Deschutes River Subbasin Assessment*, prepared by Watershed Professional Network, Boise, Idaho and Corvallis, Oregon.

UDWC,2003a. *Characterization of Select Water Quality Parameters within the Upper Deschutes and Little Deschutes Subbasins*, prepared by Jones, L., Upper Deschutes Watershed Council, Bend, Oregon.

UDWC,2003b. *Upper Deschutes Subbasin Assessment*, prepared by Yake, K.E., Upper Deschutes Watershed Council, Bend, Oregon.

UDWC,2003c. *Temperature Characterization of Watersheds in the Upper Deschutes and Little Deschutes Subbasins*, prepared by Breuner, N., Upper Deschutes Watershed Council, Bend, Oregon.

UDWC,2005. *Quality Assurance Project Plan, City of Bend Water Quality Monitoring,* Prepared by Jones, L., Upper Deschutes Watershed Council, Bend, OR.

USGS,2000. *Framework for Regional, Coordinated Monitoring in the Middle and Upper Deschutes River Basin, Oregon,* prepared by Anderson, C.W., Open-File Report 00-386, Portland, Oregon.

USFS,1996. *Upper Deschutes Wild and Scenic River Record of Decision and Final Environmental Impact Statement,* Deschutes National Forest, Bend, Oregon.

Attachment A Sampling Event Form

Attachment B Grab Sampling Results Reporting Form

Attachment C Continuous Audit Log

Upper Deschutes Watershed Council
Water Quality Monitoring Program
Technical Report

Lake Creek Restoration Project
Effectiveness Monitoring Summary 2006

Metolius River Watershed, Upper Deschutes Subbasin, Oregon

Prepared by: Lesley Jones
Water Quality Specialist
Upper Deschutes Watershed Council
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Prepared for: United States Forest Service; Deschutes National Forest
Bend, Oregon

and

Lake Creek Lodge
Camp Sherman, Oregon

Upper Deschutes Watershed Council
Bend, Oregon: August 2006

ACKNOWLEDGMENTS

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ABBREVIATIONS AND ACRONYMS

Organizations

ODEQ	Oregon Department of Environmental Quality
UDWC	Upper Deschutes Watershed Council
USFS DNF	United States Forest Service; Deschutes National Forest

Units

%Sat	percent saturation of oxygen
°C	degree Celsius
Delta-T	Absolute difference between min and max
DO	dissolved oxygen
ID	identification
Max	maximum
mg/L	milligrams per liter
Min	minimum
NTU	nephelometric turbidity units
SpC	specific conductance
TDS	total dissolved solids
Temp	temperature

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1.0 INTRODUCTION

1.1 Purpose

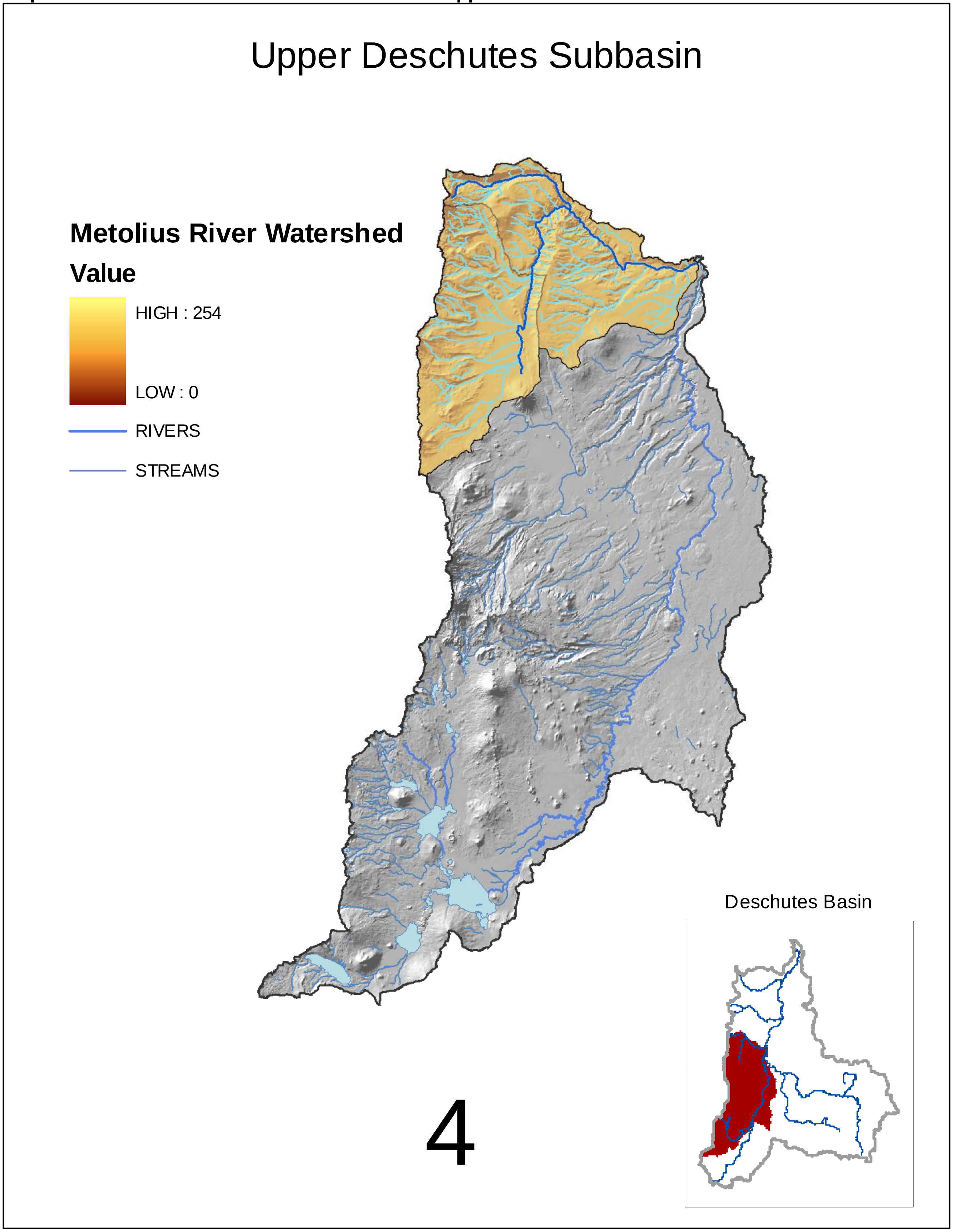
The purpose of the *Lake Creek Restoration Effectiveness Monitoring Summary* is to provide the Upper Deschutes Watershed Council (UDWC), US Forest Service Deschutes National Forest (USFS DNF), and Lake Creek Lodge with information on the pre-project surface water conditions of Lake Creek. This information, when integrated with post-project surface water conditions, documents the effectiveness of the Lake Creek Restoration Project to improve water quality to meet the needs of resident and anadromous fish. In addition, insights gained and lessons learned from the Lake Creek Restoration project can support the future development of projects that restore water quality.

1.2 Study Area

The Lake Creek Restoration Project includes 725 feet of stream channel located at Lake Creek Lodge, Camp Sherman, Oregon. Lake Creek is within the Metolius River Watershed; one of five watersheds of the Upper Deschutes subbasin (**Map 1**). In the 1930's, a large pond flanked with concrete and rock retaining walls was engineered along this reach. In 2004, a partnership between the UDWC, USFS DNF, and Lake Creek Lodge was established in order to restore fish and wildlife habitat in this reach by replacing the retaining walls and pond with a more natural stream channel.

Lake Creek is an important tributary in the Metolius River Watershed because it provides habitat critical for the successful reintroduction of chinook and sockeye salmon scheduled to begin in 2008. In addition, Lake Creek supports redband trout and bull trout populations. Lake Creek spans six miles between Suttle Lake and the Metolius River therefore each reach along this short tributary is important for sustaining local fisheries.

Map 1 Metolius River watershed location in the Upper Deschutes Subbasin



1.3 Summary of 2005 monitoring

The monitoring activities for 2006 presented in this summary include continuous multiparameter monitoring at two stations located on Lake Creek. One station is upstream of the restoration project and the second station is within the old pond at Lake Creek Lodge. The two stations are approximately one-tenth of a mile apart. Monitoring stations are listed in **Table 1**.

Table 1 Station IDs

Station ID	System	Location
TC 001.25	Lake Creek	At old pond
TC 001.35	Lake Creek	d/s Rd 1419 bridge

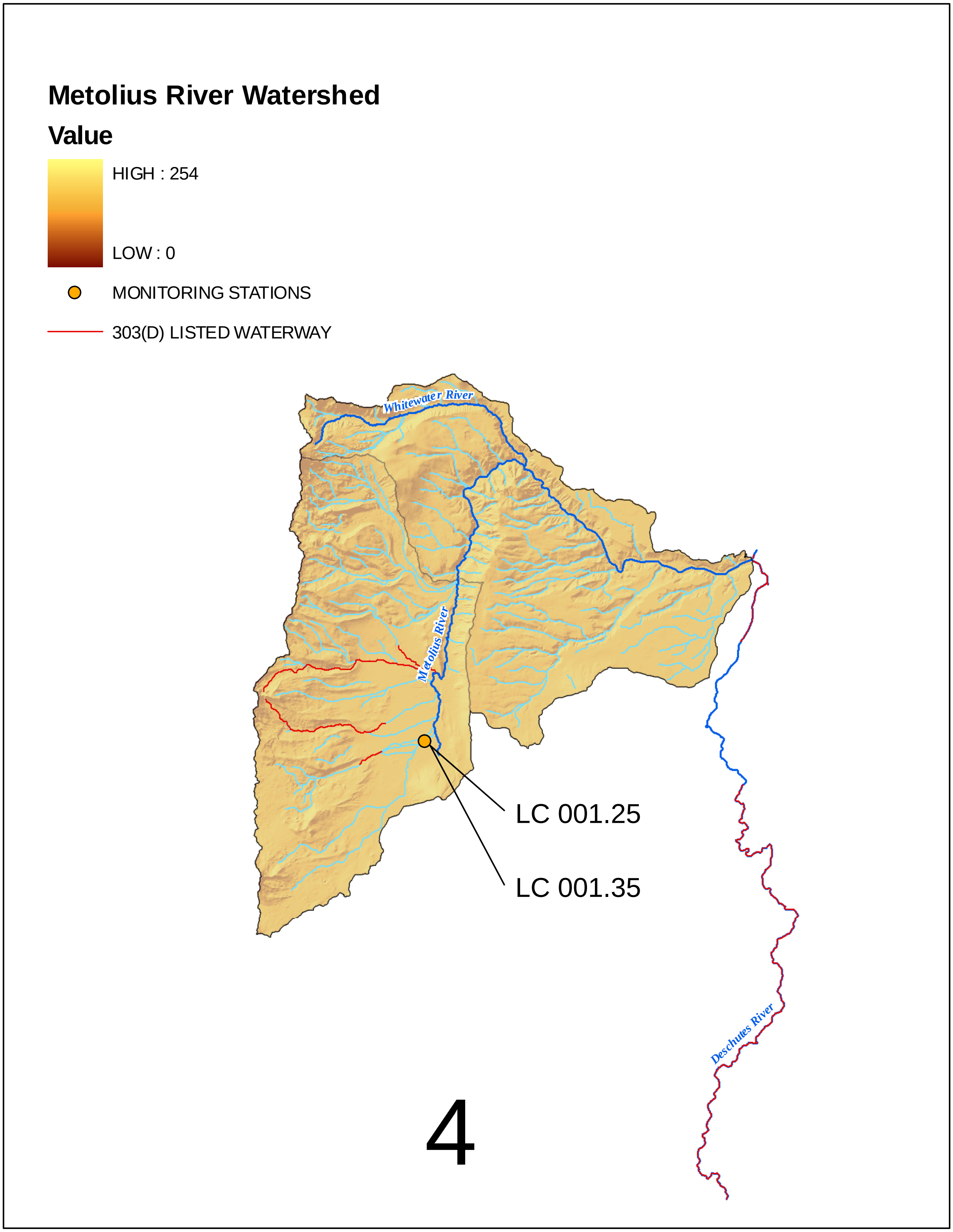
Stations listed in **Table 1** are displayed on **Map 2.** All data was collected according to the ODEQ methodologies approved in the *UDWC Water Quality Monitoring Program Standard Operating Procedures; Field* (UDWC, 2006). Data was collected between August 10, 2006 and August 12, 2006 using YSI 6920 sondes that were programmed to measure every 15 minutes and measure multiple parameters including:

- Temperature (temp),
- Dissolved oxygen (DO) and percent saturation (%Sat),
- pH, and
- Specific conductance (SpC) and total dissolved solids (TDS).

In addition, turbidity samples were collected and measured using a Hach 2100P turbidimeter.

Results are compared to the state of Oregon water quality standards set to protect the beneficial use of bull trout spawning and rearing (ODEQ, 2004). The data in this report is graded for quality according to the Oregon Department of Environmental Quality (ODEQ) assessment methodology for water quality status (ODEQ, 2005).

Map 2 Metolius River watershed, Lake Creek monitoring stations, and 303(d) listed waterways



2.0 MONITORING RESULTS

2.1 Temperature

2.1.1 Analyses

Since data was collected for two days only, the seven day moving average maximum temperature was not calculated. **Figure 1** depicts the diel fluctuations in daily temperatures for the two monitoring locations. The green line represents LC 001.35 downstream from Road 1419 bridge, which is a location within the main channel upstream from the restoration area, while the blue line represents LC 001.25 at the old pond, which is a location within the restoration area. The red line represents the state criterion of 12.0 °C set year round to protect bull trout spawning and rearing. **Table 2** depicts the summary statistics for the temperature data. The summary statistics include the degree Celsius minimum, maximum, delta-t (amount of fluctuation), average, and median values for the data displayed in **Figure 1**.

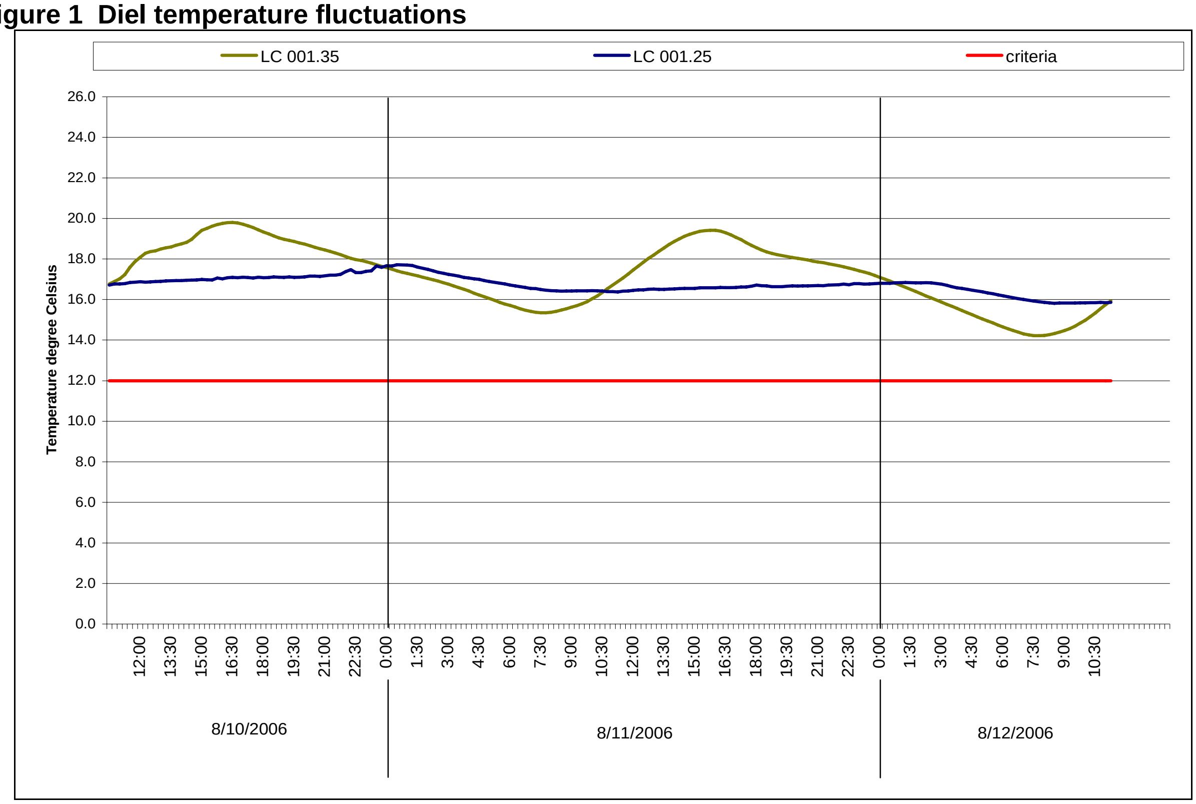
2.1.2 Interpretation

The temperature fluctuations depicted in **Figure 1** illustrate a gradual diel curve at both monitoring locations. LC 001.35 located within the main channel has a temperature fluctuation (signified by the Delta-T value) that is 2.7 °C greater than the temperature fluctuation measured at LC 001.25 at the old pond (**Table 2**). The possibility exists that both monitoring locations may exceed the state criteria for temperature since the min, max, average, and median temperatures all exceed 12 °C.

Table 2 Summary statistics for temperature data

Station ID	Min °C	Max °C	Delta-T °C	Avg °C	Med °C
LC 001.35	15.4	19.4	4.1	17.3	17.4
LC 001.25	16.4	17.7	1.4	16.8	16.7

Figure 1 Diel temperature fluctuations



2.2 Dissolved oxygen and percent saturation

2.2.1 Analyses

Figure 2 depicts the diel fluctuations in daily dissolved oxygen and **Figure 3** depicts the diel fluctuations in daily percent saturation of oxygen for the two monitoring locations. The green line represents LC 001.35 downstream from Road 1419 bridge, which is a location within the main channel upstream from the restoration area, while the blue line represents LC 001.25 at the old pond, which is a location within the restoration area. The red line represents the non-spawning, cold water state criteria not to be below of 8.0 mg/L dissolved oxygen and 90% saturation of oxygen set between June 16th and August 14th to protect aquatic species. The Oregon Administrative Rules state that when waterways drop below the minimum dissolved oxygen criterion then the percent saturation of oxygen criterion applies (ODEQ, 2004).

2.2.2 Interpretation

The fluctuations in dissolved oxygen concentrations and percent saturation of oxygen at LC 001.35 located within the main channel illustrate gradual diel curves, unlike the fluctuations in dissolved oxygen concentrations and percent saturation of oxygen measured at LC 001.25 at the old pond that are more erratic (**Figure 2** and **Figure 3**). The difference in the fluctuations equate 1.3 mg/L dissolved oxygen delta-t and 18% saturation of oxygen delta-t (**Table 3** and **Table 4**). The dissolved oxygen concentrations at LC 001.35 located within the main channel do not fall below the state criterion (**Figure 2** and **Table 3**). The dissolved oxygen concentrations and the percent saturation of oxygen at LC 001.25 at the old pond do not meet the state criteria (**Figure 3** and **Table 4**).

Table 3 Summary statistics for dissolved oxygen data

Station ID	Min mg/L	Max mg/L	Delta-T mg/L	Avg mg/L	Med mg/L
LC 001.35	8.1	10.1	2.0	8.9	8.8
LC 001.25	6.5	9.8	3.3	8.3	8.1

Table 4 Summary statistics for percent saturation data

Station ID	Min %	Max %	Delta-T %	Avg %	Med %
LC 001.35	86	104	18	93	90
LC 001.25	66	102	36	85	84

Figure 2 Diel dissolved oxygen fluctuations

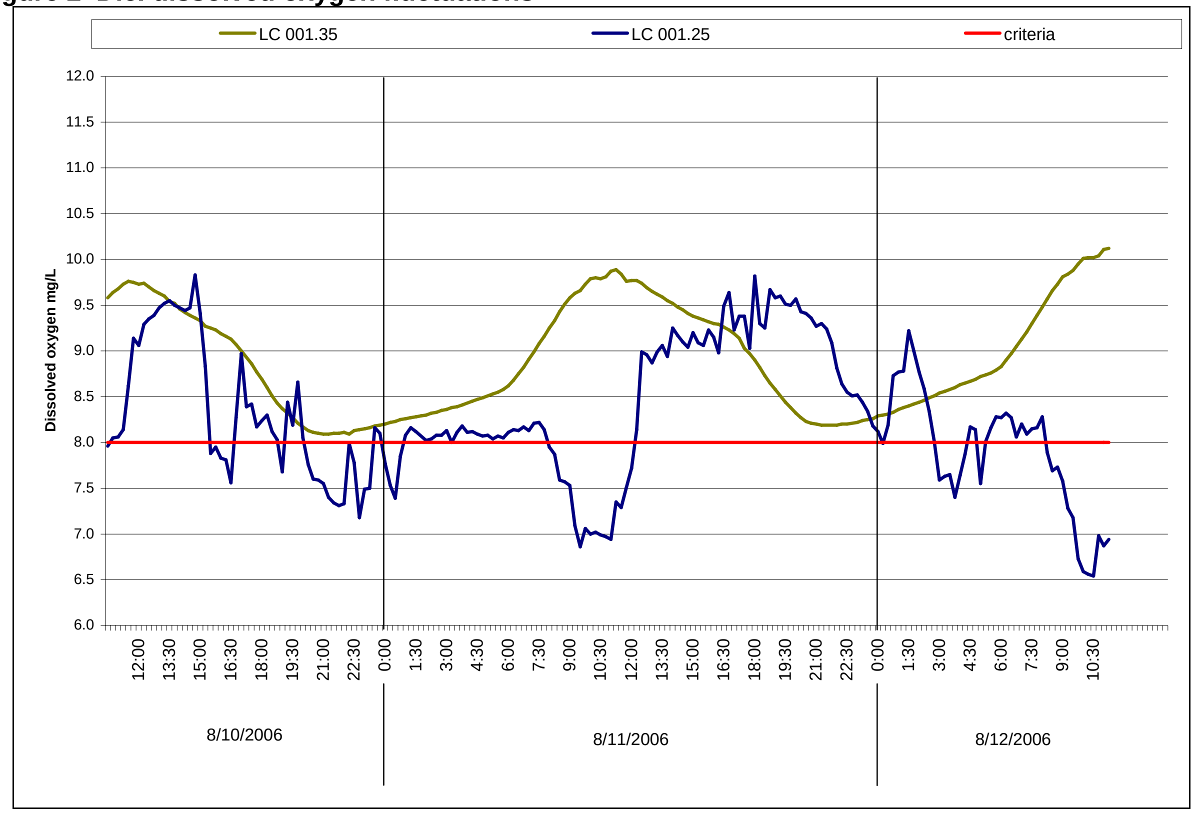
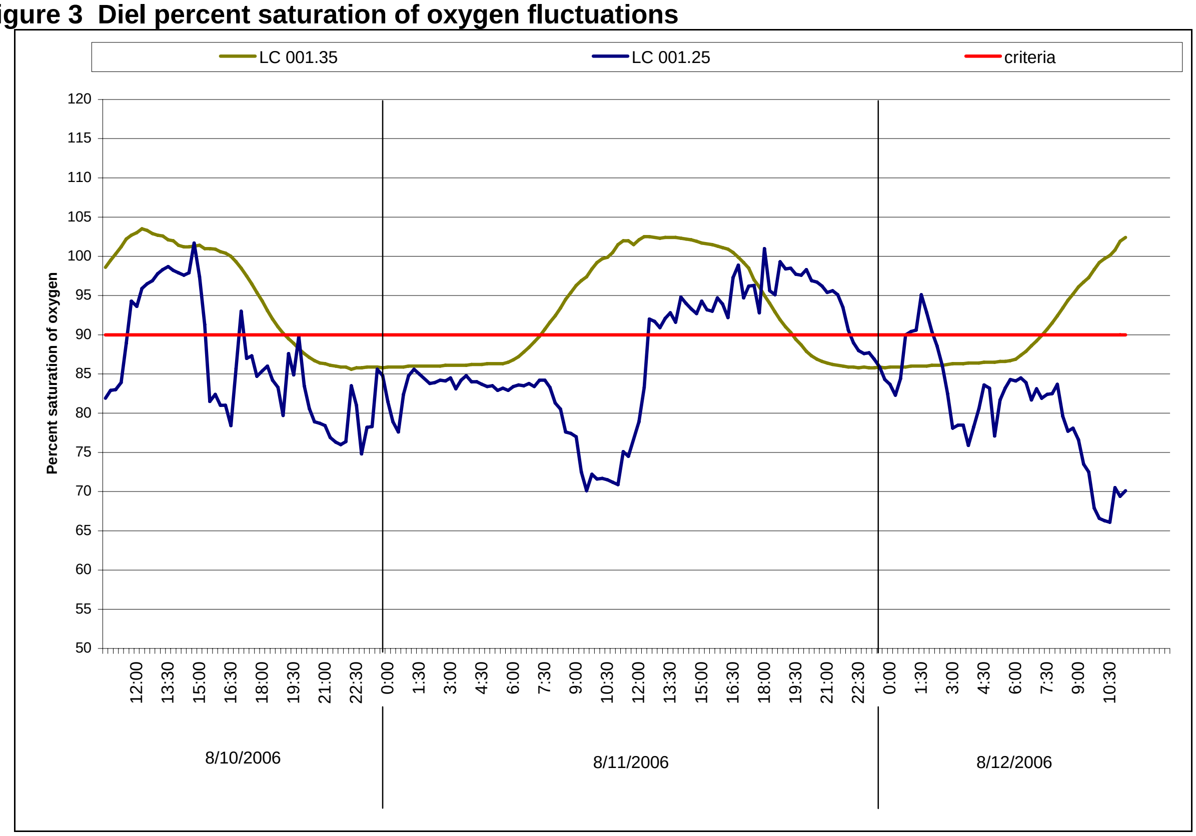


Figure 3 Diel percent saturation of oxygen fluctuations



2.3 Total dissolved solids

2.3.1 Analyses

Figure 4 depicts the diel fluctuations in total dissolved solids for the two monitoring locations. The total dissolved solids concentration is calculated using the specific conductance measurements. The green line represents LC 001.35 downstream from Road 1419 bridge, which is a location within the main channel upstream from the restoration area, while the blue line represents LC 001.25 at the old pond, which is a location within the restoration area. The red line represents the state criterion of 100 mg/L TDS set year round to protect the beneficial uses provided by freshwater streams and tributaries. The Deschutes Basin has a basin specific criterion set at 500 mg/L TDS.

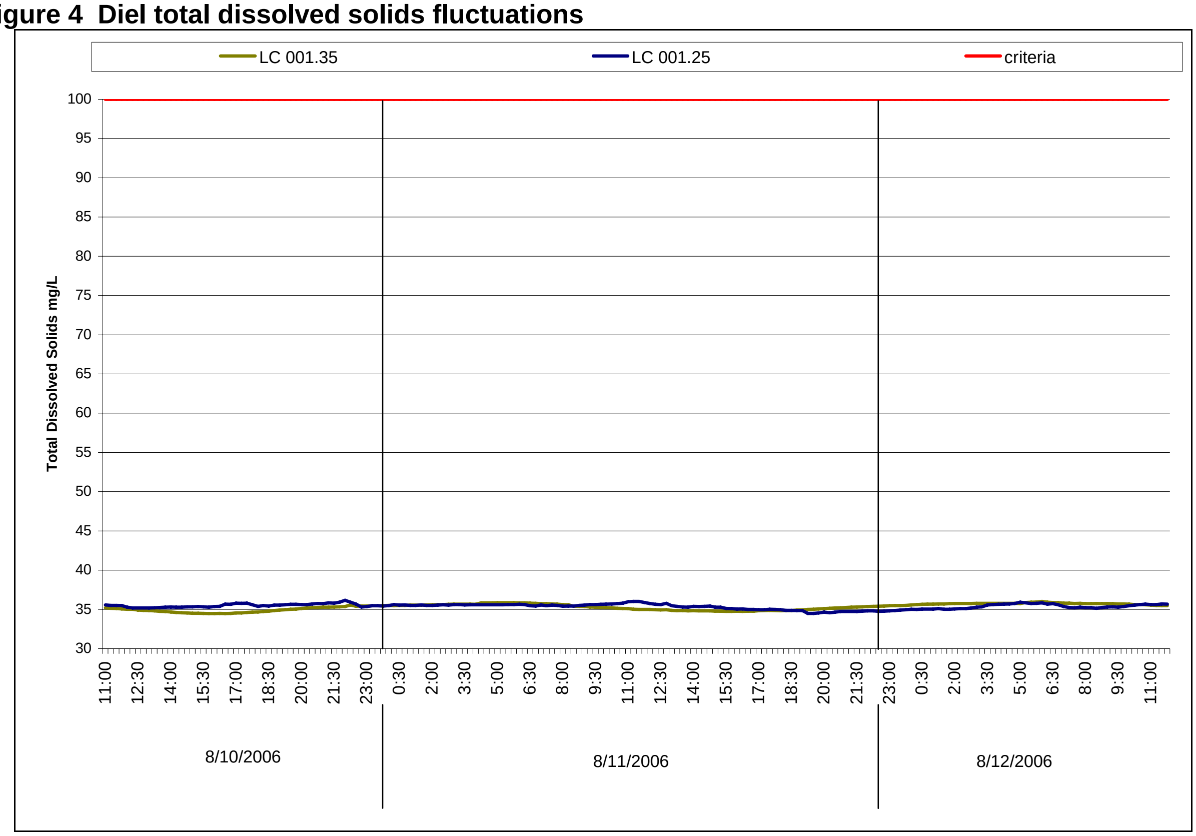
2.3.2 Interpretation

The TDS concentration at LC 001.35 located within the main channel and LC 001.25 at the old pond illustrate steady concentrations with very little fluctuation (**Figure 4)** and both monitoring locations report TDS concentrations that are well within both state and basin specific criteria. The minimum, maximum, delta-t, average, and median concentrations for TDS at both locations are the same (**Table 5**).

Table 5 Summary statistics for total dissolved solids

Station ID	Min mg/L	Max mg/L	Delta-T mg/L	Avg mg/L	Med mg/L
LC 001.35	34	36	2	35	35
LC 001.25	34	36	2	35	35

Figure 4 Diel total dissolved solids fluctuations



2.4 Turbidity

2.4.1 Analyses

Table 6 depicts the turbidity values measured on 8/12/2006 at the two monitoring locations. A numeric guideline for turbidity is recommended by OWEB under the Oregon Plan for Salmon and Watersheds as not to exceed 50 NTU. The state criterion for turbidity is narrative and allows no more than a 10% cumulative increase above background NTU.

2.4.2 Interpretation

The turbidity levels at LC 001.35 located within the main channel and LC 001.25 at the old pond illustrate levels that are well within the recommended OWEB numeric guidelines and state narrative criteria (**Table 6**).

Table 6 Summary statistics for turbidity values

Station ID	Turbidity
LC 001.35	1 NTU
LC 001.25	1 NTU

3.0 FINDINGS

There is evidence that the old pond may have stratified temperatures and oxygen layers as evidenced by:

- The difference in the temperature fluctuation pattern may be due to thermally stratified conditions within the old pond (**Figure 1**).
- Differences in fluctuations in dissolved oxygen concentrations and percent saturation of oxygen may be due to an increase in primary production within the pond. This increase in primary production may alter the natural diel fluctuations of dissolved oxygen (**Figure 2** and **Figure 3**). This is supported by the lack of temperature fluctuations within the pond that do not correspond with the sporadic fluctuations in dissolved oxygen concentrations and percent saturation of oxygen.

There is evidence that this reach may qualify for 303(d) listing as evidenced by:

- Both monitoring locations may exceed the state criteria for temperature (**Figure 1** and **Table 2**).

There is evidence that the restoration will improve dissolved oxygen concentrations and percent saturation of oxygen as evidenced by:

- LC 001.25 at the old pond does not meet state criteria for dissolved oxygen concentrations and percent saturation of oxygen, while approximately one tenth of a mile upstream at LC 001.35 located in the main channel dissolved oxygen concentrations and percent saturation of oxygen do meet the state criteria.

4.0 RECOMMENDATIONS

The following are recommendations for water quality monitoring investigations and analyses to evaluate the effectiveness of the Lake Creek Restoration Project:

- Repeat the continuous temperature, dissolved oxygen, and percent saturation measurements to evaluate if conditions return to a more natural state post restoration.

5.0 REFERENCES

ODEQ, 2004. *Oregon Administrative Rules*, Chapter 340, Division 041, Department of Environmental Quality, Oregon.

ODEQ, 2005. *Assessment Methodology for Oregon's 2004 Integrated Report on Water Quality Status*, ODEQ Water Quality Division, www.deq.state.or.us/wq/303dlist/WQ2004IntgrRpt.htm.

UDWC, 2006. *Water Quality Monitoring Program Standard Operating Procedures; Field*, prepared by Jones, L., Upper Deschutes Watershed Council, Bend, Oregon.

Upper Deschutes Watershed Council
Water Quality Monitoring Program
Technical Report

Deschutes River Temperature Summary 2004 - 2006

Upper Deschutes Subbasin, Oregon

Prepared by: Lesley Jones
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Upper Deschutes Watershed Council
Bend, Oregon: December 2006

ACKNOWLEDGMENTS

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The UDWC is thankful for the data utilized in the technical report provided via the coordinated water quality monitoring efforts of many partners in the Deschutes River watershed. In particular, the UDWC Water Quality Monitoring Program would like to extend appreciation to the OSU Undergraduate Intern 2006 Jason Brown, the UDWC Water Quality Monitoring Volunteers, the City of Bend, the Bureau of Land Management, and the United States Forest Service for their indispensable efforts towards the collection of continuous temperature data. Important information regarding flow is incorporated into the technical report and was thankfully provided by the Oregon Water Resources Department. Extended is a great thanks for the mentorship, guidance, and peer support by members of the Water Quality Committee.

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ABBREVIATIONS AND ACRONYMS

Units

C	Celsius
cfs	Cubic feet per second
RM	River mile

Organizations

BLM	Bureau of Land Management
DRC	Deschutes River Conservancy
EPA	Environmental Protection Agency
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
OSU	Oregon State University
UDWC	Upper Deschutes Watershed Council
USFS	United States Forest Service

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1.0 INTRODUCTION

1.1 Purpose

The *Deschutes River Temperature Summary 2004 - 2006* documents the status of the surface water temperatures 2004 – 2006. This information informs restoration and conservation projects that are working to improve water quality. Longitudinal temperature changes of the Deschutes River are used to demonstrate in this report that reaches with impounded waters are contributing to Section 303(d) listings for temperatures along the entire upper Deschutes River. This report also illustrates that an opportunity to cool the Deschutes River as it flows downstream is provided by the aging dams due for retrofit. This report concludes that Tumalo Creek and Whychus Creek watersheds are important areas for restoration and conservation efforts to consider in regards to cooling the Deschutes River.

1.2 Study Area

The WQ Monitoring Program coordinates monitoring across the Upper Deschutes and Little Deschutes Subbasins. This area includes 18 watersheds totaling over 3,160 square miles and over 1,800 river miles (USGS 2006). Approximately 200 historic stations are currently facilitated by our program. Across the subbasins there are multiple state of Oregon Section 303(d) listings for temperature, dissolved oxygen, pH, chlorophyll-a, turbidity, and sedimentation (ODEQ 2004b) (**Map 1**).

The Upper Deschutes Subbasin, including the upper Deschutes, Tumalo Creek, and Whychus Creek watersheds, covers approximately 2140 square miles spanning from the crest of the Cascades (10,358 feet) to Lake Billy Chinook (1,900 feet). The mean annual precipitation in the Upper Deschutes Subbasin ranges from 140 inches in higher elevations to ten inches in the lower elevations of the Deschutes River Valley. Surface water comes mainly from springs and snow/glacial melt systems with a small amount from direct precipitation runoff. A significant amount of water moves through the system as groundwater due to the highly permeable surface materials of the landscape. Cascade snow melt provides annual groundwater recharge estimated at 3,800 cubic feet per second (cfs) that mostly occurs in the higher elevation areas of the upper basin (USGS 2001).

Deschutes River watersheds

The Deschutes River headwaters are located on the Deschutes National Forest at Little Lava Lake (RM 252) where groundwater inflows appear as springs on the north side of the lake. The Deschutes River flows south from Little Lava Lake to Crane Prairie Reservoir (RM 243 – 239), then travels east through Wickiup Reservoir (RM 237 – 227). Downstream from Wickiup Reservoir, three major tributaries contribute flows to the Deschutes River and include Fall River (RM 205), Little Deschutes River (RM 193), and Spring River (RM 190). Near Spring River, a complex of groundwater springs enters the system. Next, the river flows past the Central Oregon Irrigation District diversion before crossing over the southern City of Bend urban growth boundary (UGB) (RM 172). Four impoundments along the Deschutes River are created by the Colorado Avenue Dam, Pacific Power Company hydroelectric dam (i.e. Mirror Pond), the Steidl Dam, and the North Canal Dam. After the major diversion located at the North Canal Dam and at the northern City of Bend UGB located at RM 159, Tumalo Creek is a major tributary to the Deschutes River. Downstream thirty miles, groundwater springs begin to enter the Deschutes near Lower Bridge Road (RM 133), Whychus Creek joins the Deschutes River (RM 123), and the river flows downstream to Lake Billy Chinook (RM 120).

Whychus Creek watershed

Whychus Creek is 39 RM long and is a major tributary to the Deschutes River. The headwaters are located in the Three Sisters Wilderness Area. The creek flows through the town of Sisters, gains cool flow from the Camp Polk Springs complex and Alder Springs complex, then meets up with the Deschutes River (RM 123) upstream of Lake Billy Chinook.

Tumalo Creek watershed

Tumalo Creek is approximately 20 RM long and it is a major tributary to the Deschutes River. The headwaters are from the Three Sisters Wilderness Area. The creek spills over Tumalo Falls and meets up with Deschutes River (RM 160) upstream of Tumalo State Park at the northern City of Bend UGB.

1.3 Background

The establishment of homesteaders in 1898 and agriculture in the Deschutes River Valley in 1900 marks the start of changes for the Deschutes River (UDWC 2003b). In 1901, Central Oregon Irrigation District Canal began diverting water from the Deschutes River to support agriculture. Between 1910 and 1922 the four dams through the City of Bend had been constructed for agriculture, timber, and hydroelectricity (UDWC 2003b). Upon the completion of Crane Prairie Reservoir in 1940 and Wickiup Reservoir in 1949 by the U.S. Bureau of Reclamation, the naturally stable year-round flows of the Deschutes River were greatly modified (USDI 2006).

The Deschutes River has been greatly modified from its historically stable flows in order to meet economic needs. The Deschutes River upper reach is characterized with low winter flows that are reduced for storage and high summer flows that are increased for irrigation needs (DWA 2006). The Deschutes River middle reach is characterized with low flows resulting from irrigation withdraws (DWA 2006). This fluctuation in flow to provide for irrigation has been linked to a variety of water quality impacts and is a driver of the state of Oregon 303(d) listed status of the Deschutes River (**Map 1**) (UDWC 2003a, UDWC 2003b, and DWA 2006).

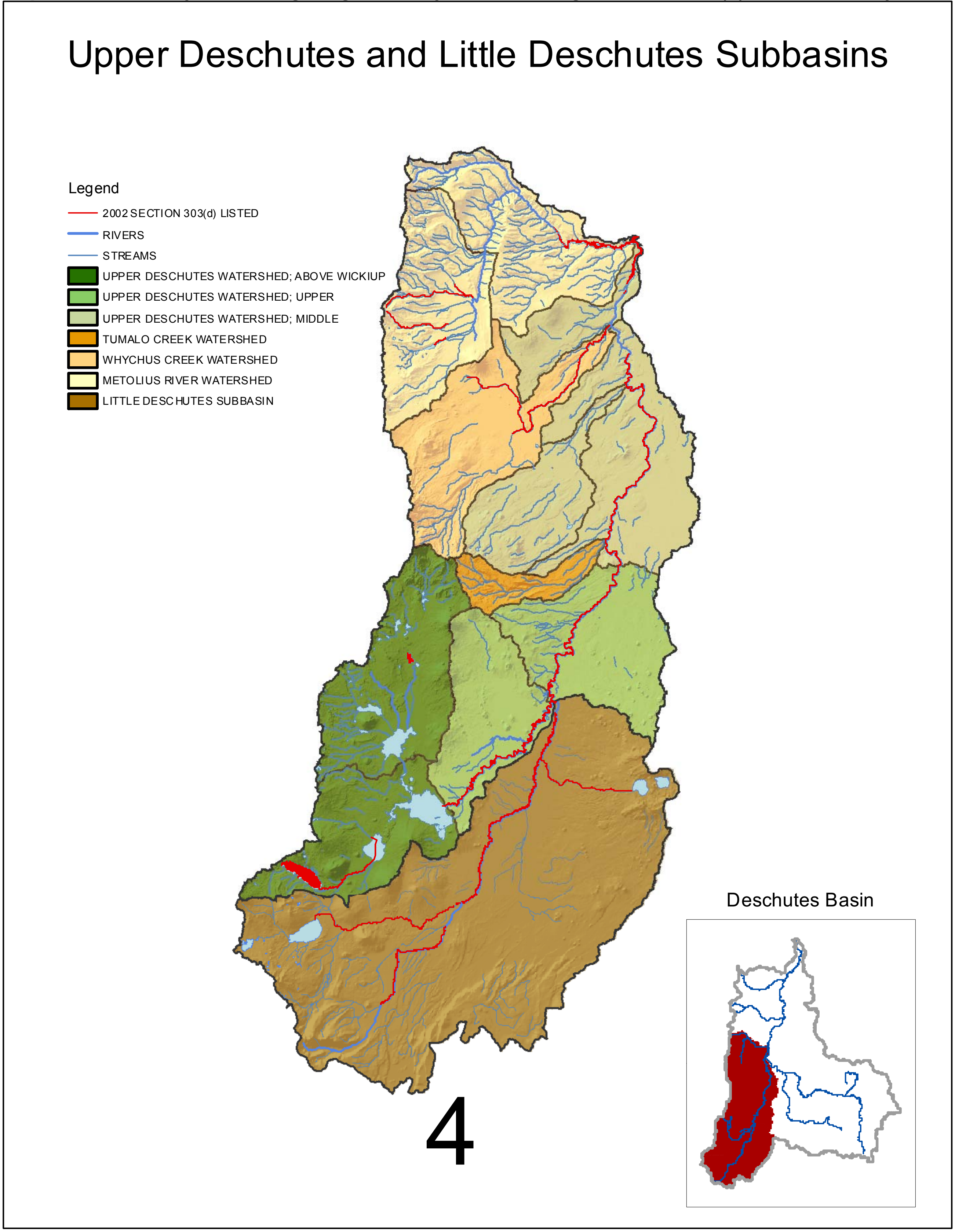
Table 1 provides the Deschutes River average daily flow on the hottest water day of the year 2006, 2005, and 2004. In 2006, The Deschutes River flow released from Wickiup Reservoir is high (1682+ cfs). Downstream, the Deschutes River gains flow (265 cfs) from tributaries and springs. The Deschutes River flow at Benham Falls is high (1947 cfs) as it flows past the southern City of Bend UGB. After passing the North Canal Dam, the Deschutes River is greatly reduced (94 cfs). Tumalo Creek contributes flow to the Deschutes River (5 cfs) as do the groundwater springs downstream of Lower Bridge Road (*300 cfs) and Whychus Creek (164 cfs). (*Flows derived by information from the OWRD synoptic data. LaMarch, J., OWRD, e-mail December 2006).

Table 1 Deschutes River average daily flow on the hottest water day 2006, 2005, and 2004

	Average daily flow (cfs)		
Gauge	**7/25/2006**	**7/20/2005**	**7/28/2004**
WICO: downstream Wickiup Reservoir	1682	1461	1533
BENO: Benham Falls	1947	1799	1870
DEBO: downstream North Canal Dam	94	78	78
TUMO: Tumalo Creek mouth	5	6	8
Groundwater springs from Lower Bridge Road to Whychus Creek*	300	300	300
SQSO+ 100 cfs groundwater springs: Whychus Creek mouth	164	107	111

*Approximate gain estimated from OWRD synoptic data August 2005.

Map 1 Water Quality Monitoring Program study area and Oregon Section 303(d) listed waterways



1.4 Monitoring

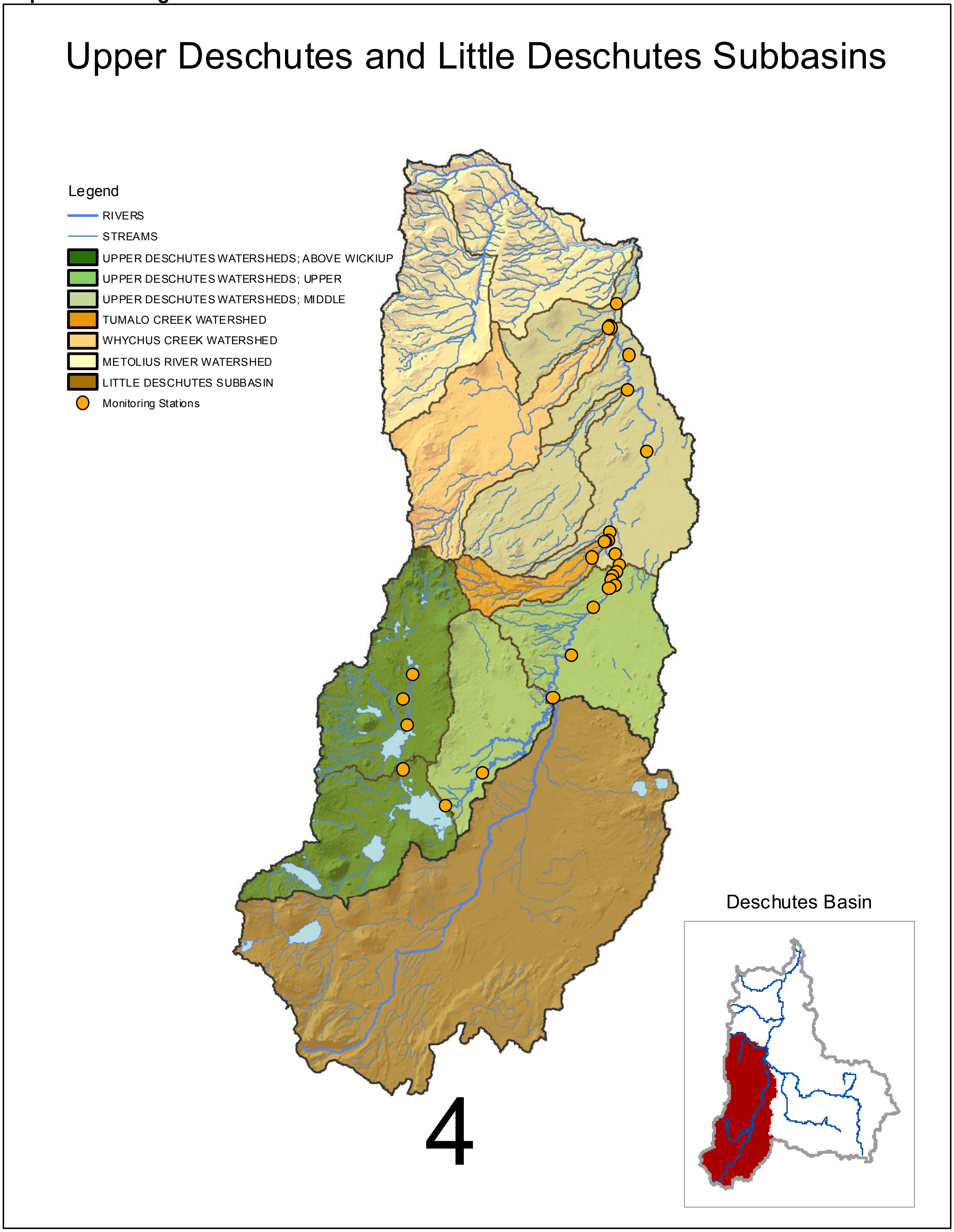
The continuous temperature monitoring activities for 2004 - 2006 presented in this summary were coordinated by the Water Quality Monitoring Program (WQ Monitoring Program). Stations are described in **Table 2**.

Table 2 Monitoring stations

	Station ID	System	Location	Latitude	Longitude	Elev	2004	2005	2006
1	DR 120.00	Deschutes River	USGS gaging station u/s Lake Billy Chinook	44.49893	-121.31991	1940	X	X	X
2	DR 123.00	Deschutes River	d/s Whychus Creek	44.46144	-121.33464	2080		X	X
3	DR 123.25	Deschutes River	u/s Whychus Creek	44.45947	-121.33108	2130	X	X	X
4	DR 127.75	Deschutes River	u/s Steelhead Falls	44.41562	-121.28984	2300	X	X	X
5	DR 133.50	Deschutes River	Lower Bridge	44.35970	-121.29378	2520	X	X	X
6	DR 141.00	Deschutes River	Tetherow Crossing	44.31246	-121.24111	2710	X		
7	DR 146.00	Deschutes River	u/s Cline Falls State Park	44.26053	-121.24707	2850	X	X	X
8	DR 158.50	Deschutes River	d/s end Tumalo State Park	44.13078	-121.32903	3190	X	X	X
9	DR 159.50	Deschutes River	Tumalo Bridge	44.12264	-121.33219	3210	X		
10	DR 160.00	Deschutes River	d/s Tumalo Boulder Field	44.11767	-121.33326	3210		X	X
11	DR 160.25	Deschutes River	u/s Tumalo Creek	44.11501	-121.33904	3240	X	X	X
12	DR 163.25	Deschutes River	Firerock footbridge	44.09530	-121.31583	3450	X	X	X
13	DR 164.75	Deschutes River	u/s Riverhouse Hotel	44.07733	-121.30592	3540	X	X	X
14	DR 165.75	Deschutes River	First St. Rapids	44.06757	-121.31297	3560	X	X	X
15	DR 166.00	Deschutes River	u/s Portland Ave. Bridge	44.06378	-121.31130	3580	X		
16	DR 166.75	Deschutes River	Drake Park Footbridge	44.06016	-121.32111	3600	X	X	X
17	DR 167.25	Deschutes River	Columbia Park Footbridge	44.05257	-121.32487	3600	X	X	X
18	DR 168.00	Deschutes River	Columbia St. Bridge	44.04413	-121.31578	3610	X	X	X
19	DR 169.00	Deschutes River	u/s end Mill Log Pond	44.03947	-121.32982	3620	X	X	X
20	DR 172.00	Deschutes River	Southern UGB	44.00850	-121.36485	3810		X	X
21	DR 173.00	Deschutes River	USFS Meadow Camp	44.00092	-121.37762	3840	X		
22	DR 181.50	Deschutes River	Benham Falls Footbridge	43.93080	-121.41107	4140		X	X
23	DR 191.75	Deschutes River	Harper Bridge	43.86336	-121.45209	4160	X	X	X
24	DR 192.75	Deschutes River	u/s Little Deschutes River	43.85365	-121.45381	4160	X	X	X
25	DR 199.00	Deschutes River	d/s General Patch Bridge	43.81778	-121.49466	4160	X		
26	DR 207.25	Deschutes River	Big Tree	43.77359	-121.52003	4170	X		
27	DR 217.25	Deschutes River	Pringle Falls Experimental Station	43.74075	-121.60672	4250	X	X	X
28	DR 237.50	Deschutes River	d/s Browns Crossing	43.74420	-121.78234	4340	X	X	X
29	DR 243.75	Deschutes River	Cow camp	43.81631	-121.77580	4450	X	X	X
30	DR 246.75	Deschutes River	d/s Deschutes bridge at pullout by mm 42	43.85823	-121.78439	4560	X	X	X
31	DR 250.50	Deschutes River	d/s Little Lava Lake	43.89670	-121.76379	4740	X	X	X
32	SC 000.25	Whychus Creek	Mouth	44.45944	-121.33669	2100	X	X	X
33	TC 000.25	Tumalo Creek	Mouth	44.11567	-121.34031	3250	X	X	X
34	TC 003.25	Tumalo Creek	d/s Tumalo Feed Canal gauge	44.08924	-121.36731	3550	X	X	X

Stations listed in **Table 1** are displayed on **Map 2.** The data in this report is graded and interpreted according to the ODEQ assessment methodology for water quality status (ODEQ, 2004 and ODEQ, 2005). The ODEQ assessment methodology dictates that the seven day moving average maximum temperature (7DAM) in degree Celsius (°C) is used to evaluate the numeric temperature criterion of 18 °C set to protect the beneficial uses of salmon and trout spawning, rearing, and migration within the Deschutes River.

Map 2 Monitoring stations



2.0 TEMPERATURE MONITORING RESULTS DESCHUTES RIVER

2.1 Longitudinal temperature status

Figure 1 shows the water temperatures of Deschutes River for all stations in 2006. The x-axis represents time and the y-axis represents the 7DAM °C. The red line represents the 18 °C state standard set to protect the beneficial use of salmon and trout spawning, rearing, and migration.

The purpose of **Figure 1** is to illustrate the range of water temperatures reported in 2006 between Wickiup Reservoir and Lake Billy Chinook. It is evident on **Figure 1** that some stations have incomplete data for 2006. These stations are detailed as follows:

- DR 123.00 Deschutes River downstream Whychus Creek — logger failed
- DR 123.25 Deschutes River upstream Whychus Creek — logger still deployed
- DR 158.50 Deschutes River downstream Tumalo State Park — logger out of water
- DR 160.50 Deschutes River upstream Tumalo Creek — logger still deployed
- Deschutes River at all stations above Wickiup Reservoir — logger failed
- TC 000.25 Tumalo Creek mouth — logger still deployed

Figure 2, Figure 3, and **Figure 4** show the water temperatures of Deschutes River for selected stations in 2006, 2005, and 2004 respectively. The selected stations illustrate the change in downstream temperatures for the Deschutes River and include:

- DR 217.25 Deschutes River at Pringle Falls Experimental Station
- DR 133.50 Deschutes River at Lower Bridge Road
- DR 123.00 Deschutes River downstream Whychus Creek

Pringle Falls Experimental Station is the most upstream station and represents the starting temperature of the Deschutes River as it is released from Wickiup Reservoir. The starting temperatures approach or exceed the state criteria. The Deschutes River experiences a general downstream warming trend as it flows to the Lower Bridge Road at which point the warmest temperatures are recorded for the system and the water is in essence evaporating. As the water flows past Lower Bridge Road toward Lake Billy Chinook, the river experiences a cooling trend as a major groundwater spring complex decreases the Deschutes River temperature below the upstream starting temperature at Pringle Falls Experimental Station.

Figure 1 Deschutes River temperature results 2006

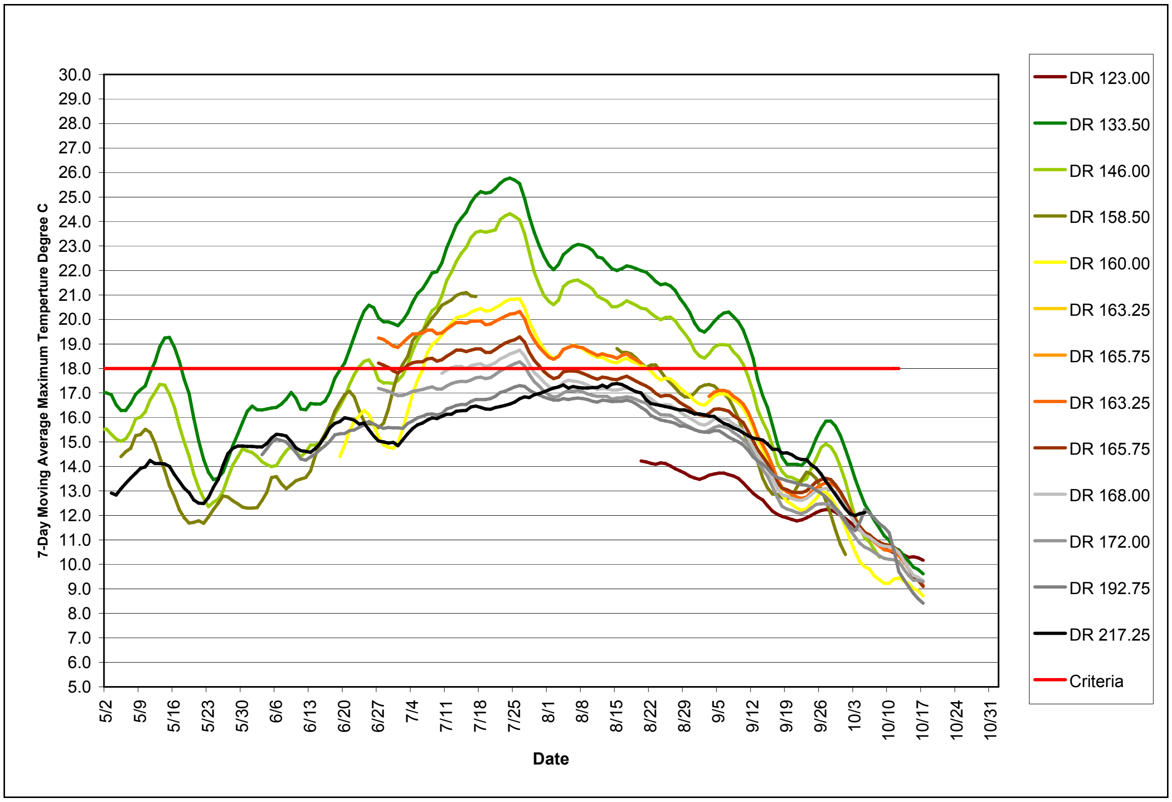


Figure 2 Deschutes River temperature results 2006; select locations

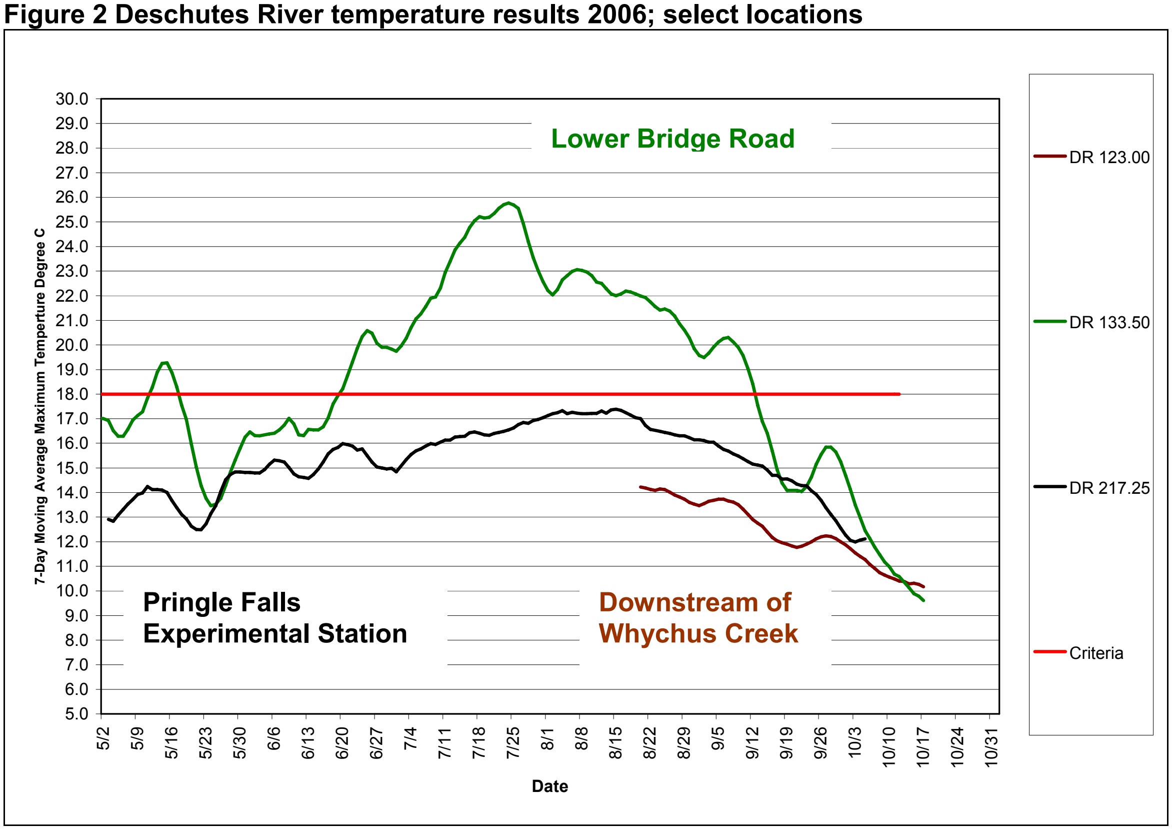


Figure 3 Deschutes River temperature results 2005; select locations

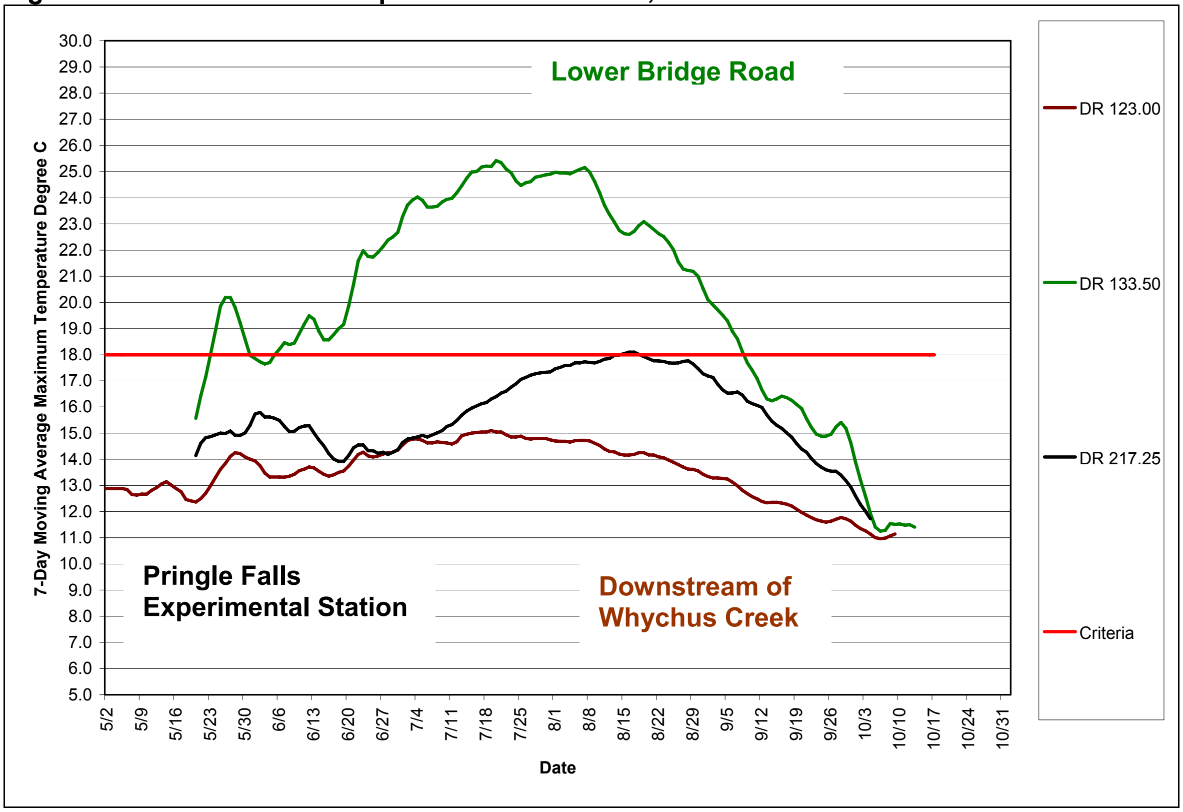
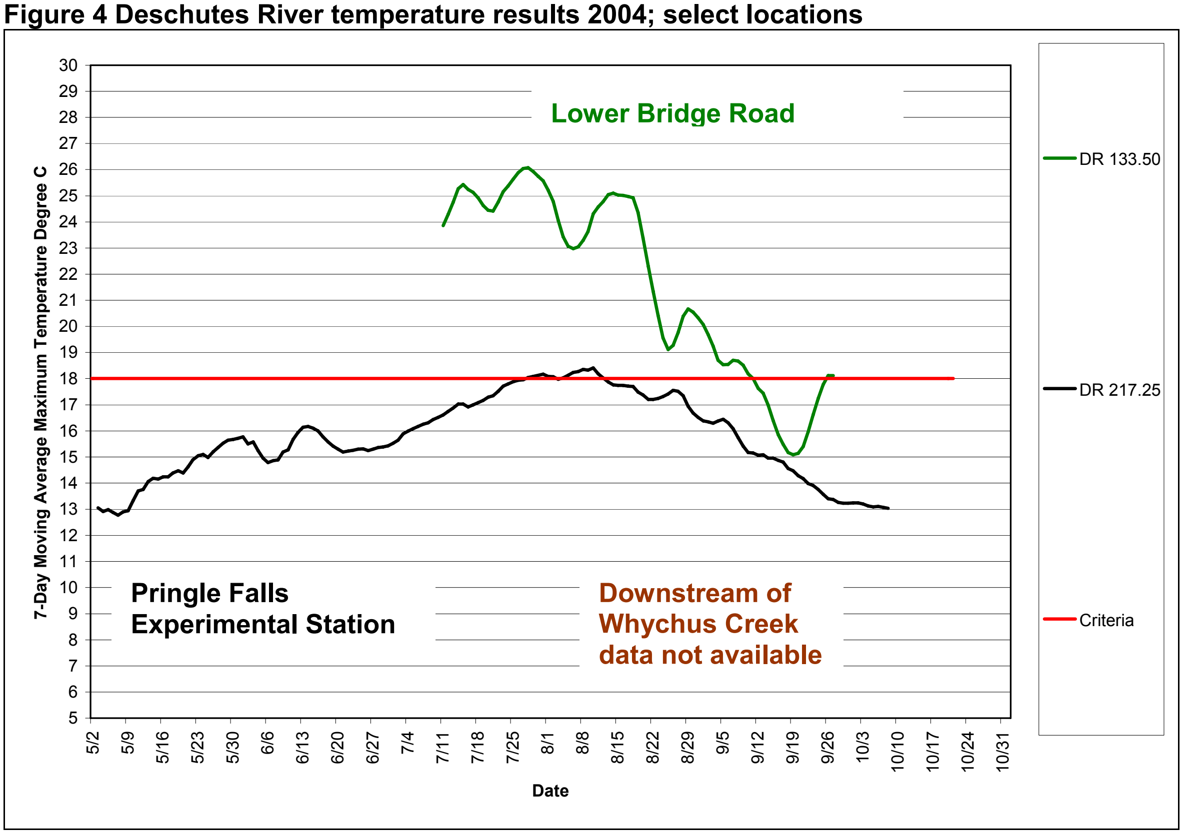


Figure 4 Deschutes River temperature results 2004; select locations



2. 2 Longitudinal temperature hottest water day and rate of temperature change

Figure 5, **Figure 7**, and **Figure 8** represent actual 7DAM °C on the hottest water day of each year: 7/25/2006, 7/20/2005, and 7/28/2004 respectively. The x-axis represents RM from upstream to downstream. Anthropogenic and natural features are provided for reference. The y-axis represents the 7DAM °C. The red line represents the state temperature standard set to protect the beneficial use of salmon and trout spawning, rearing, and migration.

Figure 6, **Figure 8**, and **Figure 10** represent the rate of temperature change in the 7DAM °C on the hottest water day of each year: 7/25/2006, 7/20/2005, and 7/28/2004 respectively. The x-axis represents RM from upstream to downstream. Anthropogenic and natural features are provided for reference. The y-axis represents the change in the 7DAM °C. The solid blue line is the average rate of temperature change for the reach (ΔT_r), which is calculated as the change in temperature within the reach over the length of the reach.

$$\Delta T_r = (T_{d/s} - T_{u/s}) / (RM_{u/s} - RM_{d/s})$$

Where:

ΔT_r	= average rate of temperature change for the reach	C / RM
$T_{u/s}$	= upstream station temperature (starting)	C
$T_{d/s}$	= downstream station temperature (ending)	C
$RM_{u/s}$	= upstream station	RM
$RM_{d/s}$	= downstream station	RM

A rate of temperature change between stations (ΔT_s) is calculated as the change in temperature between stations over the distance between stations.

$$\Delta T_s = (T_{d/s} - T_{u/s}) / (RM_{u/s} - RM_{d/s})$$

Where:

ΔT_s	= rate of temperature change between stations	C / RM

The rate of temperature change between stations (ΔT_s) is compared to the average rate of temperature change for the reach (ΔT_r). A Blue triangle indicates a rate of temperature change between stations (ΔT_s) that is *lower* than the average rate of temperature change for the reach (ΔT_r). A red diamond indicates a rate of temperature change between stations (ΔT_s) that is *higher* than the average rate of temperature change for the reach (ΔT_r).

A *higher* rate of temperature change between stations (ΔT_s) when compared to the average rate of temperature change for the reach (ΔT_r) indicates an area where water quality changes are not beneficial and that may need restoration. Conversely, a *lower* rate of temperature change between stations (ΔT_s) when compared to the average rate of temperature change for the reach (ΔT_r) indicates an area where the temperature is not changing, the water is cooling, or conservation may be considered.

Lower and higher rates of temperature change indicate influencing factors that can be used to inform restoration and conservation efforts. Several influencing factors on the rate of temperature change include:

- Climate year: hot or cold, dry or wet
- Quantity of flow: increased flow provides greater buffering of warming and cooling influences
- Anthropogenic features: dams and impoundments
- Natural features: tributaries and groundwater springs

Table 3 depicts the average rate of temperature change (ΔT_r) for three reaches of the Deschutes River in 2004 - 2006. The stations and climate are different year to year, yet the rate of temperature change (ΔT_r) (blue line) is consistent. By looking at **Figure 6**, **Figure 8**, and **Figure 10** a similar pattern 2004 - 2006 emerges in regards to where the river expresses the most warming and cooling behavior (ΔT_s) (red diamonds and blue triangles).

Table 3 Deschutes River average rate of temperature change for each reach (ΔT_r).

	ΔT_r = change in °C per mile		
Deschutes River	**2006**	**2005**	**2004**
Lava Lake to Wickiup Reservoir	No data	0.5	0.5
Wickiup Reservoir to North Canal Dam	0.1	0.0	0.0
North Canal Dam to Lake Billy Chinook	0.2	0.1	0.2

Table 4 provides a reach, 7DAM °C, rate of temperature change (ΔT_r), and flow (cfs) matrix for the hottest days in 2004 - 2006. The average starting temperature of the Deschutes River Lava Lake to Wickiup Reservoir even at high flows (above the target flow) is not compliant with state standard. The starting temperature of the Deschutes River between Wickiup Reservoir to North Canal Dam even at high flows is also not compliant. The starting temperature between North Canal Dam and lower bridge road is well over the state standard as expected with low flows. The most upstream location, which traditionally is the coolest, has on average 319 cfs daily flow (QD) that is more than the 250 cfs target downstream between North Canal Dam to Lower Bridge Road, yet the headwater reach is not compliant with the state standard. There is a need to evaluate the ability of in-stream flow restoration targets to result in cool water temperatures.

Table 4 Deschutes River hottest day matrix reach averages 2006, 2005, and 2004

Reach	Avg. ΔT_r	Avg. 7DAM °C *	Avg. QD cfs**	Target flows***
Lava Lake to Wickiup Reservoir	0.5	19.4	319	60
Wickiup Reservoir to North Canal Dam	0.0	18.3	1872	300
North Canal Dam to Lake Billy Chinook	0.2	22.1	83	250

*Average temperature for the locations monitored. **Gauges: CRAO, BENO, DEBO. ***Targets based on ODFW instream water rights for July.

The purpose of **Figure 5**, **Figure 7**, and **Figure 9** is to illustrate where the most impaired water temperature occur along the longitudinal extent of the Deschutes River. Water temperatures are above state criteria after the river leaves Crane Prairie Reservoir. Water released from Wickiup Reservoir represents a starting temperature for the Deschutes River upper reach. Temperatures are stable from Wickiup Reservoir through to the southern City of Bend UGB and are near and exceed state criteria. Temperatures are above state criteria while the river is detained by impoundments located within the City of Bend. After spilling over North Canal Dam, temperatures continue to rise until Lower Bridge Road. As the Deschutes River flows downstream from Lower Bridge Road, temperatures cool and are within the state criteria.

The purpose of **Figure 6**, **Figure 8**, and **Figure 10** is to illustrate where the most influence on water temperatures occur along the longitudinal extent of the Deschutes River. Rates of temperature change are above average for the reach after the river leaves Crane Prairie Reservoir. Water released from Wickiup Reservoir has stable temperature through to the southern City of Bend UGB as indicated by blue triangles. The rate of temperature change between stations increases as the river is detained by impoundments located within the City of Bend as indicated by red diamonds. After flowing past North Canal Dam, the rate of temperature change between stations is still elevated as indicated by red diamonds. Once the Deschutes River reaches the Lower Bridge Road, the rate of temperature change between stations is represented by blue triangles indicating that the water has reached its maximum temperature and is evaporating (~26 7DAM °C). As the Deschutes River flows downstream from Lower Bridge Road, the rate of temperature change between stations is represented by blue triangles that indicate a cooling impact on the Deschutes River.

Figure 11, **Figure 12**, and **Figure 13** illustrate the impact of anthropogenic and natural features on the Deschutes River rate of temperature change between stations. Anthropogenic features influence the Deschutes River rate of temperature change as indicated by red diamonds behind the impoundments formed by Colorado Street Dam, Bend Hydroelectric Dam, Steidhl Dam, and North Canal Dam.

Natural features influence the Deschutes River rate of temperature change as indicated in **Figure 12** and **Figure 13** as evidenced by the influence of Tumalo Creek on the Deschutes River. In 2005, a red diamond is depicted on **Figure 12** after the Deschutes River confluence with Tumalo Creek indicating no cooling affect from Tumalo Creek. In 2004, a blue triangle is depicted on **Figure 13** after the Deschutes River confluence with Tumalo Creek indicting a cooling affect from Tumalo Creek. This potential cooling is determined by flows in Tumalo Creek (see section 2.3).

Figure 5 Deschutes River hottest water day temperatures; 7/25/2006

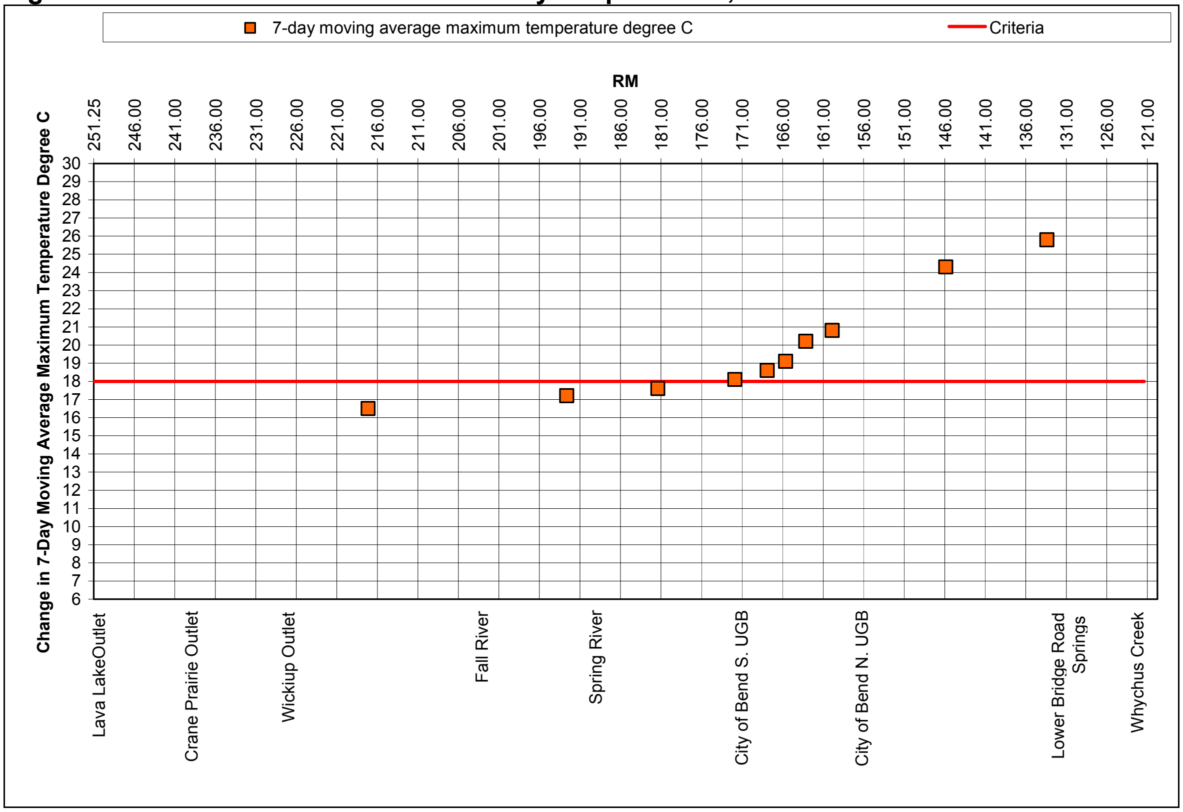


Figure 6 Deschutes River hottest water day rate of temperature change; 7/25/2006

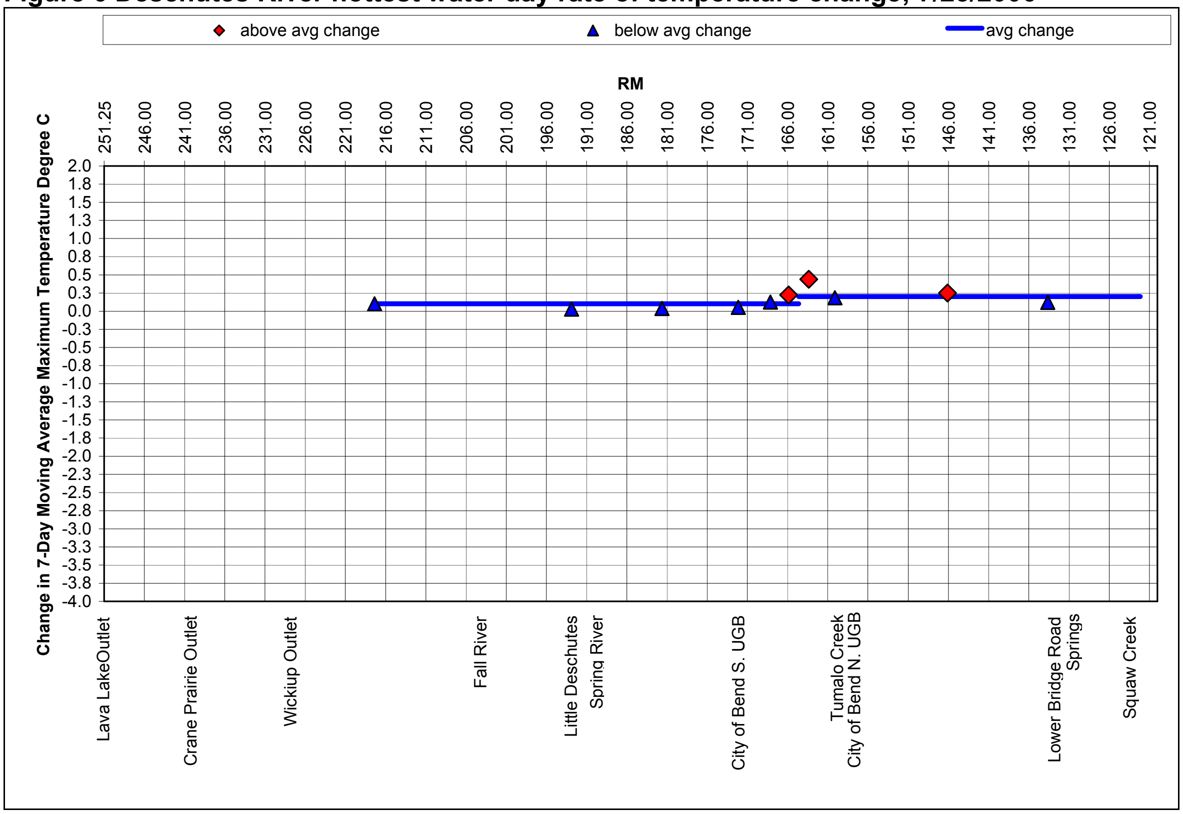


Figure 7 Deschutes River hottest water day temperatures; 7/20/2005

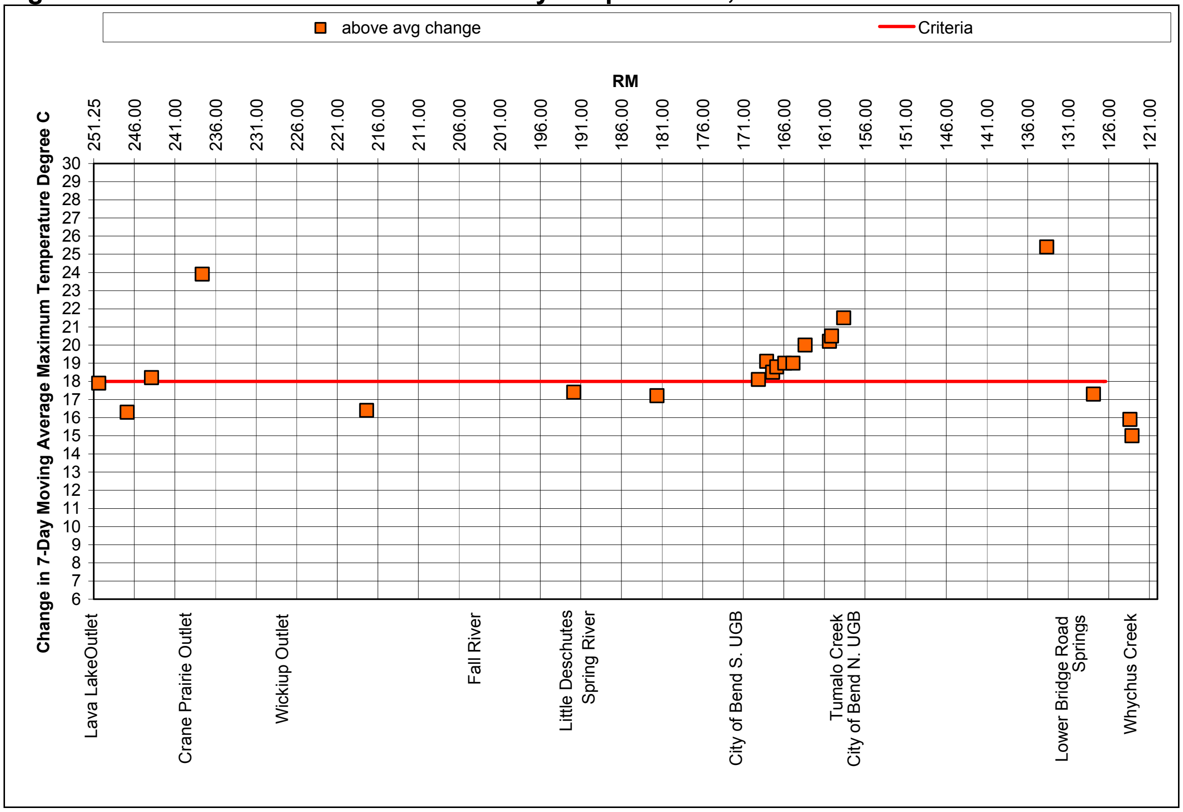


Figure 8 Deschutes River hottest water day rate of temperature change: 7/20/2005

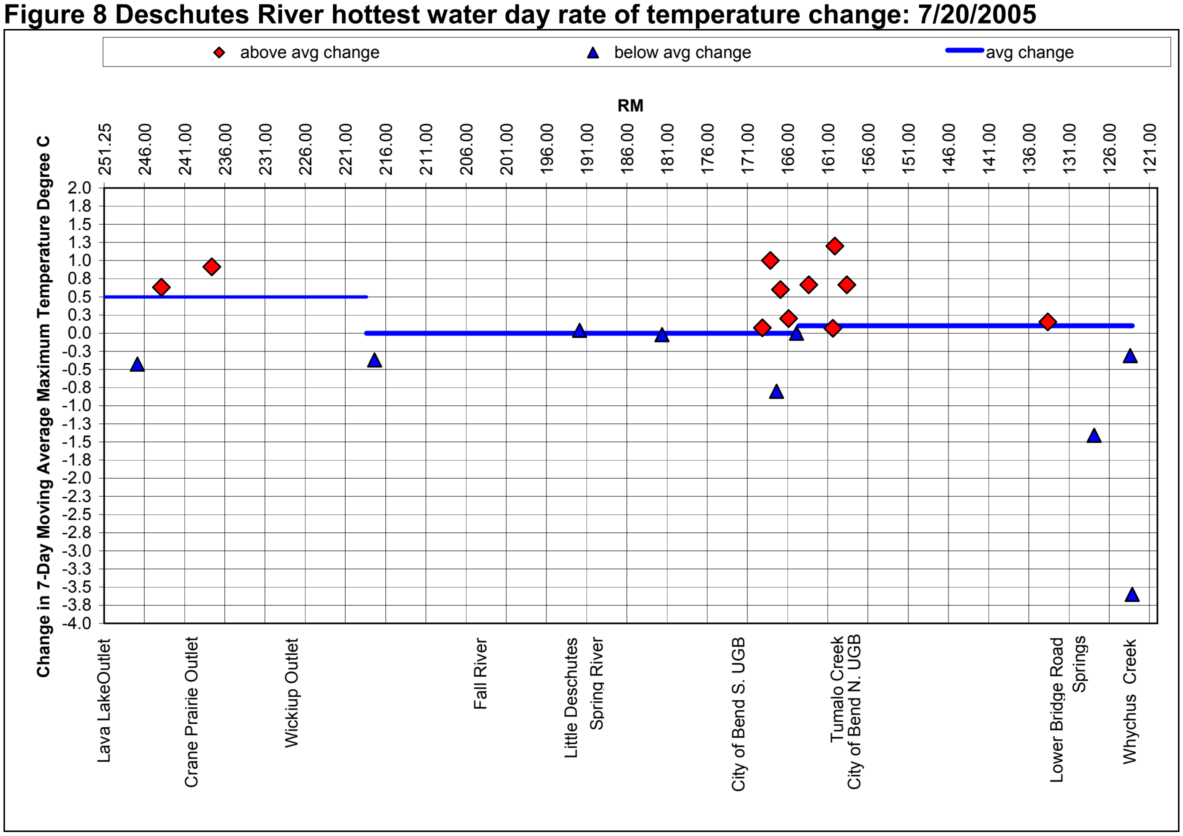


Figure 9 Deschutes River hottest water day temperatures; 7/28/2004

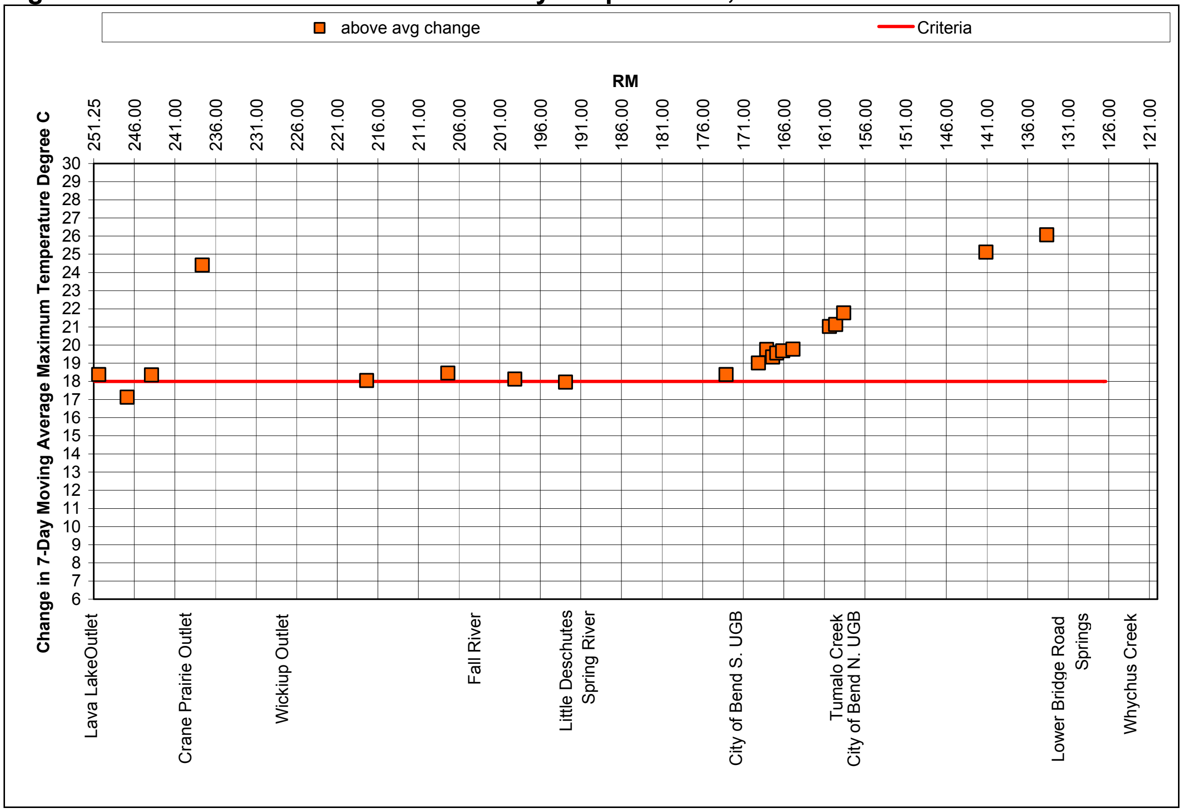


Figure 10 Deschutes River hottest water day rate of temperature change; 7/28/2004

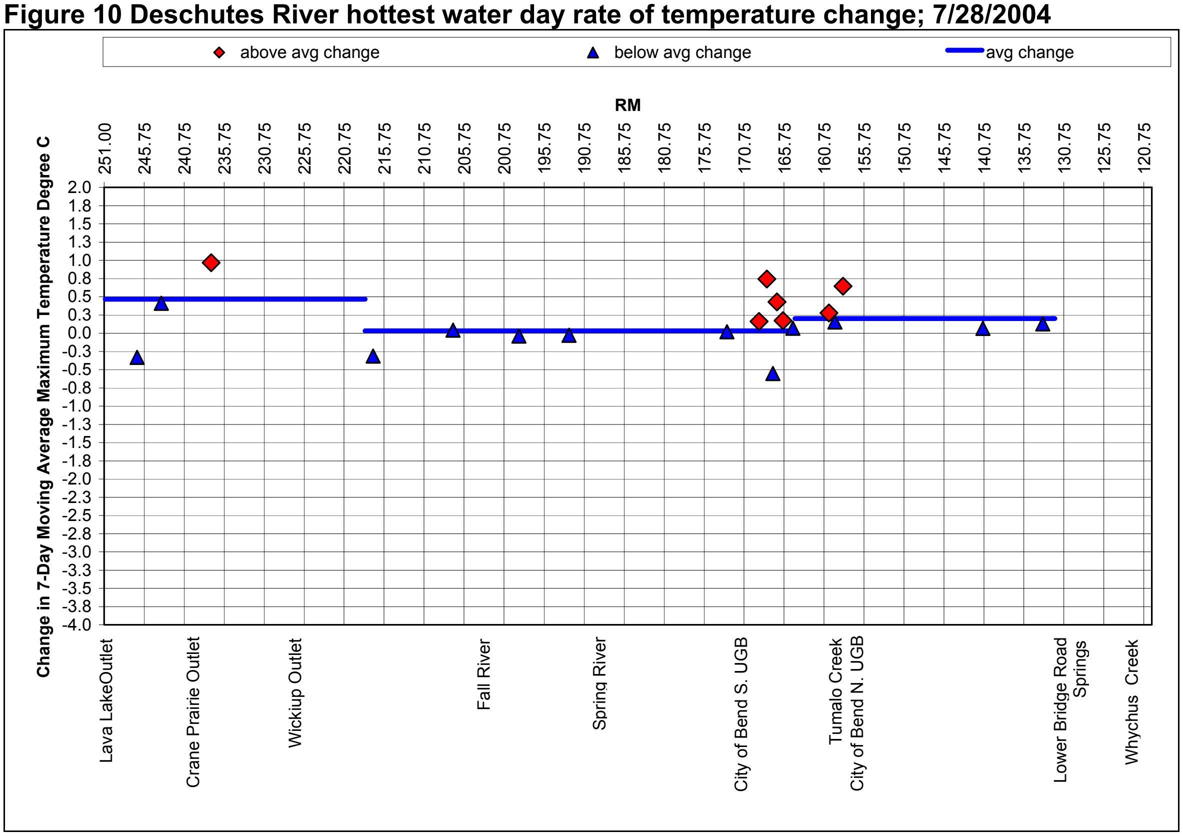


Figure 11 Deschutes River hottest water day rate of temperature change City of Bend reach; 7/25/2006

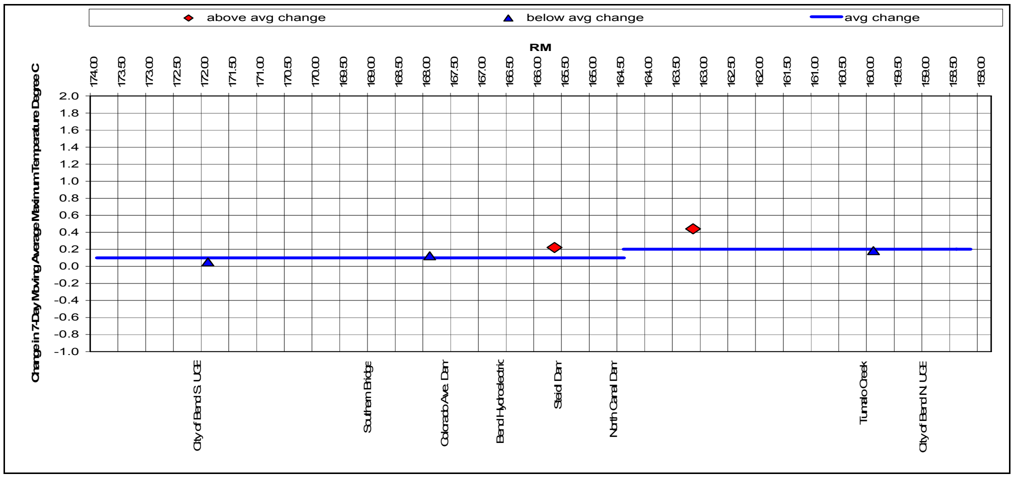


Figure 12 Deschutes River hottest water day rate of temperature change City of Bend reach; 7/20/2005

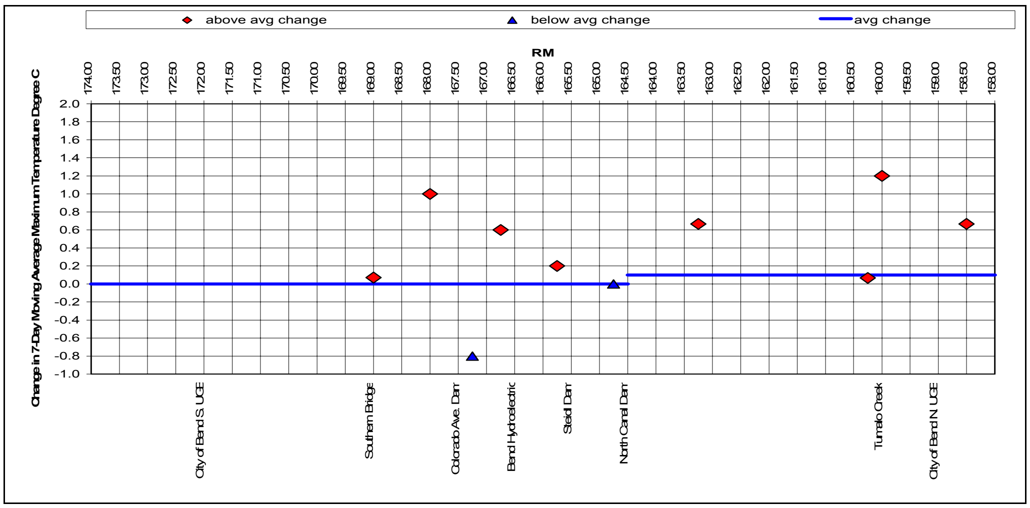
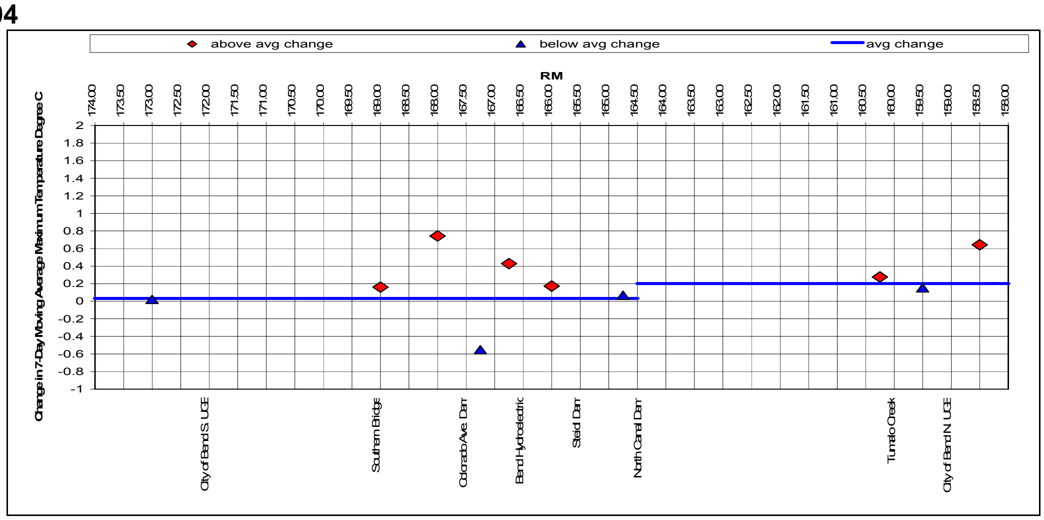


Figure 13 Deschutes River hottest water day rate of temperature change City of Bend reach; 7/28/2004



2.3 Influences of Tumalo Creek watershed on the Deschutes River

Figure 14, **Figure 15**, and **Figure 16** show the water temperatures of Deschutes River and Tumalo Creek during 2006, 2005, and 2004 respectfully. The x-axis represents time and the y-axis represents the 7DAM °C. The red line represents the 18 °C state standard set to protect the beneficial use of salmon and trout spawning, rearing, and migration. The secondary y-axis represents flow in cubic feet per second (cfs). The green line represents the Deschutes River upstream of Tumalo Creek. The orange line represents the Deschutes River downstream of Tumalo Creek. The blue line represents Tumalo Creek mouth. The dark blue line represents Tumalo Creek downstream Tumalo Feed Canal. The green dashed line represents Deschutes River flow at Oregon Water Resources Department (OWRD) DEBO gauge (Deschutes below Bend) and the dashed blue line represents Tumalo Creek flow at OWRD TUMO gauge (Tumalo Creek near Bend).

The purpose of **Figure 14**, **Figure 15**, and **Figure 16** is to illustrate the influence of Tumalo Creek on the temperatures of the Deschutes River. Tumalo Creek is significant because it is the last input of flow into the Deschutes River until groundwater influences 30 RM downstream near Whychus Creek watershed. These graphs indicate that Tumalo Creek can have a cooling influence on the Deschutes River when there are adequate cool flows in the creek.

Due to general downstream warming trends, the Deschutes River downstream of Tumalo Creek (orange line) should be warmer than the Deschutes River upstream of Tumalo Creek (green line). Yet, when Tumalo Creek contributes cool flows to the Deschutes River, the Deschutes River downstream Tumalo Creek (orange line) is cooler than the Deschutes River upstream Tumalo Creek (green line). On 6/27/2006, Tumalo Creek has high flows of 170 cfs and 7DAM °C of cold 10.9 °C water. The Deschutes River on this same day has low flows of 102 cfs and warm 19.2 °C water. The Deschutes River temperatures drop to 15.2 °C after Tumalo Creek enters the system (-4.0 °C in less than 0.25 mile).

During periods of low flow in Tumalo Creek, the Deschutes River returns to a general downstream warming rate of temperature change. Tumalo Creek will be placed on the Oregon Section 303(d) list 2004 for not meeting temperature criteria during 2004 (**Figure 16**). The 2005 data supports this listing from Tumalo Feed Canal downstream to the confluence with the Deschutes River (**Figure 15**). When Tumalo Creek is not meeting state criteria, the Deschutes River does not gain cool water.

Figure 14 Deschutes River and Tumalo Creek temperature results; 2006

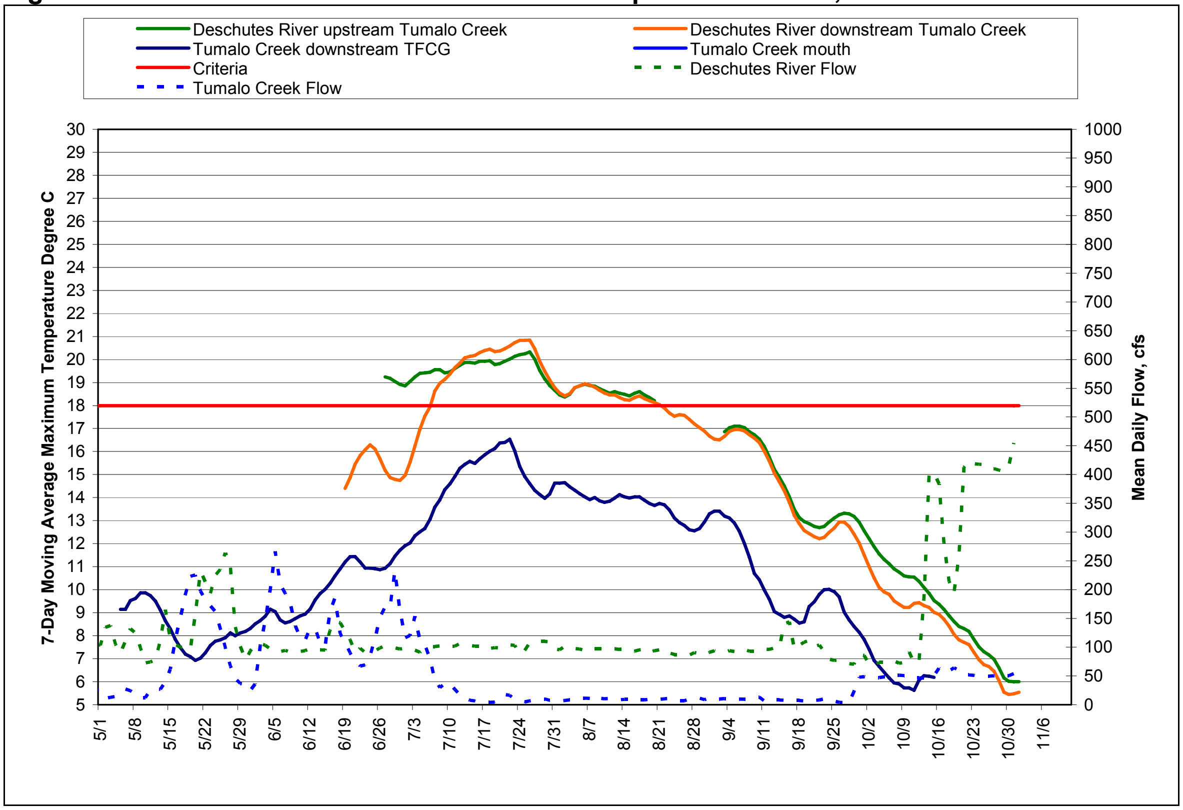


Figure 15 Deschutes River and Tumalo Creek temperature results; 2005

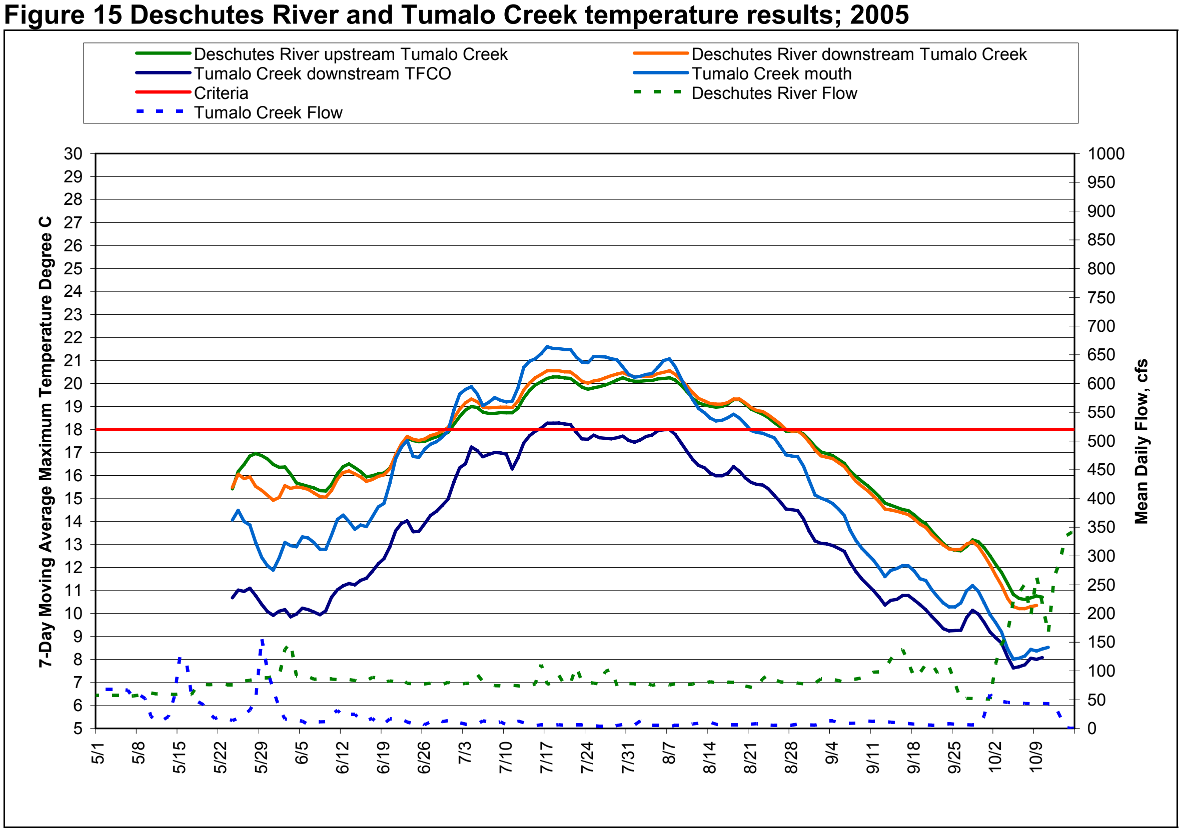
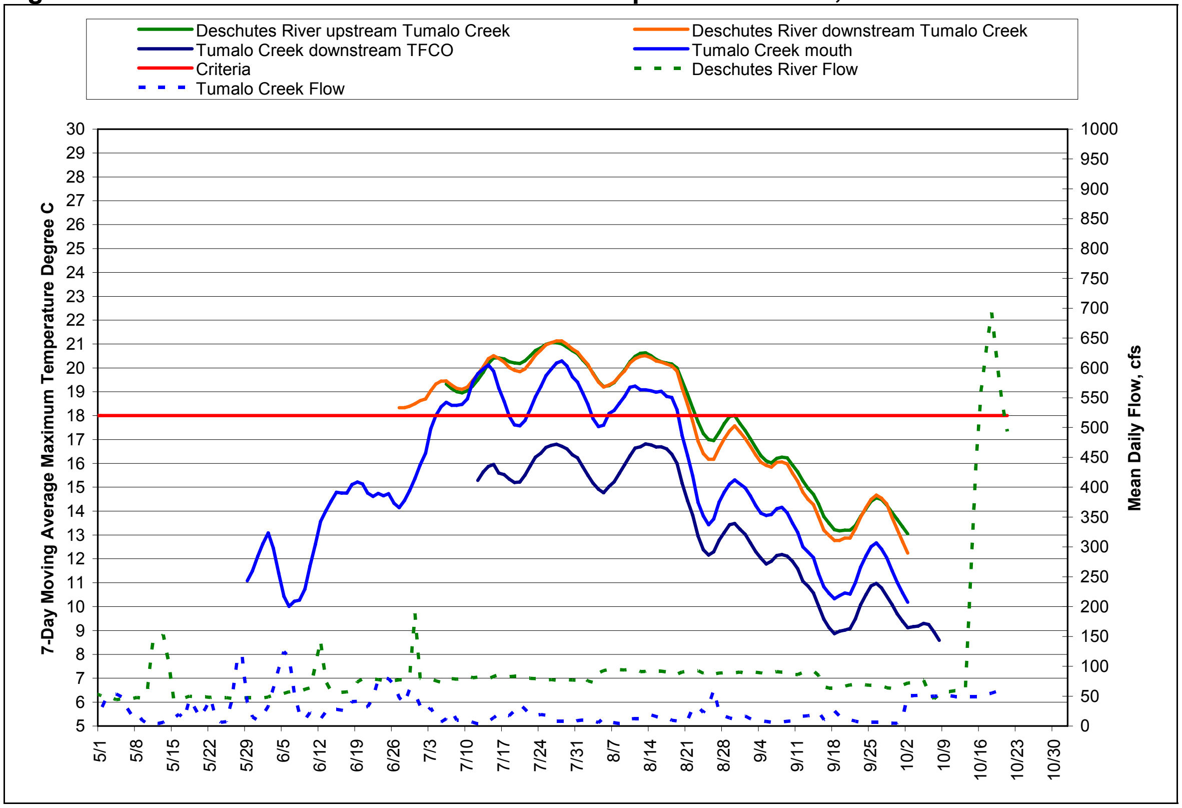


Figure 16 Deschutes River and Tumalo Creek temperature results; 2004

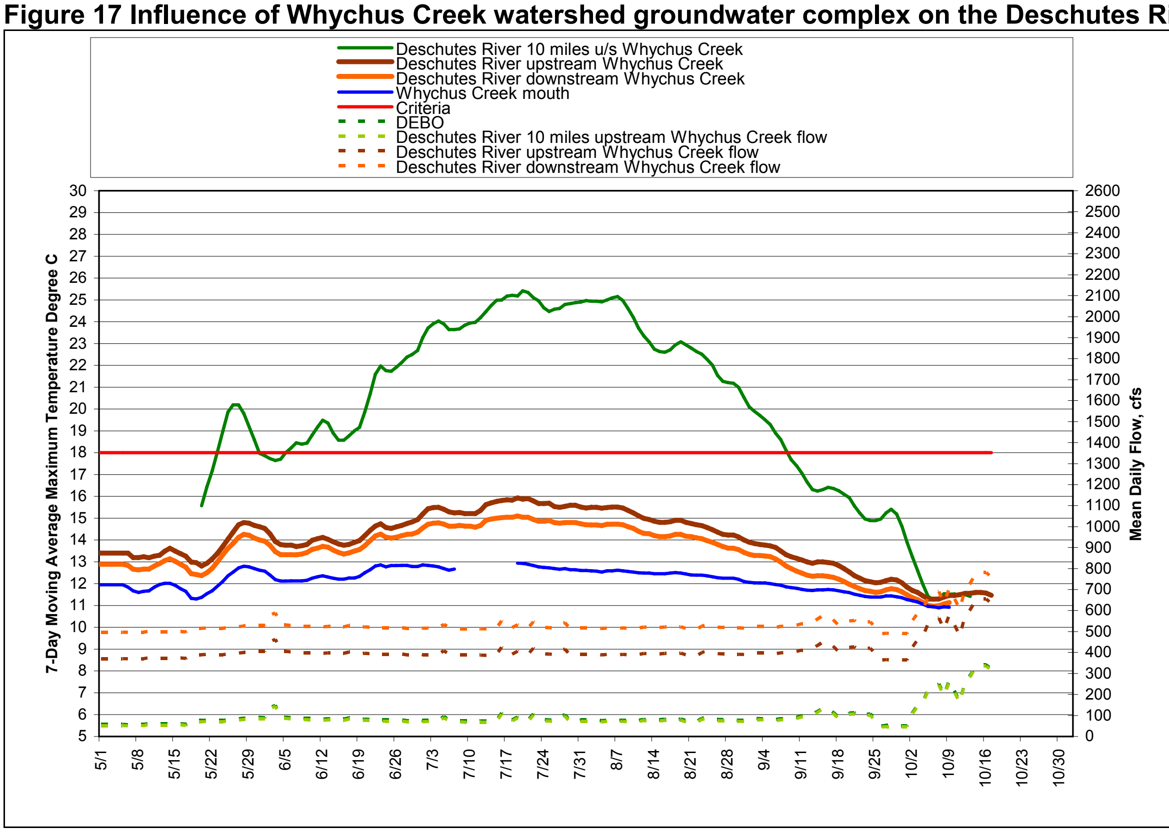


2.4 Influences of Whychus Creek watershed on the Deschutes River

Figure 17 shows the water temperatures of Deschutes River and Whychus Creek during 2005. The x-axis represents time and the y-axis represents the 7DAM °C. The red line represents the 18 °C state standard set to protect the beneficial use of salmon and trout spawning, rearing, and migration. The secondary y-axis represents flow in cubic feet per second (cfs). The green line represents the Deschutes River at Lower Bridge located approximately 10 miles upstream of Whychus Creek. The brown line represents the Deschutes River upstream Whychus Creek. The orange line represents the Deschutes River downstream of Whychus Creek. The blue line represents Whychus Creek mouth. The dashed lines represent flow at the three temperature locations. The Deschutes River upstream Whychus Creek flow is measured at OWRD DEBO gauge (Deschutes below Bend). Flows for the Deschutes River upstream Whychus Creek and downstream Whychus Creek were derived by information from the OWRD synoptic seepage analyses (LaMarch, J., OWRD, e-mail December 2006).

In 2005, the Deschutes River 7DAM °C decreases at a rate of -0.9 C/RM between the Deschutes River ten miles upstream Whychus Creek and the Deschutes River upstream Whychus Creek. Over this ten mile reach, approximately 300 cfs of cold groundwater enters the system. In addition, Whychus Creek provides another approximate 100 cfs gain and offers a local cooling rate equal to -3.6 C/mile. This illustrates that the input of cold groundwater into the Deschutes River offsets upstream influences on the rate of temperature change. Upstream restoration actions need to consider impacts on this cold water reach as more water is restored instream.

Figure 17 Influence of Whychus Creek watershed groundwater complex on the Deschutes River



3.0 INSIGHTS

There are three main insights that illustrate how restoration and conservation efforts should approach restoring the water temperatures of the Deschutes River:

1. Not all water is created equal

Water quantity and quality

While water *quantity* is important to provide connectivity to a fluvial system, the *quality* of restored water (cold or warm) is critical for aquatic species. Through instream flow restoration, even with warm water, important ecological benefits can be achieved (i.e. buffering the warming rate, connecting the river to the flood plain). Yet, if the goal is to decrease temperatures and have the waterway meet state criteria, then instream flow restoration should focus on the starting temperatures of restored waters to insure cool water for the longitudinal extent of the system.

Starting temperatures

Starting temperatures determine temperatures downstream. If the water temperature released from Wickiup Reservoir is above state criteria, it will still be above state criteria when the water reaches the City of Bend. If the water temperature of the Deschutes River downstream of Tumalo Creek confluence is above state criteria, it will still be above state criteria when the water reaches the Lower Bridge Road. If instream flow restoration efforts increase the amount of warm water released from Wickiup Reservoir and North Canal Dam, it will reduce the benefit of downstream cooling groundwater influences.

Cost of restoration

Restoration water costs different amounts per cfs. It is estimated that the potentially cold Tumalo Creek water is approximately 2-3 times more expensive than the always warm Deschutes River water (based on DRC water conservation cost estimates per conversation December 2006).

2. Tributaries are critical to mainstem water quality restoration

The Deschutes River middle reach is located downstream of North Canal Dam. Flows in this section of the Deschutes River are greatly reduced from 1947 cfs to 94 cfs (7/20/2006). The current instream flow restoration target set by DRC is 250 cfs and is based on ODFW recommendations. Tumalo Creek is the only *potential* input of cool water for the Middle Deschutes between the City of Bend and Lower Bridge Road. By restoring cold flows into Tumalo Creek, the 250 cfs target for the Deschutes River middle reach may be coolly achieved.

3. Current obstacles create future opportunities

As the river encounters the impoundments located within the City of Bend UGB, temperatures begin to rise above state criteria despite the large volume of water in the Deschutes River (1947 cfs on 7/20/2006 hottest water day). It is suspected that the waters in the impoundments thermally stratify. This in combination with aging dams that are to be scheduled for retrofit provides opportunity to pass cool water downstream.

Dams can contribute to warmer or cooler temperatures downstream, depending on their design and operation. Many dams located on the Deschutes River are aging, including all the impoundments through the City of Bend. Addressing aging dams provides opportunity to pass water from a cooler depth of the water column. This opportunity offsets the increased rate of temperature change that occurs behind impoundments.

4.0 CRITICAL QUESTIONS

The following critical questions are developed from the insights gained:

1. *Can reservoir management discover ways to cool the Deschutes River between Wickiup Reservoir and North Canal Dam therefore lowering the starting temperatures entering the City of Bend and released from North Canal Dam? Can water released from Wickiup Reservoir be cooler? Can Little Deschutes River be cooler?*

2. *Which aging dams have thermal stratification in the impounded waters therefore providing opportunity to pass cool water? How does this impact other parameters?*

3. *If temperatures are warm behind impoundments, does this promote the growth of rooted aquatic plants in sediments deposited behind dams and how does this relate to current dissolved oxygen and chlorophyll-a Oregon Section 303(d) listings?*

4. *What is the optimal balance between Deschutes River water and Tumalo Creek water considering quantity, temperature, and downstream impacts?*

5. *If potentially cold Tumalo Creek water costs more than always warm Deschutes River water, where should we invest our dollars?*

6. *Can conservation of Deschutes River water be used to enhance Tumalo Creek flows?*

7. *Is there opportunity to change the point of diversion for Tumalo Irrigation District?*

4.0 RECOMMENDATIONS

The following are recommendations for temperature monitoring investigations and analyses within the Deschutes River watersheds:

- Investigate thermal stratification behind aging dams along the Deschutes River including Colorado Avenue Dam, Pacific Power Company hydroelectric dam (i.e. Mirror Pond), the Steidl Dam, and the North Canal Dam.

- Analyze the relationship between Section 303(d) listed parameters (temperature, dissolved oxygen, and Chlorophyll-*a*) and rooted aquatic plants in the sediments deposited behind the aging dams in the City of Bend (Colorado Avenue Dam, Pacific Power Company hydroelectric dam (i.e. Mirror Pond), the Steidl Dam, and the North Canal Dam.)

- Develop temperature and flow model for the Deschutes River and major tributaries.

- Evaluate the ability of in-stream flow restoration targets to result in cool water temperatures.

- Continue temperature monitoring to capture changes within the watershed and provide water quality trend analysis.

The following are recommendations for restoration and conservation efforts within the Deschutes River watersheds:

- Restore cool starting temperatures near Crane Prairie and Wickiup Reservoir.

- Cool the Deschutes River waters entering the City of Bend and released from North Canal Dam by restoring the temperatures in the Little Deschutes River.

- Allow for a design that releases water from a cooler depth upon retrofitting of aging dams; Colorado Avenue Dam, Pacific Power Company hydroelectric dam (i.e. Mirror Pond), the Steidl Dam, and the North Canal Dam.

- Investigate opportunities to cool the Deschutes River between Tumalo Creek and Lower Bridge Road by restoring flows in Tumalo Creek.

- Ensure conservation of the groundwater springs complex that enters the Deschutes River between Lower Bridge Road (RM 133.00) and Lake Billy Chinook (RM 120.00)

- Utilize models to optimize the cost of restoration dollars dedicated to achieving cool water temperatures in the Deschutes River.

5.0 REFERENCES

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Upper Deschutes Watershed Council
Water Quality Monitoring Program
Presentation

Deschutes River Temperature Summary 2006

Upper Deschutes Subbasin, Oregon

Prepared by:

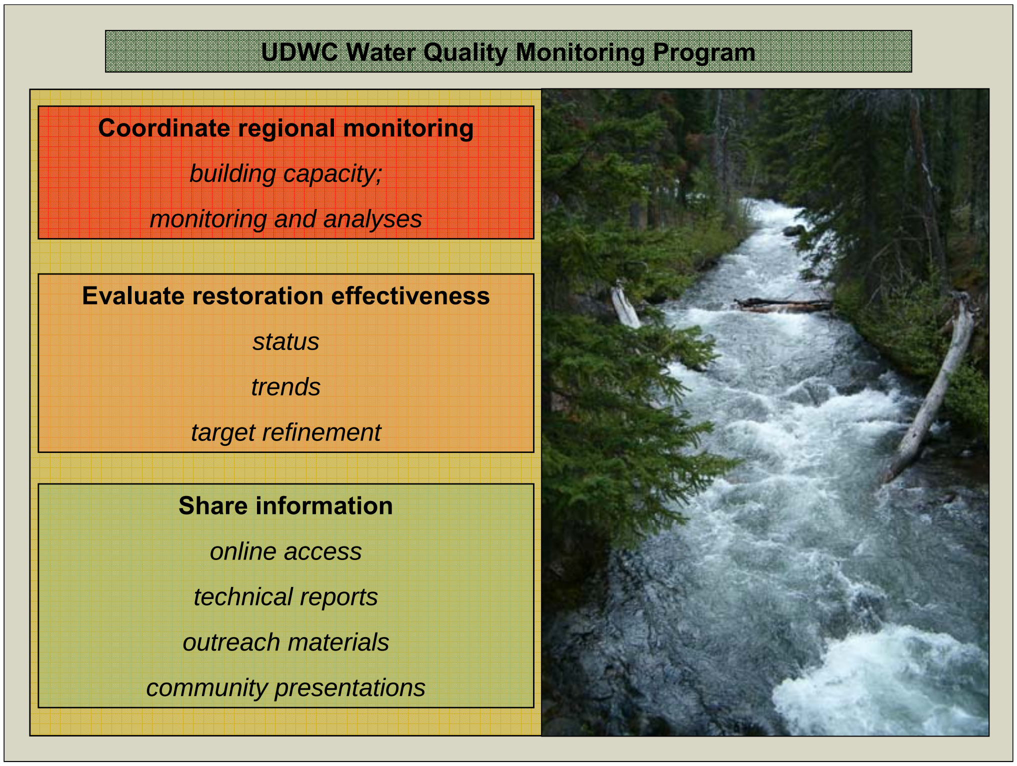
Lesley Jones
Water Quality Specialist
Upper Deschutes Watershed Council
Bend, Oregon

Upper Deschutes Watershed Council
Bend, Oregon: December 2006

UPPER DESCHUTES WATERSHED COUNCIL

Enhancing and protecting the Upper Deschutes River watershed through collaborative projects in watershed stewardship, habitat enhancement, and community awareness.

The UDWC Water Quality Monitoring Program is a part of achieving this mission and is primarily supported by OWEB and ODEQ 319 grant funding.



There are three components within the Water Quality Monitoring Program that support adaptive management of water resources.

1. Coordination of regional monitoring

- Coordinating and conducting regional temperature monitoring,
- Coordinating and conducting multiparameter monitoring, and
- Streamlining regional data submission to ODEQ.

2. Evaluate restoration effectiveness

- Analyses: status, trends, and restoration targets

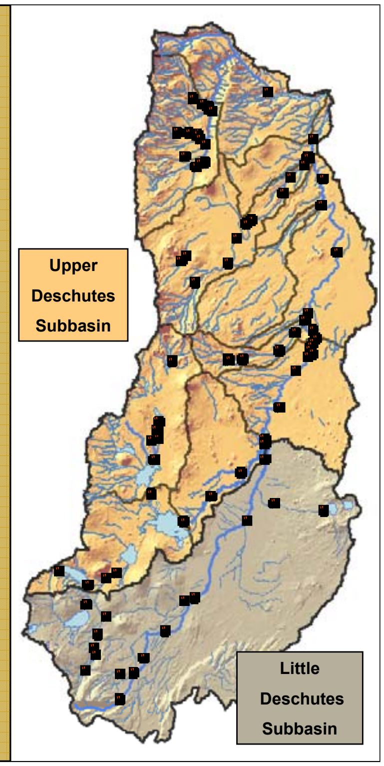
3. Share information

- **Online Access**
  - Data submission path to ODEQ and EPA, route to query data for analyses, standing historic record
- **Technical Reports**
  - Quality Assurance Project Plan represents the monitoring strategy for the program
  - SOP represents monitoring protocols and methodologies for the field
  - Summary of Activities: documents all outputs
  - Technical reports are based on watersheds or reaches and provide status, trend, and target refinement analyses
- **Outreach materials**
  - Effectiveness monitoring outreach poster and presentation for 2006 – 2008
  - Shared the outreach materials with: Academic community including COCC, OSU Cascades, OSU Corvallis, Professional community including OWEB, IMST (Independent Multidisciplinary Science Team), Local, state, and federal organizations including municipalities, DRC, ODEQ, ODFW,OWRD, USFS, BLM, BOR
- **Community presentations**
  - Foster community awareness of watersheds within the Deschutes Basin
  - Outreach to multiple audiences

Coordinate regional monitoring

Partner	Stations 2002	Stations 2003	Stations 2004	Stations 2005	Stations 2006
USFS	47	56	47	48	52
UDWC	24	22	33	33	25
City of Bend	1	1	13	13	13
ODEQ	5	5	5	5	5
BLM	0	3	3	3	3
PGE	1	1	1	1	1
	78+	87	95	88	92

Monitoring Activity	Stations 2002	Stations 2003	Stations 2004	Stations 2005	Stations 2006
Continuous multiparameter	7	0	0	3	7
Grab samples	30	5	18	18	28
Continuous Temperature	78+	89	94	87	93
Aquatic macroinvertebrates	0	0	0	9	0



The WQ Monitoring Program coordinates monitoring across the Upper Deschutes and Little Deschutes Subbasins. This area includes 18 watersheds totaling over 3160 square miles and over 1800 river and stream miles. Approximately 200 historic stations are currently facilitated by our program.

In 2006, 92 stations were coordinated by our program and monitored by various partners. In general, the number of stations monitored is consistent over time. What has changed is our capacity at each station as evident by:

1. Increase in continuous multiparameter monitoring,
2. Increase in grab sample monitoring,
3. Sustained continuous temperature monitoring, and
4. Establishment of macroinvertebrate study.

Water Quality Committee represents the foundation of our capacity building.

- Original MOU 2001 – 2006 expired, new MOU 2006 – 2011 signed in February.
- These partners represent the major restoration and monitoring efforts in the upper Deschutes Basin and provide:
    - the program's monitoring strategy in the form of a QAPP submitted to ODEQ annually for approval
    - peer review of technical reports and outreach materials
    - accountability of our program to address informational needs of natural resource managers
- Donated: ~ $ 30,000 / year – in-kind services, laboratory services, and equipment

How did our program work to increase the regional monitoring, and analyses capacity?

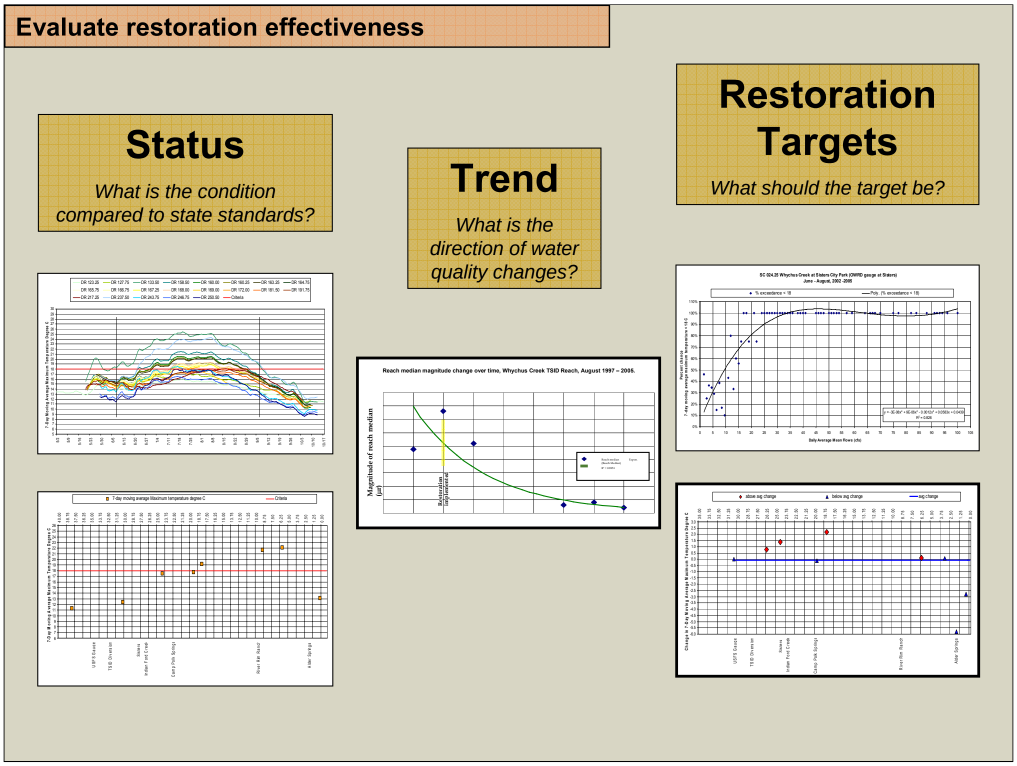
1. First our program was granted funding: 2005 – 2007 ~$122,000, current pending ~$195,000
2. Next our program collaborated with the community to build capacity and to most effectively utilize the funding:

Volunteer Monitoring Project
- 2004 – current
- Whychus Creek watershed, upper Deschutes and Tumalo Creek watersheds
- Primary benefit of increasing regional temperature monitoring capacity.
- Secondary benefit of increasing community knowledge and support of local, state, and federal restoration efforts **.**

OSU Undergraduate Internship
- Primary benefit of increasing regional temperature monitoring capacity.
- Secondary benefit of coordinating Volunteer Monitoring Project.
- Also increases community knowledge and support of local, state, and federal restoration efforts.

OSU Graduate Studies
- Primary benefit of covering implementation costs of major project.
- Secondary benefit equipment donation to UDWC.
- Utilized to develop a thesis concept that results in information that is regionally applicable and useful.

These four programs amount to $50,000 in donated services and equipment in 2006.



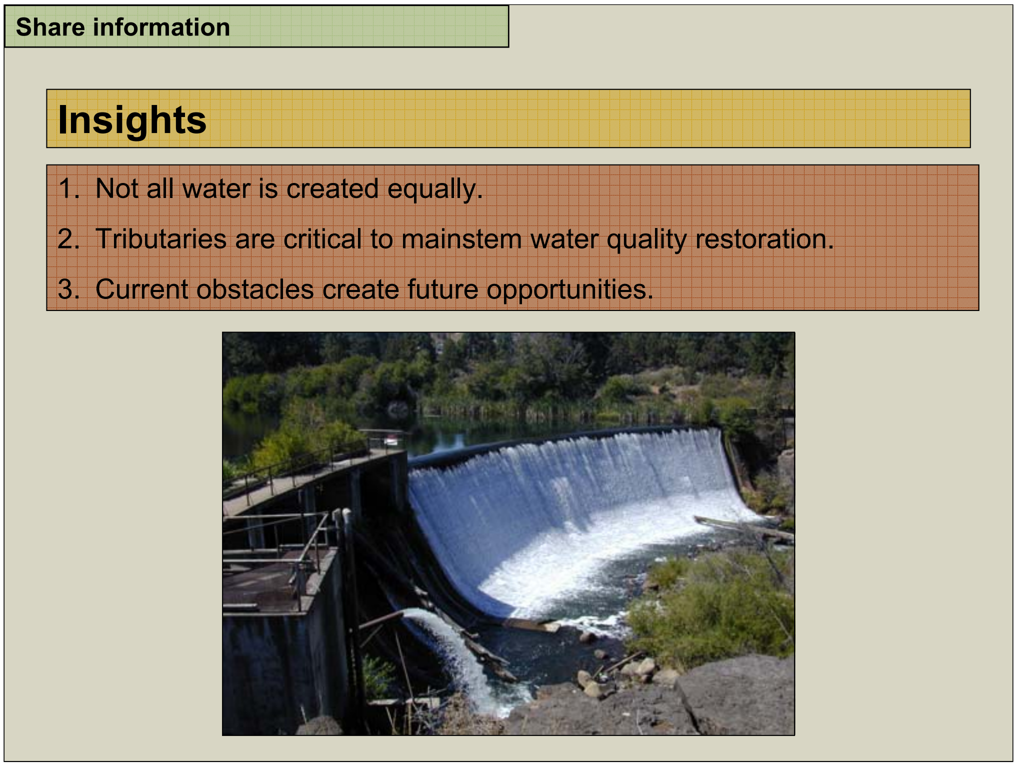
Status evaluations determine the health of the watershed by evaluating a parameter according to standards set forth by the ODEQ. These standards are set by the state in order to protect the beneficial uses of our watersheds. Status evaluations are straight forward and involve summary statistics.

Trend evaluations determine the direction of water quality changes and can be correlated with restoration projects. Trend evaluations are moderately complicated and involve non-parametric statistics that take into account seasonality.

Restoration target evaluations determine what targets are appropriate (i.e.. instream flow restoration targets) and where targets are appropriate (i.e.. reaches with the greatest restoration and conservation potential). Target evaluations are the most complicated and involve regression analyses that result in the ability to relate multiple parameters. (i.e. the restorative value of each cfs.)

There are some upcoming reports that are designed to support adaptive management of water resources and distribute these insights gained. These reports include:

- •Evaluations based on hydrologic unit boundaries,
- •Multiple parameters including chemical, physical, and biological information,
- •Status, trend, and restoration target refinement,
- •Peer reviewed statistics and scientifically credible data.

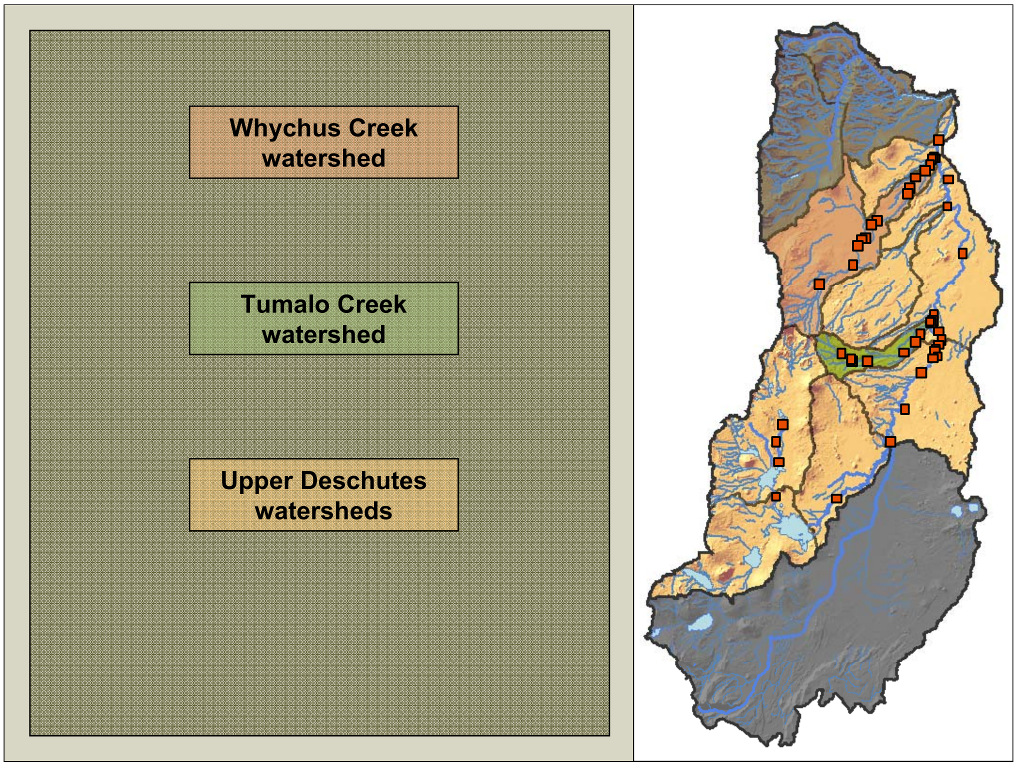


Sharing information such as insights gained is an important part of our programs contribution to adaptive management of water resources. There are three key insights that will be illustrated in the following series of graphs.

1. **Not all water is created equal**
   - Restoring instream flows is an important part of improving the ecological function of our watersheds, but the quality of the water restored matters.
   - The temperature of restored water is important (is it warm or cold).

2. **Tributaries are critical to mainstem water quality restoration**
   - Improving flows in cool tributaries that enter the Deschutes River, such as Tumalo Creek, may be more expensive per cfs yet may offer more ecological improvement to the Deschutes River.
   - Protecting the downstream groundwater influences that offset upstream impacts of the Deschutes River

3. **Current obstacles create future opportunities**
   - As systems age and retrofits are planned, opportunities to apply new information emerge.



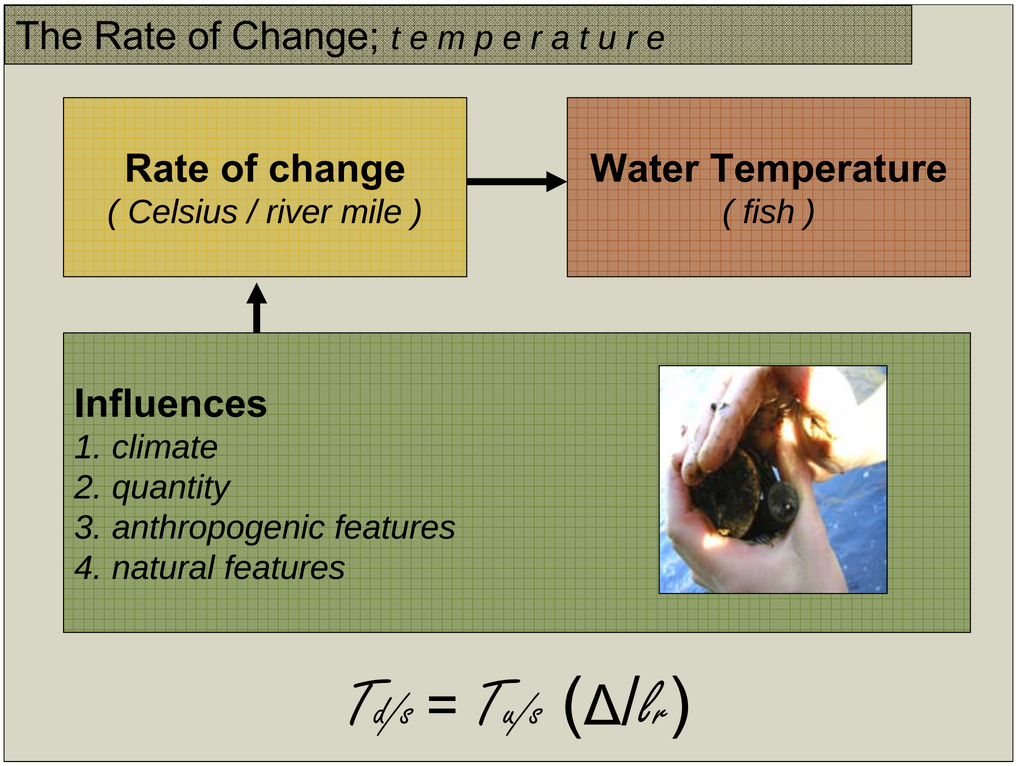
The following describes the Deschutes River status evaluations for 2004 – 2006 and the influence of Tumalo Creek and Whychus Creek watersheds during that time period.

- **Whychus Creek watershed** is 39 river miles long, the headwaters are located in the Sisters Wilderness Area, flows through the town of Sister's and meets up with the Deschutes River approximately two miles upstream of Lake Billy Chinook.

- **Tumalo Creek watershed** approximately 20 river miles long, flows through the Tumalo Falls area and meets up with Deschutes River upstream of Tumalo State Park.

- **Upper Deschutes watersheds** 133 river miles long between Lava Lake to Lake Billy Chinook, divided into 3 study areas
    - Upper Deschutes River above Wickiup Reservoir = headwaters at Lava Lake to Wickiup Reservoir outlet
    - Upper Deschutes River upper reach = Wickiup Reservoir outlet to North Canal Dam in Bend
    - Upper Deschutes River middle reach = below North Canal Dam to Lake Billy Chinook outlet

We are going to look at the Deschutes River from Wickiup Reservoir outlet to Lake Billy Chinook for 2004 – 2006. Our focus will include the most impaired summertime section of the Deschutes; the middle Deschutes reach from North Canal Dam to Lower Bridge Road. To do that, we will use the rate of change of water temperature as the river flows downstream.



The rate of change = the rate of change in degree Celsius per mile as the water flows downstream.

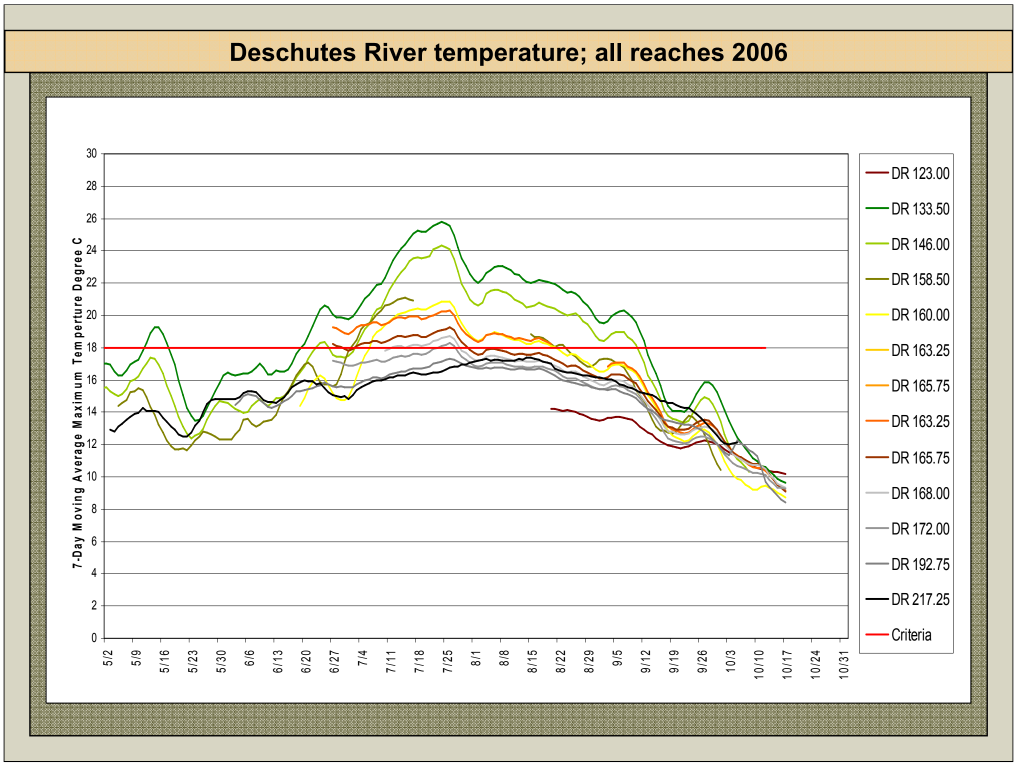
Beneficial use of fish is protected by state standards = 7-day moving average maximum degree Celsius must remain lower than 18 degree Celsius.

There are **influences** on the rate of change:

- The type of climate year; hot or cool, wet or dry?
- The more cfs in the river the better buffering capacity the river has against warming and cooling influences.
- Anthropogenic = impoundments
- Natural = cold or warm tributary, groundwater

Td/s = Tu/s (Δ/lr)

The downstream temperature is the product of the upstream temperature and rate of change over reach length. In simpler terms, both starting temperature of the water and influences on the rate of change determine the downstream temperature.



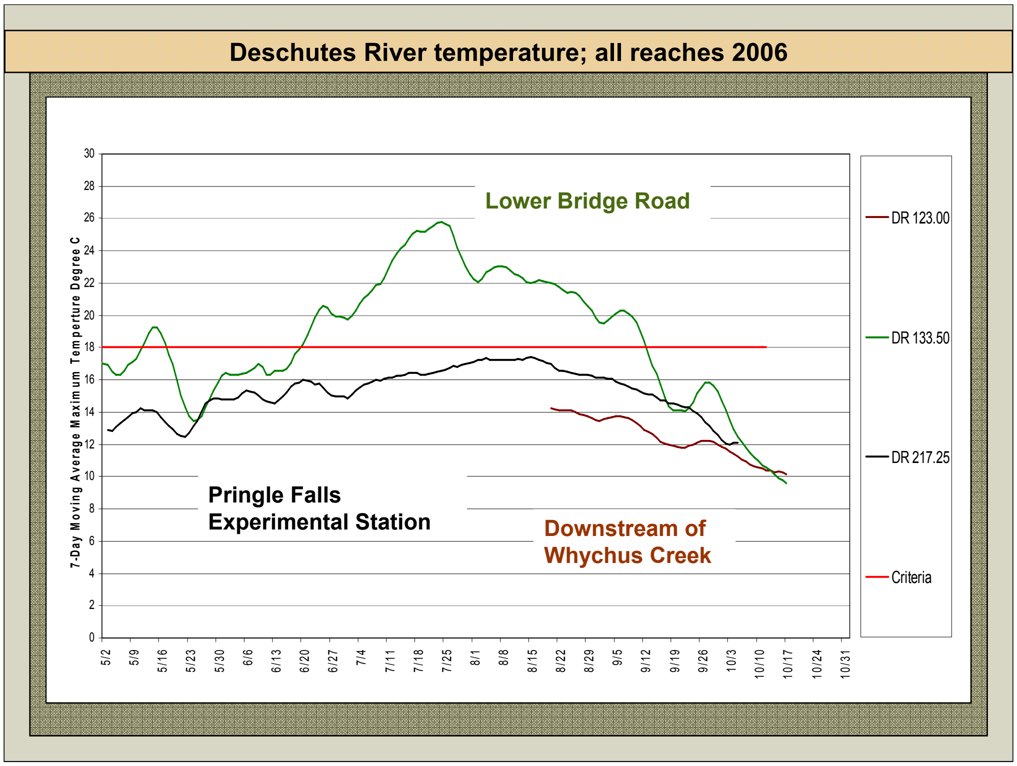
Here is all the 7-day moving average maximum temperatures for all stations in 2006.

The x-axis represents time and the y-axis represents the 7-day max in degrees C. The red line represents the 18 degree Celsius state standard set to protect the beneficial use of fish.

As you can see, there are some stations with incomplete data for this year. These include:

- Deschutes River at river mile 123.00 downstream Whychus Creek (note that this is colder than all other stations)
- Deschutes River at river mile 158.50 downstream Tumalo State Park (note chunk of data missing due to logger pulled out of water)
- Deschutes River at river mile upstream Tumalo Creek not available, logger is still stuck in field under high flows.
- All stations above Wickiup Reservoir on the Deschutes River the logger failed.

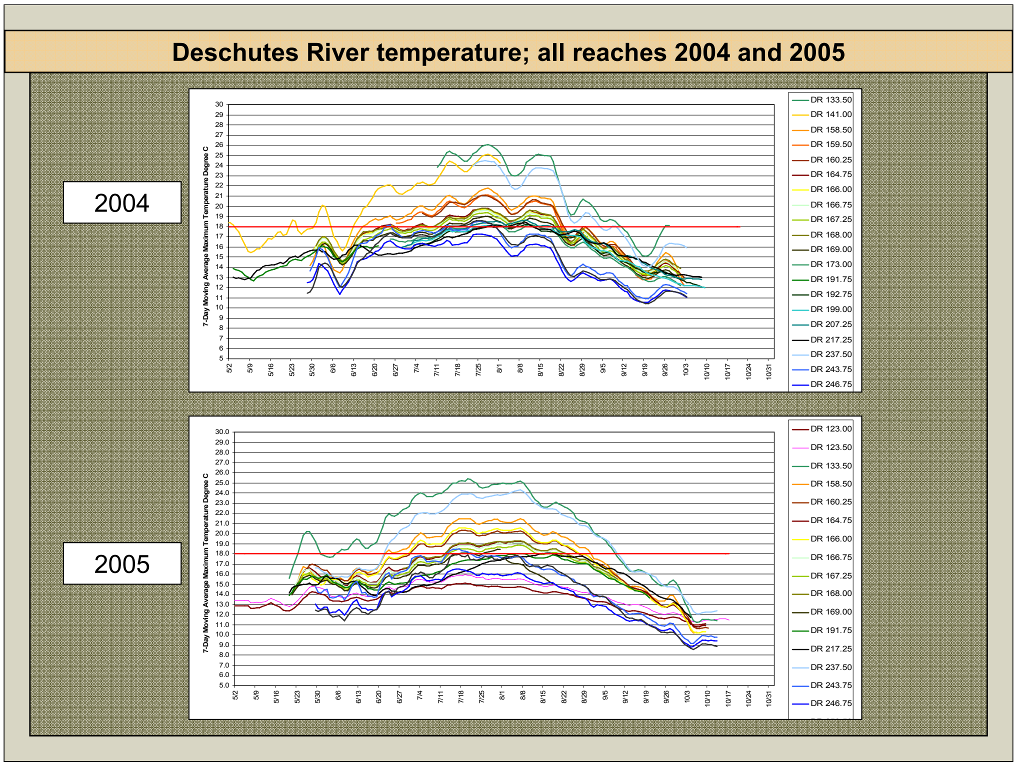
This is a busy graph, so lets simplify for discussion purposes.



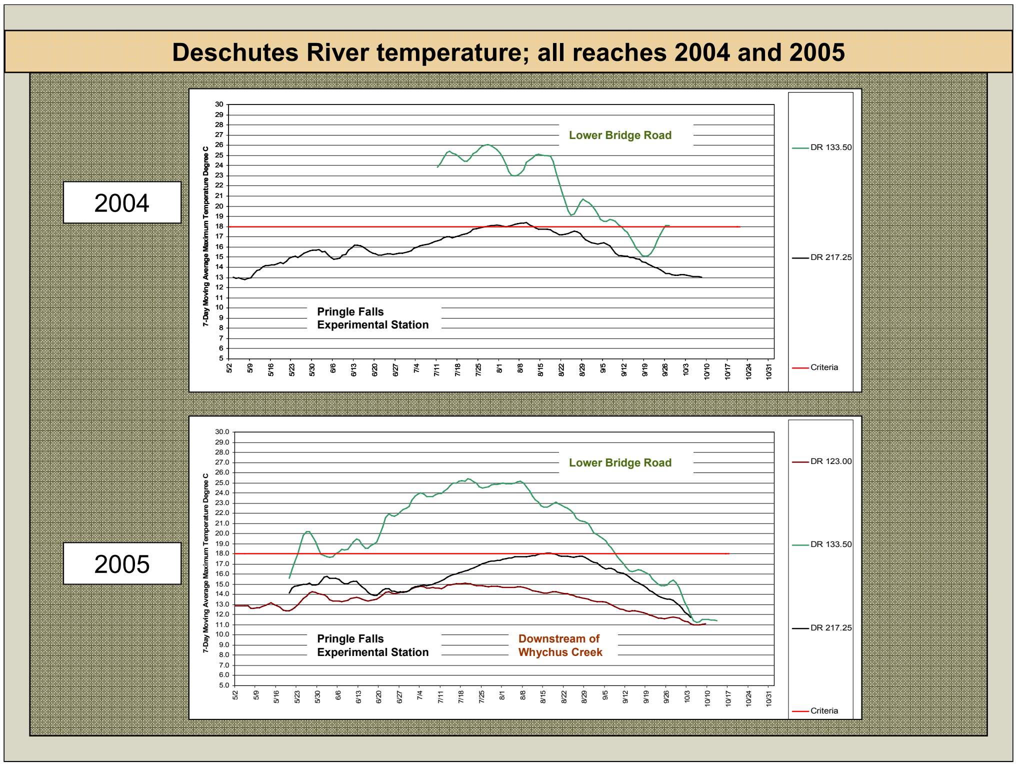
The x-axis represents time and the y-axis represents the 7-day max in degrees C. The red line represents the 18 degree Celsius state standard set to protect the beneficial use of fish.

I would like you to see the black line which represents the most upstream station (at Pringle Falls Experimental Station) should be the coolest station, yet it is not as cool as the Deschutes River downstream Whychus Creek. The warmest water temperatures are at Deschutes River mile 133.50 at Lower Bridge Road.

This is not unexpected.

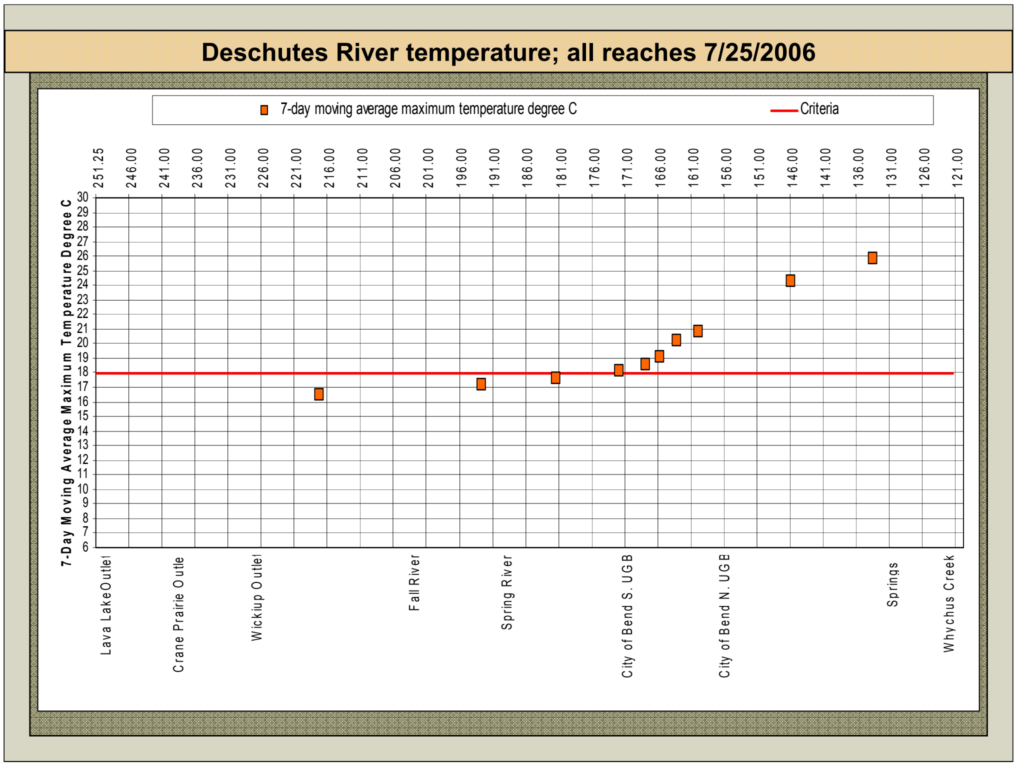


Here is all the data for 2004 and 2005.



The black line which represents the most upstream station (at Pringle Falls Experimental Station) should be the coolest station, yet it is not as cool as the Deschutes River downstream Whychus Creek. The warmest water temperatures are at Deschutes River mile 133.50 at Lower Bridge Road.

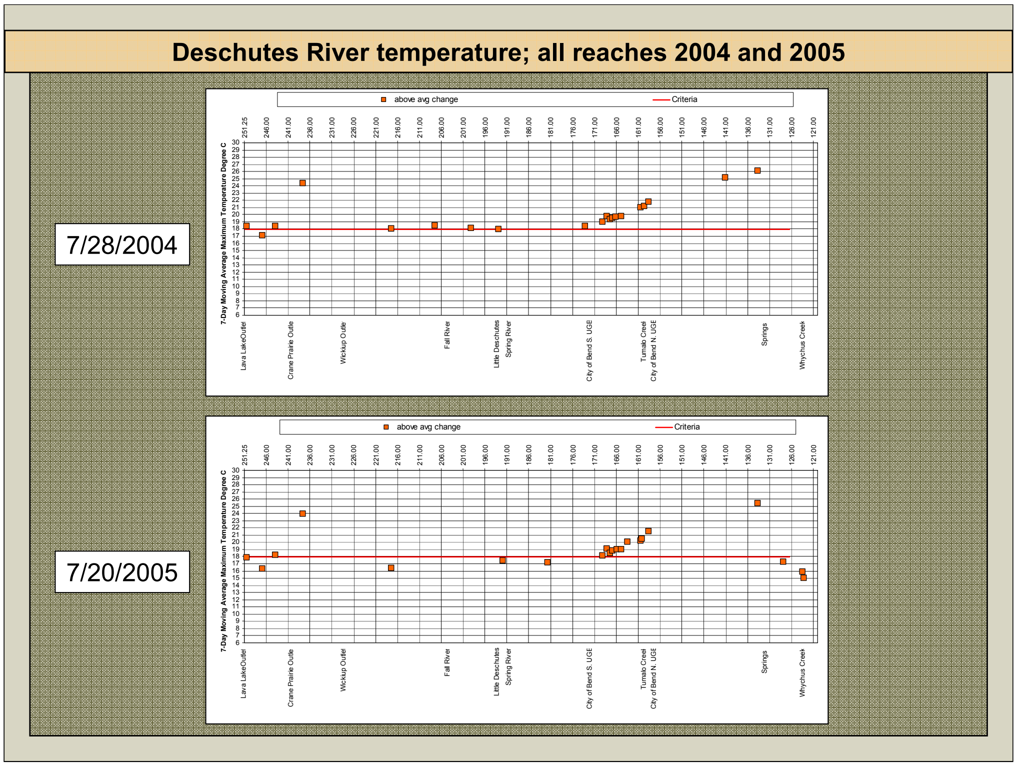
The hottest water day on the Deschutes River was 7/25/2006.



Here is the hottest water day in 2006; 7/25/2006.

The x-axis represents river miles from upstream to downstream. Anthropogenic and natural features are provided for reference. The y-axis represents the 7-day average maximum moving temperature degree Celsius. The red line represents the state temperature standard set to protect the beneficial use of fish.

Note water temperatures begin to exceed the state criteria as the water flows pass the southern urban growth boundary.



Here is the same graph for 2004 and 2005.

Note that the same water temperatures patterns are evident even with different stations over the years.

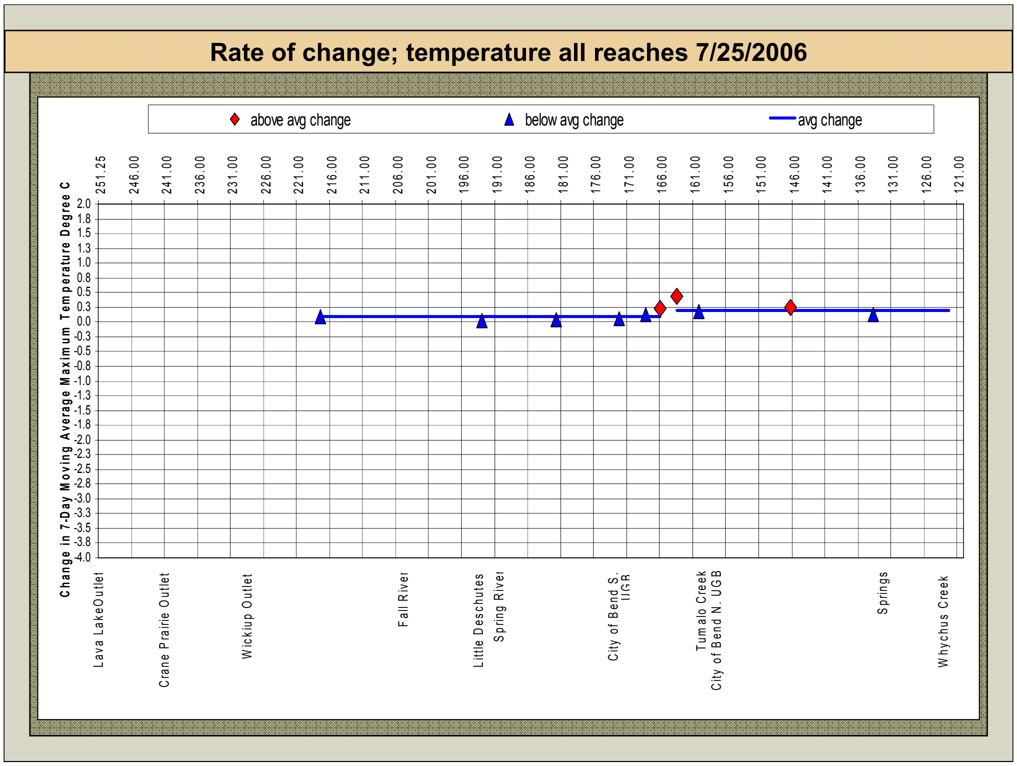
Note that the Deschutes River above Wickiup Reservoir has an influence on temperatures. Temperatures are elevated after the water flows out of the shallow and broad Crane Prairie reservoir. These warm temperatures are offset by the deeper and thermally stratified water of Wickiup Reservoir.

From Wickiup Reservoir to the urban river in the City of Bend the water temperatures are around the state criteria.

As the water becomes an urban river, the temperatures begin to exceed state criteria.

At the Deschutes River at Lower Bridge, the water temperatures are the most elevated.

The question is where should restoration focus?

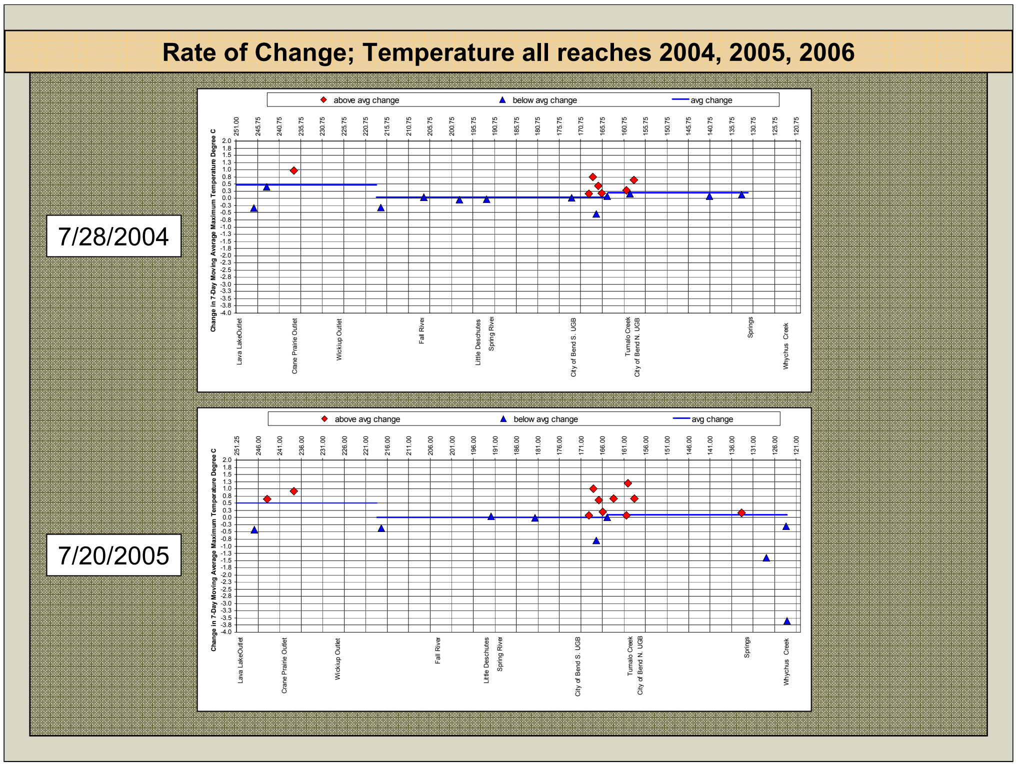


This is a graph of the rate of change of the 7-day moving average maximum temperature as the water flows downstream.

- The x-axis represents river mile and local features
- The y-axis represents the change in the 7-day moving average maximum temperature degree C
- The blue line is the average rate of change for the reach
  - Here the upper reach is 0.1 and the middle reach is 0.2.
  - The rate of change the reach = upstream temperature minus downstream temperature divided by river miles
- Blue triangles = rate of temp change is lower than the average rate of temp change per mile
- Red diamonds = rate of change is higher than the average rate of temp change per mile

The importance of looking at this is to see where rate of change is influenced and to note the possible contributing factors. This can help to *inform restoration and conservation efforts*.

Note there is no data for 2006 above Wickiup Reservoir due to logger failure.



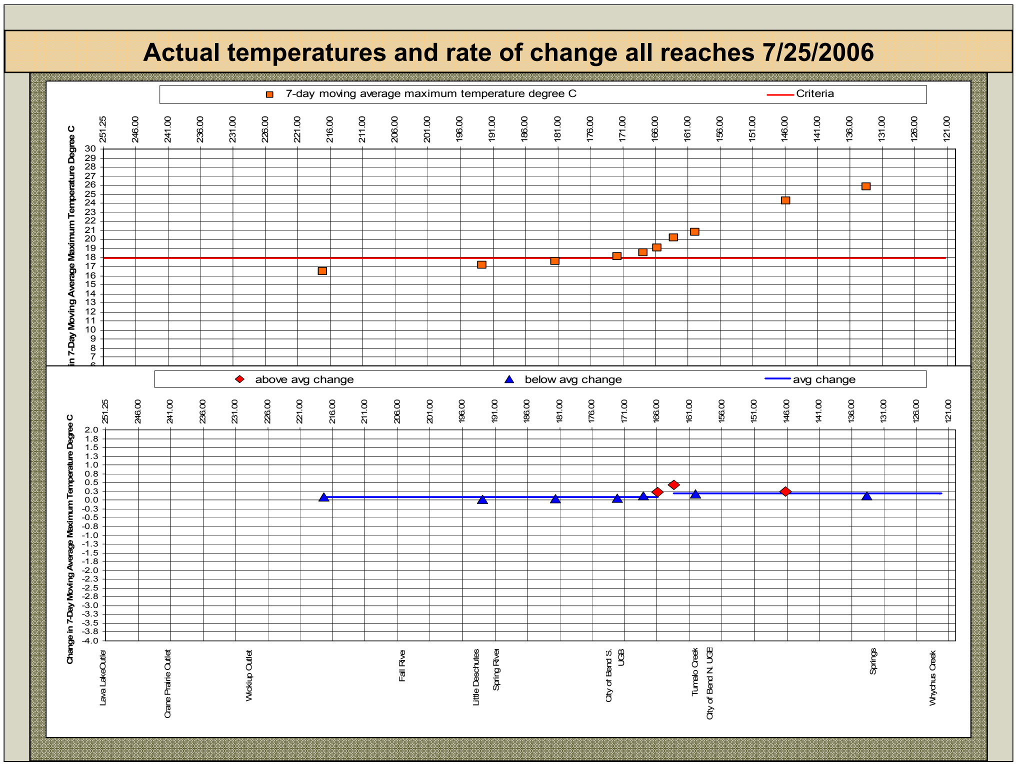
Here is the same graph for 2004 and 2005.

Note that the stations and climate are different year to year, yet the rate of change and data patterns are consistent.

Note that *restoration* efforts should focus on addressing areas that have a greater influence on the rate of change. i.e. areas with red diamonds (i.e. near where Tumalo Creek enters the middle reach).

Note that *conservation* efforts should focus on addressing areas that have cooling rate of changes. (i.e. 2005 Deschutes River near Whychus Creek.)

Examining the influences on this rate of change is important for *informing restoration and conservation efforts*.



Here is the hottest water day in 2006; 7/25/2006. Actual temperatures are compared to the rate of change in temperature as the water flows downstream.

On the top graph is the actual temperatures. The x-axis represents river miles from upstream to downstream. Anthropogenic and natural features are provided for reference. The y-axis represents the 7-day average maximum moving temperature degree Celsius. The red line represents the state temperature standard set to protect the beneficial use of fish.

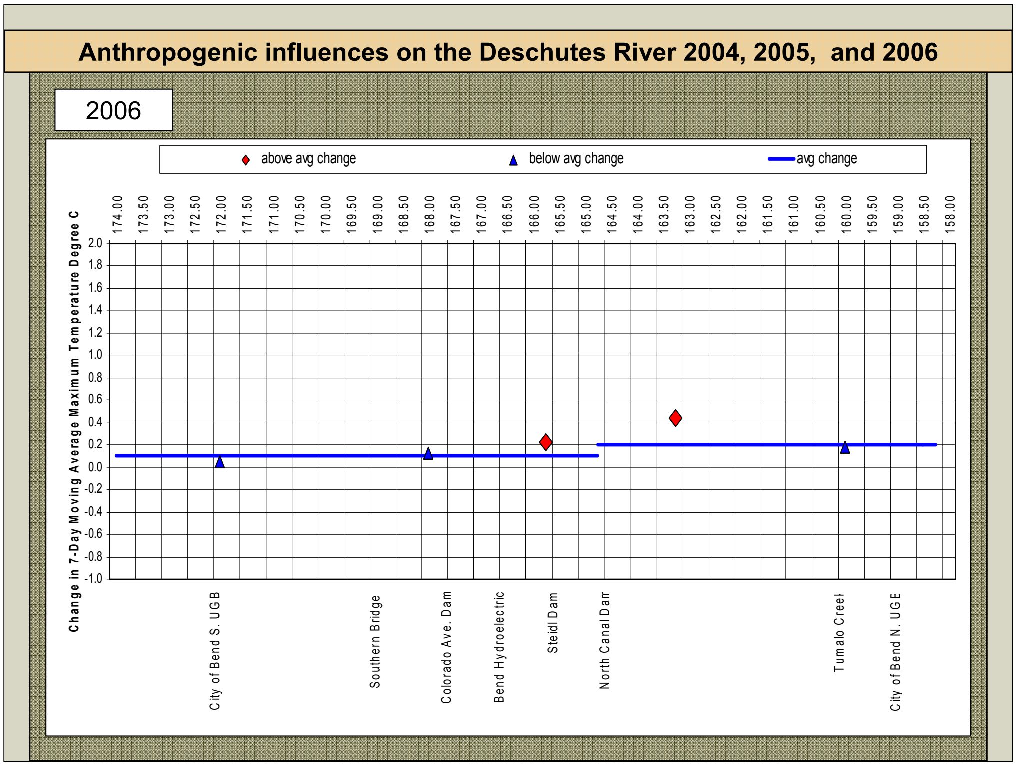
On the bottom graph is the rate of change of the 7-day moving average maximum temperature as the water flows downstream. The x-axis represents river mile and local features. The y-axis represents the change in the 7-day moving average maximum temperature degree C. The blue line is the average rate of change for the reach. Blue triangles = rate of temp change is lower than the average rate of temp change per mile. Red diamonds = rate of change is higher than the average rate of temp change per mile

Comparing actual temperatures and the rate of change provides information regarding:

- Where the most impaired water quality reaches are located and
- Which reaches are contributing to changes in water quality.

If restoration focused at the most impaired location at Deschutes River mile 133.50 at Lower Bridge Road, the area that is contributing the most to water quality impairments would not be addressed (i.e. upstream near Deschutes River mile 166.50).

The next slide we will look more closely at the rate of change as impacted by anthropogenic features.



The anthropogenic influences on the Deschutes River can be illustrated by looking at how the water quality changes as the river flows past the impoundments located within the City of Bend UGB. Note: these impoundments are not under the jurisdiction of the city and are not owned or operated by the city.

•The x-axis represents river mile and local features

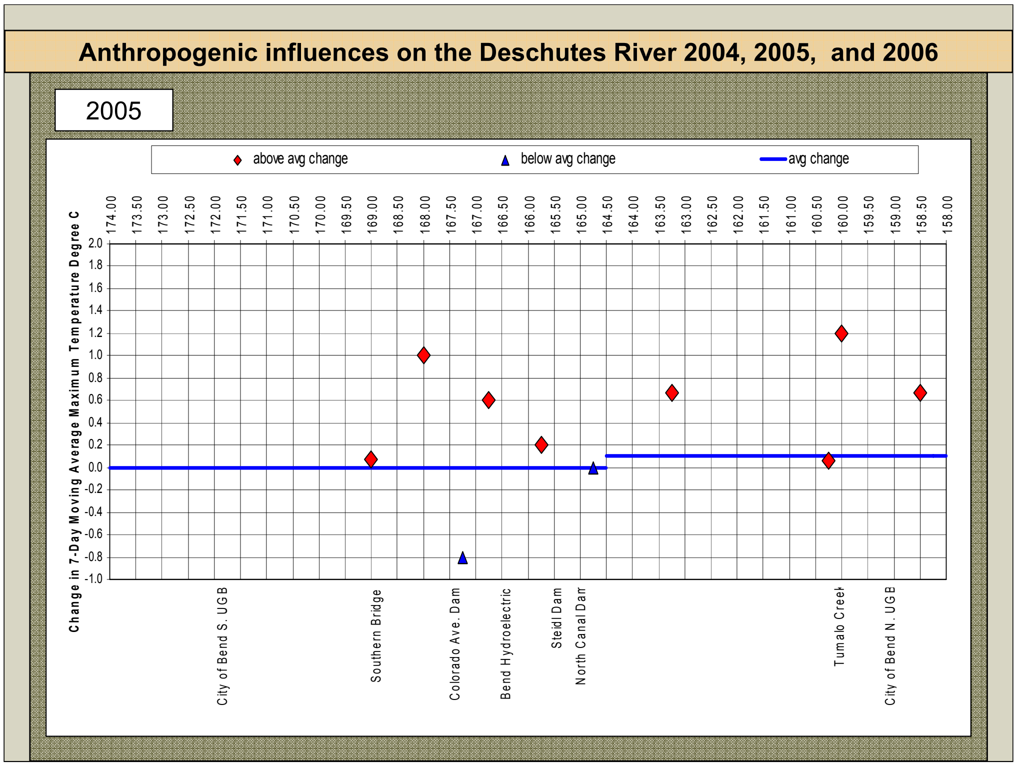
•The y-axis represents the change in the 7-day moving average maximum temperature degree C

•The blue line is the average rate of change for the reach

•Blue triangles = rate of temp change is lower than the average rate of temp change per mile

•Red diamonds = rate of change is higher than the average rate of temp change per mile

The water starts to have an increased rate of warming behind the impoundments. Once the river passes the North Canal Dam, a major diversion, flows drastically reduce from approximately 1200 cfs to less than 100 cfs. This reduction in flow decreases the buffering capacity of the river against climate influences.



•The x-axis represents river mile and local features

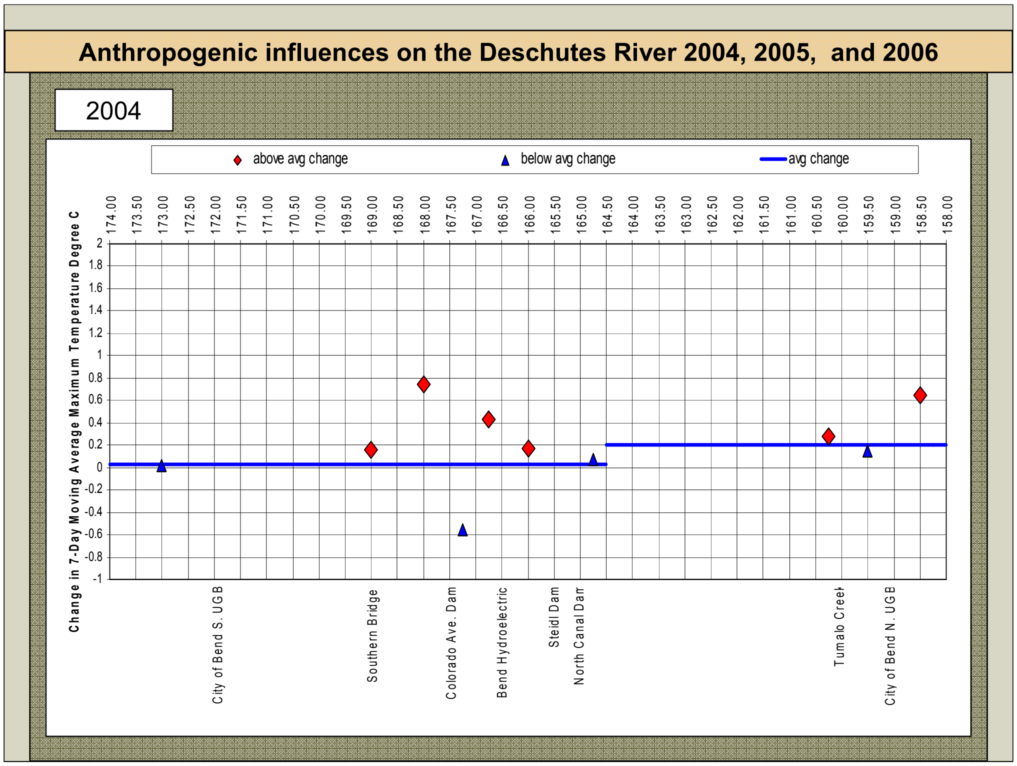
•The y-axis represents the change in the 7-day moving average maximum temperature degree C

•The blue line is the average rate of change for the reach

•Blue triangles = rate of temp change is lower than the average rate of temp change per mile

•Red diamonds = rate of change is higher than the average rate of temp change per mile

When we look back at 2005 and 2004 we continue to see the same pattern. Note how Tumalo Creek can be a warming or cooling influence on the Deschutes.



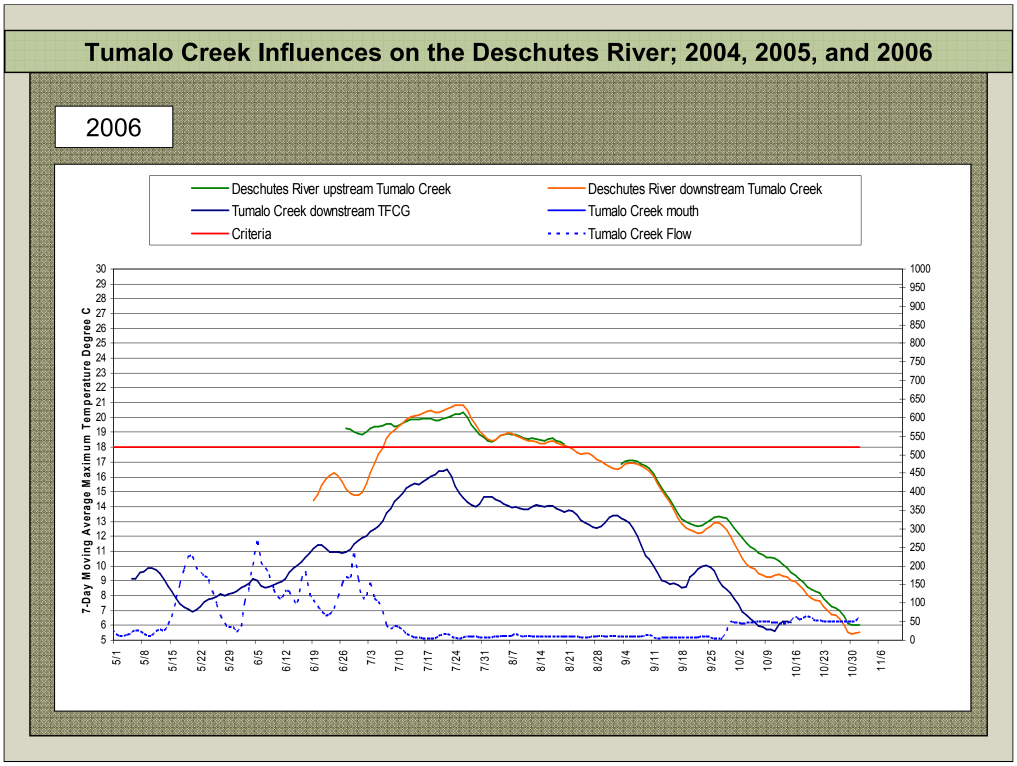
•The x-axis represents river mile and local features

•The y-axis represents the change in the 7-day moving average maximum temperature degree C

•The blue line is the average rate of change for the reach

•Blue triangles = rate of temp change is lower than the average rate of temp change per mile

•Red diamonds = rate of change is higher than the average rate of temp change per mile



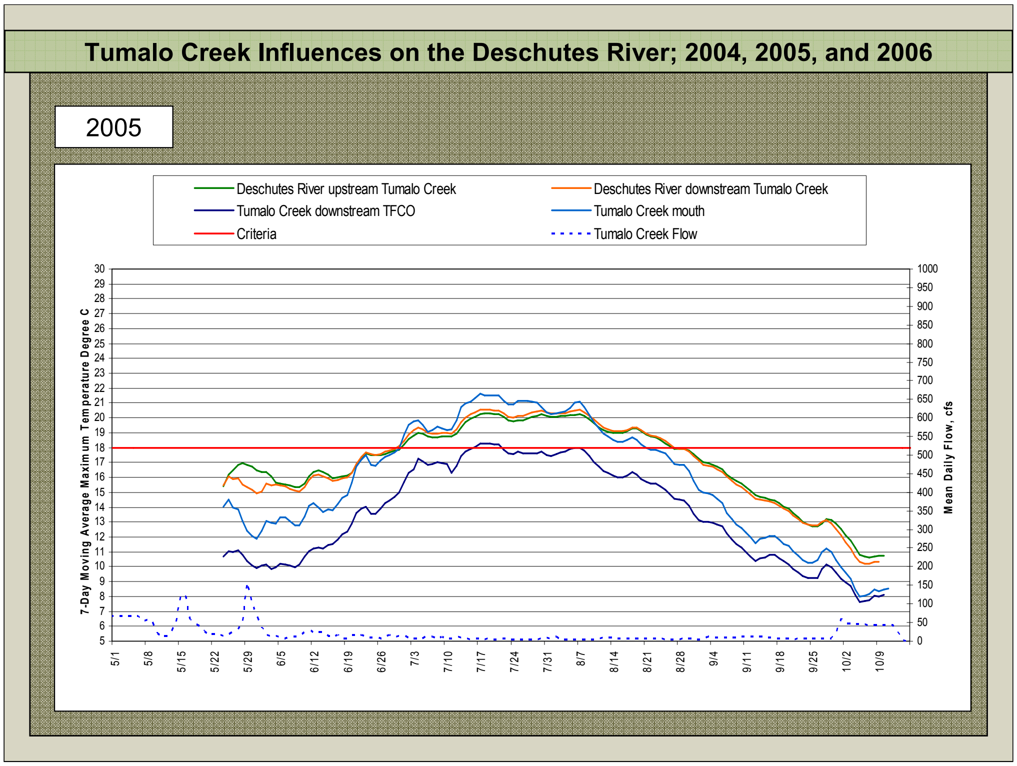
This series of graphs illustrates the influence of Tumalo Creek on the Deschutes River 2004, 2005, and 2006.

The x-axis represents time and the y-axis represents the 7-day max in degrees C. The red line represents the 18 degree Celsius state standard set to protect the beneficial use of fish.

Tumalo Creek is significant because it is the last input of flow into the Deschutes River until groundwater influences *thirty miles* downstream.

These graphs indicate that Tumalo Creek can have a *cooling influence* on the Deschutes River.

Orange line should be above the green line due to general downstream warming trend, yet commonly when Tumalo Creek is cooler than the Deschutes River, the orange line is below the green and when Tumalo Creek is warmer than the Deschutes River, the orange line is above the green.



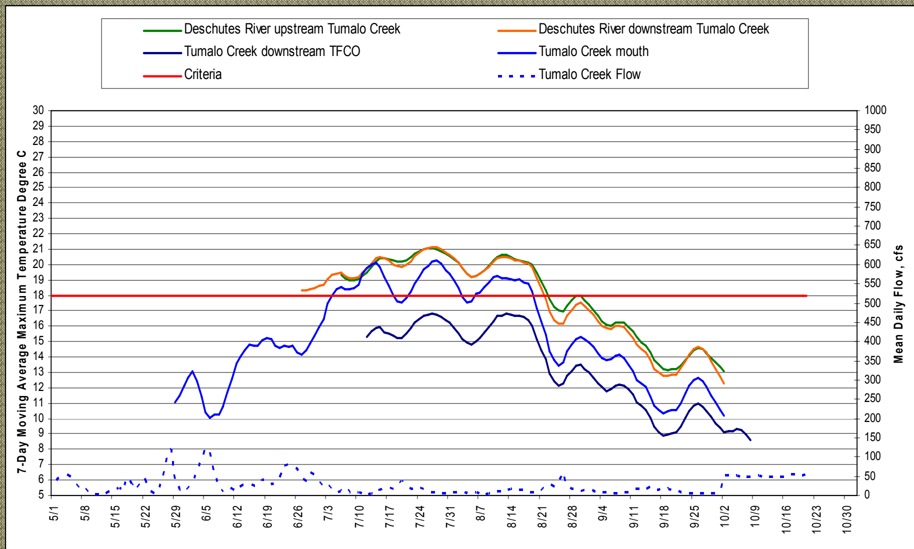
The x-axis represents time and the y-axis represents the 7-day max in degrees C. The red line represents the 18 degree Celsius state standard set to protect the beneficial use of fish.

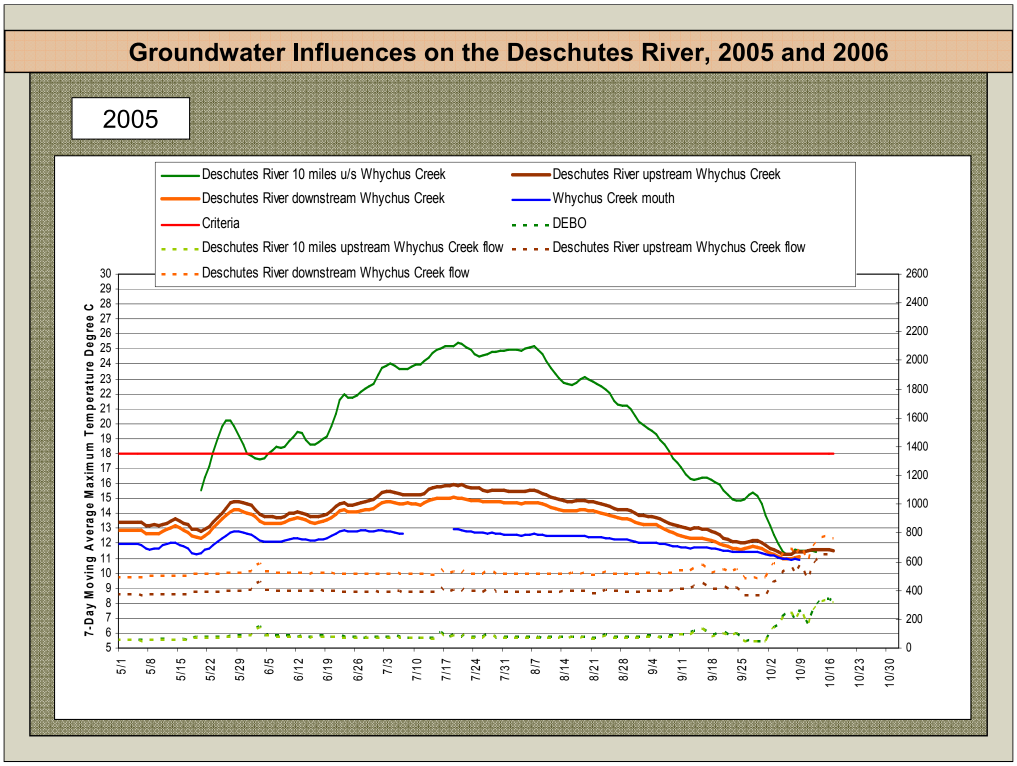
Orange line should be above the green line due to general downstream warming trend, yet commonly when Tumalo Creek is cooler than the Deschutes River, the orange line is below the green and when Tumalo Creek is warmer than the Deschutes River, the orange line is above the green.

Note that the 2004 data puts Tumalo Creek on the 2004 303(d) list that is due to be released in 2007. The 2005 data supports this listing from TFCO downstream to the confluence with the Deschutes River.

Tumalo Creek Influences on the Deschutes River; 2004, 2005, and 2006

2004





In this next graph we are looking at the influences of the *Whychus Creek groundwater spring complex* on the Deschutes River.

The x-axis represents time and the y-axis represents the 7-day max in degrees C. The red line represents the 18 degree Celsius state standard set to protect the beneficial use of fish.

The green line represents the Deschutes River at Lower Bridge located approximately 10 miles upstream of Whychus Creek. The brown line represents the Deschutes River upstream Whychus Creek. The orange line represents the Deschutes River downstream of Whychus Creek. The dashed lines represent flow at the three locations. The blue line represents Whychus Creek mouth.

In 2006, there is no data for Deschutes River upstream Whychus Creek at this time, and data downstream Whychus Creek is incomplete. Therefore we will look at 2005.

Note in 2005 that the Deschutes River 7-day moving average maximum temperature decreases at a rate of -0.9 C/mile between Lower Bridge and Whychus Creek. This is due to the groundwater that enters the system as springs and amounts to approximately 300 cfs gained. In addition, Whychus Creek offers a local cooling rate equal to -3.6 C/mile and offers another approximate 100 cfs gain.

We see here that the input of cold groundwater into the DR offsets upstream influences on the rate of change. Therefore upstream restoration actions need to consider impacts on this important cold water reach.

Insights…

1. **Not all water is created equally;** while water *quantity* matters, the *quality* of restored water (cold or warm) is important

2. **Tributaries are critical to mainstem water quality restoration;** Tumalo Creek is a potential cooling source for the middle Deschutes River

3. **Current obstacles create future opportunities;** Dams can contribute to warmer or cooler temperatures downstream

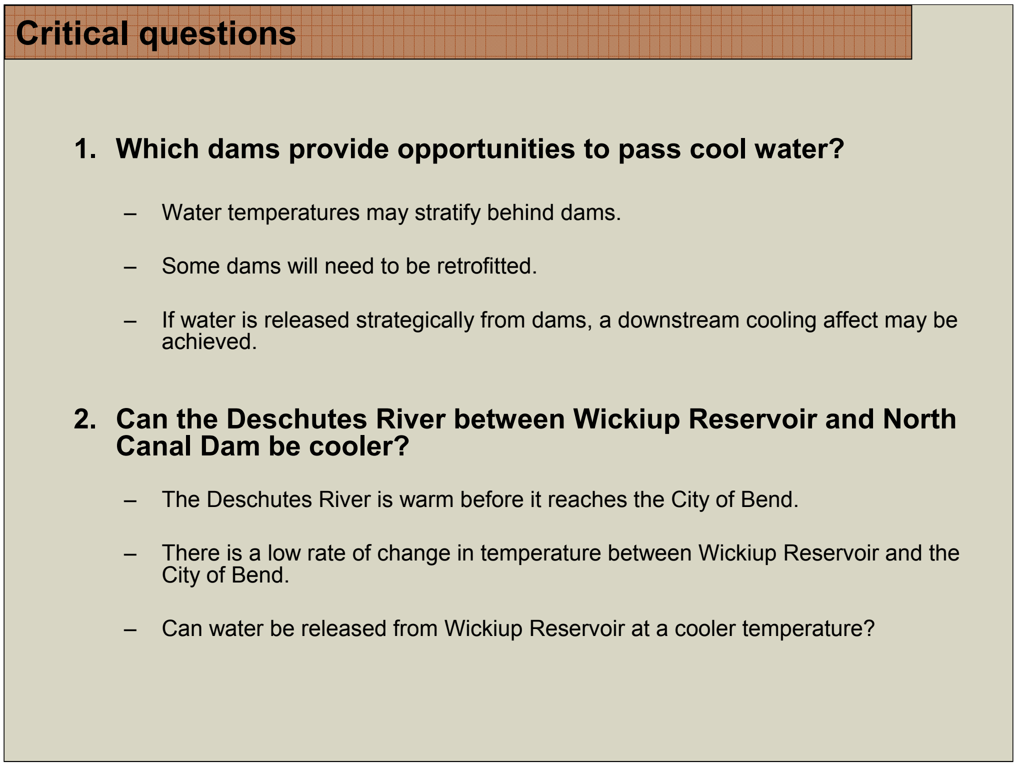
There are three main insights that illustrate how we should be approaching restoration of water temperatures of the Deschutes River:

1. **Not all water is created equal** While water *quantity* matters, the *quality* of restored water (cold or warm) is important.

- Even with warm water enhanced instream flows will have other critical ecological benefits. (i.e. buffering the warming rate, connecting the river to the flood plain)
- Starting temperatures determine temperatures downstream.
  - If the water leaving Wickiup is above state criteria, it will still be above state criteria when it reaches the City of Bend.
  - If the water downstream of Tumalo Creek confluence is above state criteria, it will still be above state criteria when it reaches the lower bridge.
  - If the restored cfs is warm, it will reduce the benefit of downstream cooling influences.
- Restoration water costs different amounts per cfs. Extremely rough estimates based on Deschutes River Conservancy estimates of future conservation costs:
  - Deschutes River from North Canal Dam cost per cfs ~ $250,000, Max 7-day ~ 21C
  - Tumalo Creek from TFCO cost per cfs ~ $700,000, cooler or warmer water?
  - Therefore cold Tumalo Creek water is ~ 2.8 times more expensive than warm Deschutes River water

2. **Tributaries are critical to mainstem water quality restoration**
  - Tumalo Creek is the only *potential* input of cool water for the Middle Deschutes between Bend and Lower Bridge
  - The question remains how much water do we need in Tumalo Creek to carry the cooling affect to Lower Bridge?

3. Current obstacles create future opportunities
  - Dams can contribute to warmer or cooler temperatures downstream, depending on their design and operation: Bottom flow = cooling, Top flow = warming



Which dams provide opportunity to pass cool water?

- •Water temperatures may stratify behind dams.
- •There is a need to address some dams due to old infrastructure (i.e. North Canal Dam).
- •If water is released strategically from dams (i.e. from a cooler depth in the water column), a downstream cooling affect may be achieved.
- •This opportunity offsets the increased temperature rate of change that occurs behind impoundments.

Can the Deschutes River between Wickiup Reservoir and North Canal Dam be cooler?

- •The Deschutes River is warm before it reaches the City of Bend.
- •There is a low rate of change in temperature between Wickiup Reservoir and the City of Bend.
- •Can water be released from Wickiup Reservoir at a cooler temperature?
- •This opportunity decreases the starting temperature at North Canal Dam.

Critical questions

3. **What is the optimal balance between Deschutes River water and Tumalo Creek water considering quantity, temperature, and downstream impacts?**

   – If cold Tumalo Creek water costs more than warm Deschutes River water, where should we invest our dollars?

   – Can conservation of Deschutes River water be used to enhance Tumalo Creek flows?

   – Is there opportunity to change the point of diversion for Tumalo Irrigation District?

   – Is there opportunity to change City of Bend drinking water withdraws from Bridge Creek in order to increase Tumalo Creek flows?

   – What temperature does the middle Deschutes River need to be in order to conserve the benefits of groundwater spring inputs downstream?

   – At the current target of 250 cfs for the Deschutes River middle reach, what temperature will the water be? Will this protect areas downstream?

What is the optimal balance between Deschutes River water and Tumalo Creek water considering quantity and temperature?

- If cold Tumalo Creek water costs ~ 2.8 times more than warm Deschutes River water, where should we invest our dollars?
- Is there opportunity to change the point of diversion for Tumalo Irrigation District?
  - Tumalo irrigation district has a diversion on the Deschutes River and Tumalo. Potential exists to transfer Deschutes water rights to TID, transfer TIDs Tumalo rights in-stream.
- Potential also exists to modify City of Bend drinking water withdraws from Bridge Creek:
  - Piping bridge creek diversion?
  - Groundwater switch?

Next steps…

Continue regional monitoring

Increase focus on critical questions

Seek new funding

Continue regional monitoring

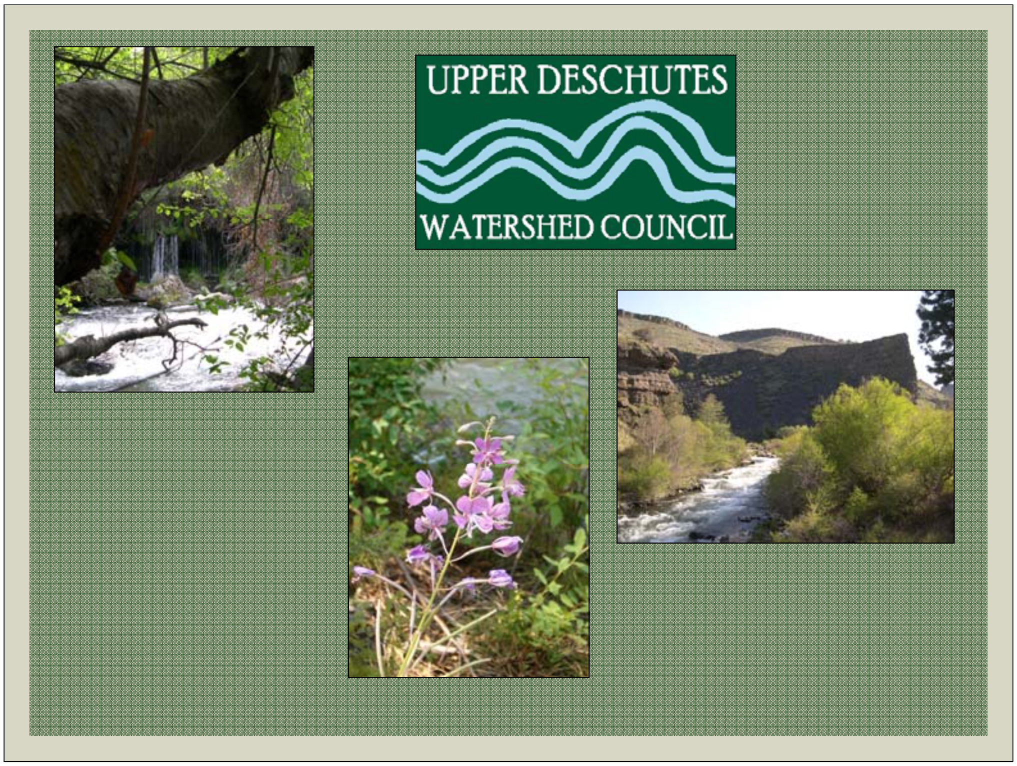
- Coordinated regional temperature monitoring provides insights such as those presented today.
- Long term monitoring strategy that is important for tracking changes in water quality over time.

Focus on critical questions

- Monitoring needs to evolve to address the questions that arise from our increased understanding.
- Short term monitoring strategy that is important for decisions being made today about our resources.

Seek new funding

- This program has funding to last the next 12 months.
- New funding opportunities may exist to answer our critical question while also supporting our regional monitoring.


UPPER DESCHUTES
WATERSHED COUNCIL

Upper Deschutes Watershed Council
Water Quality Monitoring Program
Poster Presentation

Restoration effectiveness monitoring in priority watersheds of the Deschutes Basin

Prepared by: Lesley Jones
Water Quality Specialist
Upper Deschutes Watershed Council
Bend, Oregon

Abstract
The complex issues in the Deschutes Basin are illustrative of watershed restoration challenges across Oregon. In particular, highly regulated flows have resulted in impaired water quality and a need for extensive instream flow restoration. The effectiveness of basin-wide efforts to improve water quality via instream flow restoration is of interest to natural resource decision makers who apply limited budgetary resources toward achieving balance between out of stream irrigation demands and instream ecological needs. The Upper Deschutes Watershed Council Water Quality Monitoring Program (UDWC program) prioritizes watersheds based on restoration activities, evaluates the status and trends of multiple water quality parameters that are expected to change upon restoration, and provides water quality analyses to help refine preliminary flow restoration targets. Through these services, the UDWC program provides the technical tools needed by natural resource decision makers to achieve future watershed restoration across the Deschutes Basin.

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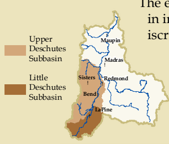
Upper Deschutes Watershed Council
Bend, Oregon: April 2006

Restoration effectiveness monitoring in priority watersheds of the Deschutes Basin

Upper Deschutes Watershed Council, Water Quality Monitoring Program, Bend, Oregon

Introduction

The complex issues in the Deschutes Basin are illustrative of watershed restoration challenges across Oregon. The regulated flow regime has resulted in impaired water quality, and basin-wide efforts are addressing this issue via aggressive instream flow restoration projects. The effectiveness of these projects in improving water quality iscritical information for natural resource decision makers who apply limited budgetary resources toward achieving balance between out of stream irrigation demands and instream ecological needs.

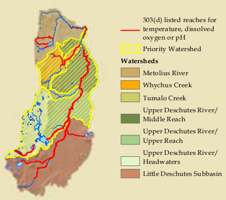


The Upper Deschutes Watershed Council Water Quality Monitoring Program (UDWC program) is currently providing this critical information by working toward answering the following questions:

- ***Where should instream flow restoration and water quality monitoring efforts focus?***
- ***What are the appropriate flow targets for watershed restoration?***
- ***Is watershed health improving as instream flow restoration occurs?***

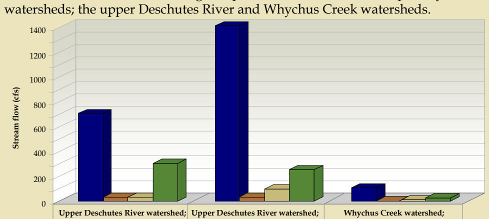
Why does the UDWC program evaluate watershed restoration effectiveness?

In the Upper Deschutes and Little Deschutes Subbasins, there are more than 380 miles of waterways listed as impaired under Section 303(d) of the Clean Water Act (ODEQ 2006a). These waterways are listed for temperature, dissolved oxygen, and pH impairments (map, right) .



The flow regime has been identified as the single most important factor contributing to these water quality impairments (BOR & OWRD 1997, USFS 1996, and USFS 1998). The flow regime in the upper Deschutes River watershed is characterized by large and sudden fluctuations between winter storage and summer releases in combination with agricultural diversions. The flow regime in Whychus Creek watershed is characterized by dewatering due to agricultural diversions. Since 1997, local, state, and federal partners have been collaborating to address impairments by improving instream flows.

Many streams in the Deschutes Basin have certificated instream water rights based on minimum flows required to support fish populations (ODEQ 2006b). These certified instream water rights serve as target flows for restoration efforts. Figure 1 provides natural, pre-1997, current, and target flows to illustrate the extent of dewatering and planned restoration for two priority watersheds; the upper Deschutes River and Whychus Creek watersheds.



	Upper Deschutes River watershed; upper reach (fall / winter / spring)	Upper Deschutes River watershed; middle reach (summer)	Whychus Creek watershed; (summer)
Natural	700	1400	100
Pre-1997	30	30	0
Current	30	90	8
Target	300	250	20

Per Deschutes River Conservancy estimates

Figure 1. Natural, Pre-1997, Current and Target Flows

The target flows are considered preliminary because it is unknown if these targets are appropriate for the restoration of ecosystem process and fisheries within the Deschutes Basin (DRC 2003). The refinement of target flows is critical to the optimization of limited funds in attaining watershed restoration, timely improvement of water quality and fish habitat, and the ultimate removal of reaches from the 303(d) list. The refinement of target flows is one way in which the UDWC monitoring program informs restoration (see Medium term goals, right).

What is the strategy of the UDWC program?

In order to inform watershed restoration efforts in the Deschutes Basin, the UDWC Program has outlined a monitoring strategy that includes measuring environmental results via outputs and outcomes as described in the logic model below.

Assumptions

1) Instream flow restoration and total maximum daily load (TMDL) implementation will effectively change waterways that are 303(d) listed.
2) Information regarding the status and trends of watershed health is required for optimizing decision making.
3) Instream flow targets can be refined to optimize limited budgetary resources.

Inputs

- Oregon Watershed Enhancement Board funding
- Oregon Department of Environmental Quality funding
- In-kind donations

Outputs

Comprehensive water quality monitoring along watershed hydrologic boundaries

	Short term	Medium term	Long term
Outcomes	Status evaluations and the establishment of baseline water quality conditions.	Trend evaluations and documentation of progress toward improving water quality conditions.	Status evaluations and evidence of success.
Outcome Measures	2001 - 2004 Development of strategic plans for efficient and effective monitoring of watershed restoration progress.	2005 - 2010 Development of appropriate target flows. Better restoration efforts due to information regarding the direction and magnitude of water quality changes.	2010 + Successful TMDL implementation and ultimate removal of waterways from 303(d) list. Balance between out of stream irrigation demands and instream ecological needs.

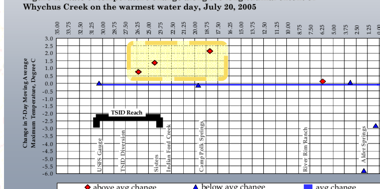
How is information being used to monitor watershed restoration effectiveness?

Short term

Status evaluations contribute to a strategic approach toward watershed restoration and effectiveness monitoring.

The purpose of Figure 2 is to identify where the most dramatic changes are occurring in the waterway so that restoration efforts can address the most influential reaches. For example, the most dramatic negative impacts, as depicted by a higher rate of warming, are in the reach downstream the Three Sisters Irrigation Diversion (TSID) at river mile 28 until downstream Camp Polk Springs at river mile 18. *This figure indicates that watershed restoration efforts should target this ten mile reach (highlighted in yellow).*

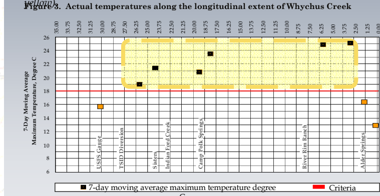
Figure 2. Rate of temperature change along the longitudinal extent of Whychus Creek on the warmest water day, July 20, 2005



The blue line represents the rate of temperature change for Whychus Creek between river mile 30 and river mile zero. The blue triangles represent stations where the rate of temperature change is equal to or lower than the rate of temperature change for the entire waterway. The red diamonds represent stations where the rate of temperature change is above the rate of temperature change for the entire waterway.

The purpose of Figure 3 is to identify the locations of temperature impairment. Although most of the temperature changes occur upstream river mile 17 (Figure 2), temperatures are impaired from downstream TSID near river mile 28 until downstream Alder Springs near river mile 2 (Figure 3). *This figure indicates that watershed restoration effectiveness monitoring should capture temperature changes that occur over this entire reach (highlighted in yellow).*

Figure 3. Actual temperatures along the longitudinal extent of Whychus Creek



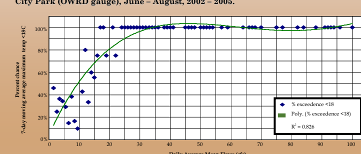
The orange squares represent the 7-day average moving maximum temperature at each station. The red line represents the state criteria for temperature.

Medium term

Refinement of target flows helps decision makers optimize limited budgetary resources toward achieving balance between out of stream irrigation demands and instream ecological needs (Figure 4). Water quality trend analyses support restoration efforts and TMDL implementation (Figure 5).

Continuous temperature data collected from an impaired station located on Whychus Creek are evaluated with respect to flow. Historic percent exceedences of temperature above state criteria are used to evaluate the preliminary flow targets. These results indicate that during the evaluated time period at the preliminary flow target of 20 cfs there was a 20% chance that temperatures exceeded state criteria set to protect the beneficial use of salmon and trout rearing and migration and at 35 cfs temperatures are 100% compliant. This information allows instream flow restoration efforts across the basin to quickly evaluate and refine flow restoration targets for

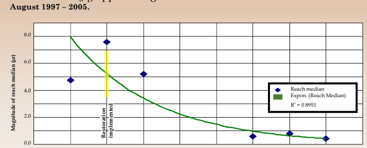
Figure 4. Percent exceedences in state criteria vs. flow, Whychus Creek at Sisters City Park (OWRD gauge), June – August, 2002 – 2005.



The blue diamonds represent the percent of exceedences 18 °C at a daily average mean flow. The green line is a polynomial line of best fit to illustrate the relationship between daily average mean flows and percent chance of exceedences.

The UDWC program medium term outcomes focus on trends via evaluating the direction of water quality changes. Figure 5 is an example of a tool to provide restoration efforts feedback as to the direction of water quality after initial instream flow restoration in 1999 changed the flows in the TSID reach from approximately 0 cfs to 6 cfs. Although temperatures in this reach are not yet compliant with state temperature standards, improvements in water quality are indicated by the magnitude of the reach median (μ_r) approaching zero.

Figure 5. Reach median magnitude changes over time, Whychus Creek TSID Reach, August 1997 – 2005.

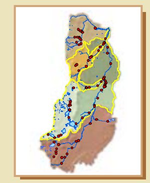


The blue diamonds represent the absolute value of the reach median (μ_r); difference between upstream year to year pairwise difference median and downstream year to year pairwise difference median. The green line is an exponential line of best fit to illustrate the change in magnitude of μ_r over time. (USGS 1991)

What type of information is being collected ?

There are three monitoring activities that are designed to inform watershed restoration efforts. Monitoring activities target priority watersheds and capture diurnal and seasonal changes in the 303(d) listed parameters at strategic stations.

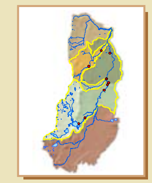
Continuous Temperature Stations



This monitoring activity focuses on the Upper and Little Deschutes Subbasins.

Grab Sampling Stations

Continuous Multiparameter Stations



These monitoring activities focus on the priority watersheds of the Upper Deschutes River and Whychus Creek. (Both monitoring activities include temperature, pH, dissolved oxygen / % saturation, specific conductance / calculated total dissolved solids, and turbidity.)

How is information is being collected?

As flows across the Deschutes Basin fluctuate season to season by as much as 1500 cfs, monitoring is challenged with attaining representative measurements in this dynamic system (photos 1 and 2).

The UDWC program is pioneering the secure deployment of innovative equipment in this environment by utilizing extendable deployment setups that can be adjusted to various flow regimes and relocated across the basin as needed (photos 3, 4 and 5). In addition, all measurements are digitally recorded with meters therefore eliminating the use of chemicals in the field environment.

Photo 1. *The Deschutes River watershed; upper reach during winter low flows.*

Photo 2. *The Deschutes River watershed; middle reach during summer low flows.*

Photos 3, 4 and 5. *Continuous multiparameter monitoring sonde deployment setup.*

Conclusions

The UDWC Water Quality Monitoring Program evaluates water quality as an indicator to watershed restoration effectiveness and provides timely insight to natural resource decision makers who are currently addressing watershed impairments linked to regulated flow regimes. This is accomplished by prioritizing watersheds based on restoration activities, evaluating the status and trends of multiple parameters that are expected to change upon restoration, and refining preliminary flow targets. The UDWC program provides the technical tools needed by natural resource decision makers to balance limited budgetary resources between out of stream irrigation demands and instream ecological needs and achieve future watershed restoration across the Deschutes Basin.

Literature Cited

BOR & OWRD, 1997. *Upper Deschutes River Basin Water Conservation Study*, United States Department of the Interior Bureau of Reclamation and the State of Oregon Water Resources Department, Oregon.

DRC, 2003. *Squaw Creek Streamflow Benchmarks*, Deschutes River Conservancy, Oregon.

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Acknowledgements

The UDWC appreciates the funding provided by the Oregon Watershed Enhancement Board and the Oregon Department of Environmental Quality in support of the UDWC program. In addition, the UDWC is thankful for guidance provided by the Water Quality Committee and the service provided by our volunteers.

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04/06

Upper Deschutes Watershed Council
Water Quality Monitoring Program
Presentation

Adaptive Management

Upper Deschutes and Little Deschutes Subbasins, Oregon

Prepared by: Lesley Jones
Water Quality Specialist
Upper Deschutes Watershed Council
Bend, Oregon

Prepared for: National Fish and Wildlife Foundation
Water Transactions Program
Quarterly meeting

Upper Deschutes Watershed Council
Bend, Oregon: May 2006

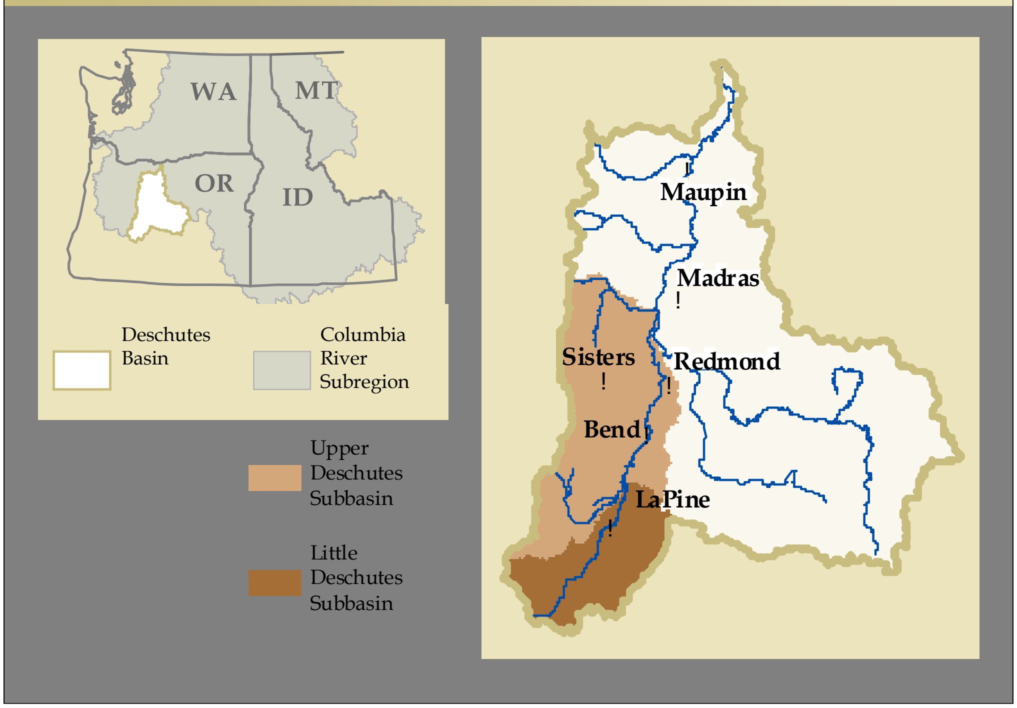
UPPER DESCHUTES WATERSHED COUNCIL

Restoration effectiveness monitoring in priority watersheds of the Deschutes Basin, Oregon

OWEB Oregon Watershed Enhancement Board

DEQ

Introduction

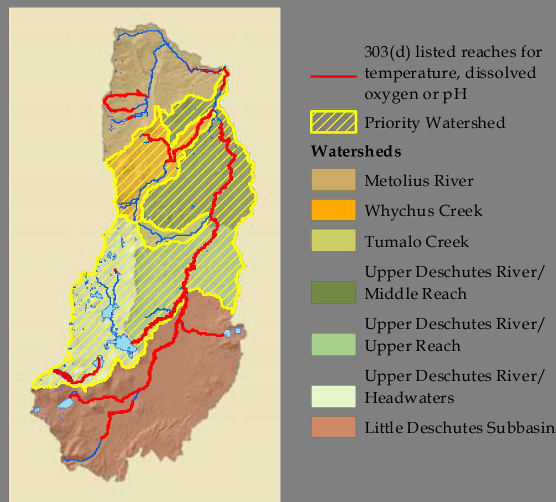


The complex issues in the Deschutes Basin are illustrative of watershed restoration challenges across Oregon. The regulated flow regime has resulted in impaired water quality, and basin-wide efforts are addressing this issue via aggressive instream flow restoration projects. The effectiveness of these projects in improving water quality is critical information for natural resource decision makers who apply limited budgetary resources toward achieving balance between out of stream irrigation demands and instream ecological needs.

The Upper Deschutes Watershed Council Water Quality Monitoring Program (UDWC program) is currently providing this critical information by working toward answering the following questions:

- ***Where should instream flow restoration and water quality monitoring efforts focus?***
- ***What are the appropriate flow targets for watershed restoration?***
- ***Is watershed health improving as instream flow restoration occurs?***

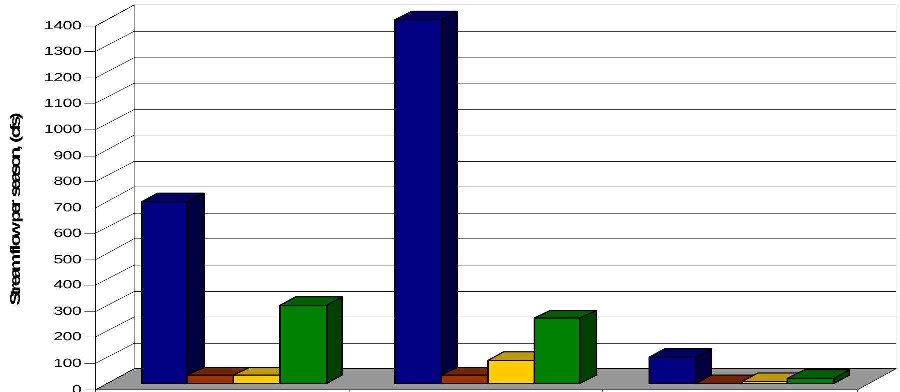
Why does the UDWC program evaluate watershed restoration effectiveness?



In the Upper Deschutes and Little Deschutes Subbasins, there are more than 380 miles of waterways listed as impaired under Section 303(d) of the Clean Water Act (ODEQ 2006a). These waterways are listed for temperature, dissolved oxygen, and pH impairments.

The flow regime has been identified as the single most important factor contributing to these water quality impairments (BOR & OWRD 1997, USFS 1996, and USFS 1998). The flow regime in the upper Deschutes

River watershed is characterized by large and sudden fluctuations between winter storage and summer releases in combination with agricultural diversions. The flow regime in Whychus Creek watershed is characterized by dewatering due to agricultural diversions. Since 1997, local, state, and federal partners have been collaborating to address impairments by improving instream flows.



	Upper Deschutes River watershed; upper reach (fall/winter/spring)	Upper Deschutes River watershed; middle reach (summer)	Whychus Creek watershed (summer)
Natural	700	1400	100
Pre-1997	30	30	0
Current	30	90	8
Target	300	250	20

The target flows are considered preliminary because it is unknown if these targets are appropriate for the restoration of ecosystem process and fisheries within the Deschutes Basin (DRC 2003). The refinement of target flows is critical to the optimization of limited funds in attaining watershed restoration, timely improvement of water quality and fish habitat, and the ultimate removal of reaches from the 303(d) list. The refinement of target flows is one way in which the UDWC monitoring program informs restoration.

Many streams in the Deschutes Basin have certificated instream water rights based on minimum flows required to support fish populations (ODEQ 2006b). These certified instream water rights serve as target flows for restoration efforts. Figure 1 provides natural, pre-1997, current, and target flows in order to illustrate the extent of dewatering and planned restoration for two priority watersheds; the upper Deschutes River and Whychus Creek watersheds.

What is the strategy of the UDWC program?

In order to inform watershed restoration efforts in the Deschutes Basin, the UDWC Program has outlined a monitoring strategy that includes measuring environmental results via outputs and outcomes as described in the logic model below.

Assumptions

1) Instream flow restoration and total maximum daily load (TMDL) implementation will effectively change waterways that are 303(d) listed.
2) Information regarding the status and trends of watershed health is required for appropriate decision making.
3) Instream flow targets can be refined to optimize limited budgetary resources.

Inputs

Oregon Watershed Enhancement Board funding | Oregon Department of Environmental Quality funding | In-kind donations

Outputs

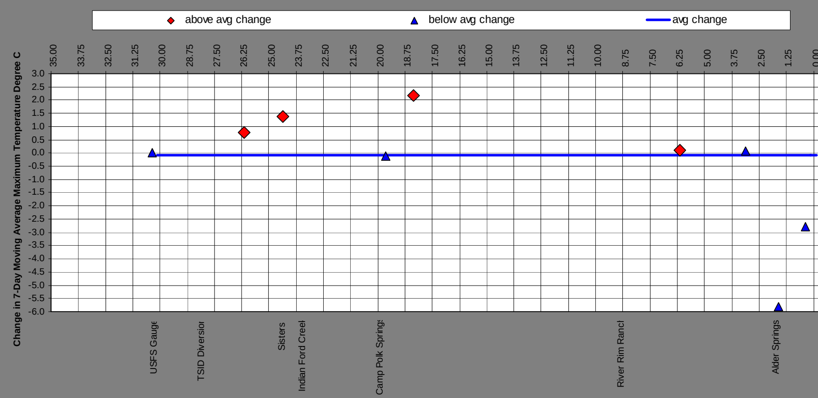
Comprehensive water quality monitoring along watershed hydrologic boundaries

Output Measures

Short term	Medium term	Long term
Status evaluations and the establishment of baseline water quality conditions.	Trend evaluations and documentation of progress toward improving water quality conditions.	Status evaluations and evidence of success.
2001 - 2004	**2005 - 2010**	**2010 +**
Development of strategic plans for efficient and effective monitoring of watershed restoration progress.	Development of appropriate target flows. Better restoration efforts due to information regarding the direction and magnitude of water quality changes.	Successful TMDL implementation and ultimate removal of waterways from 303(d) list. Balance between out of stream irrigation demands and instream ecological needs.

How is information being used to monitor watershed restoration effectiveness?

Figure 2. Rate of temperature change along the longitudinal extent of Whychus Creek on the warmest water day, July 20, 2005

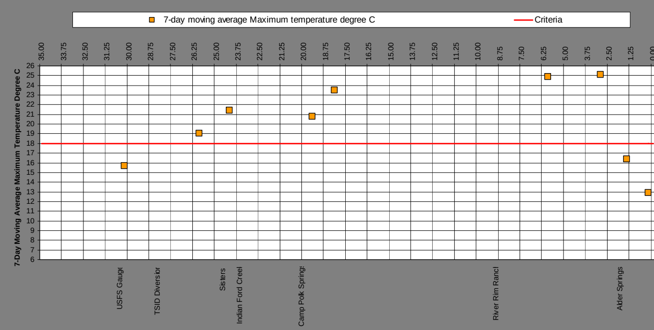


The blue line represents the rate of temperature change for Whychus Creek between river mile 30 and river mile zero. The blue triangles represent stations where the rate of temperature change is equal to or lower than the rate of temperature change for the entire waterway. The red diamonds represent stations where the rate of temperature change is above the rate of temperature change for the entire waterway.

Status evaluations contribute to a strategic approach toward watershed restoration and effectiveness monitoring.

The purpose of Figure 2 is to identify where the most dramatic changes are occurring in the waterway so that restoration efforts can address the most influential reaches. For example, the most dramatic negative impacts, as depicted by a higher rate of warming, are in the reach downstream the Three Sisters Irrigation Diversion (TSID) at river mile 28 until downstream Camp Polk Springs at river mile 18. *This figure indicates that watershed restoration efforts should target this ten mile reach.*

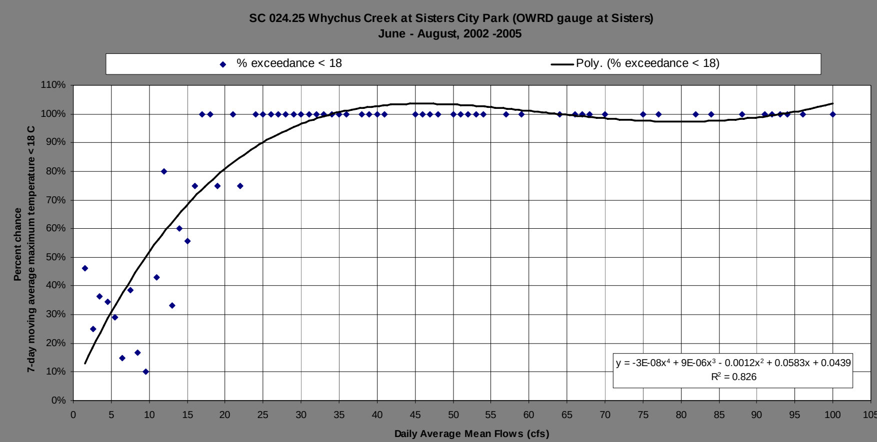
Figure 3. Actual temperatures along the longitudinal extent of Whychus Creek



The orange squares represent the 7-day average moving maximum temperature at each station. The red line represents the state criteria for temperature.

The purpose of Figure 3 is to identify the locations of temperature impairment. Although most of the temperature changes occur upstream river mile 17 (Figure 2), temperatures are impaired from downstream TSID near river mile 28 until downstream Alder Springs near river mile 2 (Figure 3). *This figure indicates that watershed restoration effectiveness monitoring should capture temperature changes that occur over this entire reach.*

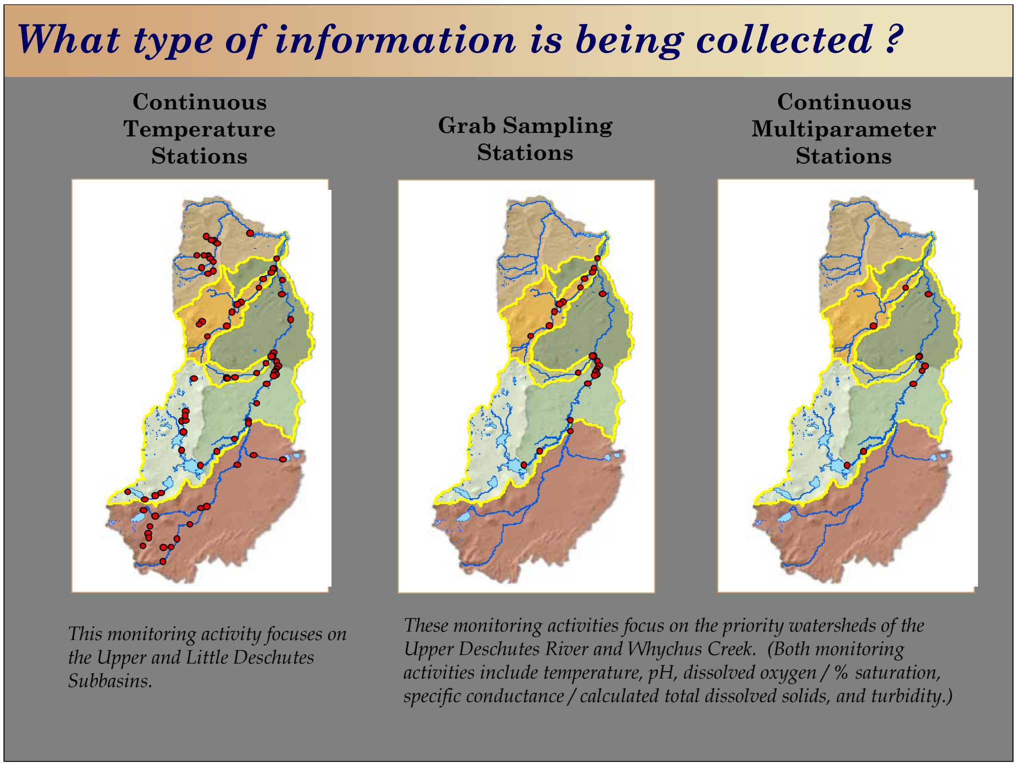
Figure 4. Percent exceedences in state criteria vs. flow, Whychus Creek at Sisters City Park (OWRD gauge), June – August, 2002 – 2005.



The blue diamonds represent the percent of exceedences 18 °C at a daily average mean flow. The green line is a polynomial line of best fit to illustrate the relationship between daily average mean flows and percent chance of exceedences.

Refinement of target flows helps decision makers optimize limited budgetary resources toward achieving balance between out of stream irrigation demands and instream ecological needs (Figure 4). In addition this analyses supports restoration efforts and TMDL implementation.

Continuous temperature data collected from an impaired station located on Whychus Creek are evaluated with respect to flow. Historic percent exceedences of temperature above state criteria are used to evaluate the preliminary flow targets. These results indicate that during the evaluated time period at the preliminary flow target of 20 cfs there was a 20% chance that temperatures exceeded state criteria set to protect the beneficial use of salmon and trout rearing and migration and at 35 cfs temperatures are 100% compliant. This information allows instream flow restoration efforts across the basin to quickly evaluate and refine flow restoration targets for each watershed.



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Upper Deschutes Watershed Council
Water Quality Monitoring Program
Presentation

Riverfest Events 2006; Discover Alder Springs and Wonders of Whychus

Whychus Creek watershed, Oregon

Upper Deschutes Watershed Council
Bend, Oregon: May 2006

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Discover Alder Springs 2006

Stop 1: Trailhead

LIMITED ACTIVITIES = mountain bikes not allowed
horses (only on Grey Butte and Ridge trail)
motorized vehicles (Henderson Flats)

WHAT'S IN A NAME? Squaw is often an offensive term to Native Americans. Earliest recorded name from 1855 Pacific Railroad reports is "Whychus" or "the place we cross the water" in the Sahaptin language. In early 1900's it was called "Clark's River". The name change to Whychus Creek (pronounced Why-choose) was approved in 2006.

WATERSHED OR CATCHMENT? Storage of freshwater, 278 sq miles total drainage, <u>Outstandingly Remarkable Geology</u> due to connection between surface and ground water with most water traveling underground.

Stop 2: Old road crossing

RESTORATION – "The return of something that was removed." Restoration of ecological processes with an emphasis on summer flow and channel morphology projects. To date 48,000+ feet of open irrigation ditches have been converted to pipe which ~ 8 cfs instream. Road closures to reduce stream sediment loading.

CONSERVATION - "Protection of a resource." Nearly 1,000 acres have been converted to natural preserves or added to the Ochoco National Grasslands for habitat restoration. Closes November 30 - April 1 for mule deer winter range and protection of soils.

ENHANCEMENT – "To increase a desired quality." Animal trails converted to maintained hiking trail systems.

Stop 3: Watershed overlook

MOUNTAIN HEADWATERS - Drains 4 major mountains and 7 remnant ice age glaciers, snow melt system, only glacial fed perennial stream in Deschutes Basin. Flashy = Average flow 105cfs, low 14cfs, high 2000 cfs on Dec. 25, 1980, 500 year flood event ~ 3400 cfs

IT'S WILD AND SCENIC - Upper 15.4 miles Whychus Creek was designated as a Wild and Scenic River by Congress in 1992.

GREAT GRADIENTS! - <u>Outstandingly Remarkable Hydrology</u> precipitation gradient is steepest in eastern Oregon, precipitation at mountains = 140 inches/year, town = 11 inches/year, dry at mouth. Elevations - South Sister = 10,350 ft, town = 3100 ft. Mouth = 2100 ft.

Stop 4: Bitterroot plateau

PLANTS LOVE MICROCLIMATES- Diversity of vegetation tied to moisture. Riparian area close to creek transitions into an upland desert forest ecological zone.

Wanderlust Tours plants overview:

There are a variety of wildflowers and plants throughout this area, and the kinds of flowers and plants change as from the top of the canyon to the canyon floor. In the zone away from the river, plants need to be highly adapted to live with a low concentration of moisture. Flowers such as the bitterroot will close themselves up in the middle of the day to avoid losing moisture, and many plants in this area can go dormant for months to years at a time. To avoid evaporation, flowers in this area do not have large lobed leaves, which is why flowers with large leaves such as the Arrowleaf Balsamroot are located down in the riparian zone and would not be able to survive on the plateau. Other flowers up in this dry area are Elegant Death Camas, Sulfur Buckwheat, Tidy-tips, Sand Lilies, Wandering Daisies, Larkspur, and Penstemon.

Stop 5: Alder spring trail geologic formation

Wanderlust Tours geography overview:

Rock layers are calendars- The formations on the rock read like a calendar of geologic time. When looking at the stratigraphy of rock layers, the youngest rocks are usually located on the top. Therefore you can get a sense of the events that took place over time and the order in which they happened by looking at all the rock layers.

Sedimentary rock- On this section, there is sedimentary rock that was left by streams and rivers before it eroded itself down the canyon over the course of millions of years. These sediments lithified into rock, and one can also get an idea of the conditions that prevailed during each of those time periods. Heavy pieces of sediment and rock indicate faster moving waters to move such large pieces. This can be due to factors such as heavy melting at the end of a period of glaciation.

Igneous rock- On top of the layers of sedimentation are rocks indicative of volcanic eruptions in the area. There are the light, pinkish colors of a pyroclastic flow. This is a combination of hot ash and rocks that form a rock called tuff. Further up and on the top of the canyon, one can see basaltic lava flows that covered this area. The rock is darker and often presents itself in columns with fissure cracks caused by the cooling conditions of the basaltic lava.

Stop 6: Alder Spring crossing

GREAT GRAVELS! Outstandingly Remarkable Geology gravel producer for the Deschutes River. Now most gravel is trapped behind dams. Various gravel sizes are distributed due to flashy flows that form a variety of aquatic habitats for fish. flow is ~ 100 cfs at the USGS gauge and ~ 20 cfs at the gauge in Sisters Park.

BOUNDLESS BUGS! Caddis, stonefly, mayfly and more…feed the fish

SUPER COLD WATER! Outstandingly Remarkable Geology creates a cool source for Deschutes River. Cool water from Alder Springs offsets upstream impacts. Cold water means good bugs, lots of oxygen, and less disease for fish.

HISTORIC AND UPSTREAM IMPACTS - Diverted for irrigation since 1890's for ~8000 acres of crops (pasture, hay/alfalfa, potatoes, mint, and grains). By 1890 140 cfs allocated. Currently ~ 265 cfs allocated. Disconnect between upper and lower reaches of creek for 100 years. Upper reach = 100+ cfs, through town to alder springs = 0 – 8 cfs, and below alder springs 100+ cfs.

UNIQUE POPULATIONS - Outstandingly Remarkable Fisheries native redband trout population is unique in upper reach due to 100 year isolation from the population at the lower reach. Disconnected system with many barriers including physical (i.e. dams) and biological (i.e. high water temperatures)

Stop 7: Campsite at Whychus Creek mouth

FISH DREAM - Once supported large steelhead and spring Chinook runs into the upper reach. Pelton-Round Butte dam was built in 1963 and stopped fish passage to the sea. The last steelhead seen in Whychus Creek was 1967. June 2005 - new license to include fish passage that will be completed in 2009. 2007/2008 - juvenile steelhead reintroduction. 2009 - Steelhead smolt reintroduction. These fish will migrate up middle Deschutes River and into Whychus Creek.

ESTABLISHING A CONNECTION
Over allocated water with multiple uses i.e. agriculture and fisheries. Deschutes River Conservancy instream flow restoration to secure 20 cfs for the creek. Controversy over piping irrigation ditches do to possible impacts on groundwater. Controversy over pumping groundwater to satisfy water needs.

WATER IS GOLD- 1.8 cfs of water rights purchased in 1999 and cost over $110,000. Current instream goal based on certified instream water rights of 20 cfs. Will this restore ecological processes? At what cost?

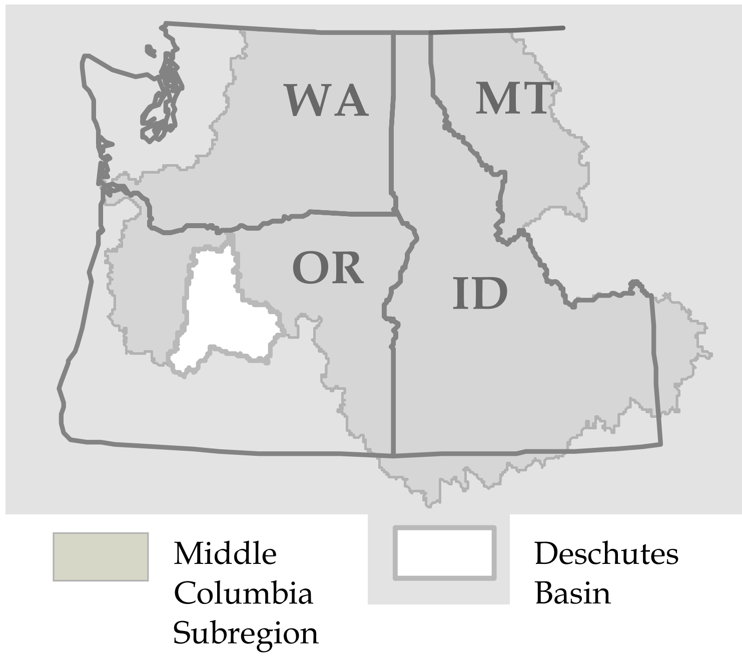
PLANT LIST

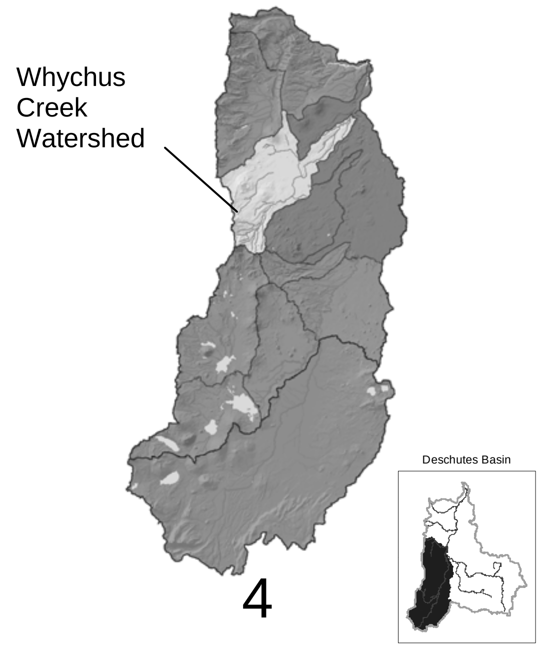
<u>Riparian</u>

Marchangia	*Marchangia berteroana*- liverwort with raised cup-shaped gemmae
Red-osier dogwood	*Cornus stolonifera*- red stems, wet areas
Scouring rush	*Equisetum sp*- in wet areas, striped stems
Willows	*Salix* sp. - wet areas

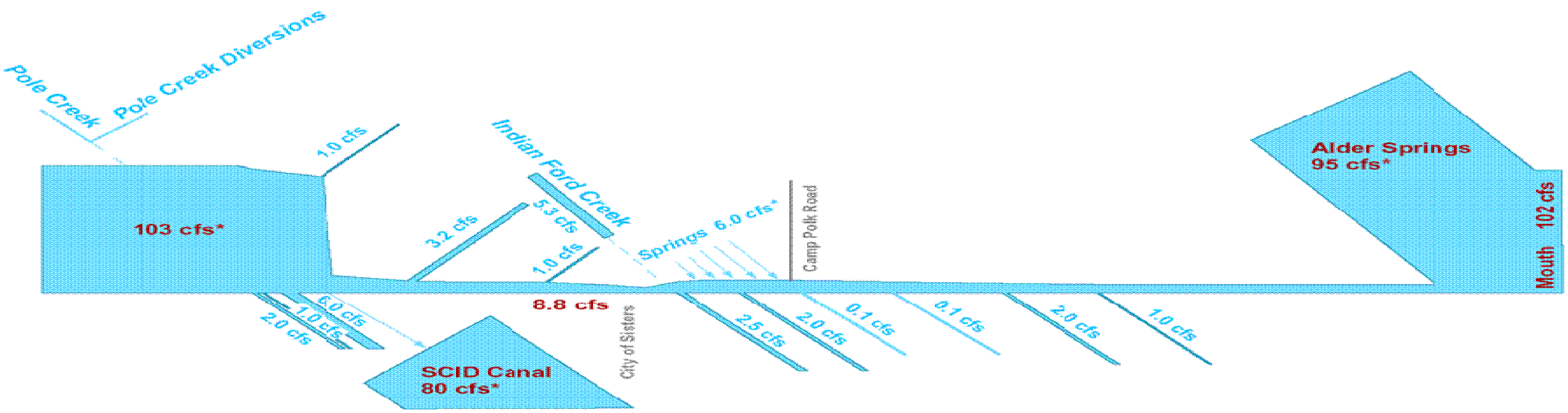
<u>Upland</u>

Arrowleaf balsamroot	*Balsamorhiza sagittata*- yellow sunflower
Bitterbrush	*Purshia tridentata*- grayish shrub
Bitterroot	*Lewisia rediviva* - resurrection flower can live 1+ yr without water
Greenleaf manzanita	*Arctostaphylos nevadensis*- oval green leaves, pink
Idaho fescue	*Festuca idahoensis*–bunch grass
Oregon grape	*Berberis repens*- shiny holly like leaves
Ponderosa pine	*Pinus ponderosa*- 3 needles in cluster
Sand lillies	*Leucocrinum montanum*- White star shaped flowers
Shrubby penstemon	*Penstemon fruticosus*- small leaves, seed stalks
Small flowered prairie star	*Lithophragma parviflora*- White tiny star flowers
Western yarrow	*Achillea millefolium*- ferny leaves, white flowers
Wax currant	*Ribes viscosissimum* - sticky leaves
Western juniper	*Juniperus occidentalis*- scalelike leaves, blue berries
Wild rose	*Rosa sp*.- pink flowers, bright red fruit
Wolf lichen	*Letharia vulpina* **–**bright lime green lichen





August Average instream flows for Whychus Creek (source: Deschutes River Conservancy



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Wonders of Whychus 2006

~ **WHATS IN A NAME?** Squaw is an offensive term to present day Native Americans. Native American names for the creek were "**Why-chus**" or "**Sesequa**". . Camp Polk soldiers in 1869 called it "**Benton Creek**". In early 1900's it was called "**Clark's River**". A name change to Whychus Creek was finally approved in 2006

~ **MOUNTAIN HEADWATERS:** Drains 4 major mountains and 7 remnant ice age glaciers, snow melt system, only glacial fed perennial stream in Deschutes Basin.

~ **ICE AGE:** Carver Lake-an ice age moraine dam lake- headwaters for South Fork; 18,000 years ago a 2 mile wide glacier advanced to within 3 miles of here.

~ **IT'S WILD AND SCENIC:** Upper 15.4 miles Whychus Creek was designated as a Wild and Scenic River by Congress in 1992. From headwaters to wilderness boundary its "Wild" (6.6 miles) from wilderness boundary to gaging station (8.8 miles) it's "Scenic".

~ **OUTSTANDING!** Hydrology (waterfalls, springs, wetlands, longterm data (since 1906=100 yrs), Geology (Increasing volcanic activity, most water flows below surface, diverse geologic features), Fish (100 year isolation Redband trout, historic runs), Ecology(old growth, hardwoods), Scenery (Diverse, unique, and low use), rich history

~ **PLANTS LOVE MICROCLIMATES:** Diversity of vegetation tied to moisture- mosses, riparian plants, trees (Ponderosa pine, Douglas fir, lodgepole pine, spruce)

~ **GREAT GRADIENTS!** Outstandingly Remarkable Hydrology precipitation gradient is steepest in Eastern Oregon, Precipitation- mountains 140 inches/year, Town-11 inches/year, dry at mouth. Elevation- South Sister-10,350 ft, town- 3100 ft. Mouth 2100 ft,

~ **WATERSHED OR CATCHMENT?** storage of freshwater, at the USGS gauge 45 sq miles of drainage, 278 sq miles total drainage, Outstandingly Remarkable Geology connection between surface and ground water with most water traveling underground, cool source for Deschutes River

~ **GREAT GRAVELS!** Outstandingly Remarkable Geology gravel producer for the Deschutes River. Now most gravel is trapped behind dams. Various gravel sizes are distributed due to flashy flows that form a variety of aquatic habitats for fish. Average flow 105cfs, low 14cfs, high 2000 cfs on Dec. 25, 1980, 500 year flood event ~ 3400 cfs, flow is ~ 100 cfs at the USGS gauge and ~ 20 cfs at the gauge in Sisters Park.

~ **A WORKING RIVER:** diverted for irrigation since 1890's, rights exist for approximately 140 cfs 1890 prior, ~ 265 cfs total, ~8000 acres of crops (pasture, hay/alfalfa, potatoes, mint, grains). Pole Creek plus 2 groundwater wells supply domestic water for Sisters. Disconnect between upper and lower reaches of creek for 100 years.

~ **A RIVER RAN THROUGH IT:** Sisters was settled because of available water from Whychus Creek for irrigation and vast pine forests for timber. Sisters was a logging town- first sawmill built on Whychus Creek in 1890, 11 mills at one time. Last mill closed in 1965

~ **OUR CHANGING FORESTS:** With logging and fire exclusion. In 1953 –97% was dominated by big pine (over 21" dbh), 1998- 9% dominated by big pine. 88% less acres are dominated by big trees. Fire is natural- Fire exclusion brings high fire risk

~ **WATER IS GOLD:** Water rights were purchased in 1999- 1.8 cfs cost over $111,198 (models estimate we need a 20-40 cfs to lower water temperatures downstream to non-lethal summer temps- The river can reach lethal levels for fish in summer.

- ~ **FISH DREAM:** Once supported large steelhead and spring chinook runs up to the lower falls near the wilderness boundary. The last steelhead seen in 1967. Pelton-Round Butte dam was built in 1963 and stopped fish passage to the sea. June 2005 new license to include fish passage that will be completed in 2009. 2007/2008 juvenile steelhead reintroduction, 2009 steelhead smolt introduction. These fish will use Whychus Creek.

- ~ **UNIQUE POPULATIONS:** Outstandingly Remarkable Fisheries native redband trout population is unique in upper reach due to 100 year isolation from the population at the lower reach. Disconnected system with many barriers including physical (ie. dams) and biological (ie high water temperatures)

- ~ **ESTABLISHING A CONNECTION:** Over allocated water with multiple uses ie. agriculture and fisheries. Deschutes River Conservancy instream flow restoration to secure 20 cfs for the creek. Controversy over piping irrigation ditches do to possible impacts on groundwater. Controversy over pumping groundwater to satisfy water needs.

- ~ **GROWING PAINS:** Growth pressure is increasing-vandalism, trash, vehicle trespass, people living in the forest

- ~ **YOU CAN BE INVOLVED IN WHYCHUS CREEKS FUTURE:** For stewardship activities call Upper Deschutes Watershed Council 382-6103, or call Maret Pajutee 549-7727 to be involved with the Wild and Scenic River Plan.

Plants! Plants! Plants! Plants! Plants! Plants! Plants! Plants! Plants!

Common name	Genus species	Description
Wolf lichen	*Letharia vulpine*	bright lime green lichen
Idaho fescue	*Festuca idahoensis*	bunch grass
Bitterbrush	*Purshia tridentate*	grayish shrub
Greenleaf manzanita	*Arctostaphylos nevadensis*	oval green leaves, pink flowers
Shrubby penstemon	*Penstemon fruticosus*	small leaves, seed stalks
Pinedrops	*Pterospora andromedea*	brown with spheres
Thimbleberry	*Rubus parviflorus*	big maple shape leaf
Wild rose	*Rosa sp.*	pink flowers, bright red fruit
Horsetail, scouring rush	*Equisetum sp.*	in wet areas, striped stems
Desert buckwheat	*Eriogonum umbellatum*	
Spirea, steeplebush	*Spirea douglasii*	brownish spires, wet areas
1Red-osier dogwood	*Cornus stolonifera*	red stems, wet areas
Oregon grape	*Berberis repens*	shiny holly like leaves
Red alder	*Alnus rubra*	small brown cones, wet areas
Serviceberry	A*melanchier alnifolia*	white flowers, blue berries
Western yarrow	*Achillea millefolium*	ferny leaves, white flowers
Whychus currant	*Ribes cereum*	pink flowers, small red berries
Sticky currant	*Ribes viscosissimum*	sticky leaves
Ponderosa pine	*Pinus ponderosa*	three needles in cluster
Mistletoe		parasitic growth on pine trees
Douglas-fir	*Pseudotsuga menziesii*	bottlebrush shape
White fir	*Abies concolor*	straggly, 2 ranked needles
Western juniper	*Juniperus occidentalis*	scale-like leaves, blue berries
Spruce	*Picea* sp.	wet areas
Willows	*Salix* sp.	wet areas
Chokecherry	*Prunus emarginata*	white flowering shrub
Lupine	*Lupinus sp.*	star shaped leaves
Hawkweed	*Hieracium sp.*	furry leaves
Arrowleaf Balsamroot	*Balsamorhiza sagittata*	yellow sunflower
Sand Lillies	*Leucocrinum montanum*	white star shaped flowers
Small flowered Prairie star	*Lithophragma parviflora*	white tiny star flowers

Upper Deschutes Watershed Council
Water Quality Monitoring Program
Presentation

Monitoring Water Quality of the Deschutes Watersheds

Upper Deschutes and Little Deschutes Subbasins, Oregon

Prepared by: Lesley Jones
Water Quality Specialist
Upper Deschutes Watershed Council
Bend, Oregon

Prepared for: Michael Fisher, PhD
Associate Professor
Central Oregon Community College
FOR 208 Soils and Watersheds

Upper Deschutes Watershed Council
Bend, Oregon: May 2006

UPPER DESCHUTES
WATERSHED COUNCIL

Enhancing and protecting the Upper Deschutes River watershed through collaborative projects in watershed stewardship, habitat enhancement, and community awareness.

OWEB Oregon Watershed Enhancement Board

DEQ

There are many monitoring efforts that are across the subbasins. These local, state, and federal efforts operate along jurisdictional boundaries. Our program coordinates efforts across jurisdictional boundaries and along watershed boundaries.

Regulations

Clean Water Act of 1972

"Restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

TMDLs

Analytical process establishing the maximum amount of pollutants that may enter a waterbody without violating water quality standards

The watershed boundary emphasis is reflected in the Clean Water Act and in future TMDLs.

What are the functions of the watershed?

- *Dissipate energy*
- *Transport sediment and gravels*
- *Filtration*
- *Habitat*

Why?... To support ecological processes

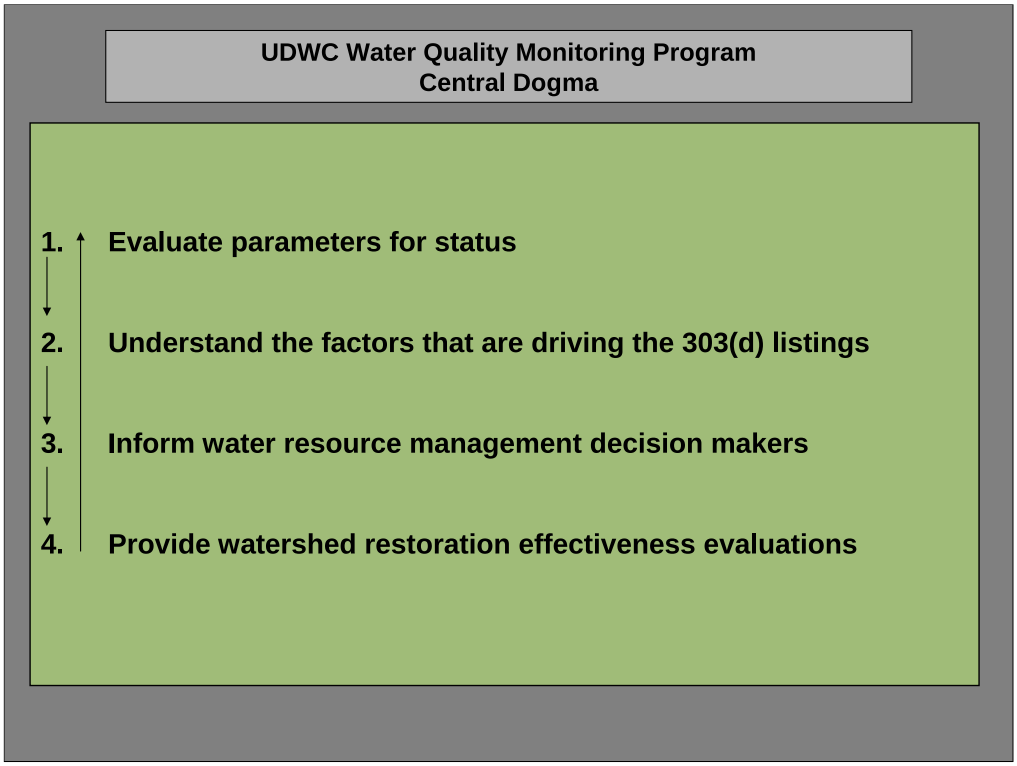
What are the functions of soils in the watershed?

- *Regulates watershed hydrology*
- *Nutrient cycling*
- *Filtration*
- *Habitat*

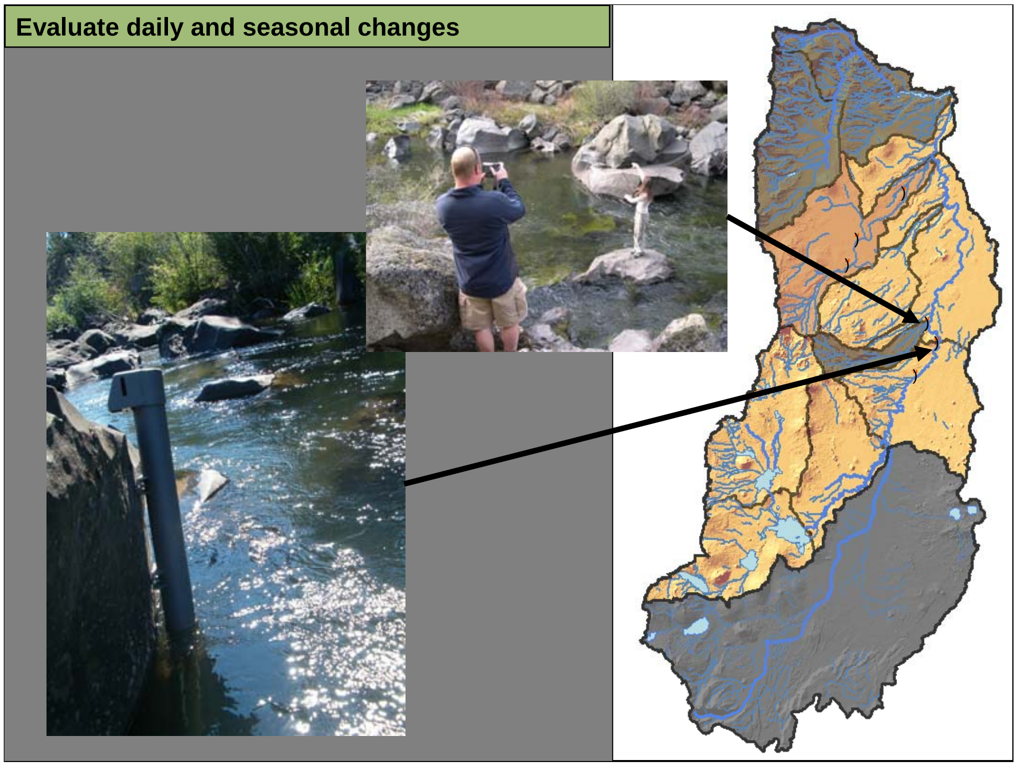
Why?... To support ecological processes


Metolius River
Crooked River
Squaw Creek
Sisters
Tumalo Creek
Bend
North
Deschutes River
Lava Lakes
Sunriver
Crane Prairie Reservoir
Wickiup Reservoir
Crescent Lake
Little Deschutes River
3. Within Bend, sediment deposits behind the four dams in Bend, creating mudflats and a substrate for algal and aquatic plant growth.
2. Stream bank erosion adds sediment to the Deschutes River. Sediment is carried downstream to the City of Bend.
1. Wickiup Reservoir reduces winter flows and increases summer flows, contributing to increased stream bank erosion
Map 1: Upper Deschutes River Watershed


What are we looking for?



Our program focuses on outcomes that inform central Oregon natural resource decision makers.



Discuss flow fluctuations

Innovative equipment

Pioneers of deployment methodologies

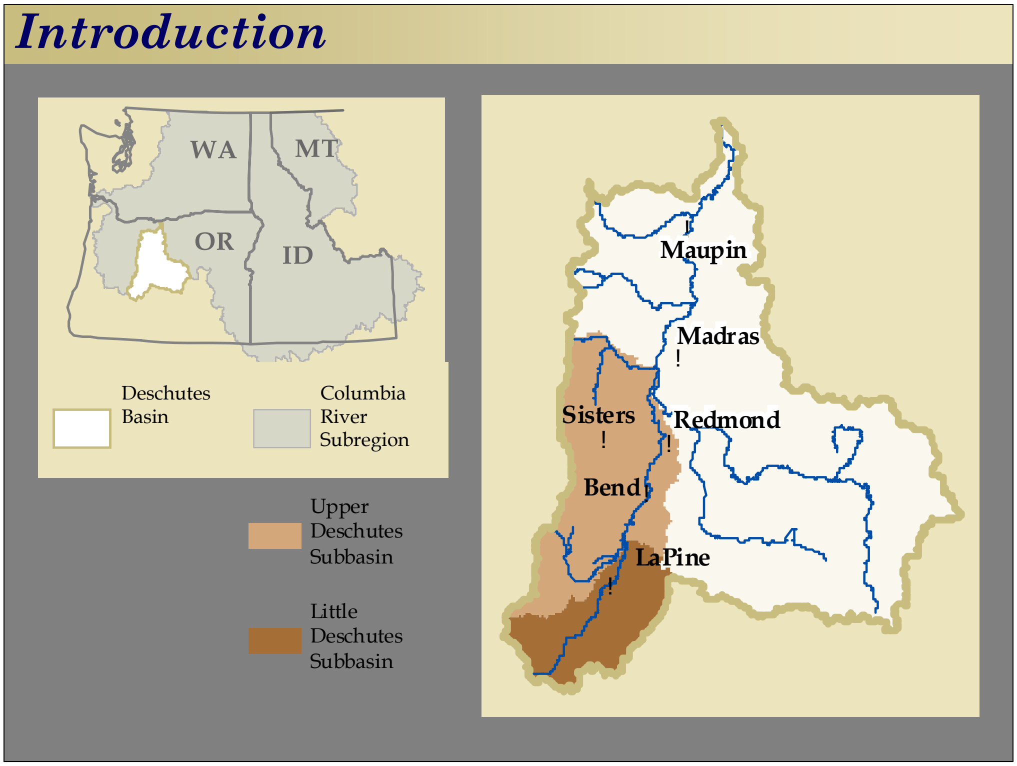
Expand into Whychus Creek for comprehensive watershed scale monitoring

UPPER DESCHUTES WATERSHED COUNCIL

Restoration effectiveness monitoring in priority watersheds of the Deschutes Basin, Oregon

OWEB Oregon Watershed Enhancement Board

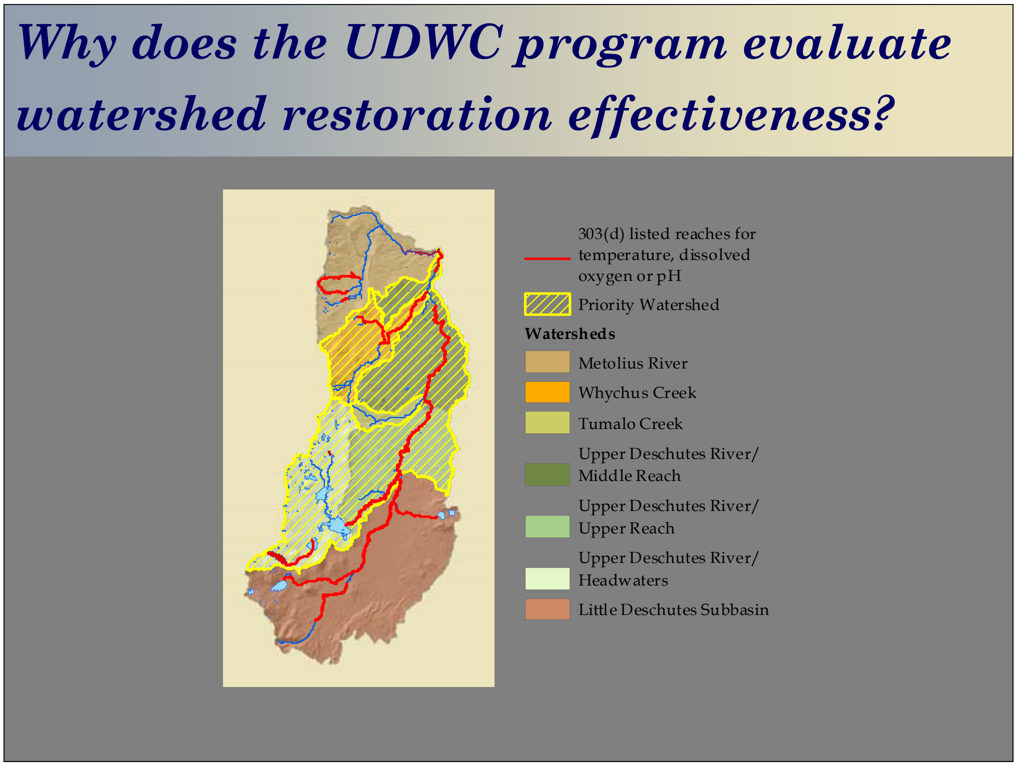
DEQ



The complex issues in the Deschutes Basin are illustrative of watershed restoration challenges across Oregon. The regulated flow regime has resulted in impaired water quality, and basin-wide efforts are addressing this issue via aggressive instream flow restoration projects. The effectiveness of these projects in improving water quality is critical information for natural resource decision makers who apply limited budgetary resources toward achieving balance between out of stream irrigation demands and instream ecological needs.

The Upper Deschutes Watershed Council Water Quality Monitoring Program (UDWC program) is currently providing this critical information by working toward answering the following questions:

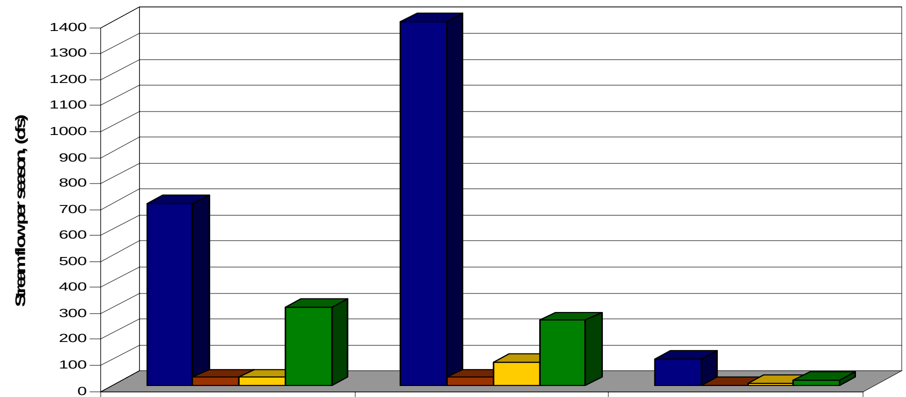
- ***Where should instream flow restoration and water quality monitoring efforts focus?***
- ***What are the appropriate flow targets for watershed restoration?***
- ***Is watershed health improving as instream flow restoration occurs?***



In the Upper Deschutes and Little Deschutes Subbasins, there are more than 380 miles of waterways listed as impaired under Section 303(d) of the Clean Water Act (ODEQ 2006a). These waterways are listed for temperature, dissolved oxygen, and pH impairments.

The flow regime has been identified as the single most important factor contributing to these water quality impairments (BOR & OWRD 1997, USFS 1996, and USFS 1998). The flow regime in the upper Deschutes

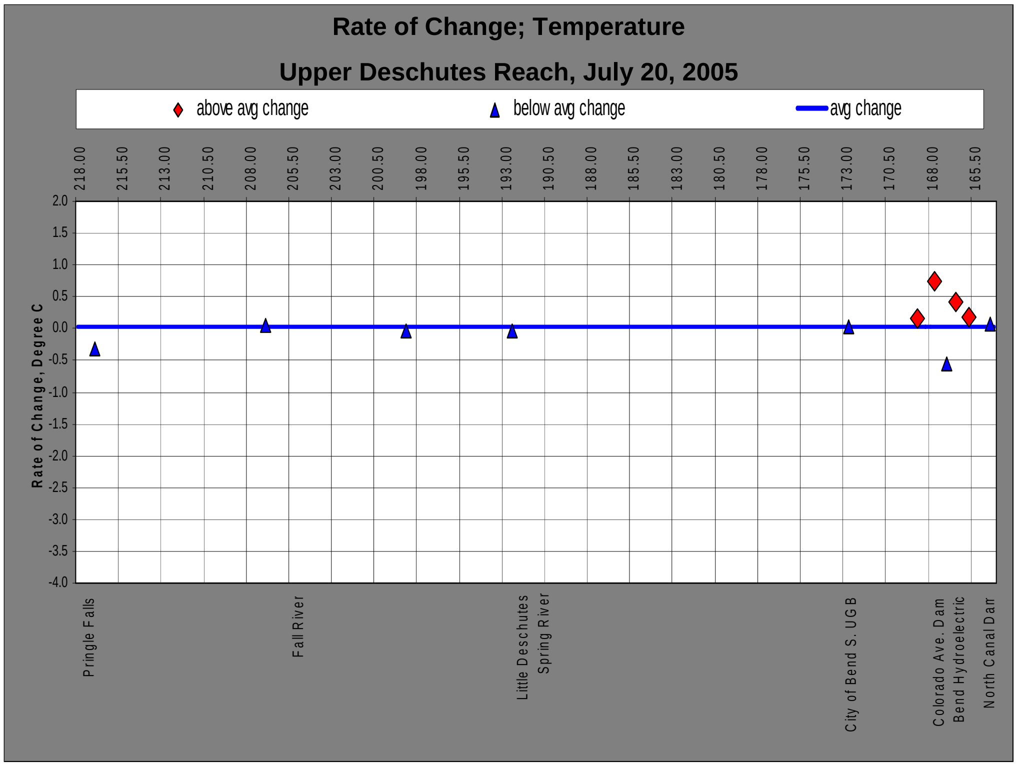
River watershed is characterized by large and sudden fluctuations between winter storage and summer releases in combination with agricultural diversions. The flow regime in Whychus Creek watershed is characterized by dewatering due to agricultural diversions. Since 1997, local, state, and federal partners have been collaborating to address impairments by improving instream flows.



	Upper Deschutes River watershed; upper reach (fall/winter/spring)	Upper Deschutes River watershed; middle reach (summer)	Whychus Creek watershed (summer)
Natural	700	1400	100
Pre-1997	30	30	0
Current	30	90	8
Target	300	250	20

The target flows are considered preliminary because it is unknown if these targets are appropriate for the restoration of ecosystem process and fisheries within the Deschutes Basin (DRC 2003). The refinement of target flows is critical to the optimization of limited funds in attaining watershed restoration, timely improvement of water quality and fish habitat, and the ultimate removal of reaches from the 303(d) list. The refinement of target flows is one way in which the UDWC monitoring program informs restoration.

Many streams in the Deschutes Basin have certificated instream water rights based on minimum flows required to support fish populations (ODEQ 2006b). These certified instream water rights serve as target flows for restoration efforts. Figure 1 provides natural, pre-1997, current, and target flows in order to illustrate the extent of dewatering and planned restoration for two priority watersheds; the upper Deschutes River and Whychus Creek watersheds.



Reach: upper Deschutes

Explain graph

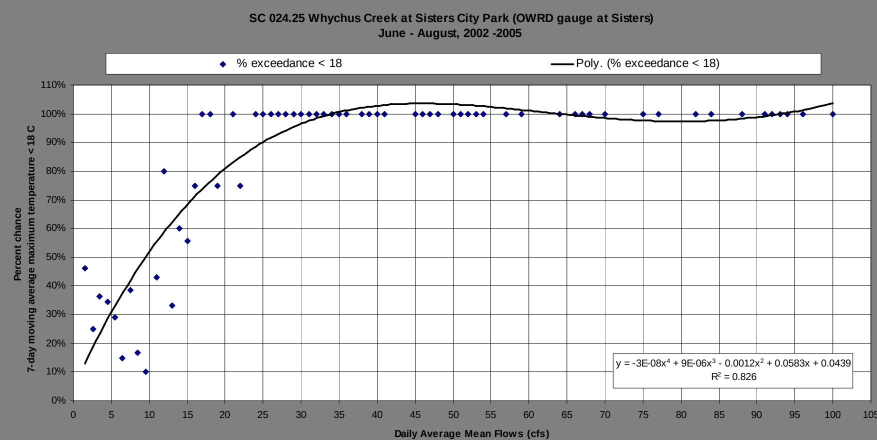
1. First graph is 2004 warmest water day 7/28/2004.
- X axis is river mile and locators each box = ~ 2.5 miles
- Y axis is the change in in 7-day moving average = the warming rate
- The blue line is the avg warming rate for the reach
  - u/s temp minus d/s temp divided by distance = warming rate for reach
  - Blue triangles = rate of temp change is lower than the average rate of temp change per mile
  - Red diamonds =rate of change is higher than the average rate of temp change per mile

Consistencies

1. Reach rate the same in 04 and 05, despite new and deleted sites (from refining sites)
2. Data pattern
3. 7/20/05 warmest water day for all three watersheds

* The importance of looking at this is to see where warming rates may be influenced. This can help to inform restoration and conservation efforts
  - Warming rates that are above the avg (red diamonds) are correlated with impoundments.

Figure 4. Percent exceedences in state criteria vs. flow, Whychus Creek at Sisters City Park (OWRD gauge), June – August, 2002 – 2005.



The blue diamonds represent the percent of exceedences 18 °C at a daily average mean flow. The green line is a polynomial line of best fit to illustrate the relationship between daily average mean flows and percent chance of exceedences.

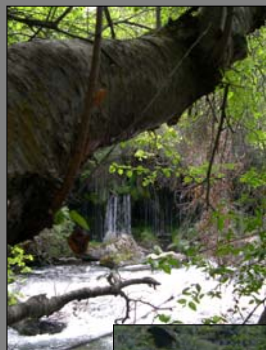
Refinement of target flows helps decision makers optimize limited budgetary resources toward achieving balance between out of stream irrigation demands and instream ecological needs (Figure 4). In addition this analyses supports restoration efforts and TMDL implementation.

Continuous temperature data collected from an impaired station located on Whychus Creek are evaluated with respect to flow. Historic percent exceedences of temperature above state criteria are used to evaluate the preliminary flow targets. These results indicate that during the evaluated time period at the preliminary flow target of 20 cfs there was a 20% chance that temperatures exceeded state criteria set to protect the beneficial use of salmon and trout rearing and migration and at 35 cfs temperatures are 100% compliant. This information allows instream flow restoration efforts across the basin to quickly evaluate and refine flow restoration targets for each watershed.

Conclusion

The UDWC Water Quality Monitoring Program evaluates water quality as an indicator to watershed restoration effectiveness and provides timely insight to natural resource decision makers who are currently addressing watershed impairments linked to regulated flow regimes. This is accomplished by prioritizing watersheds based on restoration activities, evaluating the status and trends of multiple parameters that are expected to change upon restoration, and refining preliminary flow targets. The UDWC program provides the technical tools needed by natural resource decision makers to balance limited budgetary resources between out of stream irrigation demands and instream ecological needs and achieve future watershed restoration across the Deschutes Basin.

UPPER DESCHUTES
WATERSHED COUNCIL



UPPER DESCHUTES WATERSHED COUNCIL

Upper Deschutes Watershed Council
Water Quality Monitoring Program
Outreach and Education Summary

REALMS 2006

Rimrock Expeditionary Alternative Learning Middle School

Upper Deschutes Subbasin, Oregon

Prepared by: Lesley Jones
Water Quality Specialist
Upper Deschutes Watershed Council
Bend, Oregon

Upper Deschutes Watershed Council
Bend, Oregon: December 2006

ACKNOWLEDGMENTS

The Upper Deschutes Watershed Council would like to thank the Oregon Department of Environmental Quality 319 Grant Program and the Oregon Watershed Enhancement Board for providing funding in support of outreach and education in the upper Deschutes and Little Deschutes Subbasins during 2006. The UDWC Water Quality Monitoring Program is grateful for the learning opportunities made possible by the generous contribution of the City of Bend, which provided the water quality monitoring kits utilized by the REALMS program and provided a small grant to support these kits. In addition, the UDWC Water Quality Monitoring Program would like to extend appreciation to the Healthy Waters Institute for the outreach opportunities created via partnership between the UDWC and Oregon Trout.

ABBREVIATIONS AND ACRONYMS

ODEQ	Oregon Department of Environmental Quality
OWEB	Oregon Watershed Enhancement Board
REALMS	Rimrock Expeditionary Alternative Learning Middle School
UDWC	Upper Deschutes Watershed Council

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List of Appendices

1.0 Background

In 2003, the City of Bend donated to the Upper Deschutes Watershed Council (UDWC) educational materials that included water quality monitoring kits and a small grant to cover supplies. These kits have been jointly managed by the UDWC Water Quality Monitoring Program (WQ Monitoring Program) and the UDWC Community Rivers Program. Between 2003 and 2005, the City of Bend water quality kits were utilized by multiple K–12 educators who sought to bring students to the rivers for experiential learning. Feedback from these educators identified the need to develop student friendly protocols to accompany the kits. With the success of the Healthy Waters Institute, opportunities for teachers to bring the classroom outdoors increased and the demand for the water quality kits receded. In 2006, the Rimrock Expeditionary Alternative Learning Middle School (REALMS) proposed adoption of the water quality kits, development of 'student-ease' protocols, and utilization of the kits under a watershed learning experience.

2.0 Objectives

The mission of REALMS is to, "actively challenge our students to investigate, understand, and become stewards of the human and natural world around us. To do so, we pursue experiences both inside and outside the classroom that help our students develop a core set of academic skills and learning habits; that encourage then to explore and identify their values; and that foster the inspiration that comes through service to others and adventure." The primary objective of the REALMS students was to. The ultimate placement of the City of Bend water quality monitoring kits with the REALMS program is illustrative of the city's commitment to investing in local education. Under this union, the following objectives are to be accomplished:

1. Establish 'student-ease' protocols for the City of Bend water quality kits. These 'student-ease' protocols are written by students for students.

2. Obtain UDWC Water Quality Monitoring Program Peer review of 'student-ease' protocols for scientific rigor.

3. Utilize City of Bend water quality kits to further build upon the foundation provided by the Healthy Waters Institute.

4. Provide opportunity for REALMS students to teach what they have learned to future students and create a tradition of student guided education.

3.0 Funding

The City of Bend donated the kits to the UDWC and provided a grant in the amount of $1000.00 for stocking the water quality kits to be used by educators to enhance the learning experience of local students. These kits now reside at REALMS and the UDWC WQ Monitoring Program funded by ODEQ and OWEB provides oversight in the use of the City of Bend water quality kits.

4.0 Tasks

Several tasks were accomplished during the Fall 2006 school year including:

1. The UDWC Water Quality Monitoring Program illustrated the use of the City of Bend water quality kits to the REALMS students during SalmonWatch; an outdoor educational experience provided by the Healthy Waters Institute (a UDWC and Oregon Trout joint program).

2. The UDWC Water Quality Monitoring Program provided to students in-class instruction of the following protocols and methodologies: field safety, laboratory safety, emergency actions, leave no trace monitoring, dissolved oxygen measurements, and pH measurements.

3. REALMS provided learning opportunities that connected students to local watersheds including research projects, restoration projects, and water quality science projects.

4. REALMS students practiced protocols and methodologies for water quality evaluations then translated protocols and methodologies into 'student-ease'.

Tasks to be accomplished spring 2007 school year:

1. Creation of a 'student-ease' protocol binder to accompany the City of Bend water quality kits.

2. Creation of first aid kit and safety guidelines to accompany City of Bend water quality kits.

3. Implementation of water quality science at locations selected by REALMS program and students.

4. Provision of opportunity for REALMS students to teach what they have learned to future students and create a tradition of student guided education.

5. Creation of inventory and stocking list for City of Bend water quality kits in preparation for 2007/2008 school year.

5.0 Results

Through the experience of observing protocols, practicing protocols, translating protocols, and utilization of the City of Bend water quality kits students have expressed that they have increased knowledge of:

- How to conduct good science to obtain valuable information regarding the health of the water for fish.

- How to investigate, understand, and become stewards of the human and natural world around us within the context of local watersheds.

- How to work independently and as part of a team.

- The value of community contribution and service to others.

6.0 Reference

1. REALMS: http://www.realmschool.org/

2. City of Bend: http://www.ci.bend.or.us/

3. Oregon Trout: http://www.ortrout.org/

4. UDWC: http://www.restorethedeschutes.org/

5. ODEQ: http://www.deq.state.or.us/

6. OWEB: http://oregon.gov/OWEB/index.shtml

7. Healthy Waters Institute: http://www.healthywatersinstitute.org/

Appendix A Project photo album

Photo 1. Students from REALMS discussing water quality theory and science with the Water Quality Specialist in the Metolius River watershed.

Photo 2. Students from REALMS practicing monitoring protocols with the Water Quality Specialist in the Metolius River watershed.

Photo 3, 4, and 5. After developing their own 'student-ease' monitoring protocols, REALMS students review their protocols with the Water Quality Specialist, develop a project, and set out to evaluate the health of the Tumalo Creek watershed.

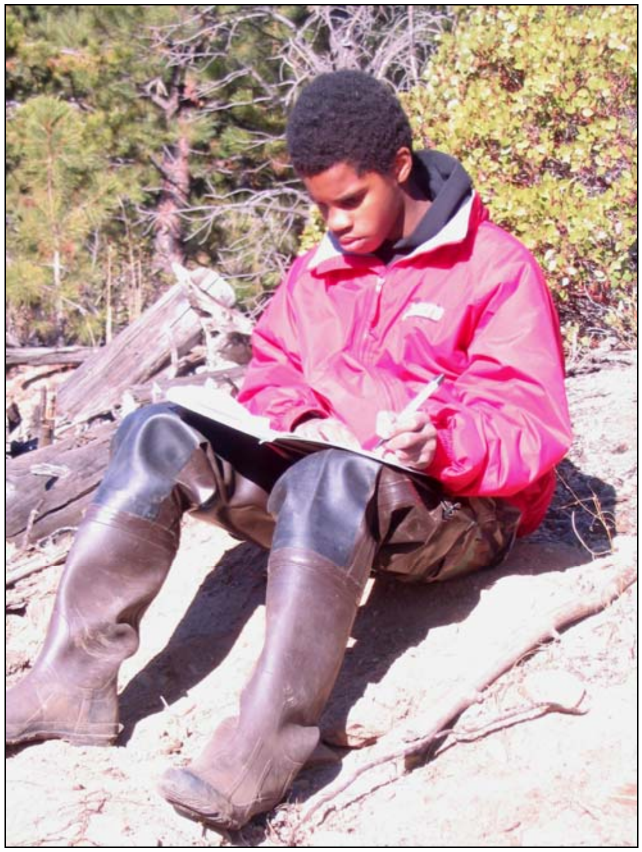


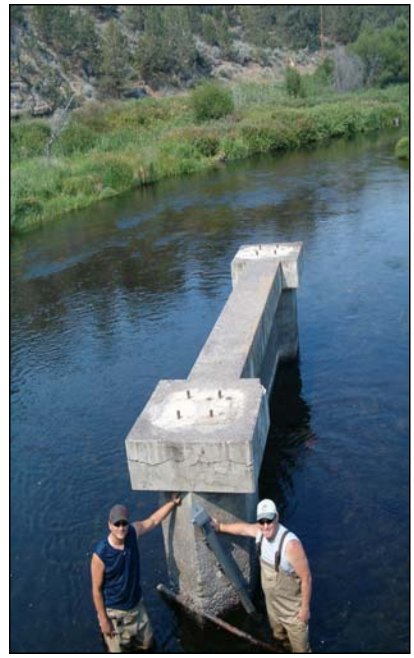
Photo 6 and 7. Along the way, REALMS students take the time to record important details and thoughts for future reference.

Oregon State University Undergraduate Intern 2006 Jason Brown selecting a temperature monitoring location on the Deschutes River at Benham Falls footbridge.

The Water Quality Specialist in a tree over the Deschutes River looks for a temperature logger that the tree fell on at Lower Bridge Road.

Target watershed multiparameter monitoring

Top: High flow at Whychus Creek City Park December 7, 2006 (average daily 62 cfs, peak 62 cfs). Bottom: Very high flow at Whychus Creek City Park December 14, 2006 (average daily 349 cfs, peak 500 cfs). Fluctuations in flow are common across the Upper Deschutes and Little Deschutes Subbasins and this condition creates a challenge to deploying water quality monitoring instruments and recording representative measurements. The UDWC WQ Monitoring Program has faced this challenge in 2006 via the application of custom deployment setups.



Custom continuous multiparameter monitoring sonde deployment setups were installed at three locations in 2006 bringing the number of continuous multiparameter monitoring stations in the upper Deschutes Basin to seven. These stations are vandal resistant and can be relocated across the basin as needed. Four small holes are drilled into rock or other structures by using a chainsaw motor and drill in order to install the extendable and retractable deployment setups. Setups are installed near flow gauges to collect continuous multiparameter water quality data that can be related to river flow.

Water Quality Specialist using the YSI 556 MPS to audit the continuous multiparameter sonde deployed in Whychus Creek at Sisters City Park Gauge.

Water Quality Specialist using the YSI 556 MPS to gather multiparameter water quality data at Whychus Creek mouth. The handheld unit provides flexibility to monitor at any location.

Riverfest 2006

Left: Aquatic macroinvertebrates are just one exciting stop on the Discover Alder Springs Riverfest event. Right: Sisters City planner pauses to admire the creek during the Wonders of Whychus Riverfest event.