BOISE RIVER ENHANCEMENT NETWORK

- We are a network of people that live, work and play in the Boise River watershed dedicated to promoting the ecological enhancement of the river

Photo: Gary O. Grimm, Mountain Visions

Lower Boise River Water Quality

Literature Review | Network Feedback | Case Studies | Prioritized Actions and Strategies

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Introduction

In a 2011 workshop titled "Lower Boise River: From Vision to Reality", participants identified water quality as a primary issue within the Lower Boise River watershed. When participants were asked what should happen next, the most common response was: "continue this group and develop a plan." Three years later, a group has been formed, the Boise River Enhancement Network (BREN). Boise River Enhancement Network participants envision a healthy Boise River that enriches the Valley's quality of life. Through a grant from the Bureau of Reclamation, the group is widening its membership, developing structure, performing outreach, and developing a watershed plan for how BREN can enhance the Boise River. As part of this planning effort, identifying key issues and possible solutions associated with Boise River water quality is critical.

Purpose

The purpose of this document is to provide a framework for the water quality section of the BREN Boise River Enhancement Plan. This is a living document that will continue to be updated with new information and revised based on expert opinion and public input. It is meant to be the reference from which the BREN Boise River Enhancement Plan will draw its information. This document is divided into the following sections:

Summary. This provides a brief overview of the information contained within this document.

Part I: **Existing Information**. This section includes an overview of the existing literature pertaining to the water quality of the Lower Boise River. Overall conclusions from the pertinent existing reports are summarized and the issues and solutions identified within those plans are outlined. Much of this information was used in a public meeting on May 12th, 2014, in which feedback was solicited and recorded.

Part II: **Network Feedback**. This section will contain the feedback from the BREN participants on water quality issues. This will include information from the October 2011 workshop and from participants at the May 12th, 2014 water quality meeting. At the May 2014 meeting, feedback on issues, solutions, additional literature, and expert reviewers was collected. The additional information and resources will be integrated into Part I on an ongoing basis.

Part III: **Enhancement Priorities**. This section presents the results of the review process and identifies the key issues and enhancement priorities.

References. This section also includes an image of the BREN database showing all sources that include a discussion on water quality, though water quality may not be the primary focus of the citation.

Summary

The water quality of the Lower Boise River, from Lucky Peak to its confluence with the Snake River, has been affected by agriculture, urbanization, municipal and industrial wastewater discharge, flow alteration, and channelization. To protect the aquatic environment and beneficial uses of the Boise River, including its tributaries, water quality criteria and total maximum daily loads (TMDLs) have been established or are in the process of being established for *Escherichia coli* (*E. coli*), sediment, temperature and total phosphorus. Overall, water quality conditions diminish in a downstream direction, with exceedances in water quality criteria occurring most frequently between Middleton and Parma, Idaho.

Water quality criteria for *E. coli* are not to exceed 126 colony forming units (CFU) per 100mL based on the geometric mean of 5 samples taken every 3 to 7 days over a 30-day period for both primary and secondary contact recreation. Total Maximum Daily Loads have been established for sections of the mainstem Boise River and are proposed for 10 tributaries (IDEQ 1999, Stone 2013). Recent monitoring indicates criteria are exceeded seasonally in most tributaries and downstream reaches of the Boise River, with a geometric mean of over 250 CFU/100 mL at Parma (IDEQ 2009) and above 700 CFU/100 mL in select tributaries (IDEQ 2012). Instantaneous samples measure above 1,000 CFU/100 mL in some areas (MacCoy 2004, IDEQ 2012, Etheridge and others 2014). One study identified sources of *E. coli* as 17% human, 22% pets, 35% avian and waterfowl, 15% wildlife, and 11% livestock (CH2MHill 2003).

Total Maximum Daily Load limits for total phosphorus (TP) are in the process of being established for the Lower Boise River, Mason Creek and Sand Hollow Creek (IDEQ 2015). However, as a tributary to the Snake River, the Boise River must meet target mean concentrations of <0.07 mg/L from May to September at its confluence as set by the Snake-River Hells Canyon TMDL (IDEQ and ODEQ 2004). Total phosphorus levels increase in a downstream direction, with several studies showing median TP levels around 0.30 mg/L at Parma (Mullins 1998b, MacCoy 2004, Wood and Etheridge 2011). Tributaries such as Conway Gulch, Indian Creek, Mason Creek, Fifteenmile Creek (at its tributaries Fivemile and Tenmile Creeks) and Sand Hollow are major sources of phosphorus (MacCoy 2004, Campbell 2009, Etheridge and others 2014). Reductions from both urban and agricultural sources will be necessary to meet future TMDL targets (Etheridge 2013).

Total Maximum Daily Load limits for suspended sediment concentrations are set at 50 mg/L for no more than 60 days and 80 mg/L for no more than 14 days for the mainstem Boise River (IDEQ 1999) and are proposed at 20 mg/L for no more than 120 days for major tributaries and drains (Stone 2013). Suspended sediment concentrations and loads tend to increase with discharge and by down valley distance (MacCoy 2004, Donato and MacCoy 2005, Etheridge and others 2014). Tributaries and drains contribute significant sediment loads to the Boise River; several studies indicate Fifteenmile Creek (and its tributaries Fivemile and Tenmile Creeks), Willow Creek, Mason Creek, Indian Creek, Conway Gulch and Dixie Drain exceed suspended sediment targets, with instantaneous measurements from 100 to 500 mg/L (IDEQ 2009, Campbell 2009, Etheridge and others 2014). Sediment criteria are generally met in mainstem river locations, except occasionally at Parma (IDEQ 2009, Wood and Etheridge 2011).

Water quality criteria for temperature have been set at <22°C daily maximum and <19°C daily mean for cold water biota, and <13°C daily maximum and <9°C daily mean for salmonid spawning. Temperature targets are exceeded primarily in the mainstem Boise River, Indian Creek, Conway Gulch, Mill Sough and Dixie Drain from April to August (IDEQ 2009), with the highest instantaneous temperature recorded in Parma at 31.1°C (MacCoy 2004). In 2014, maximum daily mean temperatures in the Boise River at Parma exceeded the criterion of 22.0°C through most of July and August (USGS 2015).

Effective solutions to water quality challenges have been identified through literature review and network feedback. Solutions typically involve pollution prevention (such as conversion to sprinkler irrigation methods and installing sediment basins); pollution treatment (improvements to wastewater treatment plants); and enhancement, management and protection of riparian and wetland ecosystems. Projects that address channel morphology, such as increasing the depth of the water column, have been shown to reduce light to the substrate, reducing temperature and periphyton growth (Sharp and Smith 2014). Pollution trading has emerged as a technique for point-source facilities to meet water quality obligations by purchasing environmentally equivalent (or superior) pollution reductions from another source, thus achieving the same water quality improvement at lower overall cost (IDEQ 2010).

Solutions to manage bacteria (*E. coli*) include but are not limited to: best management practices for livestock, such as exclusion of livestock from drains and canals, installing watering facilities and implementing prescribed grazing would limit discharge of pollutants; waste management systems and storage ponds; repairing leaky sewer lines and replacing septic systems; conversion to sprinkler or drip irrigation methods; installing filter strips; and wetland development and restoration.

Methods to lower total phosphorus levels include but are not limited to: re-use of irrigation return water; improved removal capacity at wastewater treatment plants; conversion to sprinkler or drip irrigation methods; installing filter strips; wetland development and restoration; riparian buffer enhancement; sediment basins and constructed wetlands; implementation of best management practices for construction and erosion control; improved site design and stormwater management; pollution trading; waste management systems and storage ponds; public education efforts on fertilizer use; and changes to channel geometry that increase depth of the water column.

Methods to lower suspended sediment levels include but are not limited to: effective management of irrigation water; re-use of irrigation return water; conversion of crop types; conversion to sprinkler or drip irrigation methods; installing sediment basins and constructed wetlands; riparian buffer enhancement; improved stormwater management; and construction best management practices.

Methods to reduce temperature include but are not limited to: re-vegetation of streambanks; re-use of irrigation return water; riparian and wetland conservation and enhancement; riparian buffer enhancement; construction and post-construction best management practices that mimic hydrology pre-development; methods to control thermal enrichment of stormwater and irrigation drain water; and changes to channel geometry that increase depth of the water column.

Part 1: Existing Information

Lower Boise River Watershed Overview

The Lower Boise River watershed (HUC 1234567890), located in southwest Idaho, drains 1,290 square miles and includes the Boise River, which flows 64 miles from Lucky Peak dam northeast to its confluence with the Snake River, as well as several tributaries: Dry Creek, Eagle Drain, Thurman Drain, Fifteen Mile Creek, Mill Slough, North and South Middleton Drains, Willow Creek, Mason Slough, Hartley Gulch, Indian Creek, Conway Gulch and Dixie Drain. Sand Hollow Creek, a tributary to the Snake River, is also within the watershed. Water quality is impacted by agriculture, urbanization, municipal and industrial wastewater discharge, flow alteration, channelization, among others.

Lower Boise Water Quality Standards and Total Maximum Daily Loads

Water quality standards are set by the Idaho Department of Environmental Quality (IDEQ) and established under Idaho Code IDAPA §58.01.02. Water quality standards are established to protect beneficial uses of the State's waters, such as: aquatic life support – cold water, seasonal cold water, warm water, salmonid spawning, and modified; contact recreation – primary (swimming) or secondary (boating); water supply – domestic, agricultural, and industrial; wildlife habitats; and aesthetics. Waters that do not meet standards are added to the 303(d) list and a Total Maximum Daily Load (TMDL) pollutant management plan is developed, as required by the Clean Water Act (U.S. EPA 2015). Table 1 summarizes the water quality criteria for the Lower Boise River watershed by pollutant, including TMDL targets. More information on these pollutant criteria are presented in the following section.

Table 1. Water quality criteria by pollutant in the Lower Boise River

Pollutant	Water Quality Criteria
Dissolved Oxygen	>6.0 mg/L for cold water aquatic life; >5.0 mg/L for warm water aquatic life; >4.0 mg/L for modified aquatic life. Salmonid spawning >6.0 mg/L or 90% saturation 1 day min; intergravel >5.0 mg/L for 1-day min or >6.0 mg/L for 7-day average.
E. coli	Geometric mean concentrations <126 colony forming units/100 mL for both recreational uses.
pH	between 6.5 and 9.5
Sediment	Narrative criteria – TMDLs are established if sediment is shown to impair beneficial uses. Total suspended sediment TMDL targets for select reaches of the mainstem Boise River are set at 50 mg/L for ≤ 60 days and 80 mg/L for ≤ 14 days. Targets for tributaries vary, but are generally lower; between 20 and 33 mg/L for ≤ 60 days. Tributary TMDLs are forthcoming.
Temperature	<22°C daily max and <19°C daily mean for cold water biota. <13°C daily max and <9°C daily mean for salmonid spawning.
Total Phosphorus	Narrative criteria – TMDLs are established if nutrients are shown to impair beneficial uses. As a tributary to the Snake, the LBR must reach target concentrations (0.07 mg/L May-Sep) at its confluence as set by the Snake River-Hells Canyon TMDL. TMDL for the LBR is forthcoming.

The following tables show beneficial uses, 303(d) listed pollutants and causes, and TMDL establishment for the Lower Boise River mainstem (Table 2) and tributaries (Table 3) by Assessment Unit (AU) location.

Table 2. Lower Boise River mainstem beneficial uses, 303(d) listed pollutants and causes, and TMDL establishment by Assessment Unit location.

Assessment Unit Name	Assessment Unit Number	Beneficial Uses[a]	Use Support[b]	Pollutants/Causes	Approved TMDL
Lucky Peak Dam to Diversion Dam	ID17050114SW011b_06	CWAL DWS PCR	NFS NA FS	Low flow alterations	
Diversion Dam to Veterans Memorial Parkway	ID17050114SW011a_06	CWAL SS DWS PCR	NFS NFS NA FS	Low flow alterations, Physical Substrate Habitat Alterations, Water Temperature	
Veterans Memorial Parkway to Star Bridge	ID17050114SW005_06	CWAL SS PCR	NFS NA NFS	Low flow alterations, Physical Substrate Habitat Alterations, Sedimentation/Siltation, Water Temperature, Fecal Coliform	Fecal Coliform, Sedimentation/Siltation
Star to Middleton	ID17050114SW005_06a	CWAL SS PCR	NFS NA NFS	Low flow alterations, Physical Substrate Habitat Alterations, Sedimentation/Siltation, Water Temperature, Fecal Coliform	Fecal Coliform, Sedimentation/Siltation
Middleton to Indian Creek	ID17050114SW005_06b	CWAL SS PCR	NFS NA NFS	Low flow alterations, Phosphorus (T), Physical Substrate Habitat Alterations, Sedimentation/Siltation, Water Temperature, Fecal Coliform	Fecal Coliform, Sedimentation/Siltation
Indian Creek to Mouth	ID17050114SW001_06	CWAL SS PCR	NFS NFS NFS	Low flow alterations, Phosphorus (T), Physical Substrate Habitat Alterations, Sedimentation/Siltation, Water Temperature, Fecal Coliform	Fecal Coliform, Sedimentation/Siltation

[a] CWAL – cold water aquatic life, SS-salmonid spawning, DWS- domestic water supply, PCR-primary contact recreation
[b] NFS = not fully supporting, FS = fully supporting NA = not assessed

Table 3. Lower Boise River tributary beneficial uses, 303(d) listed pollutants and causes, and TMDL establishment by Assessment Unit location.

Assessment Unit Name	Assessment Unit Number	Beneficial Uses[a]	Use Support[b]	Pollutants/Causes	Approved TMDL
Dixie Drain	ID17050114SW001_02	CWAL PCR	NFS NA	Water Temperature	
Indian Creek- 4th order below Sugar Ave. in Nampa	ID17050114SW002_04	CWAL SCR	NFS NFS	Cause Unknown (nutrients suspected), Water Temperature, Sedimentation/Siltation, Escherichia coli	
Indian Creek- New York Canal to Sugar Avenue	ID17050114SW003a_04	CWAL SS PCR SCR	NFS NFS NA FS	Causes Unknown (nutrients suspected), Water Temperature	
Tribs to Indian Creek – between reservoir and New York Canal	ID17050114SW003b_02	CWAL SS PCR SCR	FS NA NA NA		
Indian Creek between Reservoir and Sand Creek	ID17050114SW003b_03	CWAL SS PCR SCR	NFS NA NA FS	Sedimentation/Siltation	
Indian Creek and Tribs-4th order between Reservoir and New York Canal	ID17050114SW003b_04	CWAL SS PCR SCR	FS NA NA FS		
Indian Creek and Tribs-1st and 2nd order above Reservoir	ID17050114SW003d_02	CWAL SS PCR SCR	NFS NA NA NFS	Sedimentation/Siltation, Escherichia coli	

Assessment Unit Name	Assessment Unit Number	Beneficial Uses[a]	Use Support[b]	Pollutants/Causes	Approved TMDL
Indian Creek-3rd order upstream of Indian Creek Reservoir	ID17050114SW003d_03	CWAL SS PCR SCR	NFS NA NA FS	Water Temperature, Sedimentation/Siltation	
Lake Lowell	ID17050114SW004_06	CWAL WWAL PCR	NA NFS NA	Phosphorus (T)	Phosphorus (T)
Mill Slough & Phyllis Slough	ID17050114SW005_02	CWAL SS PCR	FS NS NA	Water Temperature	
Mason Creek	ID17050114SW006_02	CWAL SCR	NFS NFS	Cause Unknown (nutrients suspected), Chlorpyrifos, Malathion, Water Temperature, Sedimentation/Siltation, Escherichia coli	
Fifteenmile Creek-4th order (Fivemile Creek to mouth)	ID17050114SW007_04	MAL SCR	NFS NFS	Chlorpyrifos, Sedimentation/Siltation, Escherichia coli	
Tenmile Creek-3rd order below Blacks Creek Reservoir	ID17050114SW008_03	CWAL SCR	NFS NFS	Cause Unknown (nutrients suspected), Chlorpyrifos, Sedimenation/Siltation, Escherichia coli	
Blacks Creek and Bryans Run 1st and 2nd order	ID17050114SW009_02	CWAL	NFS	Biota/Habitat Bioassessments	
Blacks Creek 3rd order	ID17050114SW009_03	CWAL	NFS	Biota/Habitat Bioassessments	
Fivemile, Eightmile, and Ninemile Creeks-1st and 2nd order	ID17050114SW010_02	CWAL SCR	NFS NFS	Low flow alterations, Escherichia coli	

Assessment Unit Name	Assessment Unit Number	Beneficial Uses[a]	Use Support[b]	Pollutants/Causes	Approved TMDL
Fivemile Creek-3rd order	ID17050114SW010_03	CWAL SS SCR	NFS NA NFS	Cause Unknown (nutrients suspected), Chlorpyrifos, Sedimentation/Siltation, Escherichia coli	
Stewart Gulch, Cottonwood and Crane Creeks- 1st and 2nd order	ID17050114SW012_02	CWAL	NFS	Biota/Habitat Bioassessments	
Cottonwood Creek-3rd order (Fivemile Creek to Boise River)	ID17050114SW012_03	CWAL	NFS	Biota/Habitat Bioassessments	
Dry Creek, Currant and Spring Valley Creeks-3rd order sections	ID17050114SW013_03	CWAL SCR	FS FS		
Willow Creek-1st and 2nd order	ID17050114SW015_02	CWAL	NS	Biota/Habitat Bioassessments, Water Temperature	
Willow Creek- 3rd order	ID17050114SW015_03	CWAL	NFS	Sedimentation/Siltation	
Sand Hollow Creek (C-Line Canal to I-84)	ID17050114SW016_03	CWAL SCR	NFS FS	Causes Unknown (nutrients suspected), Sedimentation/Siltation	
Sand Hollow Creek- I84 to Sharp Road	ID17050114SW017_03	CWAL SCR	NFS NFS	Sedimentation/Siltation, Escherichia coli	
Sand Hollow Creek-Sharp Road to Snake River	ID17050114SW017_06	CWAL SCR	NFS NFS	Causes Unknown (nutrients suspected), Sedimentation/Siltation, Escherichia coli	

[a] CWAL – cold water aquatic life, SS-salmonid spawning, MAL- modified aquatic life, WWAL-warm water aquatic life, PCR-primary contact recreation, SCR – secondary contact recreation
[b] NFS = not fully supporting, FS = fully supporting NA = not assessed

Bacteria (*E. coli*)

The presence of *Escherichia coli* (*E. coli*) bacteria in water can indicate the presence of pathogenic microorganisms that can be harmful to human health. Under Idaho Code (IDAPA §58.01.02.251.01), there are two types of criteria for *E. coli*; action targets and compliance targets. Action targets act as triggers to conduct additional monitoring. For streams with a primary-contact recreation beneficial use, the single-sample E. coli action level is 406 colony forming units per 100 milliliters (CFU/100mL), and for streams with a secondary-contact recreation beneficial use, the single-sample E. coli action level is 576 CFU/100mL. If the action targets are exceeded, additional sampling must be performed to determine water quality criteria compliance. For waters designated for primary or secondary contact recreation, criteria for *E. coli* are not to exceed 126 cfu/100 mL based on the geometric mean of 5 samples taken every 3 to 7 days over a 30-day period (IDAPA §58.01.02.251.01).

A TMDL for bacteria in the mainstem lower Boise River was completed and approved in 1999 (IDEQ 1999). An addendum to the original TMDL sets special wasteload allocations for *E. coli* bacteria for the Avimore Development and the City of Kuna (LBWC and IDEQ 2008a). In 2014, a draft TMDL addendum proposes the establishment of 10 new *E. coli* load allocations for listed tributaries to the Boise River (Stone 2013). Since the original TMDL was approved, bacteria targets were revised from measuring for fecal coliform levels to measuring *E. coli* concentrations (IDEQ 2009).

Dissolved Oxygen

Adequate levels of dissolved oxygen (DO) is vital to fish and other aquatic life. For example, fish like trout are sensitive to low DO levels within the water and gravel substrate during spawning. Under Idaho Code (IDAPA §58.01.02.250.02), all waters of the State must have dissolved oxygen levels above 6.0 mg/L at all times for cold water biota and 5.0 mg/L at all times for warm water biota. Salmonid spawning must be above 6.0 mg/L or 90% saturation (whichever is greater) for a 1 day minimum; intergravel dissolved oxygen must be at least 5.0 mg/L for a 1-day minimum or at least 6.0 mg/L for a 7-day average mean. There are exceptions for waters below dams, and within lakes and reservoirs.

A data review in 2008 supported the de-listing of dissolved oxygen within the watershed, as this constituent was not impairing beneficial uses (IDEQ 2009). Dissolved oxygen criteria for beneficial uses are met at all locations in the subbasin and no TMDLs will be established.

Flow Alteration

Though the effects have not been fully studied within the Lower Boise watershed, flow alteration and diversion likely has an indirect impact on the level of other pollutants within the water column. Flow alteration and diversion can affect riparian areas, instream temperature, channel geomorphology, sediment loads, substrate characteristics, and other biological components of a stream's ecology.

The US Environmental Protection Agency (EPA) considers flow alteration and/or diversion to be "pollution" rather than a specific "pollutant" and thus, while it may adversely affect beneficial uses, TMDLs are not required for water bodies impaired by flow alteration or modification (Federal Register, Vol. 65, No. 135, p. 43592, July 13, 2001). Further, Idaho's water quality standards (Idaho Code IDAPA §58.01.02.050.01) cannot interfere with the "rights of Idaho appropriators, either now or in the future, in the utilization of the water appropriations, which have been granted to them under the statutory procedure". This is supported by 40 CFR §131.4(a) such that the "water quality standards shall not be construed to supersede or abrogate rights to quantities of water." Consequently, while the upper reaches of the Lower Boise River is 303(d) listed for "flow alteration" by IDEQ (1999); TMDLs will not be established for this impairment.

Nutrients

Under Idaho Code, nutrients fall under "narrative criteria" rather than "numeric criteria" because natural occurrence and variability makes general limits impractical – "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses (IDAPA §58.01.02.200.06)."

Total phosphorus (TP) is the primary nutrient of interest within the Lower Boise River watershed. Increased concentrations of TP can result in elevated algae growth that negatively impacts dissolved oxygen levels, pH, macroinvertebrate and fish abundances and community composition, and recreational conditions. Total phosphorus has been shown to affect the beneficial uses of the Snake River downstream (IDEQ and ODEQ 2004). As a tributary to the Snake, the Lower Boise River (at the confluence) must reach target concentrations as set by the Snake River-Hells Canyon TMDL, which establishes a seasonal (May 1 to September 30) instream TP target of 0.07 mg/L for the Snake River-Hells Canyon reach upstream from Brownlee Reservoir (IDEQ and ODEQ 2004). A draft 2015 total phosphorus TMDL addendum proposes similar seasonal targets for the Lower Boise River, Mason Creek, and Sand Hollow Creek (IDEQ 2015).

Total Maximum Daily Load allocations have been established for Lake Lowell to reduce TP by 37% or around 152 lbs/day; reductions in TP should lead to attainment of water quality standards with a target of 5 mg/L dissolved oxygen for warm water aquatic life (Monnot 2010).

pH

The level of pH is the measure of acidity or alkalinity in a water body, where pH 7 is considered neutral. pH affects many chemical and biological processes in water, and aquatic organisms are adapted to specific ranges of pH. Idaho Code states all waters must have pH levels between 6.5 and 9.5 (IDAPA §58.01.02.250.01). Beneficial use criteria for pH are met at all locations in the subbasin and no TMDLs will be established.

Sediment

Excess sediment impairs cold water biota by increasing temperatures, reducing light penetration and plant growth, carrying nutrients (such as phosphorus attaching to suspended sediment), covering spawning areas, among other impacts. The level of total suspended sediment shall not exceed quantities specified in Idaho Code IDAPA §58.01.02.250, or, in the absence of specific sediment criteria, quantities that impair designated beneficial uses. Suspended sediments have been shown to impair beneficial uses for cold water biota and salmonid spawning in select reaches of the Lower Boise River and tributaries (IDEQ 1999; Stone 2013). The 1999 TMDL limits set for total suspended sediment in the Boise River are 50 mg/L for no more than 60 days, and 80 mg/L for no more than 14 days (IDEQ 1999).

A draft 2014 TMDL addendum proposes a mean suspended-sediment concentration of 20-mg/L for no more than 120 days in major tributaries of the lower Boise River, including Fivemile, Tenmile, Indian, and Mason Creeks (Stone 2013). The final TMDL addendum is set to be completed in mid-2015.

Since it is easy to confuse total suspended sediment with total suspended solids, sediment criteria from this point forward will be expressed in terms of suspended sediment concentration (SSC). The use of total suspended solids was designed for analysis of wastewater samples, and is generally unreliable for the analysis of natural water samples (Gray and others 2000).

Temperature

Cold water fish and aquatic organisms are adapted to specific temperature ranges, where temperatures outside of this range can lead to stress, decreased spawning success and even mortality. Cold water also holds more dissolved oxygen and slows the growth of bacteria and algae in the water. Temperature levels are specified in the Idaho Code (IDAPA §58.01.02.250.02) where daily maximum temperature must be 22°C or less with a daily average of no more than 19°C for waters designated for cold water aquatic life. During salmonid spawning, waters must have a 13°C or less daily maximum and a 9°C or less daily average. These temperature standards are exempt "when the air temperature exceeds the ninetieth percentile of the seven (7) day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station" (IDAPA §58.01.02.080.04).

Total Maximum Daily Loads are set to be established for select reaches of the Boise River and its tributaries (IDEQ 2014). Certain reaches do not require TMDL establishment if atmospheric conditions preclude compliance with cold water biota temperature criteria during June, July and August (IDEQ 1999). An EPA review determined that past temperature monitoring was insufficient as it did not include many drains and tributaries to the Boise River (IDEQ 2009). This led to additional monitoring and TMDL establishment for select reaches within the Lower Boise River watershed.

Lower Boise Water Quality Studies

There have been numerous water quality studies performed within the Lower Boise River and its tributaries over the past three decades (see Appendix A). The following section summarizes the most recent and pertinent studies for pollutants of interest within the Lower Boise River watershed.

Bacteria (*E. coli*)

Evaluation of data collected from 1994 to 1997 by the USGS identified violations of fecal coliform bacteria State standards for primary recreation at all 12 tributary/drain sites studied and 2 sites along the Boise River near Parma, where maximum concentrations were not to exceed 500 colonies per 100 mL (Mullins 1998a). Violations for secondary contact recreation were measured along the Boise River at the Diversion Dam and near Middleton, where maximum concentrations were not to exceed 800/100 mL (Mullins 1998a). Note that these standards have since been updated.

In a 2001 land use and storm water runoff study by the U.S. Bureau of Reclamation (BOR), single sample counts for fecal coliform bacteria exceeded recreation standards (standards have since been updated) in irrigation return drains in both agricultural and urban subwatersheds after storm events (BOR 2001).

Results from a 2003 study by CH2MHill indicate that human sources comprise 17% of total identifiable bacteria throughout the watershed (CH2MHill 2003). The other 83% is made up of pets (22%), avian and waterfowl (35%), wildlife (15%), and livestock (11%). Identifiable sources only comprise 69% of the total number of sampled colonies; therefore, the actual contributions from each of these source groups may be different than these values. In general, these data show that human influences (including pets) decrease and agricultural influences increase throughout the watershed in the downstream direction.

Evaluation of the data collected from 1994 to 2002 by the USGS revealed increases in fecal coliform and *E. coli* in a downstream direction; Median fecal coliform concentrations increased more than 400 times and median *E. coli* concentrations 79 times from the Diversion Dam to Parma. Fecal coliform concentrations ranged from 3 to 3,950 colonies per 100 mL at Middleton and *E. coli* concentrations ranged from 3 to 4,800 most probable number (MPN) per 100 mL (MacCoy 2004).

An Idaho State Department of Agriculture study showed Sand Hollow (tributary to the Snake), Mason Creek, Fifteen Mile Creek, Willow Creek and Conway Gulch to exceed the *E. coli* bacteria single sample action targets for primary (406 CFU/100 mL) and secondary recreation (576 CFU/100 mL) at various times throughout the monitoring period, April 25th to October 9th, 2008 (Campbell 2009). Sand Hollow had the most occurrences (11) and the highest level (>2400 CFU) measured (Campbell 2009). Although exceedance of action targets do not constitute a violation, it is likely that Sand Hollow, Mason Creek, Fifteen Mile Creek and possibly Willow Creek would exceed the geomean criteria of 126 CFU/100 mL.

A data review by IDEQ (2009) on studies compiled from 2003 to 2008 on *E. coli* bacteria concentrations were evaluated for attainment of recreation designated uses. Measurements were taken by the City of Boise along the mainstem Boise River in AU 011a_06 (Ekhart Road, Marden Bridge, Veterans Memorial

Parkway, and Glenwood Bridge) from 2003 to 2004; AU 005-06 (at Eagle, Middleton and Caldwell) from 2003 to 2005; and AU 001_06 (near Parma) in 2005. The geomean and instantaneous data show *E. coli* concentrations exceeding TMDL targets and State standards seasonally in Middleton and Parma, with the highest geomean *E. coli* concentrations around 250 CFU/100 mL (IDEQ 2009). Single sample counts for *E. coli* bacteria exceeded action targets for primary or secondary recreation at all tributaries and drains measured, with the largest samples taken at Fifteen Mile Creek (>1,000 CFU/100 mL) and Dixie Drain (>5,000 CFU/100 mL) instantaneous measurements (IDEQ 2009). *E. coli* bacteria concentrations measured at some locations require more than 90% reductions in loads to be in conformance with TMDL limits (IDEQ 2009). Data gathered at sample locations indicate no significant change in *E. coli* bacteria load over the past five years, with the highest concentrations occurring during the summer months. Based on the data review by IDEQ, water quality standard for *E. coli* bacteria is exceeded in Indian Creek, Boise River and Mill Slough, Mason Creek, Fifteen Mile Creek, Tenmile Creek, Fivemile Creek, Boise River, Willow Creek and Sand Hollow Creek (IDEQ 2009).

A sample analysis by the City of Nampa upstream and downstream of the wastewater treatment facility on Indian Creek indicates that these facilities may have a dilution effect on bacteria loads, though the sample is too small to draw definitive conclusions (IDEQ 2009).

In 2011, geometric mean *E. coli* bacteria data were collected in Fivemile Creek, Ninemile Creek, Tenmile Creek and Fifteenmile Creek during July (irrigation season) and November (non-irrigation season) by IDEQ (2012). During the irrigation season, all four creeks far exceeded water quality criterion (126 CFU/100 mL at 30 day geometric mean) with geometric mean E. coli concentrations ranging from 699 to 767 number of E. coli per 100 milliliters. Ninemile Creek was the only creek to exceed standards during the non-irrigation season, with a geometric mean of 456 number of E. coli per 100 milliliters (IDEQ 2012).

E. coli data are collected monthly by the City of Boise (2013) Public Works Department at Veterans Memorial Park and Glenwood Bridges as required by NPDES wastewater permits. The City of Boise initiated a weekly sampling effort on the Boise River at five locations (Eckert Road to Eagle Bridge) April 2003 through October 2004 to determine if the river met TMDL limit criterion (126 CFU/100 mL at 30 day geometric mean). The results of the weekly sampling showed that the *E. coli* criterion was met during the entire sampling period, including two summer and one winter/spring seasons (City of Boise 2013). Subsequent monthly sampling shows similar *E. coli* levels, which suggests the Boise and Garden City sewer systems are not causing or contributing to exceedance of the *E. coli* water quality standards.

A water quality study in Fivemile and Tenmile Creeks (2009), Indian Creek (2010) and Mason Creek (2012) by the USGS showed *E. coli* values increased in study reaches adjacent to pasturelands and wastewater treatment facilities (Etheridge and others 2014). Samples of *E. coli* were not collected at the frequency necessary to determine water quality compliance. Samples from tributaries suggest that these streams exceed 126-MPN/100mL geometric mean criterion around 75 percent of the time during the irrigation season (Etheridge and others 2014). Historical analysis indicates that *E. coli* values exceed the more than 50 percent of the time during irrigation season and less than 25 percent of the time during non-irrigation season in the Boise River near Parma (Etheridge and others 2014).

Biological Integrity

Monitoring of macroinvertebrate and fish communities is often used to evaluate water quality conditions. Before the establishment of waste water treatment facilities in the Lower Boise Watershed, an Idaho Department of Health (1962) report showed detrimental effects in the chemical, bacteriological, and biological integrity of the Boise River from waste being discharged into the river from sources including domestic sewage, food processing plants, and urban/agricultural runoff. A USGS (Frenzel 1988) study tested for chemical constituents, macroinvertebrates, and native fish densities finding no correlation between locations above and below wastewater treatment facilities. However, in a USGS study on biotic integrity (Mullins 1998b), Index of Biological Integrity (IBI) scores for macroinvertebrates and fish were generally higher upstream of Lander Street and West Boise municipal wastewater treatment facilities. Two species of sculpin were abundant upstream of wastewater treatment facilities while none were found downstream in 1995 and only 2% fish recorded downstream of wastewater treatment facilities in 1996 compromised of sculpin, a highly sensitive native fish species commonly used as an indicator of aquatic conditions. Chlorophyll-a concentration results were higher (though not statistically significant) downstream of both facilities (Mullins 1998b).

A study by the USGS from 1995 through 2000 measured metrics for Ephemeroptera, Plecoptera, and Trichoptera (EPT) richness, Idaho River Macroinvertebrate Index (RMI), Idaho River Fish Index (RFI), and the fine sediment bioassessments index (FSBI) (MacCoy 2004). The average EPT richness was 10 and RMI scores were frequently below 16, indicating intermediate or poor water quality. The FSBI scores for the Lower Boise River were lower than upstream reference sites, indicating that macronivertibrate populations may be impacted by fine sediment. RFI scores ranging from 0 to 100 show a decrease in biotic integrity in a downstream direction, with the lowest score of 10 at Parma (MacCoy 2004). Overall results showed biological communities were depressed in the Lower Boise River, with more tolerant species present in the lower reaches from Middleton to Parma.

In a review of macroinvertebrates data collected by the USGS from 2003 to 2006, organisms that prefer warm and hot water are higher from Middleton to Parma than upstream reaches of the Boise River (IDEQ 2009). A 2003 IDEQ study found portions of Indian, Mason and Fivemile creeks are dominated by macroinvertebrate organisms that prefer hot water; Indian and Mason creeks also scored low on the Idaho River Fish Index (IDEQ 2009). Indian Creek is designated for cold water aquatic life and salmonid spawning.

Biological sampling of Mason Creek was conducted by the USGS in 2011 (Etheridge and others 2014). The invetebrate taxa richness was 19, which is low compared to forested sites in Idaho (36) and least disturbed sites along the Snake River (27) (Etheridge and others 2014). Six Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa were identified in Mason Creek, which is compared to reference sites that average about 15 taxa (Etheridge and others 2014). Invasive New Zealand mud snail (*Potamopyrgus* *antipodarum*) was abundant in Mason Creek, and may be responsible for low taxa richness and abundance. The sediment tolerant mayfly *Tricorythodes minutus* was also abundant in Mason Creek. Overall, Mason Creek was rated 26 out of 100 on the Idaho Small Stream Macroinvertebrate Index (SMI), compared to a median score of 68 for least impacted reference streams in Idaho (Campbell and other 2014). This indicates degraded water quality conditions and is below the minimum threshold for considering a water body to meet aquatic life beneficial uses (Campbell and others 2014). The fish species survey found 26 individual fish: 13 suckers, 7 trout, 4 minnows and 2 loaches (Campbell and others 2014). All of the fish measured well for health and are native cool or coldwater species, with the exception of the 2 Oriental Weatherfish (loaches) which are non-native (Campbell and others 2014). Feeding guilds ranged from herbivores to piscivore indicating that a variety of food sources support the fishery. Overall, Mason Creek rated 58 out of 100 for the Rangeland Fish Index (RFI), indicating intermediate biological integrity; the lack of sculptin, which is weighted heavily in RFI, likely influenced the lower score (Campbell and others 2014).

Dissolved Oxygen

Evaluation of the data collected from 1994 to 2002 by the United States Geographic Survey (USGS) shows median dissolved oxygen levels at 11.6 mg/L at the Diversion Dam (upstream of Barber Dam, east of Boise), 11.4 mg/L at Glenwood Bridge (Garden City), 11.7 mg/L at Middleton and 10.2 mg/L at Parma, with a minimum instantaneous concentration of 6.7 mg/L measured at Parma (MacCoy 2004).

Based on the data collected from 2003 to 2005 by the USGS and Idaho State Department of Agriculture (ISDA), beneficial use criteria for dissolved oxygen are met within the Lower Boise River and tributaries; dissolved oxygen levels measured between 6.0 and 9.5 mg/L at 14 sites located throughout the watershed (IDEQ 2009).

Results from a 2011 USGS study indicate that dissolved oxygen levels did not fall below the 6.0 mg/L for cold water aquatic life in the Boise River near Parma. Although the Parma site is not in a designated salmonid spawning reach , dissolved oxygen saturation levels did fall below the 1-day minimum of 90% saturation for 14 days during the study, 8 of which occurred during seasonally high flow events and 6 during low flows (late April 2010 and mid-August 2010/2011) (Wood and Etheridge 2011).

The USGS continuously monitors dissolved oxygen in the Boise River near Parma. In 2014, dissolved oxygen fell below 6 mg/L at Parma for short periods in June, July and August, with the lowest concentration of 5.5 mg/L measured at the end of July 2014 (USGS 2015).

Flow Alteration

The Lower Boise River subbasin has almost 500 miles of canals and drains and at least 49 permitted dams and numerous impoundments, diversions and drains to accommodate urban and agricultural activities (IDEQ 2009). All streams in the subbasin have been altered or modified and in most years 75 to 89% of the mainstem flow is diverted between Diversion Dam and the Glenwood Bridge, with an estimated 59% of diverted water returned to the mainstem through drains or subsurface flow between

Star and Parma (IDEQ 2009). Between the Glenwood Bridge and Parma, diversions remove an additional 1,600 cfs during the peak of a typical irrigation season (IDEQ 2009). It is likely that diversions and drains increase water temperature in the mainstem and it appears that the water contributed back to the mainstem by the drains is warmer than the water contributed by natural tributaries.

Nutrients - Nitrogen

A USGS study from 1994 to 1997 showed the West Boise wastewater treatment facility contributed the some of the largest loads of total nitrogen (median daily load more than 2,000 pounds per day) (Mullins 1998a).

Evaluation of data collected from 1994 to 2002 by the USGS along the Lower Boise revealed concentrations of total nitrogen increased by more than 8 times from the Diversion Dam to Parma (MacCoy 2004). Total phosphorus concentrations and Chlorophyll-*a* concentrations, used as an indicator of nutrient input and the potential for nuisance algal growth, also increased in a downstream direction. Median nitrogen concentrations of 2.17 mg/L were highest near Parma, along with the greatest range from 0.62 to 5.33 mg/L (MacCoy 2004).

The USGS monitoring total nitrogen in Fivemile and Tenmile Creeks (2009), Indian Creek (2010) and Mason Creek (2012) (Etheridge and others 2014). In the upper reaches of Fivemile and Tenmile Creeks, total nitrogen was relatively low (average 0.47 mg/L) and consisted of 19 percent nitrate+nitrite, suggesting that organic and particulate nitrogen both contribute to total nitrogen. In the lower reaches of Fivemile and Tenmile Creeks, total nitrogen measurements were higher (average 3.45 mg/L) and consisted of 89 percent nitrate+nitrite, suggesting groundwater as a source of total nitrogen (Etheridge and others 2014). In addition, total nitrogen was highest in the winter at downstream sites and lowest in the winter at upstream sites, further indicating groundwater as a source of total nitrogen in the lower watersheds of Fivemile and Tenmile Creeks (Etheridge and others 2014). Due to differences in discharge, however, total nitrogen loading in Fivemile Creek is highest during the non-irrigation season and in Tenmile is highest during the irrigation season (Etheridge and others 2014). For Indian Creek, total nitrogen generally increased by about 5 times (from 252 pounds/day to 1,460 pounds/day, non-irrigation season) in the reaches before and after the Kuna Wastewater Treatment Plant, and doubled the in reaches before and after Nampa Wastewater Treatment Plan (from 1,460 pounds/day to 3,750 pounds/day, non-irrigation season) (Etheridge and others 2014). Total nitrogen loads were highest during the irrigation season. Most total nitrogen consists of nitrate+ nitrite, suggesting that urban land use and wastewater discharges contributes most of the total nitrogen load in Indian Creek (Etheridge and others 2014). In Mason Creek, the highest total nitrogen concentrations (ranging from 3.64 to 6.25 mg/L) occur during the non-irrigation season (Etheridge and others 2014). Total nitrogen concentrations did not increase with flow and generally decrease during the “first flush” of irrigation water to Mason Creek. Alternatively, total nitrogen concentrations did increase downstream of Madison Avenue where groundwater is the primary source of flow. Between 93 and 97 percent of total nitrogen from Madison Avenue to the mouth, was dissolved inorganic nitrogen, again indicating groundwater as a source in downstream reaches (Etheridge and others 2014). In the upper portions of Mason Creek, total nitrogen concentrations were high during the non-irrigation season (6.25 mg/L) but consist of more organic or particulate nitrogen, indicating surface runoff from pastureland as a source (Etheridge and others 2014).

Nutrients - Phosphorus

A USGS water quality study measured average TP of 0.27 mg/L at all tributary and drains and in the Boise River near Parma; sampling was performed in one week rounds during the irrigation season and non-irrigation season over two years (1994-95) (Mullins 1998a). These values far exceed the current target for TP at the mouth of the Boise River (0.07 mg/L). In another USGS study from 1994 to 1997, the West Boise wastewater treatment facility was found to contribute the some of the largest median daily load of total phosphorus (810 pounds per day) (Mullins 1998b)

In land use and storm water runoff study in 2001 by the U.S. Bureau of Reclamation (BOR), there was significant positive correlation between agricultural subwatersheds and TP and nitrate + nitrite in irrigation return drains after storm events during the irrigation season (BOR 2001). During the non-irrigation season, there was significant positive correlation between agricultural subwatersheds and nitrate + nitrite (BOR 2001). However, inter-correlations between down valley distance and land use make it difficult to establish a cause and effect relationship between land use and storm water quality runoff.

Evaluation of data collected from 1994 to 2002 by the USGS along the Lower Boise revealed concentrations of TP increased by more than 7 times from the Diversion Dam to Parma (MacCoy 2004). Nitrogen concentrations and Chlorophyll-*a* concentrations, used as an indicator of nutrient input and the potential for nuisance algal growth, also increased in a downstream direction. Median TP concentrations of 0.30 mg/L were highest near Parma, while the Middleton sample site had the greatest range from 0.03 to 0.85 mg/L (MacCoy 2004). Tributaries between Middleton and Parma contributed high concentrations of TP: Fivemile Creek (1.2 mg/L), Mason Creek (0.93 mg/L), Mason Slough (0.85 mg/L), and Indian Creek (0.82 mg/L).

In order to assist IDEQ with TMDL implementation, the USGS used LOADEST software to develop regression equations and estimate loads of TP and dissolved orthophosphorus at four sites along the Boise River: below Diversion Dam, at Glenwood Bridge, near Middleton, and near Parma from 1994 to 2002 (Donato and MacCoy 2005). Regression models for TP and orthophosphorus generally were well fit on the basis of regression coefficients of determination (R2), but results varied in quality from site to site, such as areas affected by upstream wastewater-treatment plants or sparse and intermittent discharge data. Model load estimates for average daily total phosphorus indicate that reductions in load of 24 to 75 percent would be necessary to meet the proposed goal of 565 lbs/day set forth in the Snake River-Hells Canyon TMDL (Donato and MacCoy 2005). Study results indicate that higher ratios of orthophosphorus to total phosphorus indicate primarily urban wastewater origins of phosphorus, while lower ratios indicate primarily agricultural origins of phosphorus. Parma exhibited the highest OP:TP ratio during all seasons, at least 0.60 in spring and nearly 0.90 in autumn (Donato and MacCoy 2005).

In a study by the Idaho State Department of Agriculture (ISDA), four tributaries to the Boise River and one tributary to the Snake River (Sand Hollow) exceeded the Snake River-Hells Canyon (SR-HC) TMDL goal of 0.07 mg/L of TP during the entire monitoring period; monitoring was conducted bi-weekly from April 24th to October 9th, 2008 (Campbell 2009). Sand Hollow, Mason Creek and Fifteen Mile Creek had the highest TP loads at 318 pounds per day, 313 pounds per day, and 225 pounds per day, respectively (Campbell 2009). This is partly because they typically have higher discharge rates and volumes than the other tributaries. Conway Gulch had the highest concentration levels of TP (up to 0.95 mg/L) but mid-range TP loads (107 pounds per day) (Campbell 2009). Conway Gulch also had the lowest level of dissolved phosphorus, meaning that BMPs should focus on reducing particulate phosphorus. Load reductions to meet the SR-HC TMDL goal ranges from 79% to 85% in Sand Hollow, Mason Creek, Fifteen Mile Creek and Conway Gulch. Willow Creek had the lowest TP levels and loads, though still would require a 53% reduction to meet the SR-HC TMDL goal. A comparison to 1998 data showed little change in TP levels in Sand Hollow, Mason Creek and Fifteen Mile Creek (Campbell 2009).

In a USGS study (Wood and Etheridge 2011) along the Boise River near Parma, concentrations of TP exceeded the seasonal Snake River-Hells Canyon (SR-HC) TMDL goal of 0.07 mg/L in all measurements taken (WY2009 and 2010), while concentrations of chlorophyll-*a* were well below 14 µg/L (the TMDL target for the Snake River). Median TP concentrations at Parma were 0.30 mg/L in 2009 and 0.28 mg/L in 2010. Most of the TP at Parma consists of dissolved orthophosphorus and is negatively correlated with discharge, which may indicate that groundwater discharge is an important source of dissolved phosphorus (Wood and Etheridge 2011).

Another USGS study (Etheridge 2013) developed spreadsheet mass-balance models for TP using results from three synoptic sampling periods. Mass-balance model results indicated that point and nonpoint sources (including groundwater) contributed phosphorus loads to the Boise River during irrigation season. Groundwater exchange is not as significant during the non-irrigation season; however, groundwater discharge to agricultural tributaries and drains remained a large source of phosphorus in the lower Boise River. Model results indicate that point sources represent the largest contribution of TP to the Boise River year round. However, reductions from both point source and non-point source phosphorus loads may be necessary to meet TMDL targets in Parma during the irrigation season.

The City of Boise (2013) Public Works Department monitors TP levels for NPDES permit compliance. There are limited point source and nonpoint source inputs upstream of Veterans Memorial Park Bridge with stormwater being the exception. Below Veterans, the Lander Street Wastewater Treatment plant discharges significant phosphorous concentration (0.8-6.0 mg/L) and volume (15 million gallons per day) to the Boise River on a seasonal basis, complicating the TP dynamics at Glenwood; but these loads are expected to decrease significantly over the next few years. Total phosphorus concentrations remained below the current Lander NPDES permit seasonal target of 7.4 mg/L during the monitoring period. An analysis of water quality data from 2000 to 2014 at Veteran's Bridge shows a decrease in TP of 28.9% through implementation of BMPs.

An Idaho Department of Environmental Quality study (Sharp and Smith 2014) employed the AQUATOX model that simulated attached algae biomass, or periphyton, in relation to nutrient enrichment in the Lower Boise River. Model reduction scenarios to meet reasonable assurance criteria for TP include the following: point sources at 0.10 mg/L May to September and 0.35 mg/L October to April; tributaries and groundwater at 0.07 mg/L TP year-round; and stormwater wet weather loads at a 42% reduction from current conditions. The model showed that phosphorus reductions must be accompanied by reductions in all sources of organic enrichment to be effective. Increases to riparian habitat and changes to channel geometry (that increase the depth of the water column) could be employed to reduce light to the substrate, and therefore, reduce periphyton growth. Implementing TP reductions for both point and nonpoint sources will have an environmental benefit for reduction of excess algal growth throughout the lower Boise River.

A water quality study in Fivemile and Tenmile Creeks (2009), Indian Creek (2010) and Mason Creek (2012) by the USGS showed concentrations of total phosphorus exceeded the Snake River-Hells Canyon (SR-HC) TMDL seasonal water quality target of 0.07 mg/L at one or more monitoring sites in each tributary studied (Etheridge and others 2014). In Fivemile Creek, TP concentrations decreased with flow between Victory Road and Eagle Road, with dissolved orthophosphorus averaging 49% at these locations. Between Eagle Road and Franklin Road near Nampa, TP concentrations increased as much as 10 times. Measurements of TP at Franklin road average of 0.40 mg/L during the irrigation season and 1.29 mg/L during the non-irrigation season, with dissolved orthophosphorus averaging 58%. Discharge of treated wastewater as well as groundwater inputs may substantially increase TP concentrations in the lower portion of Fivemile Creek, though particulate phosphorus is a large component of TP. All samples taken in Tenmile Creek were greater than or equal to the SR-HC TMDL target of 0.07 mg/L (up to 0.35 mg/L), with dissolved orthophosphorus representing a large percentage of TP; this indicates that groundwater may be an important source of TP to Tenmile Creek. With one exception at Robinson Road, all TP samples taken within Indian Creek exceeded the 0.07 mg/L target concentration for the Boise River. Concentrations of TP increase substantially (from 0.06 to 0.21 mg/L during the non-irrigation season and 0.09 to 0.57 mg/L during the irrigation season) on Indian Creek between Robinson Road and Broadmore Way, this is likely due to discharge from two dairy operations and the City of Kuna waste water treatment plant. Between Broadmore Way and Sparrow Avenue, land use along Indian Creek transitions from agriculture to urban as Indian Creek enters the City of Nampa; at this point TP concentrations at least double, ranging between 0.98 mg/L and 1.42 mg/L with the addition of wastewater affluent from the City of Nampa waste water treatment plant. Downstream of the City of Nampa, TP concentrations in Indian Creek decrease, ranging between 0.46 to 0.75 mg/L. Ratios of orthophosphate to total phosphorus suggest the following for Indian Creek: groundwater contributes to TP in the upper reaches of Indian Creek; waste water treatment plan discharge remains a large contributor of TP; and agricultural sources of particulate phosphorus likely exist in the Wilson Drain and Riverside Canal. For Mason Creek, all sampling results exceed the 0.07 mg/L target for the Boise River and particulate phosphorus is a large component of TP loads. Total phosphorus concentrations were highest in the upper reaches of Mason Creek, ranging from 0.11 to 0.45 mg/L (Etheridge and others 2014).

Pesticides

Pesticide residue monitoring was carried out by the Idaho State Department of Agriculture at three locations along the mainstem Boise River and three tributaries/drainages (Campbell 2014a). A total of 28 pesticide compounds were identified; 18 herbicides, 7 insecticides, 2 fungicides, and 1 degradate of atrazine (Campbell 2014a). On the Lower Boise River the site furthest upstream (at Middleton) had the lowest number of total detections (37) and only 1 pesticide of concern (POC) detection; the Boise River at Notus had 94 total detections and 6 POC detections; and the Boise River at Parma (furthest downstream) had 74 total detections with 2 POC detections (Campbell 2014a). Mason Creek enters the Lower Boise River upstream of Notus had 6 POC detections (Campbell 2014a). Both Conway Gulch and Dixie Slough enter the Lower Boise River downstream of Notus. Conway Gulch had 3 POC detections and Dixie Slough had 1 POC detection (Campbell 2014a). Chlorpyrifo was detected at all of the sample sites, with the exception of samples from Middleton and Dixie Slough (Campbell 2014a). Chlorpyrifo has been proven to be moderately toxic to freshwater fish and highly toxic to aquatic invertebrates.

In 2013, the Idaho State Department of Agriculture carried out a second survey pesticide residue monitoring in Indian Creek and to three drains into Mason Creek (Campbell 2014b, 2014c). Six locations in Indian Creek were monitored from April to September; from this survey, 19 pesticides were identified with 14 herbicides, 4 insecticides, and 1 degradate of atrazine (desethyl atrazine) (Campbell 2014b). Indian Creek is vulnerable to pesticide use from agriculture, road side spraying and urban use (Campbell 2014b). For Mason Creek, pesticide monitoring of tributaries Solomon Drain, Noble Drain and Purdum Gulch was carried out from April to September 2013 (Campbell 2014c). From this survey, a total of 24 pesticides were identified with 16 herbicides, 5e insecticides, 2 fungicides and 1 degradate of atrazine (desethyl atrazine) (Campbell 2014c). Both Solomon and Noble drains contribute pesticides of concern (POC) into Mason Creek on a regular basis; five different POCs were identified, including the insecticide chlorpyrifos, which is toxic to aquatic organisms (Campbell 2014c). Purdum Gulch had a few detections of POC chlorpyrifos, but at a lesser degree than the other two drains (Campbell 2014c).

Agricultural pesticides and pesticides used in urban pest control were not detected from bottom-sediment samples collected from Fivemile, Tenmile, Indian and Mason creeks and from three sites in the lower Boise River from 2009 to 2012 by the USGS (Etheridge and others 2014).

pH

In a USGS study, values of pH ranged from 6.6 in the Boise River below Diversion Dam in 1996 to 8.9 in the Boise River near Parma in 1995 (Mullins 1998a). No pH values violated State standards, in which pH should be between 6.5 and 9.5.

Evaluation of the data collected from 1994 to 2002 by the USGS shows median pH to be 7.6 at the Diversion Dam, 8.0 at Glenwood Bridge, 8.0 at Middleton and 8.0 at Parma, with the greatest range of

6.7 to 9.1 at the Middleton site (MacCoy 2004).

Data was collected for pH by the USGS, ISDA, city of Nampa, BOR and DEQ at several locations in the Lower Boise River from 2003 to 2008 (IDEQ 2009). The Boise River at Glenwood Bridge is the only location that has exceeded pH criteria (6.4) in the past five years. Based on data reviewed by IDEQ (2009), pH criteria for beneficial uses are met at all locations in the subbasin.

In a USGS study (Wood and Etheridge 2011), pH ranged from 7.2 to 9.0 (alkaline) at Parma; the lowest values of pH were associated with spring runoff.

Sediment

A USGS water quality study measured median suspended sediment concentrations (SSC) at all tributary/drains and in the Boise River near Parma from May 1994 to February 1997 (Mullins 1998a). Median SSC ranged from 5 mg/L to 47 mg/L on the Boise River, with the highest measurements in Parma. For tributaries and drains, median SSC measured 57 mg/L on the north side of the river and 67 mg/L on south side of the river. Median SSC measured 9 mg/L from Lander, West Boise and Caldwell wastewater treatment facilities (Mullins 1998a).

In a 2001 land use and storm water runoff study by the U.S. Bureau of Reclamation (BOR), there was significant positive correlation between agricultural subwatersheds and total suspended solids in irrigation return drains after storm events during the irrigation season (BOR 2001). However, inter-correlations between down valley distance and land use make it difficult to establish a cause and effect relationship between land use and storm water quality runoff. Note that the analytical methods differ between total suspended solids, as used in this study, and suspended sediment concentration, in which water quality criteria are based. The use of total suspended solids was designed for analysis of wastewater samples, and is generally unreliable for the analysis of natural water samples (Gray and others 2000).

Evaluation of the data collected from 1994 to 2002 by the USGS shows increased suspended sediment along the Lower Boise in a downstream direction; median suspended sediment concentrations increased more than 11 times from the Diversion Dam (4 mg/L) to Parma (45 mg/L) (MacCoy 2004). Suspended sediment loads were generally greatest during the irrigation season; the largest loads were from tributaries including Indian Creek and Mason Creek (MacCoy 2004).

Using LOADEST software, the USGS estimated suspended sediment loads at the Diversion Dam, Glenwood and Parma (Donato and MacCoy 2005). Results showed that suspended sediment loads increase in a downstream direction, with the highest loads occurring in spring and lowest in autumn, corresponding with discharge (Donato and MacCoy 2005). Average daily suspended sediment concentrations for the Diversion Dam are around 37 tons/day, with a maximum monthly load of 260 tons/day. At Parma, average daily suspended sediment concentrations are around 260 tons/day, with a maximum monthly load of 1,220 tons/day. The model estimates at Parma exceed the current lower

Boise River TMDL load allocation of 101 ton/day at Parma (except in 2001) (Donato and MacCoy 2005).

Instantaneous suspended sediment concentration (SSC) data were collected from 2003 to 2008 at both mainstem control locations and 7 drain and tributary locations (IDEQ 2009). At most mainstem river locations, except for Parma, the TMDL sediment targets are met. Instantaneous measurements from Parma frequently exceeded the 60 day target of 50 mg/L and occasionally exceeded the 14 day target of 80 mg/L, with a maximum instantaneous measurement of 240 mg/L (IDEQ 2009). Of the sampled tributaries/drains to the Lower Boise River, only Willow Creek and Mill Slough appear to be within turbidity criteria or TMDL targets. Based on a review of the available data, Indian Creek, Mason Creek, Fifteenmile Creek, Tenmile Creek, Fivemile Creek, and Sand Hollow Creek contribute sediment concentrations to the Boise River that exceed TMDL mainstem targets (with measurements ranging from 50 to 340 mg/L) (IDEQ 2009). Using satellite data, it was evident that sediment plumes from specific drains and tributaries in the Lower Boise River subbasin contribute significant sediment and effluent loads (not related to wastewater treatment facilities) to the Boise and Snake Rivers (IDEQ 2009). The City of Nampa collected samples for total suspended solids from Indian Creek upstream and downstream of wastewater treatment discharge points; based on this study, the wastewater treatment plant meets the TMDL sediment targets and in most cases the effluent does not significantly alter the concentration or load of sediment in Indian Creek (IDEQ 2009). In a few instances the discharge may be serving to dilute higher concentrations of sediment from upstream (IDEQ 2009). Note that the use of total suspended solids was designed for analysis of wastewater samples and is required for NPDES permitting; however, it is generally unreliable for the analysis of natural water samples and it is not comparable to suspended sediment concentration data (Gray and others 2000).

A 2008 study by the Idaho State Department of Agriculture (ISDA) indicates that Mason Creek, Fivemile Creek and Conway Gulch deliver a significant source of sediment into the Boise River, though sediment loads have decreased in these three tributaries by 20% from data collected in 1998 (Campbell 2009). Conway Gulch and Mason Creek exceeded suspended sediment concentrations for both the 60 day criteria (50 mg/L) and the 14 day criteria (80 mg/L); Conway Gulch and Mason Creek frequently had suspended sediment concentrations above 200 mg/L and 100 mg/L, respectively, May through August 1998 (Campbell 2009). Fifteen Mile Creek exceeded the 14 day criteria and Willow Creek was the only tributary monitored that did not exceed suspended sediment criteria (Campbell 2009).

Suspended sediment samples were collected during water years 2009 and 2010 at Parma, with a median suspended sediment concentrations of 42 mg/L; samples were taken monthly October through May, bi-monthly in June and weekly July through September (Wood and Etheridge 2011).

The City of Boise (2013) Public Works Department monitors storm water sewer systems for NPDES permit compliance. Monitoring from January 2000 to September 2013 show suspended sediment concentrations to be well below water quality sediment targets; monthly averages were generally less than 10 mg/L (City of Boise 2013).

A water quality study in Fivemile and Tenmile Creeks (2009), Indian Creek (2010) and Mason Creek (2012) by the USGS showed suspended sediment concentrations exceeded water quality targets (20 mg/L over 120 days) at one or more monitoring sites in each tributary studied (Etheridge and others 2014). In Fivemile and Tenmile Creeks, suspended sediment concentrations and loads generally increase with discharge. Results from three sets of samples indicate the upper portions of Fivemile and Tenmile Creeks meet sediment criteria, while the lower reaches of Fivemile and Tenmile Creeks may exceed criteria during the irrigation season, with suspended sediment concentrations of 96 mg/L and 92 mg/L, respectively (Etheridge and others 2014). More frequent sampling would be required to determine water quality compliance. In Indian Creek, all reaches downstream of Nampa likely exceed suspended sediment criteria (instantaneous measurements range from 39 to 98 mg/L), which may indicate agricultural sources of sediment (Etheridge and others 2014). Increases in suspended sediment downstream of Wilson Drain during the non-irrigation season, indicates that Wilson Drain likely contributes suspended sediment to Indian Creek year-round (Etheridge and others). The Indian Creek watershed likely contributes between 27 and 31 percent of suspended sediment load in the Lower Boise River during the irrigation season (Etheridge and others 2014). In Mason Creek, suspended sediment concentrations are also correlated with flow, generally increase in a downstream direction and are highest during the irrigation season (instantaneous measurements range from 152 to 314 mg/L) (Etheridge and other 2014). The exception is at Mason Creek near Nampa, where the highest measured suspended sediment concentration of 505 mg/L was measured during the non-irrigation season and concentrations consequently decreased downstream; land use changes may explain this anomaly (Etheridge and others 2014). It is estimated that Mason Creek contributes 42 percent of suspended sediment load during the irrigation season and 12 percent of the suspended sediment load during the non-irrigation season to the Boise River at Parma (Etheridge and others 2014).

Temperature

Daily mean water temperature data collected by the USGS over a 50-day period from July to September 1996 showed the maximum daily average temperature for coldwater biota was exceeded by 34% at Middleton, 48% at Caldwell, and 80% near Parma (Mullins 1998a).

An evaluation of the data collected from 1994 to 2002 by the USGS indicated that median water temperature increased in a downstream direction (from 9.2 to 12.1C), with the highest instantaneous measurement of 31.1 C occurring at Parma in mid-summer 1996 (MacCoy 2004).

Based on the data collected by the City of Boise from 2003 to 2007, water temperature at all but one location (Boise River at Lucky Peak) in the Lower Boise River subbasin exceeds numeric criteria at some time of every year (IDEQ 2009). Most locations generally exceed temperature criteria from April through August and for brief periods between September and November. However, monitoring data collected near Middleton shows median water temperature exceeded criteria as early as mid-February in 2005. Because most of the criteria exceedances occur in late fall and early spring, it is unlikely that the air temperature exemption would apply. In another study, instantaneous temperature data collected by the USGS, ISDA, and City of Nampa near stormwater discharge locations in the Boise area were mostly within the established permit limits except in a few locations in early spring. Based on a review of all available data, water temperature exceeds beneficial use criteria in most stretches of the Boise River and in Indian Creek, Conway Gulch, Mill Sough and Dixie Drain (IDEQ 2009).

Temperature monitoring by the City of Boise (2013) Public Works Department for NPDES permit compliance shows nine consecutive years (2004-2012) with no exceedance of cold water aquatic life criterion and on average, <8 and <6 days per year of exceeded the salmonid spawning criterion at Glenwood Bridge and Veterans Memorial Parkway, respectively (less than 10% threshold). Most significant exceedances of the cold water aquatic life water quality standards occurred during August and September when there is little, if any, discharge from the stormwater drains.

The USGS continuously monitors water temperature near Parma. For water years 2009 and 2010, temperatures ranged from 0.1°C to 26.0°C with a maximum daily mean of 23.7C (Wood and Etheridge 2011). In 2014, temperatures ranged from 0.9°C to 25.7°C with a maximum daily mean of 23.8°C; maximum daily mean temperatures exceeded the criterion of 22.0°C through most of July and August (USGS 2015).

Solutions Identified in the Literature

An extensive literature review was conducted for solutions to water quality impairments for the Lower Boise River watershed. Issues and solutions identified during local workshops are detailed in Part II: Network Feedback. The following solutions were ranked by some members of the expert review panel.

Bacteria (*E. coli*)

1. Livestock exclusion from drains and canals; livestock watering facility; prescribed grazing; fencing; nutrient /manure management (IDEQ 2003)
2. Waste management systems and storage ponds (IDEQ 2003)
3. Repairing leaky sewer lines; repair or replace older septic systems or connect them to sewer lines; providing pump outs of recreational sewage (IDEQ 2003)
4. Filter strips (IDEQ 2003)
5. Conversion to sprinkler or drip irrigation methods for agricultural applications (IDEQ 2003)
6. Wetland development and restoration (IDEQ 2003)

Nutrients - Total Phosphorus

- Implementation and proper maintenance of construction erosion controls (City of Boise 2013)
- Improved site design and stormwater management (Ecosystem Sciences 2003)
- Re-use of irrigation return water
- Improved street sweeping (City of Boise 2013)
- Public education efforts on fertilizer use (City of Boise 2013)
- Removal of phosphorus from residential fertilizers by major fertilizer companies (City of Boise 2013)
- Wastewater treatment facilities meeting NDEPS permit requirements that may require modification (City of Boise 2013)
- Conversion to sprinkler or drip irrigation methods for agricultural applications (IDEQ 2003)
- Improved surface systems, use of polyacrylamide
- Livestock exclusion to drains and canals; livestock watering facility; prescribed grazing; fencing; nutrient/manure management (IDEQ 2003)
- Waste management systems and storage ponds (IDEQ 2003)
- Sediment basins and constructed wetlands (Tiedemann and Anderson 2015)
- Filter strips (IDEQ 2003)
- Wetland development and restoration (IDEQ 2003, Ecosystem Sciences 2003)
- Riparian buffer enhancement (Ecosystem Sciences 2003)
- Pollution trading (LBWC and IDEQ 2008b)
- Changes to channel geometry that decrease the width to depth ratio, increasing the depth of the water column, are beneficial to reducing light to the substrate(Sharp and Smith 2014)

Pesticides

1. Integrated pest management program (City of Boise 2013)
2. Evaluate pest control needs, select proper pesticide and conduct maintenance and calibration of equipment to match application rates to pest problem (Campbell 2014a)
3. Implement best management practices such as conservation buffers, vegetation filter strips, sediment basins, and pump back systems (Campbell 2014a)
4. Technologies to reduce drift and spray overlap
5. Irrigation system and crop conversions

Sediment

1. Controlling irrigation water effectively to reduce erosion (IDEQ 2003)
2. Re-use of irrigation drainage water
3. Conversion of crop types (i.e. high residue crops such as winter wheat) (IDEQ 2003)
4. Conversion to sprinkler or drip irrigation methods for agricultural applications (IDEQ 2003)
5. Sediment basin, underground outlet, buried pipeline, straw mulching, filter strips, conservation tillage and cropping sequence (IDEQ 2003)
6. Sediment basin and constructed wetlands (Tiedemann and Anderson 2015)
7. Riparian buffer enhancement (Ecosystem Sciences 2003)

- Improved surface systems; use of polyacrylimide
- Construction erosion and sediment controls (City of Boise 2013)
- New and redevelopment design standards for on-site retention or/and WQ treatment (City of Boise 2013)
- Best Management Practices (BMPs) including: schedule of activities; maintenance and operating procedures (e.g. sweeping, inspection, cleaning); treatment requirements; education and management practices to control site runoff, spillage or leaks, waste disposal, and drainage from raw material storage; and, effective tracking and documentation of activities (City of Boise 2013)
- Improved site design and stormwater management (Ecosystem Sciences 2003)
- Infrastructure management (City of Boise 2013)

Temperature

1. Re-vegetation of streambanks, where applicable (IDEQ 2003)
1. Re-use of irrigation drain water
2. Construction and post-construction BMPs that preserve or mimic the predevelopment hydrologic regime at urbanized sites (IDEQ 2003)
3. Riparian and wetland conservation and enhancement (Ecosystem Sciences 2003)
4. Enhance riparian forest buffers (Ecosystem Sciences 2003)
5. Changes to channel geometry that decrease the width to depth ratio, increasing the depth of the water column, are beneficial to reducing light to the substrate(Sharp and Smith 2014)

6. Methods to control the thermal enrichment of stormwater and irrigation drain water (IDEQ 2003)
7. Most methods to control suspended sediment

Data Gaps

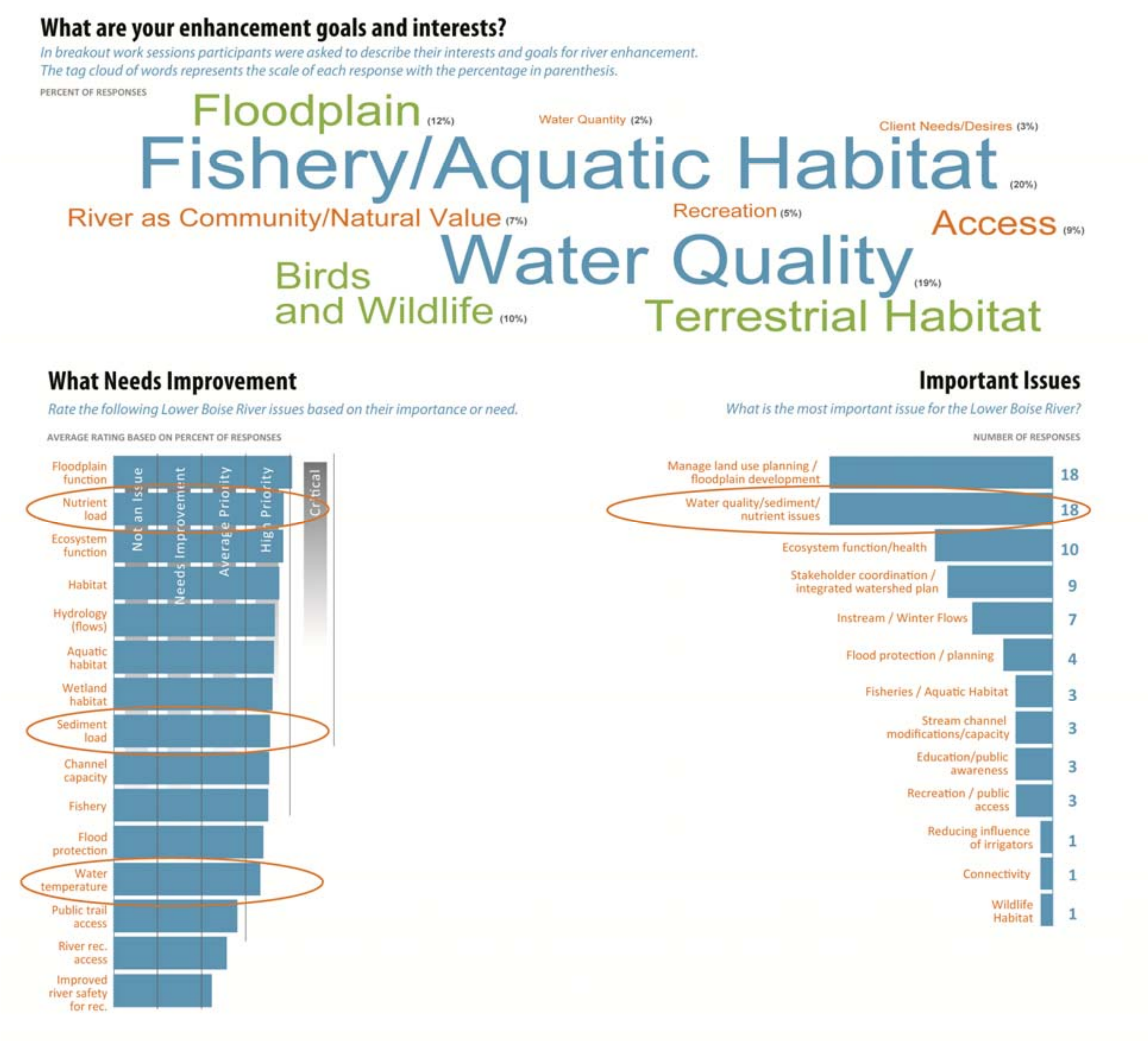
1. A map of the entire surface hydrology of the valley
2. Temperature – year round temperature data for tributaries and drains to LBR; daily maximum temperatures and winter daily averages at Middleton and Caldwell
3. Intergravel DO data (especially February through June)
4. Winter flows for tributaries to LBR; water quality analysis in relation to discharge
5. Expanded water quality analysis of point and non-point sources.
6. Improved data on natural background conditions and identification of natural reference sites
7. Extent of local and regional groundwater systems
8. Hydrogeologic relationship between surface water and groundwater; local and regional groundwater systems; or geothermal systems and adjacent or overlying non-thermal water.
9. Sediment – substrate monitoring; sediment bedload data; stream bank erosion rates; substrate and water column particle size data and long-term channel geometry data.
10. Improved water quality monitoring across multiple season/years over a greater extent of the watershed.
11. Seasonal variation in ground-water movement.

- Monitoring framework to link water quality trends to BMP implementation at a subwatershed level
- Algae data for hot summer, drought conditions and associated DO
- Improved data (if any) of historical land use and development; future growth models
- Septic system water quality influence and evaluation

Part II: Network Feedback

2011 Boise River from Vision to Reality Workshop

During and following the October 2013 workshop participants provided feedback though working groups and an online survey. The graphics presented below represent the synthesis of this feedback as it pertains to water quality within the Boise River.



May 12, 2014 Water Quality Meeting

At this meeting, participants were provided handouts detailing the overall conclusions, issues and solutions from the preliminary literature review. Fifteen participants provided written comments and feedback. Although not all participants in the meeting provided written feedback, they all participated in the discussion which consisted of small group discussions and presentation of ideas to the larger group on issues and solutions. Their written feedback is summarized in the table below.

Issues and Solutions Identified

ISSUES	SOLUTIONS
Dissolved Oxygen • Low levels of dissolved oxygen in waters within the watershed lead to poor conditions for the persistence of biologically diverse aquatic habitats	• Implement improvement projects at sites most likely to provide beneficial secondary effects to waters with depressed levels of DO • Addition of aquatic and riparian habitat components to encourage biodiversity (large woody debris, riparian vegetation installation, control of invasive species, in-stream flow modification, modification of channel morphology) • Installation of aeration or flow systems in lentic waters having particularly poor DO conditions • Floating wetland islands
Bacteria • Present everywhere and there is a steady stream of people getting sick from *E. coli* every summer	• Livestock exclusion and offsite watering facility development • Vegetative buffers and sediment basins • Enhancement and improvement of current stormwater management practices • Improvements to Wastewater effluent pre-discharge treatment methods and practices
Flow Alteration • Flow directly influences pollution but is not a "pollutant"; therefore, is not subject to water quality standards regulation	• Water reuse at WWTP • Increase cost of water to incentivize conservation and best management practices • Increase winter flow through leasing and acquiring of water rights; working with rule curve
Nutrients - Total Phosphorus • Difference between particulate TP and dissolved TP (orthophosphate) – sediment basins and other BMPs that lower sediment inputs will not address orthophosphate. • Total phosphorus has compounding factors • Many farmers do not take soil samples and over-fertilize their crops	• Wetlands can hold onto sediments and also uptake dissolved nutrients, such as orthophosphates. However, wetlands can harbor *E. coli* • Irrigation conversion – from flood irrigation to sprinkler or drip irrigation lowers overall fertilizer use and limits runoff that includes pollutants • Pollution trading for phosphorus • Soil testing demonstration

ISSUES	SOLUTIONS
Nutrients – Total Phosphorus (continued) • There are nutrient management plans in place for CAFOs – for the most part they are meeting their input goals. Tightly regulated by the state.	• Phosphorus control mechanisms for urban runoff • Incentivize use of fertilizer that does not have dissolved phosphorus (orthophosphate). • Maintenance and optimization of the system would result in significant water quality improvements • Identification and implementation of innovative nutrient control mechanisms (biological control, fixation and metabolization, nutrient sinks, wetlands, sedimentation basins)
Nutrients - Nitrogen • Efforts to reduce phosphorus can also result in a decrease in microbial processes that remove nitrogen from water, which means as phosphorus levels decreases, nitrogen levels may rise	• Plan for dealing with Nitrogen now – dynamics will • change once phosphorus levels decrease
Total Suspended Solids • Tributaries and Drains are major sources of sediment loads in the Lower Boise River • The urban stormwater system is not equipped to handle sediment • The quality of maintenance of ditches, drains and sediment basins has decreased, partially a result of land leasing. • Sediment TMDLs have been in place since 2001, but not much progress has been made • Identification of known and unknown outlets contributing large quantities of sediment (particular drains or canals) has not been conducted throughout the watershed • Maintenance and upgrades to existing infrastructure is not adequate to treat increases in sediment discharge rates.	• An issue that is important to all stakeholders, farmers and irrigators want canals to be free from sediments. There is a lot of maintenance cost and time involved in keeping these clean. Potential for collaborative efforts. • Maintenance and optimization of irrigation and municipal infrastructure would likely result in water quality improvements • Irrigation conversion – from flood irrigation to sprinkler or drip reduces erosion, runoff and sediment inputs • Urban pilot projects for sediment control mechanisms aimed at reducing urban stormwater runoff and associated sediment discharge • Reduce sediment coming off of fields • Suspended sediment is an issue BREN can make a difference in – no teeth for sediment control • Sediment reduction also reduces contaminant absorption • Incentives for sediment capture for agriculture • Wetlands or basins at drain returns • Have one entity in charge of maintenance – changing out pumps, cleaning ditches, sediment basins; install automated head gates

ISSUES	SOLUTIONS
Temperature • Temperature issues are tied to sediment through heat absorption on particle • The old floodplain had better canopy cover and side channels that helped lower temperatures; we no longer have this structure anymore. Is a cold water fishery realistic in some areas? • Resource conflict – trees along canals could lower temperatures but irrigation districts want the areas around canals clean for maintenance purposes • Tributaries are a major source • There is no easy answer to address temperature; need large scale changes to approach temperature • Climate change will exacerbate • Temperature issues may be related to gravel pits and groundwater connections	• Selling point for what BREN can do – that it will help with temperature in the long run • Shade tributaries, small creeks, streams, drains, and irrigation canals • Shade the water with floating treatment wetlands • Set goals for lowering temperatures incrementally • Reduce non-temp stressors on fish so they can tolerate temperature stress, if possible
Other Impairments - Pesticides • Pesticide residues are present in LBR, tributaries • Open nature of drains/canals leads to people dumping all sorts of pollutants into them	• Piping irrigation water • Develop management plan for chlorpyrifos • Apply buffers and sediment basins • Education regarding pesticide use
General • Climate change will exacerbate water quality problems • Lack of information in regard to water use, drainage system, purpose of drainage system and history, hydrology and chemistry processes • Lack of incentives for effluent control from non-point source discharge • Loss of connectivity and riparian zone • Lack of funding. For example, the NRCS has 96 applications, only 20 can be funded. • IBI score literature needs to be updated • Cadastral surveys on Boise River	• Focus on solutions with overlapping benefits and control multiple pollutants • Public Education and Awareness o Joint problem and joint responsibility o Can result in in health benefits to the community o Include visual depiction of issues. o Make print/video/audio resources available on large scale • Pollutant Trading o Quantify results of projects and use toward pollution trading o Investigate new trading opportunities (such as shading for temperature trading) o Have third party measure and monitor nutrient loading for permits • Facilitation and Funding o Add funding data to online network o Work with agriculture community – help to obtain small grants and highlight best practices o Investigate incentive programs – cost sharing, enforcement, monitoring services

ISSUES	SOLUTIONS
General (continued)	o Facilitate partnership between regulated and non-regulated entities for pollutant trading and/or reductions o Participate in IPDES process o Investigate and facilitate public/private partnerships for funding o Attend NRCS state technical committee meetings to guide application process (WQ requirements) required for funding • Monitoring o Target specific outlets for sampling & treatment o Monitoring for dry flow (non-running) stormwater areas to determine water source o Monitor projects (BMP implementation) and increase visibility of project applications o Support demo project – increase funding for experiments, paid visibility • Stormwater subwatershed planning

Part III: Enhancement Priorities

Prevent Pollution On-Site

Improvements to Stormwater Management Practices

Reducing and managing stormwater on-site is the best way to prevent nutrients and sediment in stormwater from entering storm drains and ultimately the Boise River. Temperature benefits may also be realized as less storm water runoff results in less warm water re-entering the Boise River. Some innovative techniques include using permeable pavers in alleys and roadways instead of concrete or asphalt, installing stormwater tree trenches between the curb and sidewalk absorb runoff, and installment of bio-swales and bio-retention systems that absorb runoff into the soil. Installment of sediment basins, robust street sweeping and educational programs to reduce over-fertilization of lawns are time-tested ways to reduce stormwater pollution.

Enhancement locations: Residential, commercial, arterial and alley ways within urban/suburban areas

Affected pollutants: phosphorus, sediment, E. coli, temperature, oils and other soluble nutrients

Conversion to Sprinkler or Drip Irrigation

Conversion to sprinkler and drip irrigation systems use less water, less fertilizer and result in limited sediment runoff (and virtually no runoff with drip irrigation). This means there is less polluted return water entering the system and it means conservation of topsoil for farmers. Temperature benefits may also be realized as less irrigation return water results in less warm water re-entering the Boise River. Sprinkler and drip systems can be cost prohibitive to install and may not work for all crops; therefore, it is important to consider an array of solutions for agricultural sub-watersheds.

Enhancement locations: Agricultural fields that utilize flood irrigation techniques, where applicable

Affected pollutants: Phosphorus, sediment, pesticides, other nutrients, and temperature

Improved Manure Management

Poor grazing management can impact water quality through bacterial contamination, nutrient over-enrichment, and soil erosion from pastures. It can also lead to reduction of riparian vegetation that would otherwise buffer the stream from pollution runoff. In addition, nutrients from livestock and poultry manure can be a source of water pollution when not managed effectively both on-site or when applied to cropland. Best management practices for livestock include exclusion of livestock from drains and canals, installing watering facilities, and implementing prescribed grazing. Installment of waste management systems and storage ponds are already required for concentrated animal feeding operations as regulated by the Clean Water Act; such improvements for smaller facilities could lead to water quality improvements. Precise application of manure and irrigation water management could reduce polluted runoff from croplands.

Enhancement locations: small animal feeding facilities and grazing pastures.

Affected pollutants: phosphorus, sediment, E. coli, temperature and other nutrients

Intercept Pollution Downstream

Re-use of Irrigation Drainage Water

Capture and reuse of excess irrigation water can reduce pollutants such as sediment, phosphorus and pesticides from entering tributaries and the Boise River. Reusing water on the same field for irrigation also allows water users to achieve maximum beneficial use of the water, reduce the amount of water that needs to be diverted, and may reduce the need for fertilization. Irrigation return water can also be rerouted for use to downstream users. However, treatment of return water may be necessary if the water contains too many nutrients.

Enhancement Locations: Onsite reuse at sites that implement flood irrigation and irrigation return drains before they enter major tributaries.

Affected Pollutants: Phosphorus, sediment, pesticides and other nutrients

Sediment Basins and Constructed Wetlands

Sediment basins and constructed wetlands can be very effective at removing soluble pollutants, such as phosphorus, and sediment from both agricultural and urban runoff. Water slows as it enters the sediment basin and particulates then settle out of the water column. Wetland systems then use the biological and naturally occurring chemical processes in water and plants to remove pollutants.

Enhancement locations: Stormwater runoff, below individual farms or at the end of irrigation ditches

Affected pollutants: Sediment, phosphorus, oils and other soluble nutrients.

Riparian Buffer Enhancement

Enhancement or planting of streamside vegetation, where applicable, will help buffer water from sediment and nutrient runoff and provide shading, which reduces the amount of thermal energy. The width, height and species composition all influence the functionality and value of riparian buffers. Therefore, establishment of native trees, such as black cottonwood, increase water quality and provide habitat value. A river set back that allows the establishment of broad riparian buffers would lead to water quality benefits.

Enhancement Locations: Lower portions of the Boise River, especially from Caldwell to the mouth of the river, and all tributaries below Eagle Island.

Affected pollutants: E. coli, Sediment, Phosphorus and Temperature

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Appendix A: BREN Water Quality Database

The following table is a select portion of the BREN database showing all sources that include a discussion on water quality, though water quality may not be the primary focus of the citation.

Author	Date	Title	Area/Extent
Etheridge, A.B., MacCoy, D.E. and Weakland, R.J. (USGS)	2015	Water-quality and biological conditions in selected tributaries of the Lower Boise River, Southwestern	Fivemile, Tenmile, Indian and Mason Creeks
Teidemann, R. and Anderson, H. (Watershed Solutions, Inc.)	2015	North Alkali Drain water quality improvement pilot project: project summary and report of preliminary r	North Alkali Drain
Sharp, D. and Smith, T. (IDEQ)	2014	Lower Boise River Phosphorus - Aquatox Model Report	Lower Boise watershed
City of Boise Parks & Recreation	2014	Boise River Master Plan	Boise River, Eckert to Glenwood Bridge
City of Boise, Ada County, Boise County, IDL, IDFG, BOR, USFWS	2014	Interagency Foothills Management Plan - Draft	Boise Foothills
City of Boise	2014	Dixie Drain Memo	Dixie Drain
Campbell, K. (ISDA)	2014	Lower Boise River and Select Drainages Pesticide Residue Evaluation 2013	Lower Boise watershed
Campbell, K. (ISDA)	2014	Indian Creek pesticide residue evaluation: April through September 2013	Indian Creek
Campbell, K. (ISDA)	2014	Evaluation of Solomon Drain, Noble Drain, andPurdum Gulch for Transport of Pesticide Residues into M	Mason Creek
Idaho Department of Environmental Quality	2014	Idaho's 2012 Integrated Report	Idaho, statewide
Stone, H. (IDEQ)	2013	Lower Boise River Tributaries 2013 Addendum, Draft	Lower Boise river tributaries
USACE, Walla Walla District	2013	Boise River at Eagle Island Ecosystem Restoration Project, Draft Environmental Assessment	Boise River at Eagle Island
USACE, Walla Walla District	2013	Boise River at Eagle Island Ecosystem Restoration Project, Feasibility Report	Boise River at Eagle Island
Public Works Department Environmental Division, City of Boise	2013	2013 Stormwater Program, Annual Report	Boise River in Boise
Boise State University	2013	Boise State University Storm Water Management Program NPDES Permit No. IDS-027561	Boise River and tributaries
Etheridge, A. (USGS)	2013	Evaluation of total phosphorus mass balance in the Lower Boise River, southwestern Idaho	Lowe Boise watershed
Karie Pappani, Delwyne Trefz, and Jason Miller (Idaho SWC)	2012	Lake Lowel Watershed (17050114SW004_06) Total Maximum Daily Load Implementation Plan for Agric	Lake Lowell watershed
Wood, M.S. and Etheridge, A.B. (USGS)	2011	Water-quality conditions near the confluence of the Snake and Boise Rivers, Canyon County, Idaho	Boise River and Snake River confluence
Idaho Department of Environmental Quality	2010	Lake Lowell TMDL: Addendum to the Lower Boise River Subbasin Assessment and Total Maximum Dail	Lake Lowell
RIME	2010	Treasure Valley Future Water Demand, Draft	Lower Boise watershed
Bjorneberg, D.L. and A.B. Leytem (USDA)	2010	Sediment and nutrient reductions in constructed ponds in an irrigated 1 watershed.	Twin Falls
Idaho Department of Environmental Quality	2010	Water quality pollutant trading guidance	Idaho, statewide
Idaho Department of Environmental Quality	2009	Lower Boise River: TMDL Five-Year Review	Lower Boise watershed
Campbell, K. (ISDA)	2009	Water quality monitoring report, Lower Boise River and Snake River Tributaries	Lower Boise River and Snake River Tributaries
Lower Boise Watershed Council and IDEQ	2008	Lower Boise River Implementation Plan Total Phosphorus	Lower Boise watershed
Lower Boise Watershed Council and IDEQ	2008	Sediment and Bacteria Allocations Addendum to the Lower Boise River TMDL	Lower Boise watershed
U.S. Bureau of Reclamation	2007	Finding of No Significant Impact and Final Environmental Assessment: Pioneer Irrigation District Propos	Boise River, Caldwell
Lower Boise Watershed Council and IDEQ	2007	Lower Boise River, Total Phosphorus Allocations for the Snake River-Hells Canyon TMDL	Boise River from Lucky Peak to Snake River
CH2M Hill	2007	Lower Boise Tributaries Use Attainability Analysis	Fivemile, Blacks, Tenmile and Fifteenmile Creeks
Natural Resources Conservation Service	2007	Lower Boise - 17050114 - Subbasin Profile	Lower Boise watershed
Lower Boise Watershed Council	2007	Umbrella Framework for Lower Boise River Total Phosphorus Allocations	Boise River from Lucky Peak to Snake River
Skinner, K.D.	2006	Estimating streambed seepage using head as a tracer on the Lower Boise River, Canyon County, Idaho	Lower Boise watershed
MacCoy, D.E. (USGS)	2006	Fish communities and related environmental conditions of the Lower Boise River, Southwestern Idaho,	Lower Boise River, Ada County to Canyon County
Hardy, M.A., Parliman, D.J. and I. O'Dell	2005	Status of and changes in water quality monitored for the Idaho statewide surface-water-quality networ	Idaho, statewide
U.S. Bureau of Reclamation	2005	Finding of No Significant Impact Partial Assignment of New Union Ditch Company Ltds Contract Entitle	Boise River upstream of Lucky Peak
Donato, M.M and MacCoy, D.E. (USGS)	2005	Phosphorus and Suspended Sediment Load Estimates for the Lower Boise River, Idaho, 1994-2002	Boise River from Lucky Peak Dam to Snake River
Lindley, D.	2005	Wetland restoration site evaluation: Island Creek, Eagle, Idaho	Boise River at Eagle Island
Ecovista	2004	Boise, Payette, and Weiser Subbasins Management Plan	Boise, Payette and Weiser Subbasins

Author	Date	Title	Area/Extent
Interim Legislative Committee on Natural Resources	2004	Treasure Valley Working Group, Final Report Draft	Lower Boise watershed
MacCoy, D.E. (USGS)	2004	Water-quality and biological conditions in the Lower Boise River, Ada and Canyon Counties, Idaho, 199	Lower Boise River, Ada County to Canyon County
Weast, C. (Trout Unlimited)	2004	A summary of recommendations and strategies for trout conservation on the Lower Boise River, Idaho	Lower Boise from Lucky Peak to Snake River
U.S. Bureau of Reclamation	2004	Finding of No Significant Impact and Final Environmental Assessment: Lucky Peak Water Service Contra	Lucky Peak
Ross & Associates Environmental Consulting, Ltd.	2004	Water quality pollutant trading in Idaho: A step-by-step agricultural community guidebook	Lower Boise watershed
Ecosystem Sciences, LLC	2003	Design Principals and Practice, Urban Ecology: Lower Boise River Designs to Improve Water Quality	Lower Boise watershed
Idaho Department of Environmental Quality	2003	Implementation Plan for the Lower Boise River Total Maximum Daily Load	Lower Boise watershed
CH2M Hill	2003	Lower Boise River Coliform Bacteria DNA Testing, Final Report	Boise River from Lucky Peak to Snake River
Community Planning Association of Southwest Idaho, IDWR, Idaho W	2002	Treasure Valley's Water Future: Summary of the Treasure Valley WaterSummit, January 14-15, 2002	Lower Boise watershed
Idaho Department of Environmental Quality	2001	Blacks Creek Subbasin Assessment	Blacks Creek
Idaho Department of Environmental Quality	2001	Fivemile and Tenmile Creek Subbasin Assessment	Fivemile and Tenmile Creeks
Idaho Department of Environmental Quality	2001	Indian Creek Subbasin Assessment, Draft	Indian Creek
U.S. Bureau of Reclamation	2001	Land Use Effects on the Quality of Storm Water Runoff in the Boise Valley	Boise Valley
Idaho Department of Environmental Quality	2001	Lower Boise River Nutrient & Tributary Subbasin Assessment	Lower Boise river tributaries
Idaho Department of Environmental Quality	2001	Lower Boise River Nutrient Subbasin Assessment	Lower Boise River
Idaho Department of Environmental Quality	2001	Lower Boise River Tributary Subbasin Assessment Appendices List	Lower Boise river tributaries
Idaho Department of Environmental Quality	2001	Mason Creek Subbasin Assessment	Mason Creek
Maret, T.M., MacCoy, D.E., Skinner, K.D., Moore, S.E. and I. O'Dell	2001	Evaluation of macroinvertebrate assemblages in Idaho rivers using multimetric and multivariate techni	Boise River and North Fork
U.S. Army Corps of Engineers	2001	U.S. Army Corp of Engineers Project Partnership Kit	Nationwide
Spatial Dynamics	2000	Public Lands Open Space Management Plan for the Boise Foothills	Boise Foothills
Ross & Associates Environmental Consulting, Ltd.	2000	Lower Boise River effluent trading demonstration project: summary of participant recommendations fo	Boise River from Lucky Peak to Snake River
Spatial Dynamics, Mary McCown, Agua Tierrra Environmental Consu	1999	Boise River Resource Management and Master Plan	Boise River, Barber Park to Glenwood Bridge
Idaho Department of Environmental Quality	1999	Lower Boise River TMDL: Subbasin Assessment Total Maximum Daily Loads	Lower Boise watershed
Mullins, W.H. (USGS)	1999	Biological Assessment of the Lower Boise River, October 1995 through January 1998, Ada and Canyon	Boise River, Ada County and Canyon County
Idaho Department of Environmental Quality	1998	Water Temperatures in the Lower Boise River: Conditions and Sources	Lower Boise watershed
Parliman, D.J. and J.M. Spinoza (USGS)	1998	Ground-water quality in northern Ada County, Lower Boise River Basin, Idaho, 1985-96	Lower Boise watershed
Mullins, W.H. (USGS)	1998	Water-quality conditions of the Lower Boise River, Ada and Canyon Counties, Idaho, May 1994 througl	Boise River, Ada County and Canyon County
Mullins, W.H. (USGS)	1998	Biotic integrity of the Boise River upstream and downstream from two municipal wastewater treatmen	Boise River in Boise
Kjelstrom, L.C. (USGS)	1995	Data for and adjusted regional regression model of volume and quality of urban storm-water runoff in	Boise and Garden City
Long, R.B. and J. Zhang	1995	Economic causes of non-point pollution in the Boise River	Boise River from Lucky Peak to Snake River
USACE, Walla Walla District	1995	Lower Boise River and Tributaries, Idaho: Reconnaissance Study	Boise River from Lucky Peak Dam to Snake River; Mo
U.S. Bureau of Reclamation	1994	Lower Boise River Irrigation Waste Water Reuse Assessment	Lower Boise watershed
Frenzel, S.A.	1988	Physical, Chemical and Biological Characteristics of the Boise River from Veterans Memorial Parkway,	Boise River from Veterans Memorial Parkway to Star
Asbridge, G. and T.C. Bjorne	1988	Survey of Potential and Available Salmonid Habitat in the Boise River	Boise River from Lucky Peak Dam to Snake River
Lewis, R.E. and H.W. Young	1982	Thermal springs in the Lower Boise River Basin, south-central Idaho	Lower Boise Basin
Gibson, H.R.	1975	Survey of Fish Populations and Water Quality in the Boise River from its Mouth Upstream to Barber Da	Boise River from Barber Dam to Snake River
Idaho Department of Health, Engineering and Sanitation Division	1962	Report of Pollution Problems in the Boise River: Ada and Canyon Counties, Idaho, 1959-1962	Boise River, Ada County and Canyon County
Renner, F.G.	1936	Conditions Influencing Erosion on the Bosie River Watershed	Boise River, Arrowrock to Snake River confluence