Lower Boise River TMDL

Subbasin Assessment, Total Maximum Daily Loads

December 18, 1998
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Table of Contents

List of Figures

List of Tables

1.0 Executive Summary

The lower Boise River watershed drains 1290 square miles of rangeland, forests, agricultural lands, and urban areas. The lower Boise River is a 64 mile stretch that flows through Ada County, Canyon County, and the city of Boise, Idaho. The watershed also drains portions of Elmore, Gem, Payette, and Boise counties. The river flows in a northwesterly direction from its origin at Lucky Peak Dam to its confluence with the Snake River near Parma, Idaho. Major tributaries include (but are not limited to) Fifteenmile Creek, Mill Slough, Mason Creek, Indian Creek, Conway Gulch, and Dixie Drain.

Section 303(d) of the Federal Clean Water Act requires states to develop a Total Maximum Daily Load (TMDL) allocation plan for water bodies determined to be water quality limited. A TMDL allocation plan documents the amount of a pollutant a waterbody can assimilate without exceeding a state's water quality standards, and allocates that amount as loads to point and nonpoint sources. TMDLs are defined in 40 CFR Part 130 as the sum of the individual Waste Load Allocations (WLA) for point sources and Load Allocations (LA) for nonpoint sources, including a margin of safety and natural background conditions.

The Idaho Water Quality Standards designate cold water biota, primary contact recreation, secondary contract recreation, domestic water supply, and agricultural water supply for the lower Boise River from Lucky Peak to Veteran's State Park. Salmonid spawning is also a designated use from Diversion Dam to Veteran's State Park. From Veteran's Park to Caldwell, the river is designated for cold water biota, salmonid spawning, primary contact recreation, and agricultural water supply. From Caldwell to its mouth, the Boise River is designated for cold water biota, salmonid spawning, primary contact recreation, secondary contact recreation, and agricultural water supply. Contact recreation uses are not fully supported in the lower Boise River from Star to its mouth. Both salmonid spawning and cold water biota are not fully supported uses in any segment of the lower Boise River. Sediment, temperature, flow, and habitat conditions contribute to the impairment of cold water biota. Fecal coliform bacteria impair contact recreation uses downstream of Star.

Water quality standards the state of Idaho are intended to provide protection for designated uses. TMDL targets are based on these water quality standards. Numeric water quality standards are used to develop bacteria load allocations. The narrative water quality standard for sediment is interpreted and applied as two acute and chronic numeric concentrations for suspended sediment in the lower Boise River. Sediment load and waste load allocations for sources are based upon maintaining suspended sediment concentrations at or below the chronic criterion, 50 mg/l, at all points in the Boise River. Bacteria load requirements for sources are based upon existing state criteria fecal coliform bacteria. Until TMDLs are issued for the lower Snake River, review of nutrient and aquatic growth conditions in the lower Boise River will continue. Upon completion of the lower Snake River and Brownlee Reservoir TMDLs, phosphorus (both total and dissolved species) in the lower Boise River watershed will be evaluated with respect to the conclusions of those TMDLs and aquatic growth in the Boise River.

Seven stream segments within the watershed, other than the mainstem segments of the lower Boise River, are listed as water quality limited on the 1996 303(d) list. The segments are Black's Creek, Fivemile Creek, Tenmile Creek, Mason Creek, Indian Creek from its headwaters to the New York Canal, Indian Creek from the New York Canal to the Boise River, and Sand Hollow Creek. Since the tributaries are sources of pollutants to the Boise River, load allocations for sediment and bacteria are included at the mouth of two of the listed tributaries, as well as all of the other major tributaries to the lower Boise River. Two of the listed streams, Fivemile and Tenmile Creek, join to form Fifteenmile Creek, which also receives load allocations for sediment and bacteria. The listed tributaries do not receive TMDLs along their length. Two of the listed streams are proposed de-listing on the 1998 303(d) list, which is not yet final. Issues related to the appropriate classifications, segment definitions, and beneficial uses for the listed tributaries remain unresolved. DEQ has deferred TMDL development in those segments until the year 2000 to allow time for finalization of the 1998 303(d) list and progress related to classification and use designations.

An implementation plan will be developed by the Lower Boise River Watershed Advisory Group and supporting agencies to specify the activities needed to meet the load allocations for suspended sediment, suspended solids, and bacteria presented in this document. During implementation, additional water quality information will be collected through a jointly funded monitoring plan, by municipal wastewater treatment plants, and by a state Department of Agriculture investigation of tributaries to the Boise River. Because the lower Boise River is a major tributary to the lower Snake River, phosphorus (total and dissolved) will be examined for possible load and waste load allocations after completion and approval of the lower Snake River and Brownlee Reservoir TMDLs.

2.0 Subbasin Assessment

2.1 Watershed Characterization 17050114

The lower Boise River watershed, Hydrologic Unit Code (HUC) 17050114, is located in southwest Idaho (Figure 1). The watershed drains 1290 square miles of rangeland, forests, agricultural lands, and urban areas. The lower Boise River is a 64 mile stretch that flows through Ada and Canyon counties and the cities of Boise and Caldwell, Idaho. The watershed also drains portions of Elmore, Gem, Payette, and Boise counties. The river flows in a northwesterly direction from its origin at Lucky Peak Dam to its confluence with the Snake River near Parma, Idaho. Major tributaries include Indian Creek, Fivemile Creek, and Tenmile Creek (Figure 2).

Topography of the watershed is diverse, consisting of the Boise Front foothills and mountains which terminate abruptly along the north side of the flat, Boise River valley floor. The area also includes remnants of seven alluvial, step-like terraces (north and south of the river), and a lava plain dotted with several shield volcanos and cinder cones in the southern region of the watershed. Streams flowing off the Boise Front generally flow southwesterly; south of the Boise River, the streams flow northwesterly. Elevation in the watershed ranges from 6575 feet at Boise Peak to 2200 feet at the mouth of the Boise River. Relief varies according to topography; terraces are level while areas of the Boise Front are quite steep (30% to 65% slopes).

Geology

The lower Boise watershed lies within the western Snake River Plain. The rocks within and northeast of the Boise Front are granites of the Idaho batholith. Northern margins of the river valley (foothills area) are basin-fill sediments composed of interbedded gravels, sands, silts, and clays. Multiple terraces that developed throughout the Quaternary period comprise much of the valley. All terrace deposits are pebble to cobble gravel with a coarse sand matrix. Thin wind-blown deposits of loess differentially cover the terrace surfaces. Shield volcanos, basaltic cones, and lava flows bound and cover the southern region of the watershed. Some basalt flows bury former alluvial surfaces and all flows are differentially covered by thin loess deposits (Othberg, 1994).

Soils in the valley are derived predominantly from river and wind born materials. The soils generally have weakly developed profiles, are unleached, alkaline, and have high natural fertility. Soil textures found in the watershed are silty and sandy loams in the river bottoms and terraces and loamy sands and sandy loams in the foothills (Collett, 1980 and Priest and others, 1972).

Figure 1. Location of the lower Boise River watershed.

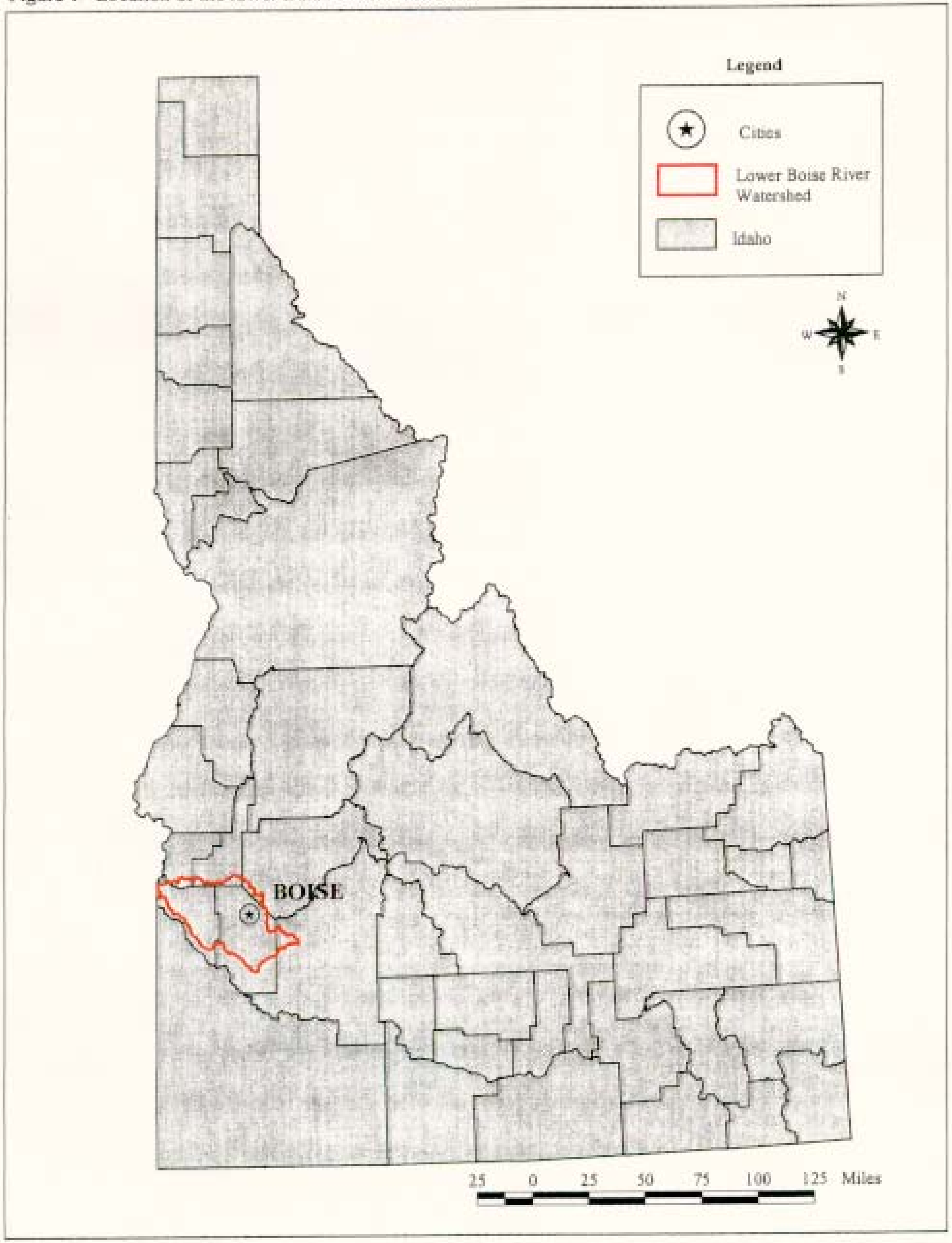
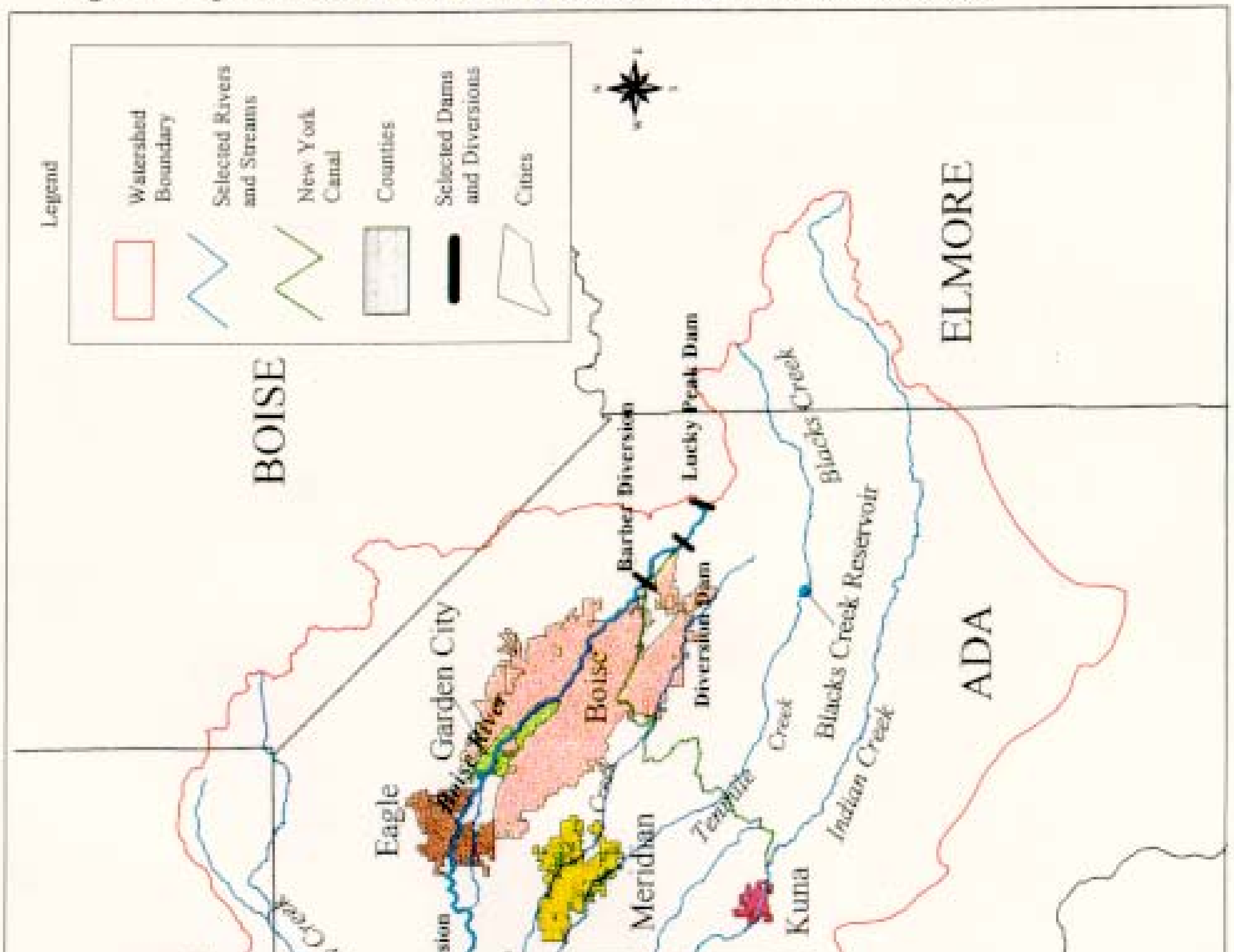


Figure 2. Major cultural features and tributaries in the lower Boise River watershed.



Climate

Climate within the watershed is temperate to arid. The summer months are hot and dry while the winters are cold and wet, though generally not severe. The average summer temperature during the period of 1975-1995 was 70.4°F in Boise, with an average daily maximum temperature of 86.1°F. In winter, the average temperature in Boise from 1975-1995 was 30.9°F and the average daily maximum temperature was 39.0°F (Climate Data Center, 1997). Average annual precipitation of the watershed ranges from about 24 inches at higher elevations of the Boise Front to around 8 inches in the southernmost region of the watershed. Average annual precipitation during the period of 1975 -1996 in Boise was 12.31 inches and 10.59 inches at Parma (Climate Data Center, 1997). Most precipitation falls during the colder months. Snow accumulation is typically light in the lowlands and usually melts shortly after it falls.

Surface Hydrology

The presence of upper Boise (Anderson Ranch and Arrowrock) and lower Boise (Lucky Peak, Diversion Dam, and Barber Dam) reservoirs and dams, numerous diversions, and local flood control policies have significantly altered the flow regime and the physical and biological characteristics of the lower Boise River (Figure 3). Lucky Peak Dam, the structure controlling flow at the upstream end of the watershed, was constructed and began regulating flow in 1957. Water is released from the reservoir to the Boise River just a few miles upstream from Boise. Water releases from the reservoir are managed primarily for flood control and irrigation. Other management considerations include power generation, recreation, maintenance of minimum stream flows during low flow periods and release of water to augment salmon migration flows in the Snake River. Figure 4 shows mean monthly flows for the Boise River below Lucky Peak Dam, United States Geological Survey (USGS) Station 13202000, before construction of Lucky Peak Dam and under current regulated flow conditions. Flow regulation for flood control has replaced natural, short duration (two to three months), flushing peak flows with longer (four to six months), greatly reduced, peak flows. Water management has increased discharge during the summer irrigation season and significantly decreased winter low flows.

The regulated annual hydrograph can be divided into three flow regimes. Low flow conditions generally begin in mid-October when irrigation diversions end. The low flow period extends until flood control releases begin, sometime between the end of January and March. Flood flows generally extend through June, and releases for irrigation control flows from July through mid-October.

Figure 4 shows mean monthly flow for the Boise River near Boise from 1984 through 1996. The current flow management regime began in 1984. The U.S. Bureau of Reclamation (USBR) reserves 102,300 acre-feet of storage to maintain instream flows during the winter low flow period. Storage water provides winter instream flows of 80 cfs from Lucky Peak Dam. The Idaho Fish and Game (IDFG) seeks a minimum target release of 150 cfs for fish protection. IDFG has secured 50,000 acre-feet of storage water in Lucky Peak Reservoir to augment winter low flows. With both of these sources it is frequently possible to maintain winter flows of 240 cfs. Flood season flows for the Boise River below Lucky Peak Dam range from about 2000 to 6500 cfs. Irrigation season flows typically range from 2000 to 4000 cfs.

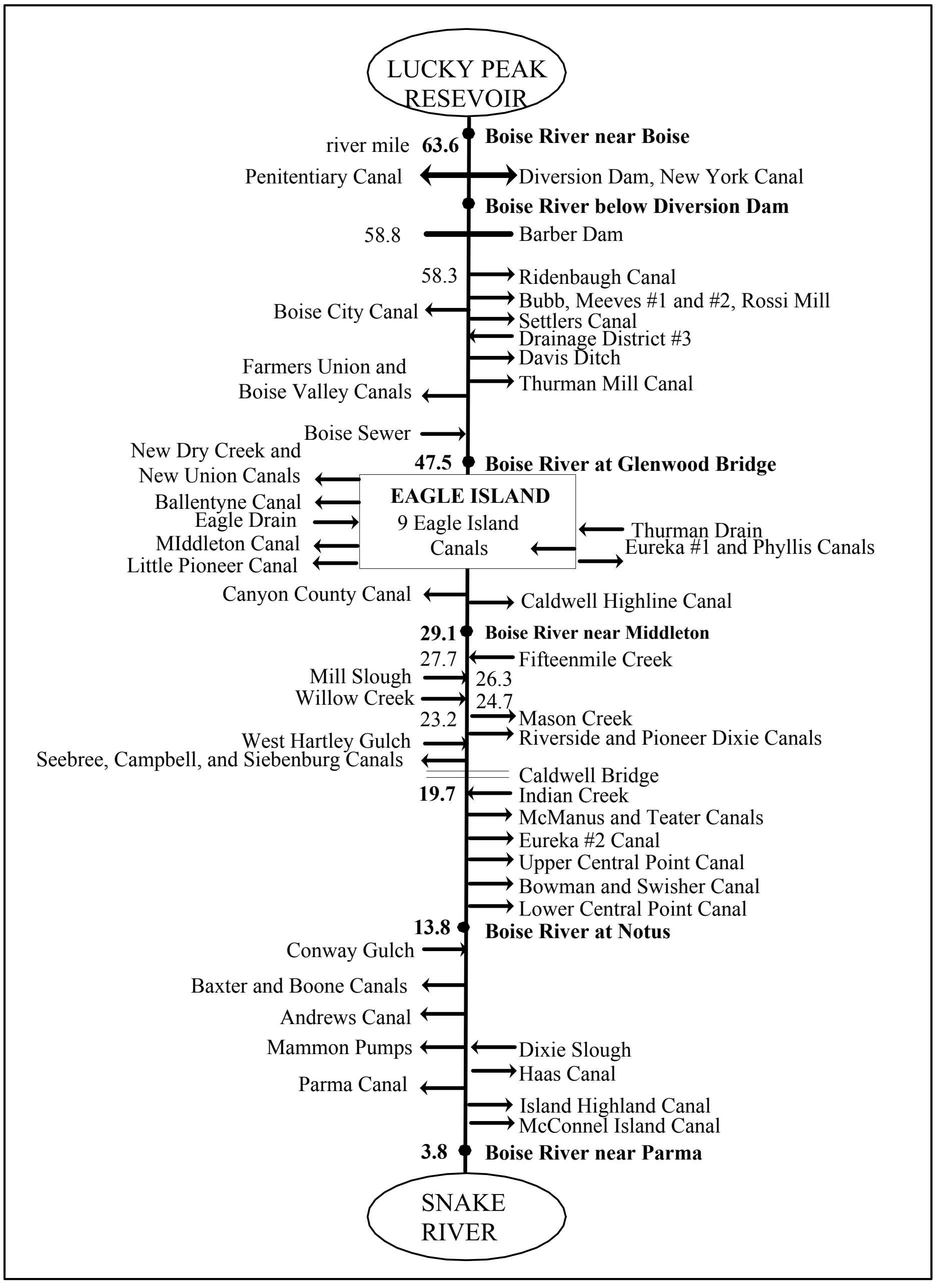


Figure 3. Locations of primary diversions, dams, and drains along the lower Boise River (revised from Warnick and Brockway, 1974). USGS gaging stations in bold type. Diagram is not to scale.

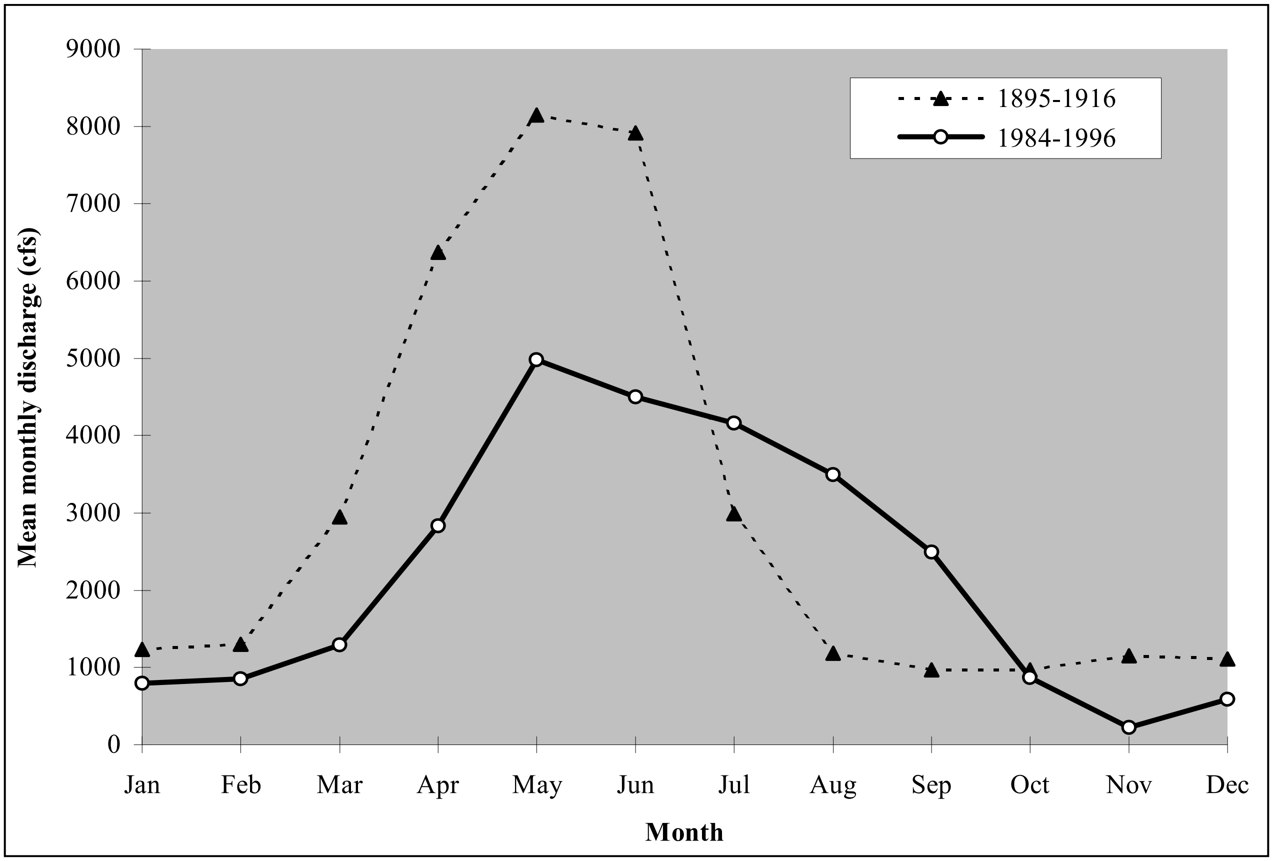


Figure 4. Regulated and unregulated mean monthly discharge in the Boise River near Boise, USGS gaging station 13202000.

Figure 5 shows mean annual discharge in the Boise River near Boise, which is located just below Lucky Peak Dam. The last twenty years of flow records show that a prolonged period of below average flows occurred from 1987 through 1995. After flows returned to near or above the long term average, 1997 proved to be a year of unusually high flows.

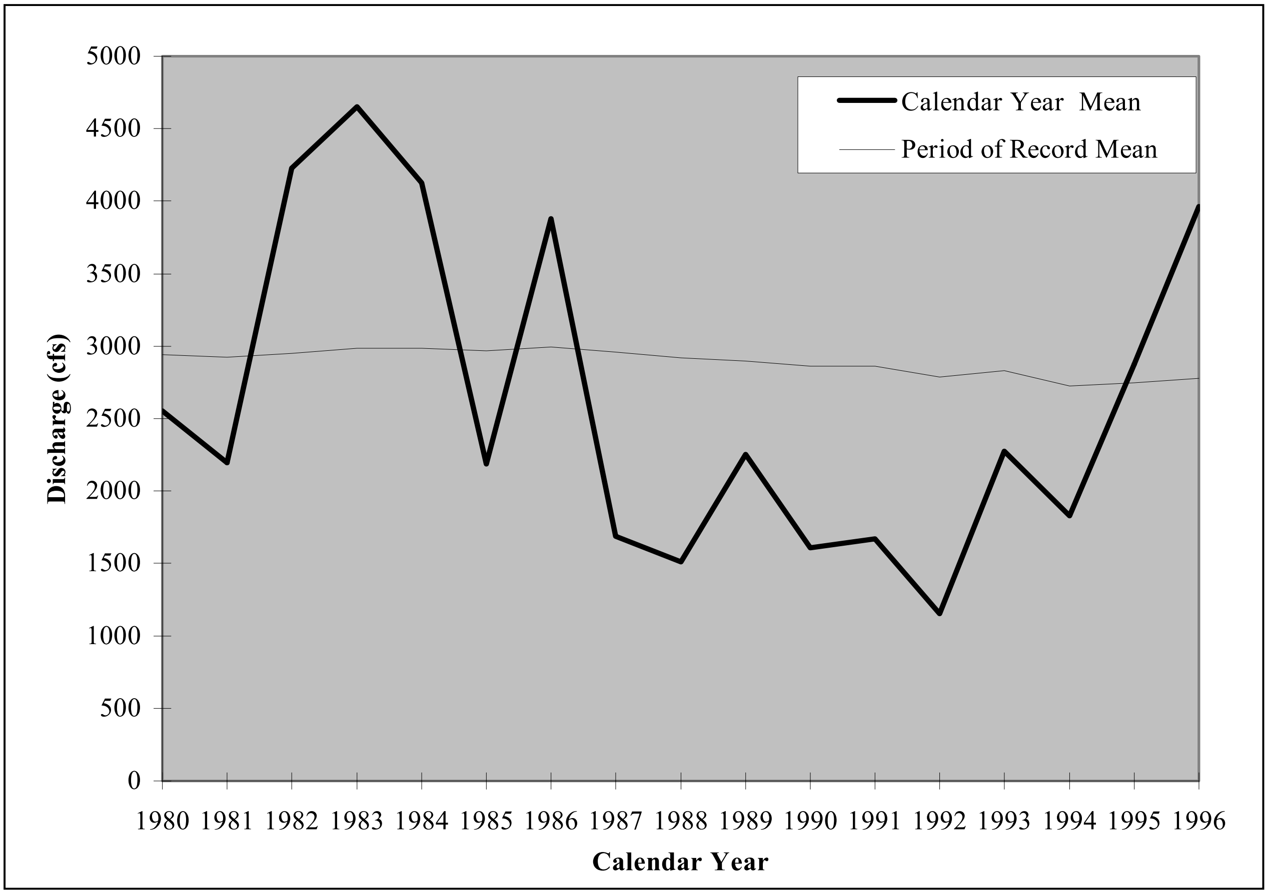


Figure 5. Mean annual discharge, Boise River near Boise (above Diversion Dam), USGS gaging station 13202000.

During the irrigation season, numerous diversions carry water to irrigate fields along the north and south sides of the river. Based on location and quantity of diversions and drains the lower Boise River can be divided in two parts at Middleton. The majority of the water that is diverted from the river is removed beginning at Diversion Dam and ending at the Star Road diversion. Over half of the average annual discharge of the river is diverted before it passes the City of Boise. Most drains return to the river below Middleton. Many return flows join the river in the vicinity of Caldwell, while two other large return flows enter between Caldwell and Parma.

The reach from Middleton to Caldwell usually has the lowest flows during the irrigation season. Figure 6 shows that monthly average flows at Middleton are typically equal to or less than the Lucky Peak Dam release all year round. During the irrigation season, the monthly average flows at Middleton and Parma are significantly less than at the upstream gaging station. In low water years, diversions have reduced instream flows to as low as 200 cfs at Middleton during the irrigation season.

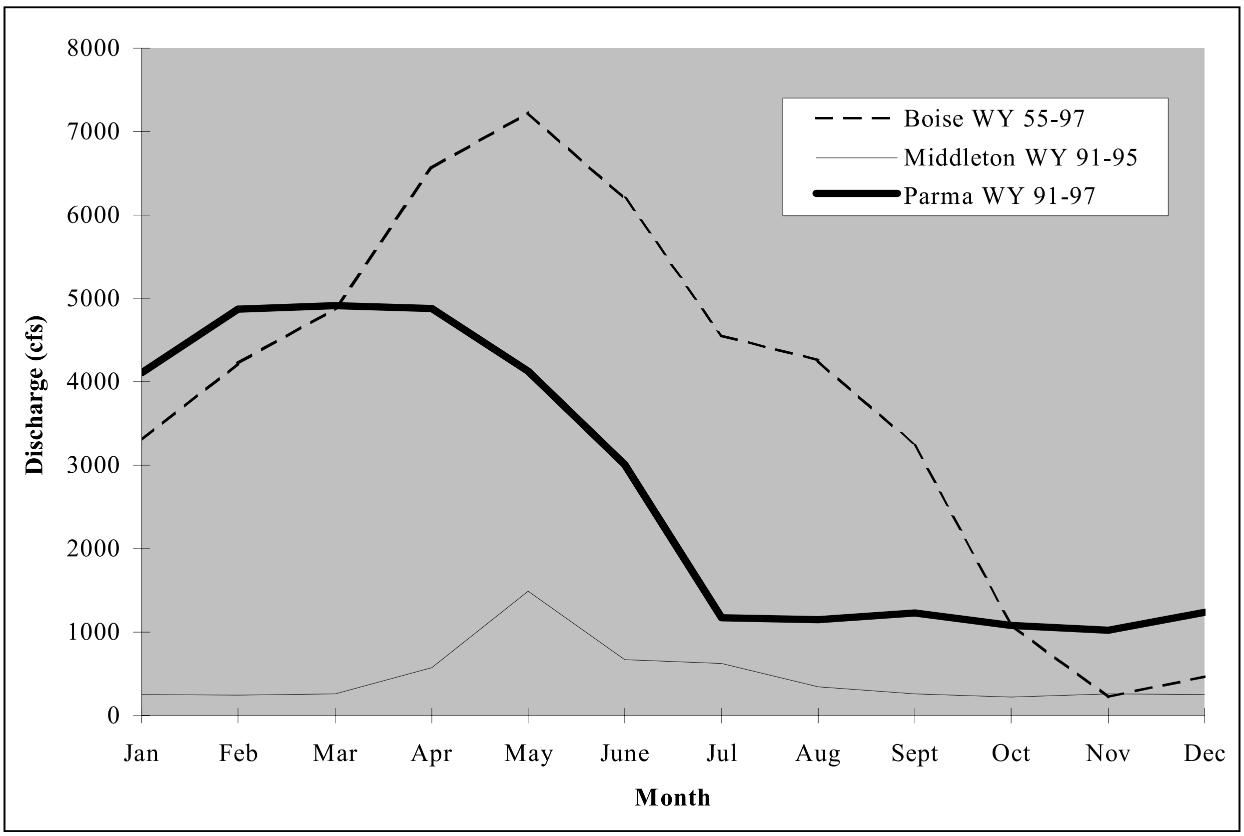


Figure 6. Monthly average discharge in the Boise River at USGS gages near Boise, Middleton, and Parma.

Diversions from the Boise River typically exceed total river discharge in low flow years, because return flows are rediverted for irrigation in a lower stretch of the river. The repeated use and reuse of water is a complicating factor in determining the fate of pollutants discharged to the river and the effects of pollutant reductions at different locations. The shear number of canals and laterals in the watershed suggest the complexity of interpreting flow conditions and pollutant fate (Figure 7).

In addition to affecting river flows, irrigation practices have also altered drainage patterns in the watershed. Water does not follow natural drainage paths in much of the lower Boise valley. Natural drainages in the lowlands and irrigated areas of the valley have been deepened, lengthened, straightened, and diverted while drains, laterals, and canals have been constructed. The stream alterations and man-made waterways have created new drainage areas that are significantly different from the natural subwatershed areas. Figure 8 depicts the current drainage areas of the lower Boise watershed (David Ferguson, unpub. data, 1997). The boundaries were field mapped in the summer of 1997 using 1:24,000 topographic maps.   The subwatersheds are shown in Figure 9. Subwatersheds were delineated by the Idaho Department of Water Resources (IDWR), in cooperation with other agencies, using USGS 1:100,000 hydrography information. Drainage areas delineated by Ferguson will be used for this Total Maximum Daily Load (TMDL) because they more accurately identify the lands contributing to each drain that enters the Boise River.

Figure 7. Lower Boise River watershed surface hydrology.

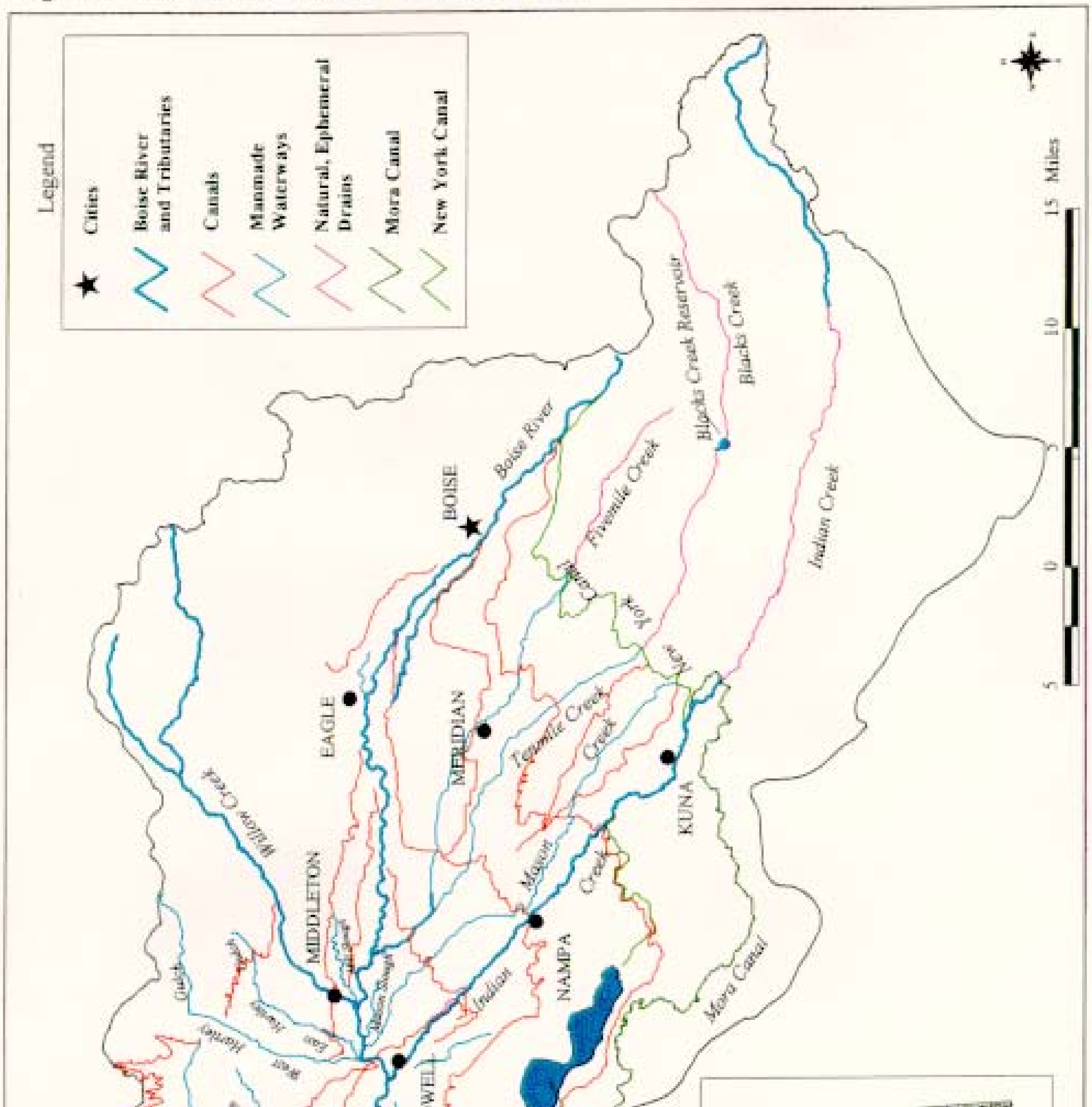


Figure 8. Drainage areas in the lower Boise River watershed.

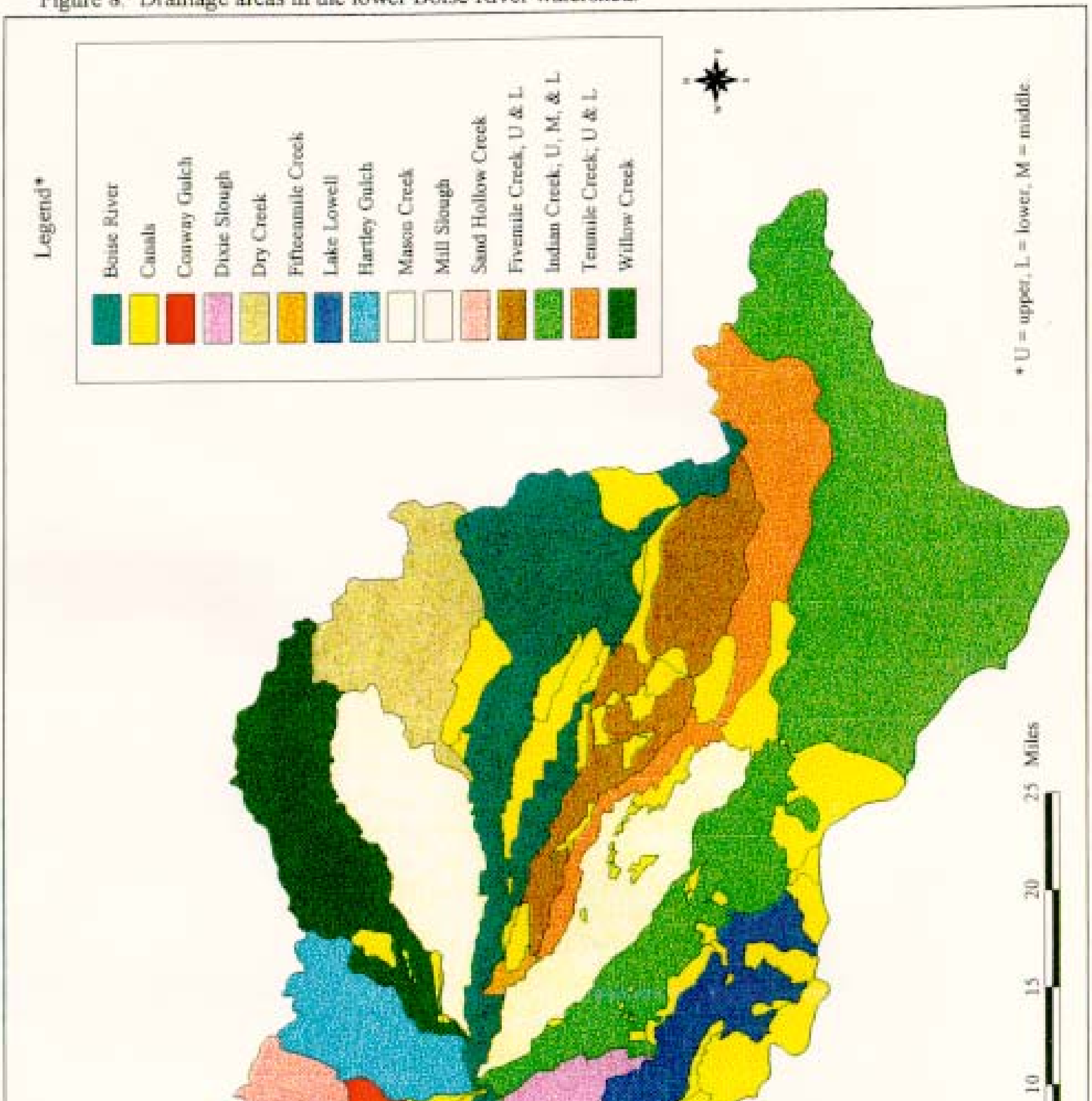
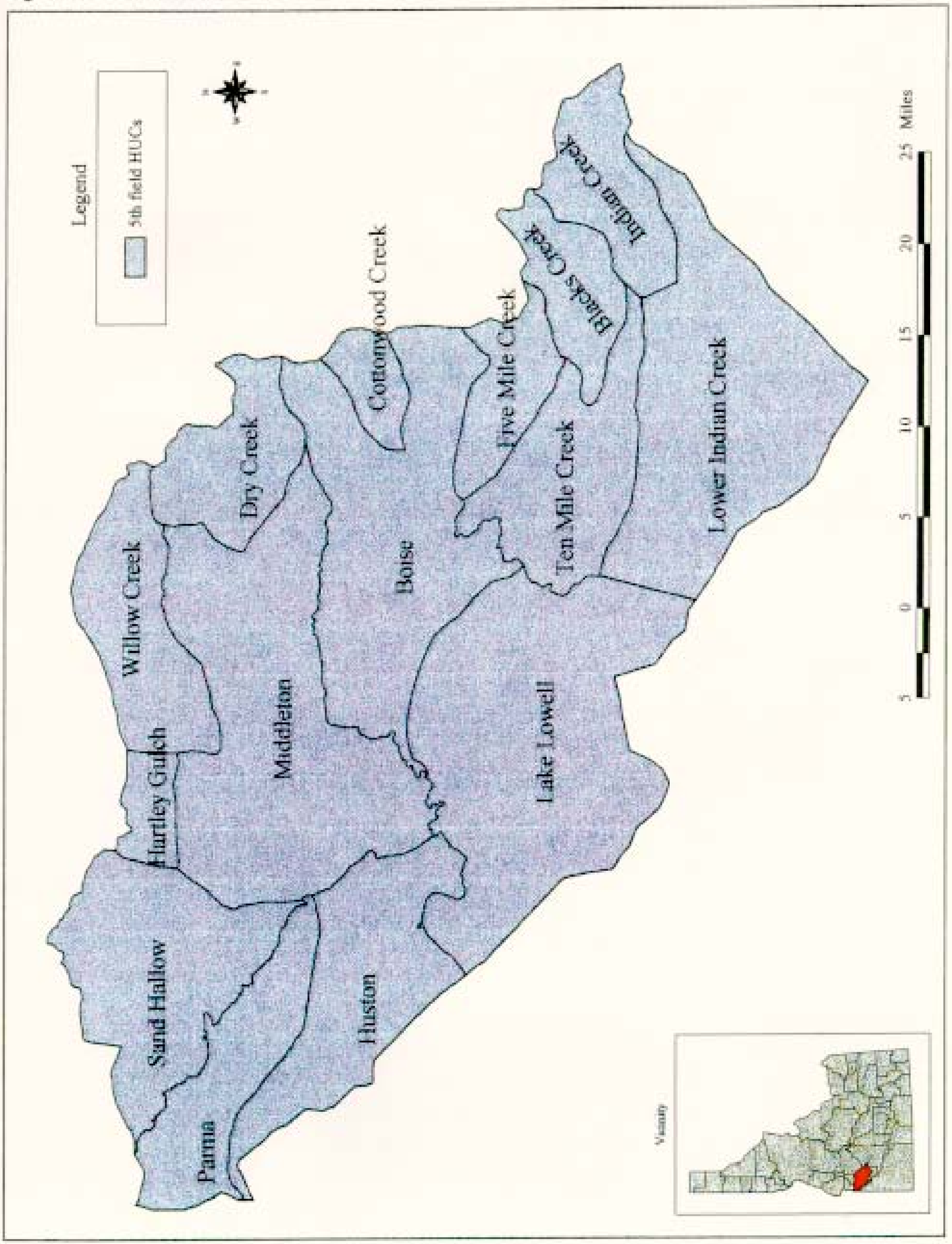


Figure 9. Subwatersheds in the lower Boise River watershed.



Ground Water Hydrology

The lower Boise valley is underlain by two major cold water (less than 85°F) aquifers: 1) the shallow, unconfined Boise River gravel aquifer and 2) deep, semi-confined to confined Idaho Group aquifer. The boundaries of the confined, semi-confined, and unconfined aquifer system are related to changes in the types and occurrence of lake and river sediments, and crustal faulting. Primary water yielding strata are interbedded sand, silt, and claystone of the Idaho Group (Squires and others, 1992). Studies by Dion (1972) and Burnham (1979) show canal seepage and irrigation application as a source of recharge to the shallow aquifer.

Historically, ground water levels were lower than they are today. Starting as early as the 1860's, farmers in the valley started diverting water from the river for irrigation. As the extent of irrigated area increased, large amounts of water were applied to the surface by flood or furrow irrigation methods and ground water levels rose throughout a large part of the valley by tens of feet. High ground water levels began to interfere with soil and crop health. In response, numerous drains were constructed and existing ephemeral drainage ways were deepened and widened in the early 1900's to drain excess ground water.

Ground water levels have been relatively stable in the lower Boise valley since the many drains and wells were dug back in the 1910's and 1920's . Recent studies by Squires and others (1993) and Tungate and Berenbrock (1995) show declining water levels in the Boise City area. Ground water table maps show an average decline of ten feet in 90% of the Boise City area during the period of 1970-1992 (Tungate and Berenbrock, 1995). A slight increase was seen in five small areas around the Boise River and Boise Front. These declines have been attributed to increased ground water withdrawals and artificially induced ground water gradients from long-term wells in southeast Boise and to the west (Squires and others, 1993).

The Boise River both gains and loses ground water depending on location and season. Generally, the river loses water to ground water in the reach above Glenwood Bridge, although it also gains in this reach depending on season and flow conditions. From Glenwood Bridge to the mouth the river generally gains water from ground water. During flood flow conditions between March and June the river may lose water to ground water, when ground water levels are lowest.

Channel and Substrate Characteristics

The valley of the lower Boise River is broad, sloping gently to the northwest with multiple river terraces positioned laterally along its floodplain. The river channel is classified as a type F from Lucky Peak Reservoir to Diversion Dam and a type C from Diversion Dam to its mouth according to the Rosgen classification scheme (Rosgen, 1994). The F type channel is deeply entrenched, low gradient (<0.02), has a high width/depth ratio, and a riffle/ pool morphology. The C type channel is characterized as low gradient (<0.02) and meandering with a riffle/ pool morphology, high width/depth ratio, and a broad, well-defined floodplain. At low flows (fall and winter) the reach from Diversion Dam to the mouth is often a braided, type D channel. The

Boise River has a gradient of 0.002 and width/depth ratios of greater than 30 along its length (Asbridge and Bjornn, 1988).

The river bottom from Lucky Peak Dam to Barber Dam is composed of cobble-size (64 to 256 mm) material and sand-size (<2 mm) sediment. During high flows sand-size sediment builds up behind Diversion Dam. After the irrigation season (mid-October) the gates at the base of Diversion Dam are opened and the sediment is washed downstream. Sediment is retained behind Barber Dam and is flushed downstream only during high flows. Gravel recruitment below Lucky Peak Dam is limited by the presence of the dams thus, the river below Barber Dam is said to be "sediment starved". Cobbles embedded primarily in sand armor the channel bottom from Barber Dam to the River's confluence with the Snake River. Pebble (8 to 64 mm) and sand size material are found in point-bar and transverse bar deposits along the length of the river and the interstices between cobbles.

The Boise River exhibits other characteristics typical of a river with managed flow. Flow regulation has caused narrowing of the river channel and channel degradation immediately downstream of the dam with aggrading conditions further downstream. Braiding and sinuosity are largely absent because the sediment supply and peak flows have been reduced. Channelization and the construction of dikes and levees for irrigation have also contributed to the loss of braiding and sinuosity.

In addition, floodplains of the river are being converted to residential and commercial land use resulting in changes in river morphology, hydrology and water quality. Bank armoring to prevent loss of land during high flow conditions and numerous diversion structures have altered flow instream characteristics.

Biological Characteristics

The lower Boise River is home to numerous species of wildlife. The canopy along the river reach near Barber Dam provides winter roosts for bald eagles. Downstream, Eagle Island hosts a great blue heron rookery (Resource Systems, Inc., 1983). Other birds and mammals living in the lower Boise River corridor include but, are not limited to egrets, ducks, geese, deer, beaver, and muskrat. The river corridor supports two heron rookeries, in the Wood Duck Island subdivision and near the Monroc facility in Eagle.

The lower Boise River supports a natural and stocked fishery. Two reaches, Lucky Peak to Star and Star to the mouth, support distinctly different fish. The river above Star is a cold water fishery composed primarily of the salmonids mountain whitefish, rainbow trout, and brown trout. Above Star the river is regularly stocked with rainbow trout by IDFG. Cool and warm water species dominate the river below Star with suckers, dace, carp, and large and small mouth bass being most abundant. The river below Star supports few if any trout species, however mountain whitefish are seasonally abundant, especially in the fall-winter period.

Cultural Characteristics

The Boise River valley was first explored in 1811 by overland explorers of John Jacob Astor's Pacific Fur company. The Boise valley was settled in 1863. Gold discoveries in 1862 in the nearby mountains prompted the founding of Boise City. Soon thereafter bottomland three to five miles north and south of the Boise River, from Boise to its confluence with the Snake River, was claimed and cultivated. Eventually, settlements such as Caldwell, Notus and Parma emerged along the Boise River.

The first water conveyances were constructed in response to low water years and increased settlement along the river. Small canals were built as early as 1863 by individuals and large groups. The small canals provided water to the bottomlands and low benches of the lower Boise River valley. Early settlement beyond the low benches was uncommon due to the lack of accessible water.

The valley began to change with the coming of the Oregon Shortline Railroad in 1887 and completion of the Phyllis and Ridenbaugh Canals in 1890 and 1891 respectively. The canals provided water to the desert and enabled settlement beyond the Boise River bottomlands. By 1900 it is estimated that 465 miles of canals, ditches, and laterals had been constructed in the Boise Valley, capable of serving 100,000 acres of land (United States Bureau of Reclamation, 1996). The federal Reclamation Act of 1902 allocated funds to support the Boise Project (1904) further reclamation of the Boise Valley. The Boise Project, overseen by the U.S. Bureau of Reclamation, included construction of the following: Diversion Dam (1908), New York Canal (1909 and 1912), Lake Lowell (1909 and 1911), Arrowrock Dam (1915). Additional dams on the lower Boise include Barber Dam (1905) and Lucky Peak Dam (1957).

The Boise Project, completed in 1915, provided irrigation water to many acres beyond the Boise River floodplain. Additional canals and diversions were added throughout the valley to further supplement irrigation efforts by 1927. However, problems with excessive standing water in some areas of the valley began to arise as early as 1910. Nace and others (1957) documented the rise of ground water levels of 140 feet or more between 1914 and 1953 in some parts of the valley. To combat the rising water table, ditches were dug (325 miles by 1953) and pumps were installed to drain excess ground water (Nace and others, 1957).

Passage of the Clean Water Act in 1972 brought about reductions in point source discharges of pollutants through the National Pollutant Discharge Elimination System (NPDES) permitting program. The permit program is used to control and monitor point sources that discharge into waters of the United States. Major point sources discharging to the lower Boise River and its tributaries are shown in Table 1.

Table 1. Municipal wastewater treatment plants (WWTP) and selected major point sources discharging to the lower Boise River and its tributaries.

Point Source	Design/Permit Flow (MGD)	Receiving Water
City of Boise - Lander Street	15	Boise River
City of Boise - West Boise WWTP	24	Boise River, South Channel
City of Meridian WWTP	2.82	Fivemile Creek and Boise River
Star Water and Sewer District	0.33	Lawrence-Kennedy Canal
City of Nampa WWTP	11.76	Indian Creek
City of Middleton WWTP	1.83	Boise River
City of Caldwell WWTP	8.48	Boise River
City of Wilder WWTP	0.075	Wilder Ditch Drain
City of Notus WWTP	0.056	Conway Gulch
City of Parma WWTP	0.31	Sand Hollow Drain
IDFG Fish Hatchery	20	Wilson Drain
Armour Fresh Meats	0.475	Indian Creek

The lower Boise River is a natural resource used by everyone in the community. Consumptive use of the lower Boise River is primarily for irrigation of agricultural cropland. The river also serves as a water supply for the city of Boise and industries of the valley. Within the city of Boise, the river is a focal point for recreational use. Activities such as swimming, floating the river in inner tubes, rafting, kayaking and fishing are common on the river during the summer and fall. Adjacent to the river is the Boise River greenbelt which is used by many for walking, biking, and rollerblading.

Demographics and Economics

The lower Boise River watershed has experienced rapid population growth over the last decade. Ada County was one of the fastest growing counties in the United States from 1990 to 1996 with population increases of more than 25%. Population increased over 14% in Canyon County for the period of 1990 to 1996. Population projections for the two counties show continued growth at slower rates. According to the Ada Planning Association (1997), the population of Ada County for 1996 was 260,543 with projected populations of 284,269 for the year 2000 and 366,497 for the year 2020. Canyon County population in 1996 was estimated to be 102,840 and is projected to be 125,429 in the year 2000 and 188,215 in the year 2020 (APA, 1997). By year 2005, Ada and Canyon counties will likely represent one-third of the state's population.

Primary economic centers of the watershed are located in Ada and Canyon Counties. Ada County is a government, corporate headquarters and financial center. Canyon County has a strong agricultural base and is an important center for production and processing of agricultural goods.

Land Ownership and Land Use

Land ownership in the watershed is a mixture of federal, state, county, municipal and private ownership. Ada County is 47% private and 45% federal, in contrast to Canyon county which is 93% privately owned. Land use in the watershed is shown in Figure 10 and Table 2. Rangeland comprises 51% of the watershed; irrigated croplands and pasture together comprise 31%. Throughout the watershed, especially Canyon and Ada Counties, agricultural lands are being converted to suburban residential and commercial land use. An example of the land conversion trend is seen in Canyon County, where the number of very small farms or ranchettes (less than 10 acres) increased by nearly 40% during the period of 1978 to 1987 (Canyon County, 1995).

Figure 10. Land use/land cover in the lower Boise River watershed (modified from IDWR 1994 data).

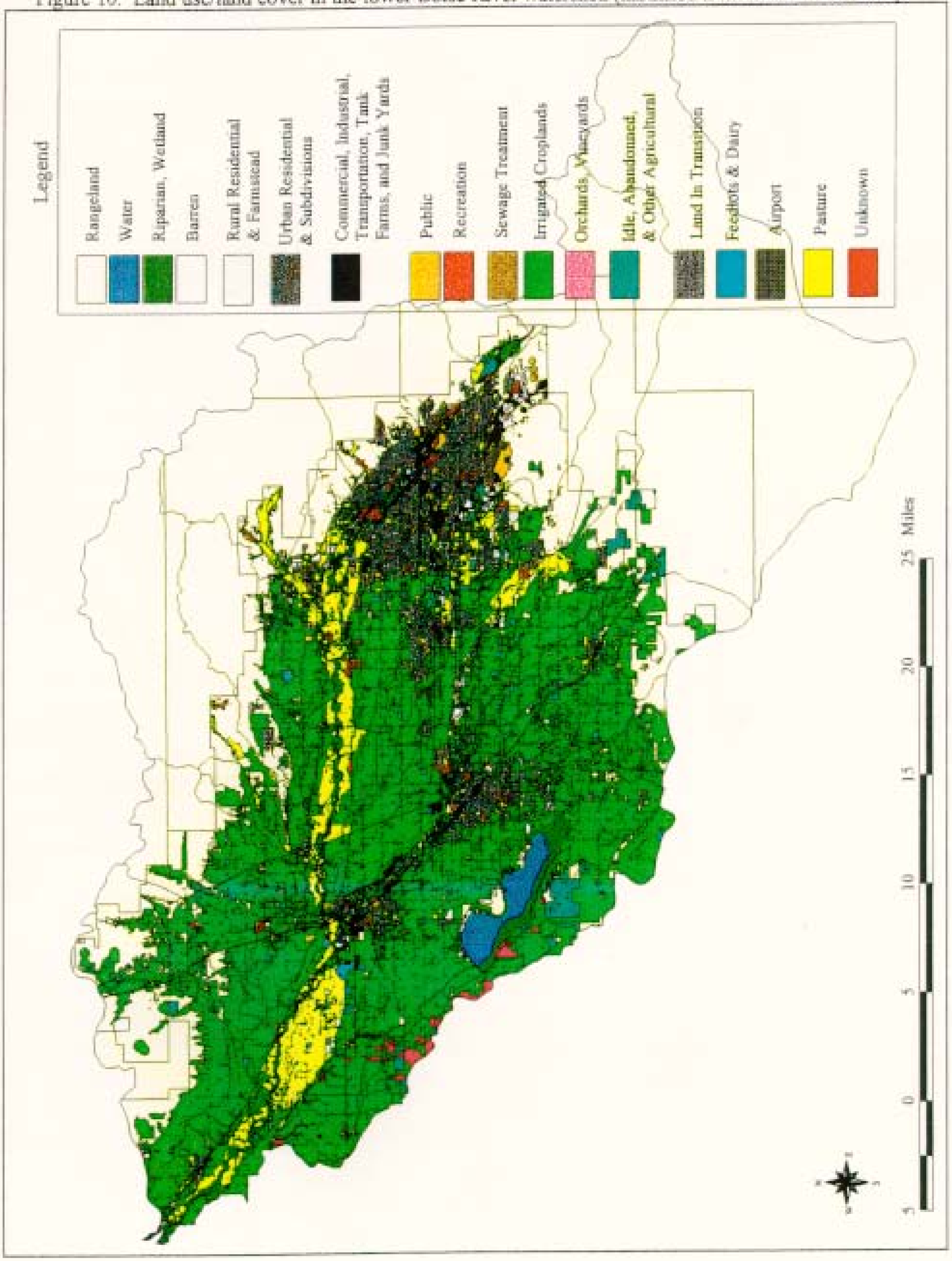


Table 2. Land use in the lower Boise River watershed.

Land Use/Land Cover	Acres	Percent of Total Area
Rangeland	425,731	50.7
Water	8,154	1.0
Riparian, Wetland	12,994	1.5
Barren (without vegetation)	4,377	0.5
Rural Residential and Farmstead	23,199	2.7
Urban Residential and Subdivisions	30,132	3.5
Commercial, Industrial and Transportation	15,672	1.8
Public (parks, schools, churches, hospitals, cemeteries, state and federal facilities)	4,018	0.5
Recreation	3,745	0.4
Sewage Treatment	560	0.1
Irrigated Cropland	245,653	29.3
Orchards and Vineyards	2,892	0.3
Idle, Abandoned and Other Agriculture	18,778	2.2
In Transition	3,623	0.4
Feedlots and Dairies	3,208	0.4
Airports	807	0.1
Pasture	33,220	4.0
Unknown	113	<0.1

Public Involvement

Two groups within the lower Boise Valley are actively working to enhance the health and environment of the lower Boise River. The Lower Boise River Water Quality Plan (LBRWQP) was initiated in 1992 by stakeholders interested in water quality in the river, and was designated as the Watershed Advisory Group (WAG) for this watershed in July 1996. As the WAG, the group is responsible for advising the Idaho Division of Environmental Quality (DEQ) on the development of TMDLs in the watershed. Boise River 2000 focuses on issues related to the management of water quantity and flood control. Both groups are comprised of representatives from local and state government, environmental and recreation groups, agriculture, industry, flood control and drainage districts and concerned citizens. The primary goal of each group is to help improve and maintain the overall quality of the Boise River.

2.2 Water Quality Concerns and Status

Four segments of the lower Boise River are listed on the 1996 Section 303(d) list for the state of Idaho. The four segments and the pollutants identified for each segment are summarized in Table 3. Figure 11 shows the location of the listed segments. Table 3 also identifies the pollutants that are proposed for removal from the 1998 Section 303(d) list because they were determined not to be impairing beneficial uses. The memorandum recommending delisting dissolved oxygen (DO) and oil and grease and the supporting documentation is included in Appendix A.

Table 3. Summary of Section 303(d) listed stream segments the lower Boise River.

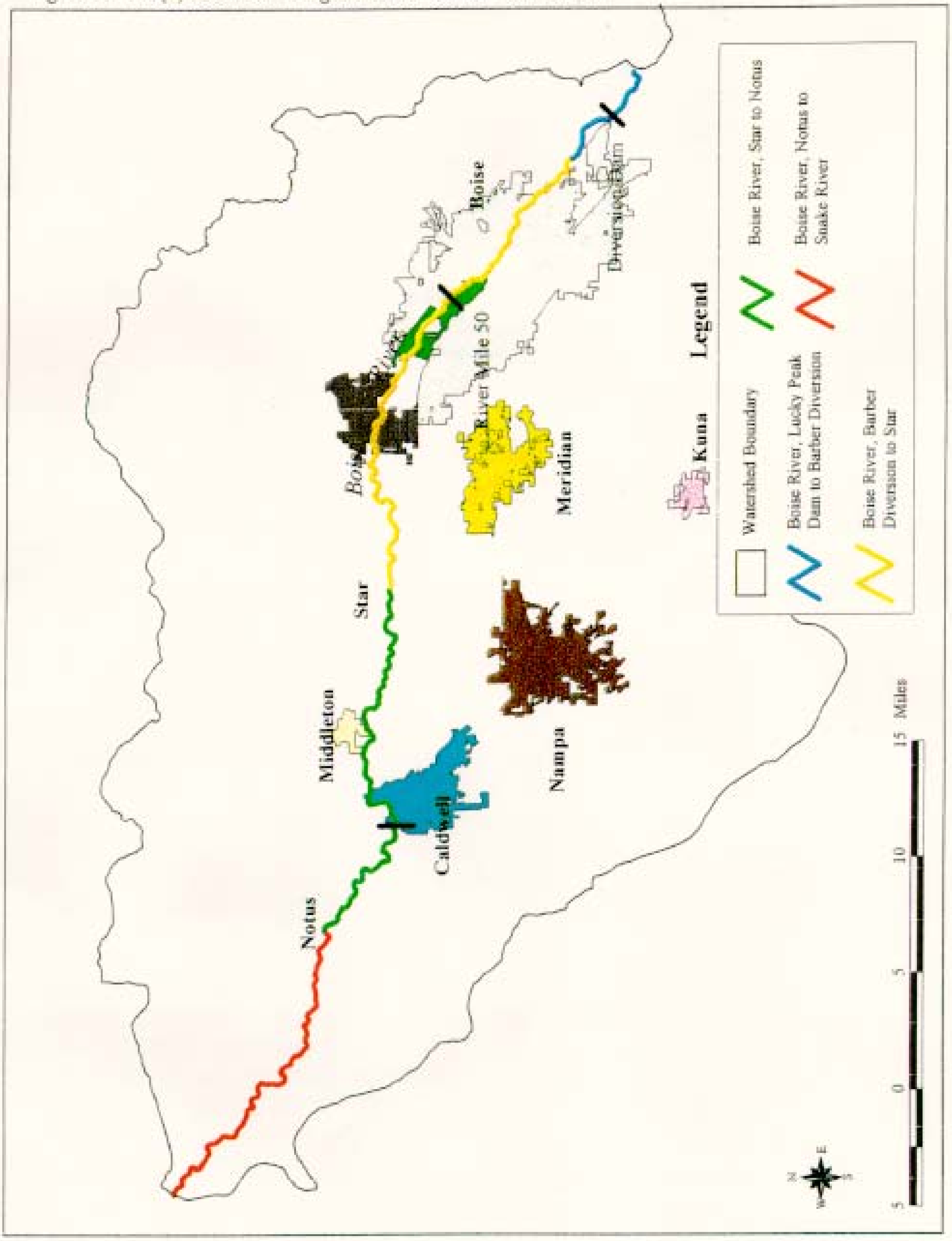
NAME	BOUNDARIES	POLLUTANTS 1996 303(d) list	Pollutants Delisted in 1998
Boise River	Lucky Peak Dam to Barber Diversion	Flow Alteration	
Boise River	Barber Diversion to Star	Sediment, DO, Oil & Grease	DO, Oil & Grease
Boise River	Star to Notus	Nutrients, Sediment, DO, Temperature, Bacteria	DO
Boise River	Notus to Snake River	Nutrients, Sediment, DO, Pathogens, Temperature	DO

Surface Water Beneficial Use Classifications

Surface water beneficial use classifications are intended to protect the various uses of the state's surface water. Idaho waterbodies that have designated beneficial uses are listed in Idaho's Water Quality Standards and Wastewater Treatment Requirements. They are comprised of five categories: aquatic life, recreation, water supply, wildlife habitat and aesthetics.

Aquatic life classifications are for waterbodies that are suitable or intended to be made suitable for protection and maintenance of viable aquatic life communities of aquatic organisms and

Figure 11. 303(d) listed stream segments for the lower Boise River.



populations of significant aquatic species. Aquatic life beneficial uses include cold water biota, warm water biota and salmonid spawning.

Recreation classifications are for waterbodies which are suitable or intended to be made suitable for primary and secondary contact recreation. Primary contact recreation is prolonged and intimate human contact with water where ingestion is likely to occur, such as swimming, water skiing and skin diving. Secondary contact recreation consists of recreational uses where raw water ingestion is not probable, such as wading and boating.

Water supply classifications are for waterbodies which are suitable or intended to be made suitable for agriculture, domestic and industrial uses. Industrial water supply applies to all waters of the state. Wildlife habitat waters are those which are suitable or intended to be made suitable for wildlife habitat. Aesthetics is a use that applies to all waters of the state.

IDAPA 16.01.02.140 designates beneficial uses for selected waterbodies in the Southwest Idaho Basin. Undesignated waterbodies are presumed to support cold water biota and primary or secondary contact recreation unless the Department of Health and Welfare, Idaho Division of Environmental Quality determines that other uses are appropriate.

Beneficial Uses of the Lower Boise River

Beneficial uses are designated in IDAPA 16.01.02.140 for three segments of the Boise River below Lucky Peak Dam. The designated uses for each segment are shown in Table 4. IDAPA 16.01.02.140.03 modifies the designations shown in Table 4, specifying that the Boise River from Lucky Peak Dam to Diversion Dam is not protected for salmonid spawning. The boundaries for lower Boise River segments on the Section 303(d) list do not correspond to the boundaries for the designated uses. Figure 11 shows the listed stream segments.

In addition to designated uses, waterbodies are also protected for existing uses. Secondary contact recreation is an existing use in the Boise River in the segment from River Mile 50 to Caldwell. Data collected by the USGS in December 1996 and August 1997 suggest that salmonid spawning is an existing use for the Boise River from Caldwell to the mouth. Fish sampling showed mountain whitefish present on both dates and the December 1996 sampling included multiple age classes of mountain whitefish. Mountain whitefish typically spawn between October and March. The presence of warm and cool water species, such as large and small mouth bass and catfish, in the Boise River from Caldwell to the mouth indicate that warm water biota is also an existing use in this reach.

The Boise River from Lucky Peak Dam to River Mile 50 is also designated as a Special Resource Water. Designation as a Special Resource Water affords this segment additional protection from pollutants discharged by point sources.

Table 4. Designated beneficial uses for the Boise River below Lucky Peak Dam.

Segment	Designated Uses
Boise River, Lucky Peak Dam to River Mile 50 (Veteran's Parkway)	Domestic Water Supply Agricultural Water Supply Cold Water Biota Salmonid Spawning Primary Contact Recreation Secondary Contact Recreation
Boise River, River Mile 50 (Veteran's Parkway) to Caldwell	Agricultural Water Supply Cold Water Biota Salmonid Spawning Primary Contact Recreation
Boise River, Caldwell to mouth	Agricultural Water Supply Cold Water Biota Primary Contact Recreation Secondary Contact Recreation

Applicable Water Quality Criteria

The Idaho Water Quality Standards and Wastewater Treatment Requirements contain numeric criteria necessary to protect beneficial uses. The following water quality criteria are applicable to the pollutants of concern listed on the 1998 Section 303(d) list for existing and designated uses on the Boise River.

Bacteria

Both primary and secondary contact recreation beneficial uses have associated numeric criteria in Idaho's Water Quality Standards and Wastewater Treatment Requirements.

primary contact recreation (May 1 - September 30) fecal coliform bacteria colonies:

- may not exceed 500/100 ml at any time;
- may not exceed 200/100 ml in more than 10% of the total samples taken over a thirty day period; and
- may not exceed a geometric mean of 50/100 ml based on a minimum of five samples taken over a thirty day period (IDAPA 16.10.02.250.01.a).

secondary contact recreation (all year) fecal coliform bacteria colonies:

- may not exceed 800/100 ml at any time;
- may not exceed 400/100 ml in more than 10% of the total samples taken over a thirty day period; and
- may not exceed a geometric mean of 200/100 ml based on a minimum of five samples taken over a thirty day period (IDAPA 16.01.02.250.01.b).

Sediment

Sediment shall not exceed quantities specified in 250., or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Sub 350.02.b (IDAPA 16.01.02.200.08).

Turbidity

For cold water biota, turbidity below any applicable mixing zone set by the Department of Health and Welfare, Idaho Division of Environmental Quality, shall not exceed background turbidity by more than 50 Nephelometric Turbidity Units (NTU) instantaneously or more than 25 NTU more than 10 consecutive days (IDAPA 15.01.02.250.02.c.iv).

Nutrients

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 16.01.02.200.06).

Temperature

For warm water biota, waters are to exhibit the following characteristics:

> Water temperatures of 33° C or less with a maximum daily average no greater than 29° C. (IDAPA 16.01.02.250.02.b.ii).

For cold water biota, waters are to exhibit the following characteristics:

> Water temperatures of 22° C or less with a maximum daily average no greater than 19° C. (IDAPA 16.01.02.250.02.c.ii).

For salmonid spawning, waters are to exhibit the following characteristics during the spawning and incubation period for the particular species inhabiting those waters:

> Water temperatures of 13° C or less with a maximum daily average no greater than 9° C. (IDAPA 16.01.02.250.02.d.ii).

Criteria for salmonid spawning are applicable only during the time period listed in IDAPA 16.01.02.250.02.d.iv for the species inhabiting the waterbody. The time periods that apply for species in the Boise River are: rainbow trout, January 15 to July 15; brown trout, October 1 to April 1; mountain whitefish, October 15 to March 15.

Summary and Analysis of Existing Water Quality Data

Numerous sources of data are available within the lower Boise River watershed to describe physical and chemical water quality, biological communities, habitat, geology, and climate. Geologic studies of the Treasure Valley are available, dating to the late 1800's. The Idaho Climate Data Center routinely records weather information at three sites in the Treasure Valley. At some sites, climate records date back to the turn of the century. The USGS has collected flow and water quality data in the Boise River below Diversion Dam, Glenwood Bridge (at Boise), near Middleton and near Parma from the early 1970's to the present. Specific dates and monitoring sites are shown in Table 5 and on Figure 12. Water quality data have also been collected by USBR, and municipalities with NPDES permits for wastewater treatment plants and stormwater discharge. For example, Boise conducts quarterly monitoring at three sites along the river, while Meridian collects daily temperature and chlorine information in the South Channel of the river around Eagle Island during discharges. The ConAgra, Armour Fresh Meats facility in Nampa also collects water quality information in Indian Creek pursuant to its NPDES permit.

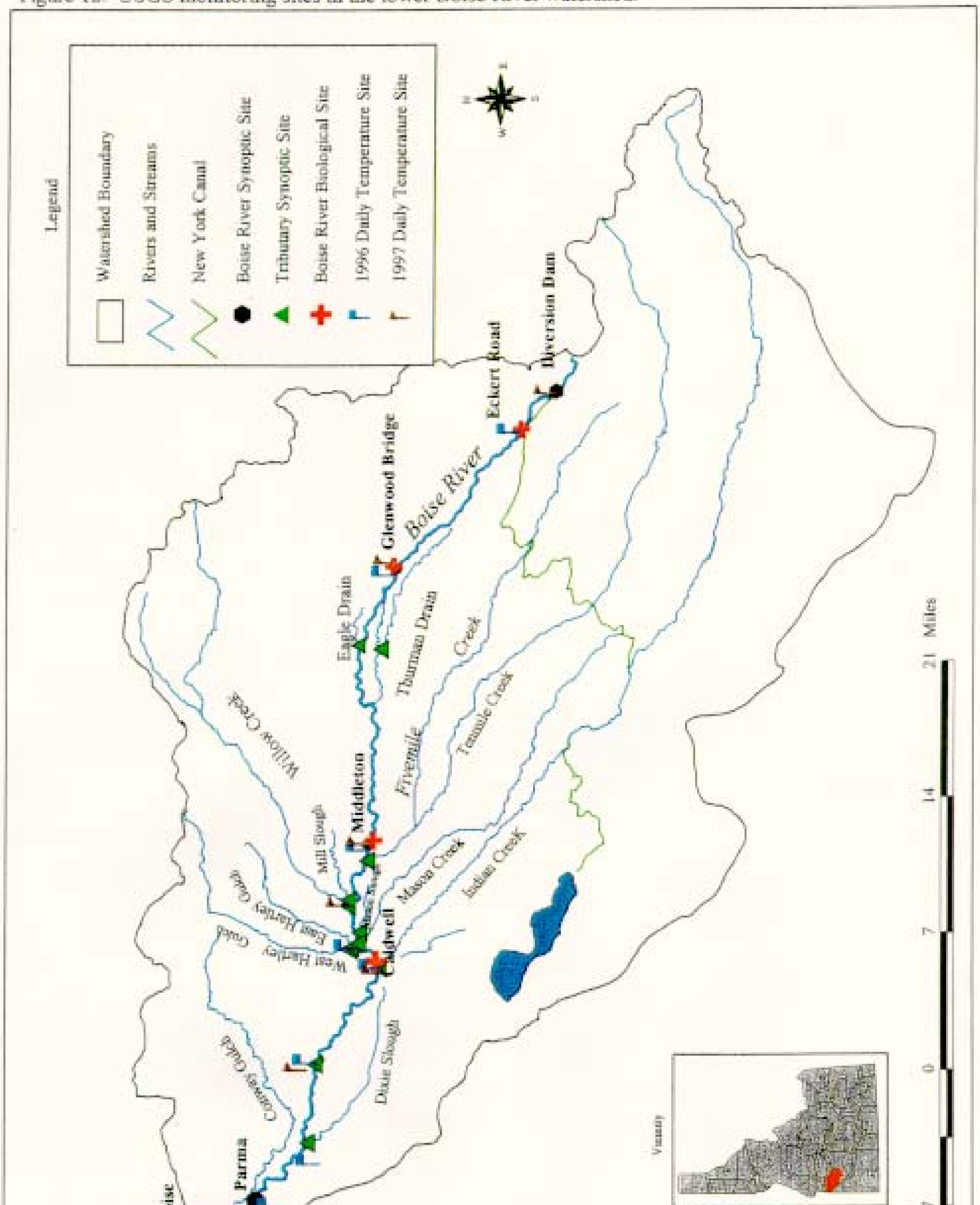
Recent data collected by the USGS from the Boise River and selected tributaries is part of a multi-year monitoring plan jointly funded by DEQ, LBRWQP and the USGS. The monitoring project includes collection of water quality data from four Boise river sites and twelve tributaries, aquatic biology data from five river sites and habitat data from three river sites at Eckert Road, near Middleton and at the mouth. The USGS monitors at the mouth of the following tributaries to the Boise River: Eagle Drain, Thurman Drain, Mill Slough, Fifteenmile Creek, Mason Slough, Mason Creek, Willow Creek, East and West Hartley Gulch, Indian Creek, Conway Gulch and Dixie Drain. Tributary monitoring for general water quality parameters (six times per year) began in 1994 and continues to the present.

The USGS also collects data about the abundance, makeup and distribution of fish populations in the river, benthic macroinvertebrates, and algae. The USGS began biological monitoring in 1995, and collects samples once per year at Eckert Road, Glenwood Bridge, Middleton, Caldwell, and Fort Boise (the mouth of the river). IDFG has collected data on fish populations and aquatic habitat, primarily for the reach of the river between Barber Park and Star where there is extensive angling pressure. Habitat assessments are few and limited to the river near the City of Boise. Asbridge and Bjornn (1988) evaluated habitat conditions in the river above Star. With the exception of data collected by the USGS in 1997, very little quantified information about habitat is available downstream of Star. DEQ must use water quality, fish and benthic macroinvertebrate data to infer habitat conditions where other data are not available.

Table 5. Dates of water quality and biological monitoring data at USGS sampling sites.

Site	Water Quality Monitoring Dates	Biological Monitoring Dates
Diversion Dam	Nov. 1990 to Sept. 1991 Oct. 1992 to the present	NONE
Eckert Road	NONE	Oct. 1995, Oct. 1996, Aug. 1997
Glenwood	Oct. 1970 to Sept. 1973 Oct. 1987 to Sept 1988 Oct. 1989 to the present	Oct. 1995, Oct. 1996, Aug. 1997
Middleton	Oct. 1976 to Sept. 1977, Nov. 1991 to the present	Oct. 1995, Oct. 1996, Aug. 1997
Caldwell	Temperature only, 1996,1997	Oct. 1995, Oct. 1996, Aug. 1997
Parma	Various dates 1973 to 1976 Oct. 1986 to the present	NONE
Fort Boise	NONE	Oct. 1995, Oct. 1996, Aug. 1997

Figure 12. USGS monitoring sites in the lower Boise River watershed.



Water Quality Problems

DEQ used the lower Boise River water quality, biological, and habitat data to assess the support status beneficial uses in the river. The concentrations of listed pollutants in relation to applicable criteria are used to assess the status of beneficial uses and pollutants contributing to impairment. Evaluation of fish, benthic macroinvertebrates and habitat give additional direct and indirect information about the status of aquatic life uses. In any location where criteria listed pollutants are exceeded on an ongoing basis, a beneficial use is likely to be impaired. If beneficial uses are impaired by a Section 303(d) listed pollutant, a TMDL for that pollutant is required.

Contact Recreation

The Boise River is listed for bacteria from Star to Notus, and from Notus to the Snake River. Bacteria data indicate that primary (May 1 to September 30) and secondary (year round) contact recreation beneficial uses are not fully supported from Star to Notus and Notus to the Snake. Fecal coliform bacteria, monitored by the USGS since November of 1991 in the Boise River near Middleton, exceeded primary contact recreation criteria three times and exceeded secondary contact recreation criteria once (Table 6). Data collected by the USGS near Parma from 1986 to the present show that bacteria exceeded the secondary contact recreation instantaneous criterion fourteen times, and exceeded the primary recreation instantaneous criterion twenty one times (Table 7). A TMDL is needed for bacteria in the Boise River from Star to the Snake River. A more detailed assessment of bacteria data is included in Appendix B.

Table 6. Dates when fecal coliform bacteria exceeded applicable criteria in the Boise River near Middleton.

Date	Fecal Coliform Bacteria, #/100 ml at Middleton
5/15/96	k630 (p)*
8/22/96	640 (p)
8/11/97	830 (p/s)

(p) = primary contact recreation criteria exceeded;
(s) = secondary contact recreation criteria exceeded;
*k = estimated value

Table 7. Dates when fecal coliform bacteria exceeded applicable criteria in the Boise River near Parma.

Date	Fecal Coliform Bacteria, #/100 ml	Date	Fecal Coliform Bacteria, #/100 ml
5/28/87	2000 (p/s)	5/10/94	1000 (p/s)
5/23/88	1000 (p/s)	8/16/95	k670 (p)*
7/20/88	k1000 (p/s)*	5/17/96	3000 (p/s)
5/8/89	1100 (p/s)	6/10/96	k3600 (p/s)*
5/21/90	980 (p/s)	8/21/96	k2400 (p/s)*
7/12/90	510 (p)	5/22/97	960 (p/s)
1/16/91	1000 (s)	7/18/97	610 (p)
5/20/91	540 (p)	8/12/97	1100 (p/s)
9/10/91	620 (p)	5/13/98	>3400 (p/s)
5/12/92	780 (p)	7/15/98	640 (p)
5/13/93	590 (p)	8/18/98	510 (p)
3/1/94	k1000(s)*		

(p) = primary contact recreation criteria exceeded;
(s) = secondary contact recreation criteria exceeded;
*k = estimated value

Aquatic Life

The lower Boise River from Lucky Peak Dam to the confluence with the Snake River is designated for cold water biota. In addition, the part of the river that extends from the Diversion Dam to Caldwell is designated for salmonid spawning. Recent data indicate that salmonid spawning is likely an existing use in the river from Caldwell to the mouth. The condition of fish and benthic macroinvertebrates in the Boise River indicate that cold water biota and salmonid spawning uses are impaired in all segments of the river. Temperature and sediment are the pollutants causing impairment of aquatic life. In addition, flow alteration and habitat conditions impair aquatic life uses in the Boise River. A more detailed evaluation of aquatic life conditions in the lower Boise River is included in Appendix C.

Benthic Macroinvertebrates

Aquatic insects and worms, as a group called benthic macroinvertebrates, are useful indicators of habitat and water quality conditions. Benthic macroinvertebrates are important consumers of algae and detritus in streams, and are a food source for many species of fish. In the Boise River, benthic macroinvertebrate data are available from the USGS for five sites sampled in October of 1995 and 1996. The sites include Eckert Road, Glenwood Bridge, Middleton, Caldwell, and Fort Boise (near the mouth of the river).

Habitat and water quality conditions can be inferred from the numbers and types of pollution tolerant and pollution intolerant organisms present at a site. Benthic macroinvertebrate data indicate that the Boise River has degraded habitat from Eckert Road to its mouth, with habitat conditions for benthic organisms generally declining to a low point near Middleton and Caldwell. Physical and chemical water quality conditions in the Boise River, with the exception of temperature, probably have little effect on the benthic community (B. Mullins, 1997, personal communication).

Interpretation of benthic macroinvertebrate data is based on a guide published by Aquatic Biology Associates (Wisseman, 1996). High predator richness is an indication of a healthy stream, as is an increasing number of scrapers relative to another site in the same river. An abundance of Ephemeroptera, Plecoptera, and Tricoptera (EPT taxa) is an indicator of high predator richness. EPT taxa are generally most rich in cold, clean waters with good quality gravel substrates. When collector-gatherer organisms represent a disproportionately large percentage of the total population at a site, conditions are generally degraded by nutrient and organic loading. Specific organisms can also be useful indicators of habitat and water quality conditions. Intolerant stoneflies (Plecoptera) are generally present in large numbers only where water temperatures are cold and fine sediments are minimal. Naididae are worms that tolerate fine sediment substrates. Tricorythodes minutus is a tolerant organism that increases in abundance and percent of the total population as habitat and water quality conditions decline.

The lower Boise River habitat and temperature conditions are degraded with respect to the health of the benthic community, as indicated by the USGS samples from 1995 and 1996. In the upper reaches, benthic macroinvertebrates are adversely affected by high levels of embeddedness and heavily armored substrate. The limited number of Plecoptera present in the lower reaches of the river are probably due to lack of good gravel substrates and warm temperatures. The limited number of EPT taxa at all sites, and the decline of the EPT taxa from Eckert Road to the mouth of the river also suggest degraded conditions. The benthic data at the mouth of the river do not consistently indicate that conditions near Fort Boise are better or worse than at the upstream sites.

In 1995 and 1996, predator species were a small percent of the total benthic macroinvertebrate population at all sites, never exceeding 4.5%. Scraper species represented four to 7% of benthic macroinvertebrates at Eckert Road and Glenwood Bridge in both years, but declined to below 1% in one year at Middleton and Caldwell. Collector-gatherer species double as a percent of the total population from Eckert Road to Parma.

Stoneflies are quite scarce even at Eckert Road, absent at Middleton in 1995, and scarce at Middleton in 1996. In both 1995 and 1996 stoneflies are completely absent from Caldwell and the mouth of the Boise River, probably due to the high level of fine sediment in the river. In each year, Tricorythodes minutus, a tolerant organism, represents a much larger percentage of the population at the downstream sites (Middleton, Caldwell, and Fort Boise) than at Eckert Road or Glenwood Bridge. Total Chironomidae, or tolerant midges, also increase as a percent of the total benthic population at Middleton, Caldwell, and Fort Boise relative to the upstream sites. Baetis tricaudatus, an intolerant organism, declines in abundance and as a percent of the total benthic population at Middleton and Caldwell relative to the upstream stations.

Fisheries

Fish populations in the Boise River include rainbow trout, brown trout, mountain whitefish, sculpin, redside shiner, sucker, and chub. The fish are not evenly distributed throughout the river, and some species are more successful in sustaining their populations than others. The Boise River experiences intense angling pressure. Currently, natural reproduction of both wild and hatchery trout stocks is insufficient to sustain populations. As a result, the IDFG must stock between 50 and 60 thousand hatchery, catchable sized rainbow trout and thousands of brown trout fingerlings annually.

Distribution and Presence

Brown and rainbow trout generally are limited to the portion of the river upstream of Star Diversion. Trout populations are sustained by stocking programs and limited natural reproduction. Rainbow trout observed at Middleton may be incidental or may be from Indian Creek, which had a significant natural trout population prior to a major fish kill in 1986. Mountain whitefish, a cold water salmonid species, have been found in all reaches of the river from Lucky Peak Dam to its mouth at all sampling dates. Table 8 shows the results of USGS fish sampling in the Boise River in October 1996 and August 1997. The data presented below indicate the presence or absence of species at each site. Numbers of fish are not representative of actual fish populations in the river. High flows in August 1997 precluded use of sampling techniques that provide reliable indicators of species abundance. Also, the data include the sum of two sampling events at Middleton and near Fort Boise, but only one each for Loggers Creek, Glenwood Bridge, and Caldwell.

Cold water biota use the Boise River as habitat from Lucky Peak Dam to the confluence with the Snake River. Fish sampling shows that mountain whitefish, a cold water species, are present along the length of the river, during both the summer (1997) and winter (1996). Past studies by IDFG confirm the presence of cold water species from Lucky Peak Dam to the Snake River. Salmonid spawning is also an existing use in all reaches of the river from Diversion Dam to the mouth. Trout and mountain whitefish are known to spawn to a limited extent in the river between Diversion Dam and Star. Trout are absent downstream of Star and salmonid spawning is limited to mountain whitefish. Multiple age classes of mountain whitefish, including young of year fish, were found downstream of Star, demonstrating that spawning is likely occurring.

Table 8. Number of fish collected by the USGS in the lower Boise River, 1996 and 1997.

Species	Loggers Creek	Boise River at Glenwood Bridge	Boise River at Middleton	Boise River at Caldwell	Boise River near Fort Boise
Carp	0	0	35	5	10
Chiselmouth	1	1	364	20	14
Northern Squawfish	0	2	86	0	0
Dace	3	33	389	0	14
Redside Shiner	0	16	66	120	1
Suckers	0	117	315	52	178
Sunfish	0	0	12	0	13
Rainbow Trout	21	5	2	0	0
Brown Trout	3	2	0	0	0
Mountain Whitefish	94	68	129	5	15
Sculpin	118	5	0	0	0
Tui Chub	0	0	0	0	24
Catfish	0	0	1	1	4
Total	240	249	1399	203	273

Water Quality Conditions

The Boise River is listed for sediment from Barber Diversion to the Snake River and for temperature from Star to the Snake River. Temperature and sediment are the listed pollutants impairing aquatic life in the Boise River. Temperature criteria for cold water species are exceeded frequently in the river from Middleton to the mouth during warmer months. Suspended sediment in the river frequently exceeds concentrations that have adverse affects on cold, cool and warm water species. In addition, the river substrate is embedded by sediments that impair aquatic species.

Temperature

The water released from Lucky Peak Dam has a fairly stable temperature during the summer because the water leaves the reservoir through deep penstocks. As the water moves downstream it gradually becomes warmer and its temperature fluctuates more widely over time. When water reaches Parma it is significantly warmer than at the other upstream measuring stations and is often warmer than the cold water biota criteria during July and August. A summary of temperature conditions follows. A more detailed analysis of temperature problems and the sources of temperature load to the river is included in Appendix F.

Cold Water Biota Criteria

The daily maximum (22° C) and maximum daily average (19° C) criteria for cold water biota are not exceeded in the available data from Diversion Dam through the Glenwood Bridge site. In the vicinity of Middleton and downstream to the mouth of the river, both the daily maximum and the maximum daily average criteria are exceeded frequently. The USGS water temperature data from Parma show that during July and August, more than 20 days may exceed both the 22° C instantaneous and 19° C daily average criteria. Temperatures in the 23° C to 25° C range are not uncommon at Parma during July and August. Figure 13 and Figure 14 show daily maximum water temperatures measured at Middleton and Parma in 1996 and 1997. Figure 15 and Figure 16 show daily average temperatures at Middleton and Parma, calculated for dates with sufficient data.

Salmonid Spawning Criteria

From Star to the mouth of the Boise River, the salmonid spawning water temperature criteria are applicable from October 15 to March 15 to protect mountain whitefish. The river is designated for salmonid spawning from Diversion Dam to Caldwell. From Caldwell to the Snake River, salmonid spawning is an existing but not a designated use. The applicable criteria limit the water temperature to a daily maximum of 13° C and a maximum daily average of 9° C. Available temperature data from Caldwell do not show that the salmonid spawning daily maximum criterion has been exceeded, however the data are insufficient to conclude that the criterion is being met. Samples were not taken during the hottest part of the day and thus do not represent daily maximum temperatures.

Daily data from the river near Parma from 1987 through 1995, show that water temperatures exceed the daily maximum limit from one to twelve times per month during October, depending on the year. The water temperatures at Parma also exceeded the daily maximum limit in the first two weeks of March during hot, dry years (1992 and 1994). The total number of days on record with water temperatures greater than 13° C at Parma is 45 out of 1361 spawning days from 1986 to 1995, or 3%. The criterion is exceeded at the beginning and the end of the October 15 to March 15 spawning period.

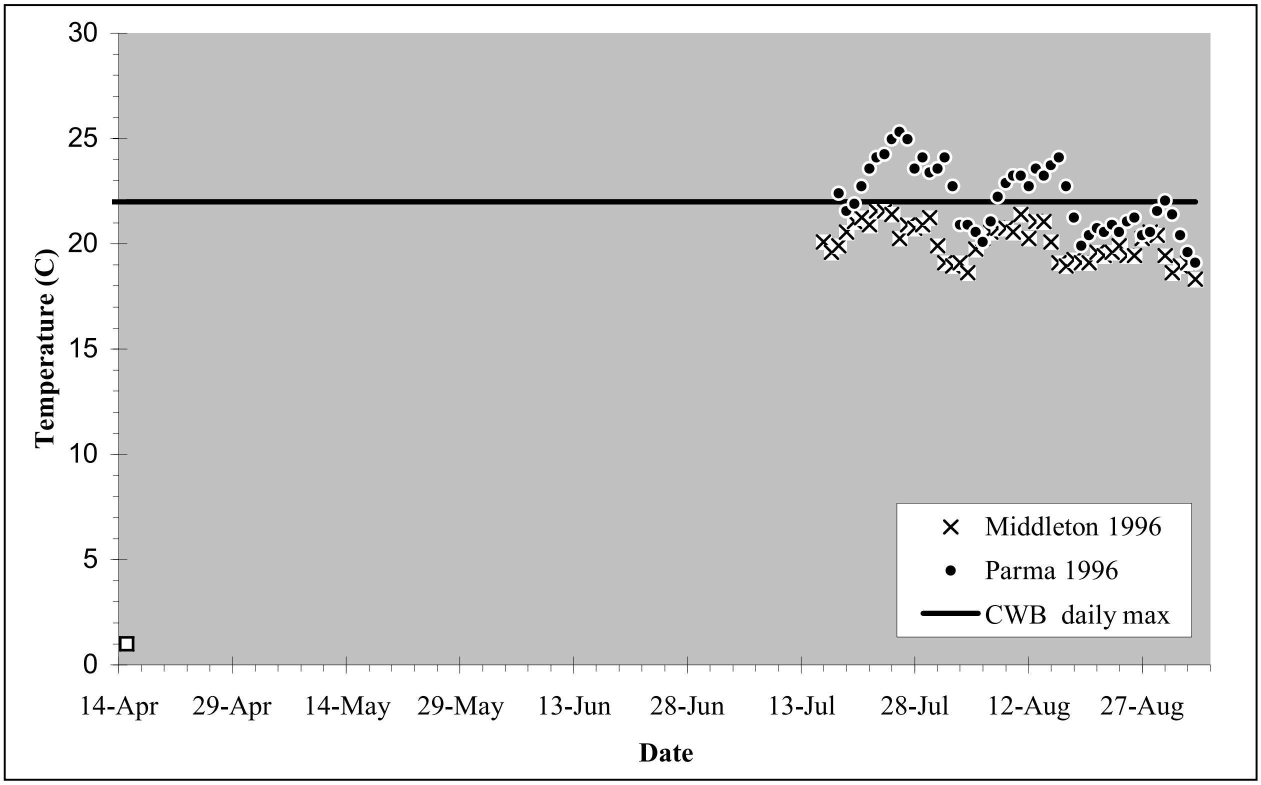


Figure 13. Daily maximum temperatures in the Boise River near Middleton and Parma: 1996.

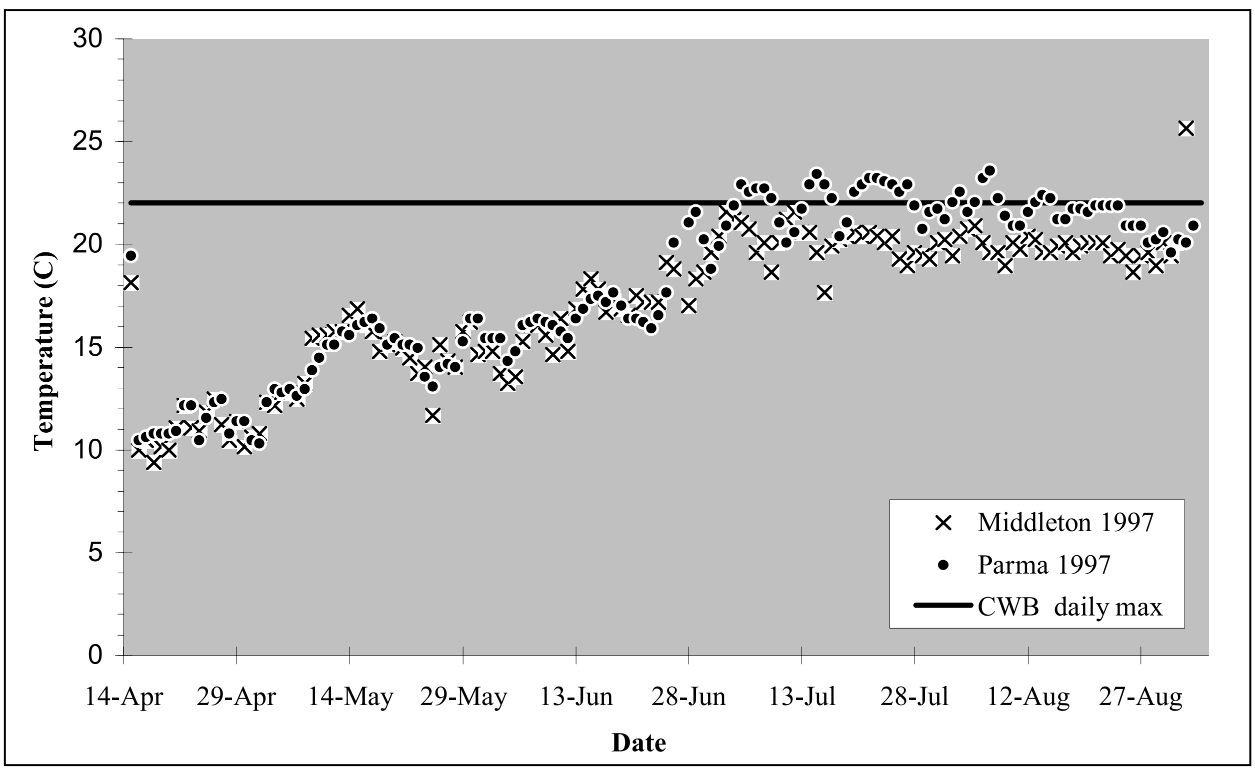


Figure 14. Daily maximum temperatures in the Boise River near Middleton and Parma: 1997.

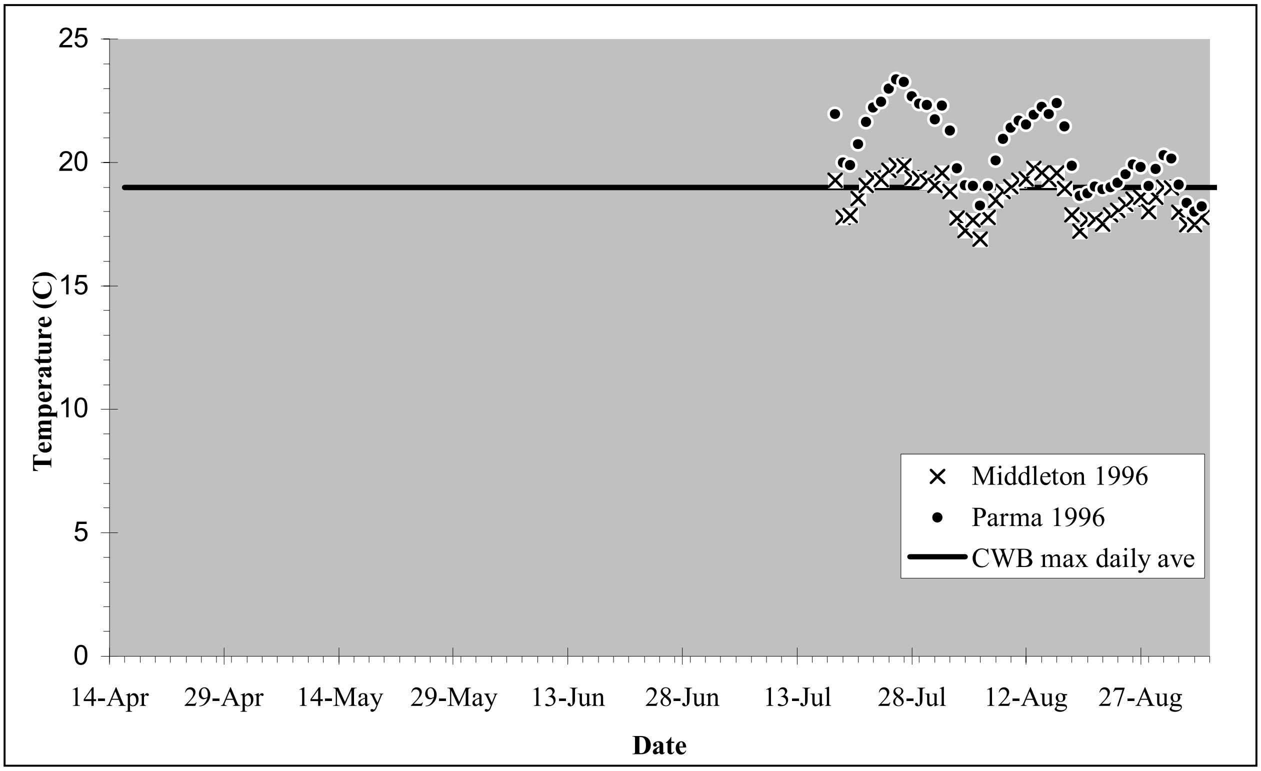


Figure 15. Daily average temperatures in the Boise River near Middleton and Parma: 1996.

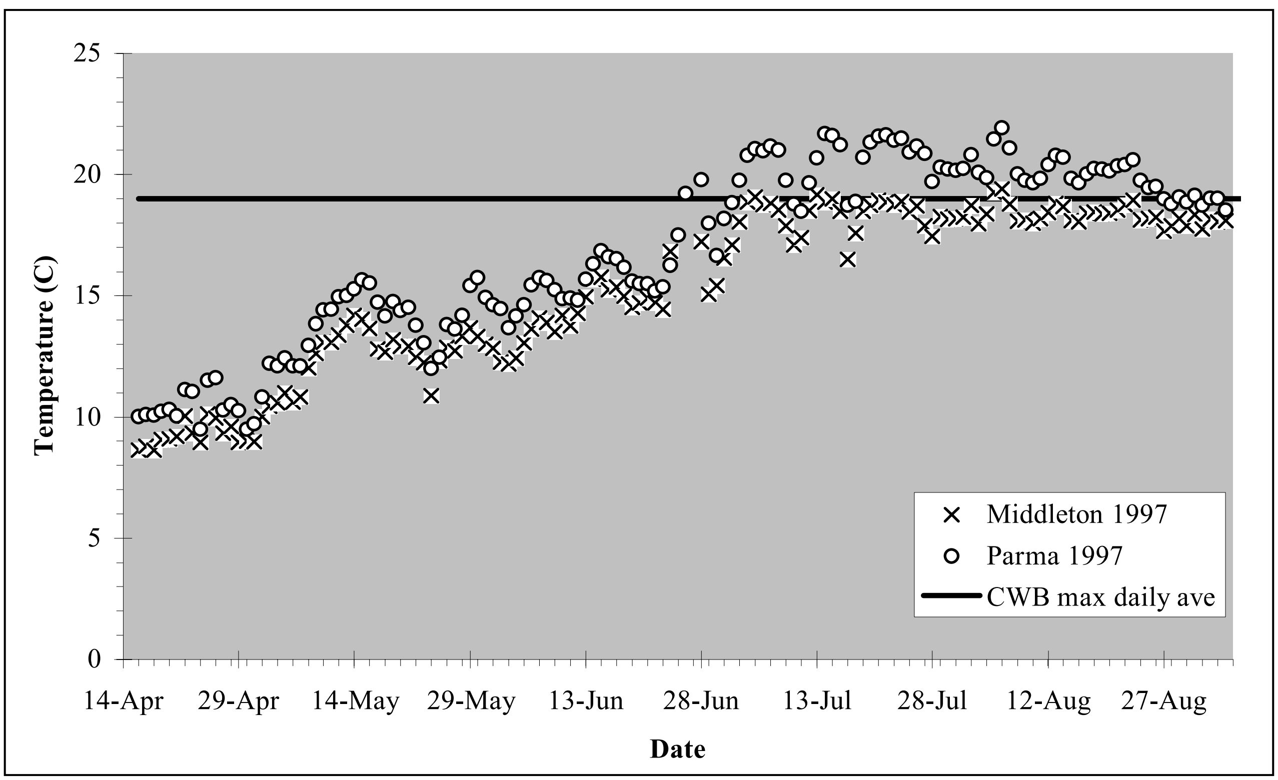


Figure 16. Daily average temperatures in the Boise River near Middleton and Parma: 1997.

Water temperatures at Parma (1987 to 1995) exceed the maximum daily average criterion (9° C) salmonid spawning a total of 230 times out of 1361 spawning days. About 74% of the criteria exceedences occur in either October or March. The remaining daily average exceedences occur primarily in November and February.

Sediment

Sediment impairs aquatic life beneficial uses all along the river, from Barber Diversion to the confluence with the Snake River. Near the City of Boise, structures at Diversion Dam and Barber Diversion capture significant accumulations of sand that damage fish habitat behind each dam. Concentrations of suspended sediment are low below Diversion Dam, but some sand is likely moving downstream as bedload. As the sand washes downstream, it contributes to high levels of embeddedness in the stream bed from Diversion Dam to Star that limit the spawning of trout and whitefish. Downstream of the Star Road diversion, sediment load from agricultural drains increases significantly. Sands continue to contribute to high levels of embeddedness, the proportion of fine sediment in the substrate increases and the concentration of suspended sediments in the water column increases. Increased turbidity has often been noted in the Boise River downstream of Middleton.

In general, the portion of the Boise River near the city has an armored substrate that consists primarily of large cobbles. Of the cobbles, pebbles, and gravel present, more than 60% were embedded in the 25% to 49% range during a 1987 survey (Asbridge and Bjornn, 1988). Embeddedness exceeding 32% is generally considered to indicate impaired habitat. Most pea gravels in Loggers Creek were also embedded in the 25% to 49% range during the same study, limiting the value of the substrate for salmonid spawning.

More recently, the USGS has measured embeddedness and substrate particle size at Eckert Road and near Middleton in November 1997 (W. Mullins, USGS, written commun., 1997). Ocular embeddedness estimates at Eckert Road ranged from 2 (50% - 75% embedded) in a deep run to 4 (25% - 50% embedded) in riffles. All embeddedness observations at the site near Middleton were rated as 1 (≥ 75%) or 2. Pebble count data from the same sites indicate a much higher proportion of sand and silt (about 48% compared to about 18%) near Middleton than at Eckert Road. Gravels were found at both sites, although the proportions were greater at Middleton than Eckert Road. The substrate at Eckert Road is dominated by cobbles, very coarse gravels and sand.

Sediment suspended in the water column can adversely affect aquatic life. Many fish species are adapted to high suspended sediment levels for short durations that commonly occur during natural spring runoff events. However, longer durations of exposure can interfere with feeding behavior, damage gills, reduce available food, reduce growth rates, smother eggs and fry in the substrate, damage habitat and induce mortality. Eggs, fry and juveniles are particularly sensitive to suspended sediment, although at high enough concentrations adult fish are affected as well. Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on suspended sediments in streams and estuaries. For rainbow trout, lethal effects, which include reduced growth rate, begin to be observed at concentrations of 50 to 100 mg/l when those concentrations are maintained 14 to 60 days. Similar effects are observed for other species. Adverse effects on habitat, especially spawning and rearing habitat were noted at similar concentrations.

From 1994 through 1997, when the USGS sampled the four main river stations, suspended sediment concentrations in the lower Boise River occasionally exceed 50 mg/l at Glenwood Bridge (4 out of 29 measurements) and Middleton (1 out of 22 measurements) and more frequently at Parma (10 out of 26 measurements). Concentrations ranged as high as 245 mg/l at Parma. Highest concentrations are generally observed during spring runoff, although 245 mg/l of suspended sediment was measured at Parma on July 19, 1995 and concentrations exceeding 50 mg/l have been observed in every month from February to August. The data are insufficient to determine the duration of high suspended sediment concentrations.

CH2MHill, under contract to the LBRWQP, prepared a detailed assessment of sediment conditions in the lower Boise River and resulting impacts on aquatic life (Appendix G). They concluded that:

- during the low flow period, geometric mean and 90th percentile suspended sediment concentrations do not exceed 42 mg/l;

- geometric mean and 90th percentile suspended sediment concentrations below Diversion Dam and Glenwood Bridge do not exceed 45 mg/l during any season; and

- 50 mg/l suspended sediment concentration is exceeded at Parma during the high and irrigation flow periods based on the geometric mean and 90th percentile concentrations and at Middleton during the high flow period based on the 90th percentile concentration.

Suspended sediment concentrations are also lowest in the tributaries to the Boise River during the low flow period. Generally, sediment concentrations in the tributaries are higher than in the main stem. Mason Creek, Conway Gulch and Fifteenmile Creek have the highest sediment concentrations during the high flow and irrigation flow periods. In terms of load, Dixie Drain, Mason Creek and Fifteenmile Creek are the largest contributors of sediment to the Boise River.

Nutrients and Nuisance Aquatic Growth

Nuisance aquatic growth can adversely impact aquatic life and recreation. Algae of various types grow in the water and on the bed of the Boise River. Algae provide a food source for many aquatic insects, which in turn serve as food for fish. Algae grow where sufficient nutrients (nitrogen, phosphorus) are available to support growth. Flows, temperatures, and sunlight penetration into the water all must combine with nutrient availability to produce conditions suitable for photosynthetic growth. When nutrients exceed the quantities needed to support primary productivity, algae blooms may develop. Death and decomposition of algae creates an oxygen demand. If the demand is high enough because of an algae bloom, dissolved oxygen (DO) concentrations in the water body may decline to low levels that harm fish. Algae blooms and excessive rooted aquatic macrophytes can physically interfere with boating, swimming and wading. Also, decomposing algae can create objectionable odors and some species may produce toxins that could impair agricultural water supply.

High concentrations of phosphorus have been documented in the Boise River at Glenwood Bridge from 1989 through 1994 (Figure 17). Phosphorus in the river at Middleton and Parma are significantly enriched (Figure 18). Under the right conditions, algae blooms may be possible. Total phosphorus concentrations in samples collected by the USGS since 1994 range from well below the EPA guideline value for flowing waters of 0.1 mg/l at Diversion Dam to as high as 0.8 mg/l at Middleton and 0.5 mg/l at Parma. Exceptionally high concentrations were measured at Glenwood Bridge and Middleton in 1992. The highest concentrations occur during low flow conditions, which are generally in the winter when aquatic plant growth is less of a concern. However, low flow conditions prevailed throughout the drought year of 1992. Total phosphorus concentrations during the growing season at Middleton and Parma are more than sufficient to support algae growth.

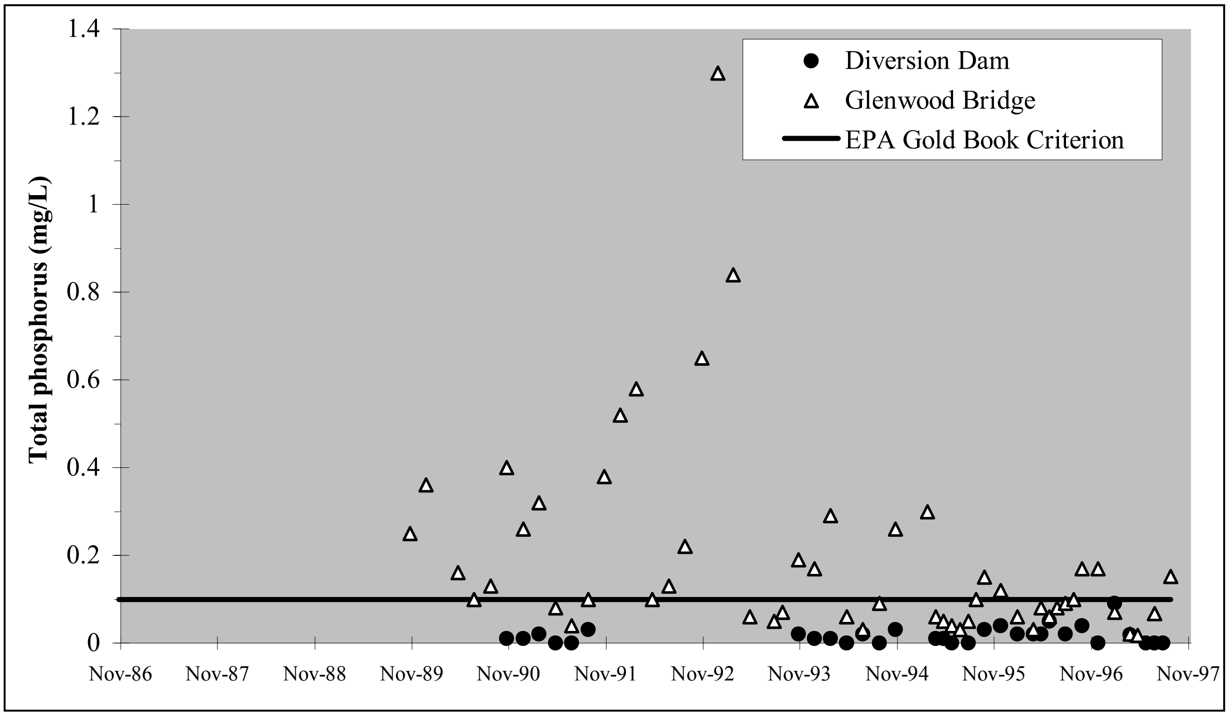


Figure 17. Total phosphorus levels in the Boise River at Diversion Dam and Glenwood Bridge: 1986-1997.

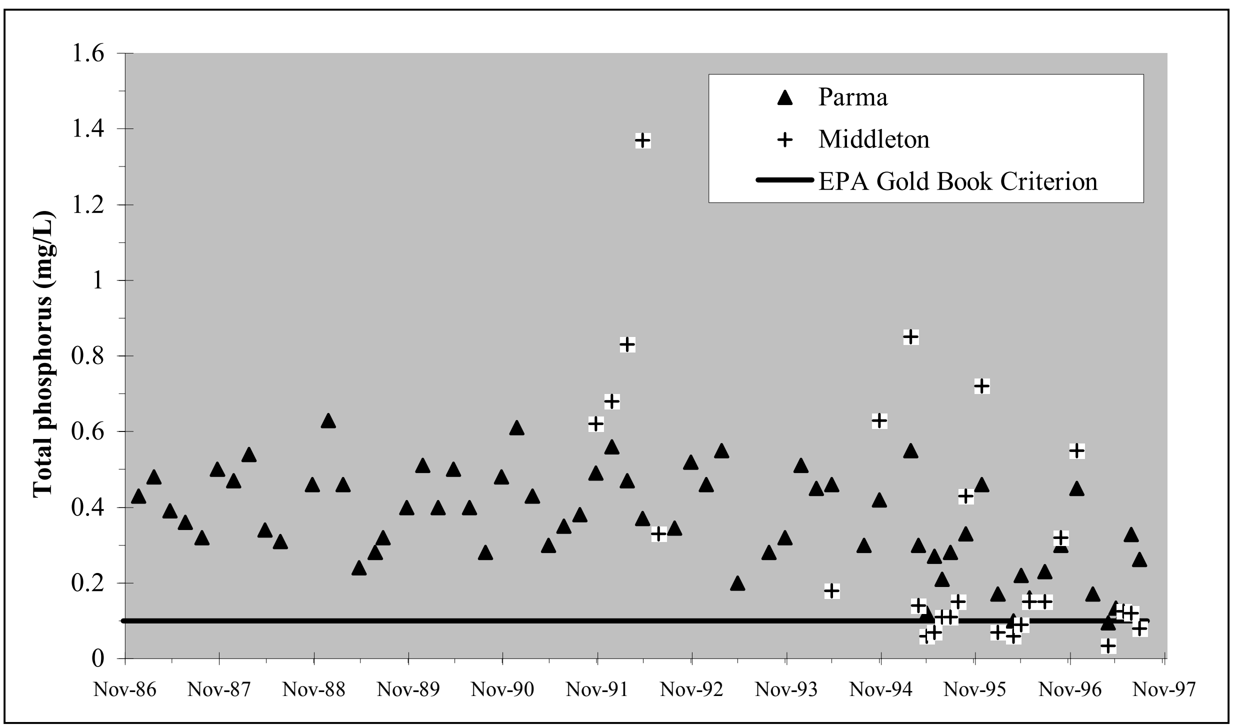


Figure 18. Total phosphorus levels in the Boise River near Parma and Middleton: 1986-1997.

Ortho-phosphate concentrations follow a similar pattern to total phosphorus with respect to flow conditions and location. Highest concentrations are during low flow periods, concentrations increase downstream, and ortho-phosphate is more than adequate to support nuisance aquatic growth under the right conditions. Bothwell (1988, 1989) and Horner and others (1983) have shown that phosphorus concentrations as low as 25 to 50 ug/l are sufficient to support growth of periphyton communities. Generally, ortho-phosphate concentrations are 75% to 80% of total phosphorus concentrations in the Boise River.

Dissolved oxygen can be a direct indicator of nuisance aquatic growths. No DO concentrations less than 6.0 mg/l, the cold water biota criterion, have been recorded from Lucky Peak to the mouth of the River in the data available from 1986 to the present (Table 9). DO data from the 1970s Glenwood Bridge, Middleton and Caldwell were not included in this analysis because these data are not representative of current conditions in the river.

Table 9. DO data available the lower Boise River watershed, 1986 to the present.

Site	Sampled By	Frequency	Dates
Boise River below Diversion Dam	USGS	Bimonthly or Monthly	November 1990 - present
Boise River at Glenwood Bridge	USGS	Bimonthly or Monthly	November 1989 to present
Boise River near Middleton	USGS	Bimonthly or Monthly	November 1991 to present
Boise River near Parma	USGS	Bimonthly or Monthly	November 1986 to present
Boise River at Eckert Road, Glenwood Bridge, Middleton, Caldwell and Parma	USGS	Hourly 24 hour periods	August 1997
Boise River at Veteran's Parkway, Glenwood Bridge and Eagle Bridge	City of Boise	Quarterly	January 1993 to December 1996
South Channel Boise River at Eagle Island, upstream and downstream of discharge	City of Meridian	Daily	April 24, 1992 to December 31, 1996

In August 1997, the USGS took hourly DO measurements over twenty four hour periods at five sites in the river to assess the possibility that DO might fall below the criteria during a DO sag in the late evening or early morning. The expected night time sag DO concentrations was observed but the concentrations never dropped below the criteria. The lowest 24 hour average DO concentration (7.5 mg/l) occurred at Middleton.

During the salmonid spawning season, a few DO measurements have been slightly less than the 75% of saturation required by the water quality standards. DEQ concluded that the few times DO fell below 75% of saturation does not impair aquatic life, because occurrences are rare (only 14 recorded during the 1990s), close to the criterion (67% to 74.5% of saturation) and concentrations of DO always meet or exceed the required 6.0 mg/l.

Chlorophyll-a in algae in the water column and in the algae attached to rocks (periphyton) are commonly used to measure algal productivity. The USGS measured chlorophyll-a in the water column in the Boise River at Diversion Dam, Glenwood Bridge, Middleton, and Parma ten times in 1995 and 1996 (Figure 19 and Figure 20). None of the measured values exceed 20 ug/l. Idaho does not have a numeric criterion for chlorophyll-a. Oregon's criterion is 15 ug/l. When the Oregon criterion is exceeded, a determination is made to determine if a beneficial use is adversely impacted. North Carolina has a chlorophyll-a criterion of 40 ug/l. Comparing the USGS data to these criteria, and considering that the USGS has not measured a single exceedence of the 6 mg/l DO criterion for aquatic life, DEQ has concluded that nutrients are not causing excessive growth of water column algae.

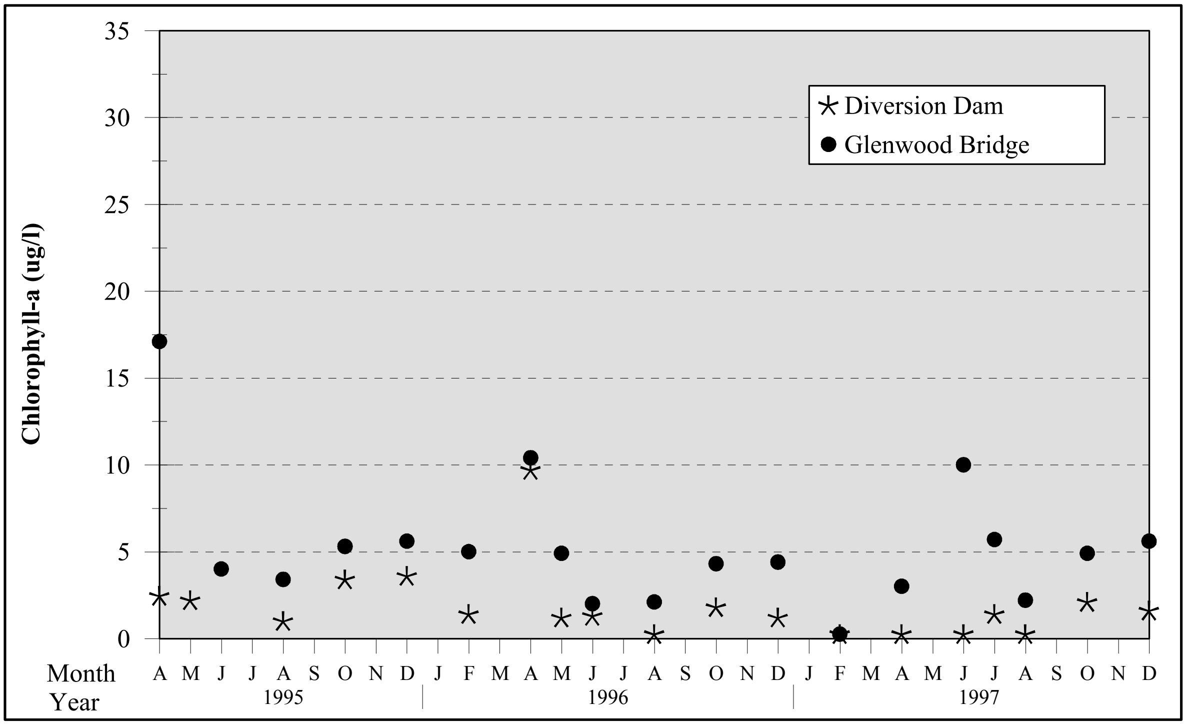


Figure 19. Chorophyll-a concentrations in the Boise River at Diversion Dam and Glenwood Bridge: 1995-1997.

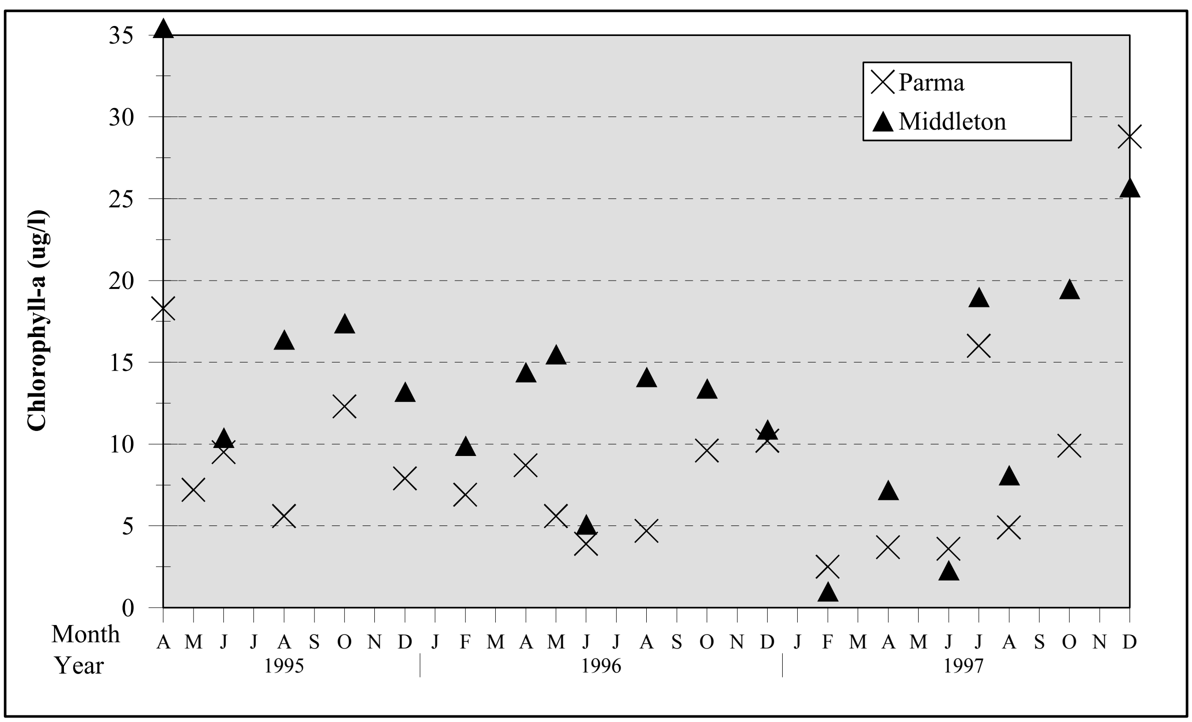


Figure 20. Chlorophyll-a concentrations in the Boise River near Parma and Middleton: 1995-1997.

Chlorophyll-a data from periphytic algae do not provide an equally clear conclusion. Periphyton grow on pebbles and cobbles along the stream bed. In streams that are not impacted by an over abundance of nutrients, the periphytic algae grow as single celled organisms called diatoms that are kept in check by the grazing of aquatic insects. When nutrient availability exceeds the basic needs of diatoms, other species, including bulky, filamentous algae such as *Cladophora* may grow on the stream bed. The bulky filamentous algae can cause significant aesthetic and water quality impairments including reduced DO concentrations, odors and clogging of irrigation pipes and ditches.

DEQ does not have a numeric criterion for periphytic chlorophyll-a. Several authors have suggested that periphyton chlorophyll-a values from 100 to 200 mg/m^2 constitute a nuisance threshold, above which aesthetics are impaired (Horner and others, 1983, Watson and Gestring, 1996; Welch, and others, 1988; Welch, and others, 1989). However, no thresholds have been proposed adverse impacts to aquatic life. Impacts to aquatic life would generally be identified based on DO problems.

The USGS collected periphyton samples in the Boise River at Eckert Road, Glenwood Bridge, Middleton, Caldwell and the mouth in October of 1995 and 1996. Chlorophyll-a in periphyton ranges from a low of .025 mg/m2 at Eckert Road to a high of 933 mg/m2 at Caldwell (Figure 21). The highest values are consistently found at Middleton and Caldwell, where diversions result in lower flows and water temperatures begin to increase.

While periphyton chlorophyll-a values exceed suggested nuisance thresholds in these segments, the absence of DO problems indicates that nutrients were not causing impairment of aquatic life in the Boise River during the sampling periods. However, the high nutrient concentrations and low flow conditions in the Middleton and Caldwell reaches suggest that in drought years, if flows are low enough, conditions in the river may support sufficient algae growth to impair aquatic life or recreational uses. This possibility is supported by the presence of masses of filamentous algae and rooted aquatic macrophytes in canals in the Boise River valley. When the enriched river water is diverted into unshaded, low gradient canals with slower flow velocities, algae and rooted aquatic macrophytes grow freely.

It is also possible that high sediment concentrations in the river below Caldwell are preventing algae growth by limiting the amount of light that penetrates the water column. If sediment concentrations in the summer are reduced, algae growth in the reach of the river below Caldwell may increase.

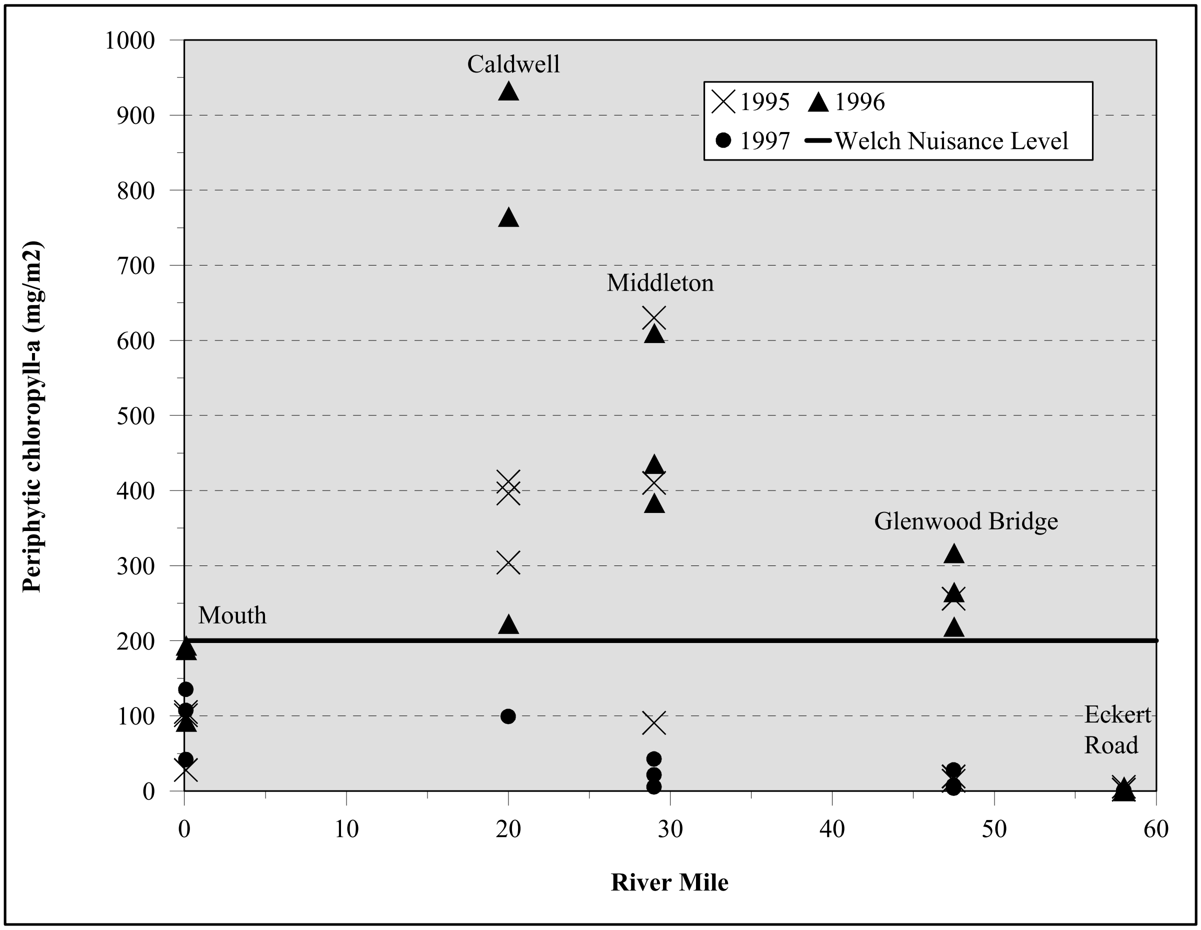


Figure 21. Periphytic chlorophyll-a concentrations in the Boise River near the mouth, Caldwell, Middleton, Glenwood Bridge, and Eckert Road: 1995-1997.

Nutrients in the Boise River also contribute to impairment of beneficial uses in the Snake River and Brownlee Reservoir. The Boise River discharges to the Snake River near Fort Boise. Sampling conducted by Idaho Power Company (IPC) has shown that significant water column algae blooms develop in the Snake River just downstream from the mouth of the Boise River. From March through October of 1995, IPC staff sampled 80 drains and tributaries entering the Snake River from Celebration Park to Porter's Island. They found that the Boise River contributed from about 30% to 50% of the total ortho-phosphate entering that reach of the Snake River, including from the Snake River upstream of Murphy (Myers and others, 1997). They have also shown that the nutrient and algae loads entering Brownlee Reservoir from the Snake River are primary causes of depressed DO concentrations in the metalimnion and epilimnion in the reservoir in summer months (Harrison and Anderson, 1997). Brownlee Reservoir has DO concentrations below applicable criteria every summer in some parts of the reservoir. Some years depressed DO concentrations result in fish kills. TMDLs for the Snake River and Brownlee Reservoir are scheduled for completion in 2001.

Status of Beneficial Uses

Contact recreation uses are not fully supported in the Boise River from Star to the mouth due to bacteria levels that exceed state water quality standards. Both salmonid spawning and cold water biota are not fully supported uses in any segment of the lower Boise River (Table 10).

Sediment, temperature, and flow and habitat conditions in the river all contribute to impairment of cold water biota and salmonid spawning. Natural reproduction of trout is limited, primarily due to lack of suitable spawning gravel sites, the highly embedded and armored substrate and low winter time flows that preclude access to cover and side channels. Generally, trout do not inhabit the river below Star due to physical barriers, warm temperatures and lack of suitable habitat. Suspended sediment and water temperature in the river regularly exceed conditions that adversely affect early life stages of all fish, both cold and warm water biota.

Table 10. Status of aquatic life uses in the lower Boise River.

Segment	Designated Uses	Existing Uses	Impaired Uses	Listed Pollutants Causing Impairment	Other Causes of Impairment
Boise River Lucky Peak Dam to Barber Diversion	CWB, SS	CWB, SS Trout, Mountain Whitefish	CWB, SS		Flow alteration, habitat modification (lack of cover, lack of gravels, channelization, embedded and armored substrate), sediment
Boise River Barber Diversion to Star	CWB, SS	CWB, SS Trout, Mountain Whitefish	CWB, SS	Sediment	SAME as ABOVE
Boise River Star to Notus	CWB, SS	CWB, SS Trout (?), Mountain Whitefish	CWB, SS	Sediment Temperature	SAME as ABOVE
Boise River Notus to Snake River	CWB	CWB, SS Mountain Whitefish, Seasonal	CWB, SS	Sediment Temperature	SAME as ABOVE

Many of man's activities in the lower Boise River watershed contribute to degradation of flow and habitat conditions. Flow manipulation for flood control and irrigation, impoundments, flood control actions such as clearing debris and constructing levees, gravel mining, unscreened diversions, angling pressure and barriers in the river all have adverse affects on habitat. It is DEQ's position that habitat modification and flow alteration, which may adversely affect beneficial uses, are not pollutants under Section 303(d) of the Clean Water Act. There are no water quality standards habitat or flow, nor are they suitable for estimation of load capacity or load allocations. Because of these practical limitations, TMDLs will not be developed to address habitat modification or flow alteration.

In the Boise River, actions taken to address suspended sediment will also improve habitat conditions. In addition, DEQ anticipates that these other causes of impairment will be addressed in the implementation plan developed for this TMDL.

The available data do not show major impairment of beneficial uses due to nutrients and associated nuisance aquatic growths. High nutrient concentrations and periphytic algae levels above suggested nuisance thresholds together imply that nutrients are a potential threat to aquatic life and recreational uses.

Data Gaps

This assessment has identified several data gaps that limit full assessment of the affects of the listed pollutants on beneficial uses. While the best available data was used to develop the current TMDL, DEQ acknowledges there are unresolved questions, as outlined in Table 11. In addition, DEQ has proposed revisions to the Idaho water quality standards for temperature and bacteria through the rulemaking process. These changes in water quality standards, if adopted and approved may necessitate changes in the TMDL.

Several efforts to gather additional bacteria, sediment, temperature and nutrient data are either underway, have been planned, or are the subject of ongoing discussions between EPA, DEQ, the WAG and various stakeholders. The information developed through these efforts may be used to revise the appropriate portions of the TMDL, and determine and adjust appropriate implementation methods and control measures. Changes in the TMDL will not result in the production of a new TMDL document. Minor changes will be handled through a letter amending the existing document(s), more extensive changes will be handled through supplementary documentation or replacing chapters or appendices. The goal will be to build upon rather than replace the original work wherever practical. The schedule and criteria for reviewing new data is more appropriately addressed in the implementation plan, due 18 months after approval of this document. The opportunity to revise the TMDL and necessary control measures is consistent with current and developing EPA TMDL guidance which emphasizes an iterative approach to TMDL development and implementation. However, any additional effort on the part of DEQ to revise the TMDL or implementation plan and control measures must be addressed on a case-by-case basis as additional funding becomes available.

Table 11. Data gaps identified during development of the lower Boise River TMDL.

Pollutant or Other Factor	Data Gap
Flow	winter flows for tributaries to the Boise River
Fish	larval and juvenile fish data during high and irrigation flow periods
Bacteria	only instantaneous bacteria data available; cannot evaluate the frequency with which the monthly geometric mean criterion bacteria is exceeded
Sediment	only instantaneous suspended sediment data available; cannot evaluate duration of concentrations
	bedload data
	stream bank erosion rates
	substrate and water column particle size data
	long term channel geometry data
	intergravel DO data
Temperature	data to evaluate winter daily average temperatures at Middleton and Caldwell
	data to evaluate daily maximum temperatures at Middleton and Caldwell
	winter temperature data for drains
Nutrients	algae data for hot summer, drought conditions and associated DO

Under the lower Boise River monitoring program currently funded by DEQ, the LBRWQP and the USGS, the USGS will continue collecting physical, chemical and biological information in the river and from selected tributaries on a less frequent basis after 1998. The agreement calls collecting continuous temperature data in the river to allow analysis of daily average and maximum temperatures. The USGS has also installed three sites for long term evaluation of habitat conditions.

The City of Boise is collecting data in 1998 to assess the duration of sediment concentrations during high flow and irrigation flow conditions. The LBRWQP has submitted a proposal for Section 319 funding to sample bacteria and conduct DNA analysis to identify bacteria sources. Point source permits that EPA is developing for wastewater treatment facilities at Boise, Nampa and Caldwell and a meat processing plant in Nampa are likely to include additional instream monitoring requirements to help evaluate the affects of discharge from these facilities on the Boise River.

2.3 Pollution Source Inventory

Sediment enters the Boise River largely from nonpoint sources. The wastewater treatment plants and gravel mining operations that discharge to the river are generally subject to relatively strict sediment limits in NPDES permits. Nonpoint sources of sediment include agricultural activities, stormwater runoff, runoff from construction activities and bank erosion. The most significant sources of sediment from agricultural practices are likely surface irrigated land and streambank trampling due to unrestricted use of streamside areas by livestock. Construction activities on sites that exceed five acres are subject to a general NPDES permit that requires best management practices to limit sediment releases. Construction in the river channel is subject to stream alteration permits issued by the Idaho Department of Water Resources. These permits generally include requirements for best management practices (BMPs) to reduce sediment releases to the river. Agricultural activities are exempt from stream alteration permits. Some fine sediment passes through Lucky Peak Dam and Diversion Dam and into the river but no data are available to determine the amount. Agricultural activities that generate sediment include surface irrigated row crops and surface irrigated pastures. A substantial amount of the sediment that erodes from agricultural lands is deposited in drains and canals and may be liberated during maintenance activities. Sediment may also be liberated from the river substrate when irrigators alter instream structures to improve diversions.

Most bacteria also likely comes from nonpoint sources. Wastewater treatment plants are subject to relatively strict effluent limits for bacteria. Possible nonpoint sources of bacteria include agricultural operations (primarily livestock), failed septic systems, and wildfowl populating the river corridor. Generally, septic systems are designed to prevent any bacteria from reaching either ground water or surface water. However it is possible that there are some failed septic systems in the valley. There may also be an unknown number of grey water discharges to canals, drains and streams.

Most large confined animal feeding operations (CAFOs), confined feeding areas (CFAs) and dairies are subject to discharge limits under general NPDES permits. To be regulated under a general NPDES permit, CAFOs and CFAs must meet size criteria and be considered significant contributors of pollutants. All dairies that have a permit to sell milk are subject to the Idaho Department of Agriculture (IDA) dairy inspection program. Dairies are required to have adequate waste management practices subject to the Rules Governing Dairy Waste, IDAPA 16.01.02350.03.g and IDAPA 02.04.14. Smaller CAFOs and pasture grazing are not regulated.

Animal waste that is removed from dairies, CAFOs and CFAs in liquid or solid form may be applied to agricultural lands as a soil amendment. Operators subject to an NPDES permit are required to land apply waste at agronomic rates and maintain adequate record keeping of waste management. The IDA has proposed draft rules to ensure proper management of land applied animal waste at other facilities, but these activities are currently unregulated. The extent to which land application of animal waste is a source of bacteria is unknown.

Nutrients are discharged into the river from both point and nonpoint sources. None of the NPDES permits for wastewater treatment plants or the few industrial facilities in the valley include effluent limits for phosphorus and most limit ammonia but no other forms of nitrogen. Phosphorus concentrations in effluent from selected wastewater treatment plants are shown in Table 12.

Table 12. Total phosphorus concentrations and flow in selected major wastewater treatment plants in the lower Boise River Valley.

Facility	Design Flow, MGD	Maximum Phosphorus Concentration, mg/l	Average Phosphorus Concentration, mg/l	Minimum Phosphorus Concentration, mg/l
City of Boise Lander Street	15	6.50	4.12	3.20
City of Boise, West Boise	16	11.60	6.05	3.00
City of Meridian	2.82	4.40	3.11	1.18
City of Nampa	11.76	10.90	7.70	5.37
City of Caldwell	7.78	6.70	4.32	2.46

Nonpoint sources of nutrients include runoff from agricultural operations, including irrigated row crops, pasture, animal management operations, stormwater runoff and ground water. Nutrients that enter the river from ground water generally have their source in the same land use activities that contribute nutrients directly to surface water. A notable exception is septic systems. In areas that lack sewering and wastewater treatment, septic systems may contribute nutrients to ground water that eventually reach the Boise River directly or via drains.

Temperature increases in the Boise River are affected by point and nonpoint source discharges, water management practices, alteration of the river channel and atmospheric sources. Water leaving Lucky Peak Dam is relatively cool. Wastewater treatment plants and a few industrial facilities discharge water that carries a heat load both directly to the Boise River and indirectly into streams and drains that discharge to the river. Few of the NPDES permits for these facilities include effluent limits temperature. A relatively small amount of geothermal water is discharged to the river in the Boise area after use for heating. Water that is diverted and spread on the land irrigation of agricultural and residential land is heated and returns to the river via drains. Both air temperature and direct solar radiation are significant sources of heat load to the river, especially in the summer.

The Boise River channel has been significantly altered from it's natural condition due to flood control and the downstream affects of Lucky Peak Dam. Channelization, clearing for flood control purposes and altered flow regimes have reduced natural braiding and riparian areas, and tend to create a wide, shallow channel. These factors increase the river's ability to absorb heat from the atmosphere.

3.0 Pollution Control Efforts

Nonpoint Sources

In both Ada and Canyon Counties, there are water quality programs for nonpoint source pollutant reductions. Most of the agricultural programs are federally funded through the Natural Resource Conservation Service (NRCS), through past and present Farm Bills authorized by the United States Congress. These programs are targeted at the agricultural community to assist with conservation practices. In Canyon County, the Canyon Soil Conservation District (SCD) has a State Agricultural Water Quality Program (SAWQP) project in Conway Gulch that addresses on farm sediment reductions. SAWQP is a State of Idaho water quality program to provide cost share incentives to local operators for pollutant reductions.

The agricultural community, through local SCDs, has demonstrated a willingness to protect water quality in the lower Boise River valley. The Conway Gulch SAWQP project treated about 9,279 acres of agricultural lands with BMPs to reduce sediment load to the river. Ada SCD works with agricultural operators in Ada County to provide technical assistance for implementation of BMPs.

The Ada SCD has worked with Ada County Highway District to develop a demonstration project that uses sediment ponds and wetlands to treat stormwater runoff. They are planning a second project in cooperation with the Boise Department of Parks and Recreation to treat river and stormwater from the Boise City Canal.

Current federal funding of the Environmental Quality Incentive Program (EQIP) is targeted livestock feeding operations (CAFOs and CFA). Participation from local operators has been competitive the available funds from this program.

Stormwater within the City of Boise is subject to a stormwater NPDES permit. Ada County Highway District, Drainage District 3, the City of Boise, Idaho Department of Transportation, District 3, and Boise State University are all co-applicants for the permit, which has not been issued yet. The permit will require implementation of BMPs to control stormwater runoff within the affected area. In the future, stormwater from smaller municipalities will also be subject to NPDES permits.

Point Sources

The wastewater treatment plants that discharge to the lower Boise River or its tributaries all provide secondary treatment of wastewater from the municipalities. Boise, Caldwell and Nampa have all considered nutrient reduction alternatives in their wastewater treatment facility plans. The City of Boise recently completed upgrades to it’s Lander Street plant that provide nitrification and denitrification. These improvements improve process control, reduce nitrogen in the effluent and will enable the plant to biologically remove phosphorus in the future.

The State of Idaho, through a revolving fund, offers facilities either grants or low interest loans for upgrades.

All of the municipalities are currently regulated under the NPDES permitting program. Armour Fresh Meats and IDFG's Nampa fish hatchery both discharge to Boise River tributaries, pursuant to NPDES permits. In addition there are eleven smaller facilities that are subject to NPDES permits in the valley and discharge pollutants of concern. Wasteload allocations (WLAs) from the lower Boise River TMDL will be incorporated in to NPDES permits for all facilities discharging the pollutants addressed in this TMDL. Each permitted facility is required to monitor their effluent to determine compliance with their individual NPDES permit. Existing permits will be modified and any pending new permits will be issued after the completion of the TMDL .

In 1995 a Memorandum of Understanding (MOU) between the Environmental Protection Agency (EPA), DEQ and IDA was signed to provide IDA authority to oversee the waste management at dairies statewide. This MOU has provided an enforcement mechanism to assure dairies adequately manage animal waste.

In 1996 EPA reissued the Idaho general NPDES permit CAFOs. This new general permit allows permitted facilities to discharge animal waste only during unusual climatic events. The new permit also requires permitted facilities to land apply animal waste at agronomic rates, and requires record keeping of animal waste management practices. It is believed these provisions will reduce discharges to surface waters, and reduce impacts to ground water.

Reasonable Assurance

Watersheds that have a combination of point and nonpoint sources where pollution reductions goals can only be achieved by including some nonpoint source reduction, the TMDL must incorporate reasonable assurance that nonpoint source reductions will be implemented and effective in achieving the load allocation (EPA, 1991). The lower Boise River TMDL will rely substantially on nonpoint source sediment and bacteria reductions to meet the load capacity needed to achieve desired water quality and to restore designated beneficial uses. If appropriate load reductions are not achieved from nonpoint sources through existing regulatory and voluntary programs, then reductions must come from point sources.

The state has responsibility under Sections 401, 402 and 404 of the Clean Water Act to provide water quality certification. Under this authority, the state reviews dredge and fill, stream channel alteration and NPDES permits to ensure that the proposed actions will meet the Idaho's water quality standards.

Under Section 319 of the Clean Water Act, each state is required to develop and submit a nonpoint source management plan. Idaho's Nonpoint Source Management Program (Bauer, 1989) was submitted and approved by the EPA. The plan identifies programs to achieve implementation of BMPs, includes a schedule for program milestones, is certified by the state attorney general to ensure that adequate authorities exist to implement the plan and identifies available funding sources.

Idaho's nonpoint source management program describes many of the voluntary and regulatory approaches the state will take to abate nonpoint pollution sources. Since the development of the nonpoint source management program in 1989, revisions of the water quality standards have occurred. Many of these revisions have adopted provisions for public involvement, such as the formation of Basin Advisory Groups (BAGs) and WAGs (IDAPA 16.01.02.052). The WAGs are to be established in high priority watersheds to assist DEQ and other state agencies in formulating specific actions needed to control point and nonpoint sources of pollution affecting water quality limited waterbodies. Upon approval of this TMDL by EPA/Region 10, LBRWQP, the designated WAG for the lower Boise River watershed, with the assistance of appropriate federal and state agencies, will begin development of an implementation plan that is to be completed within eighteen months.

The Idaho water quality standards refer to existing authorities to control nonpoint pollution sources in Idaho. Some of these authorities and responsible agencies are listed in Table 13.

Table 13. State of Idaho's regulatory authority nonpoint pollution sources.

Authority	IDAPA Citation	Responsible Agency
Idaho Forest Practice Rules	16.01.02.350.03(a)	Idaho Department of Lands
Rules Governing Solid Waste Management	16.01.02.350.03(b)	Idaho Department of Health and Welfare
Rules Governing Subsurface and Individual Sewage Disposal Systems	16.01.02.350.03©	Idaho Department of Health
Rules and Standards for Stream-channel Alteration	16.01.02.350.03(d)	Idaho Department of Water Resources
Rules Governing Exploration and Surface Mining Operations in Idaho	16.01.02.350.03(e)	Idaho Department of Lands
Rules Governing Placer and Dredge Mining in Idaho	16.01.02.350.03(f)	Idaho Department of Lands
Rules Governing Dairy Waste	16.01.02.350.03.(g) or IDAPA 02.04.14	Idaho Department of Agriculture

The State of Idaho uses a voluntary approach to control agricultural nonpoint sources. However, regulatory authority can be found in the water quality standards (IDAPA 16.01.02.350.01 through

16.01.02.350.03). IDAPA 16.01.02.054.07 refers to the Idaho Agricultural Pollution Abatement Plan (Ag Plan) (IDHW and SCC, 1993) which provides direction to the agricultural community approved BMPs. A portion of the Ag Plan outlines responsible agencies or elected groups (SCDs) that will take the lead if nonpoint source pollution problems need to be addressed. For agricultural activity, it assigns the local SCDs to assist the landowner/operator with developing and implementing BMPs to abate nonpoint pollution associated with the land use. If a voluntary approach does not succeed in abating the pollutant problem, the state may seek injunctive relief for those situations that may be determined to be an imminent and substantial danger to public health or environment (IDAPA 16.01.02.350.02(a)).

The Idaho Water Quality Standards and Wastewater Treatment Requirements specify that if water quality monitoring indicates that water quality standards are not being met, even with the use of BMPs or knowledgeable and reasonable practices, the state may request that the designated agency evaluate and/or modify the BMPs to protect beneficial uses. If necessary the state may seek injunctive or other judicial relief against the operator of a nonpoint source activity in accordance with the Director of the Department of Health and Welfare's authority provided in Section 39-108, Idaho Code (IDAPA 16.01.02.350).

The water quality standards list designated agencies responsible for reviewing and revising nonpoint source BMPs. Designated agencies are Department of Lands for timber harvest activities, oil and gas exploration and development and mining activities; the Soil Conservation Commission for grazing and agricultural activities; the Department of Transportation for public road construction; the Department of Agriculture for aquaculture; and DEQ for all other activities (IDAPA 16.01.02.003).

Best management practices for urban and suburban stormwater include educational activities, construction site runoff control, and on site detention of runoff. The Ada County Highway district makes use of 28 management practices, while the City of Boise applies 33 distinct management practices for stormwater. Appendix K of the Draft Technical Appendices includes copies of Ada County Highway District and Boise City stormwater management practice lists.

Five examples of significant agricultural water quality projects in place or planned for the lower Boise River watershed are the Mason Creek Environmental Quality Incentives Program (EQIP), the Lower Boise River EQIP area, the Conway Gulch Water Quality Incentives Program (WQIP), the Fivemile Creek WQIP, and the Conway Gulch State Agricultural Water Quality Program (SAWQP). Mason Creek is the newest program, scheduled to begin in 1999 with funding of roughly $760,000 for conservation contracts with growers. The lower Boise River EQIP area plan began in 1997, while the Conway Gulch and Fivemile Creek WQIP plans began in 1996. The Conway Gulch SAWQP project has put sediment management practices in place since 1983. Complete information on these projects, including the types of management practices applied, is available through the Idaho Soil Conservation Commission.

4.0 Load Analyses and Allocations

The lower Boise River has four segments on the 303(d) list. The segments are located from Lucky Peak Dam to Barber Diversion, Barber Diversion to Star, Star to Notus, and Notus to the Snake River. The segments have flow alteration, sediment, dissolved oxygen, oil and grease, nutrients, bacteria, and temperature listed as pollutants. Among the listed pollutants, sediment and bacteria are causing impairment and require load allocations. From Star to Notus and Notus to the Snake River, temperature criteria are not met, and an appropriate response is outlined. Flow alteration will not be addressed in the TMDL itself, since alterations of flow are not allocatable pollutants, and because water rights issues are not within the purview of DEQ. Other stream segments within the lower Boise River watershed, including Black's Creek, Fivemile Creek, Tenmile Creek, Indian Creek, Mason Creek, and Sand Hollow Creek are on the 1996 303(d) list. These segments are subject to load reduction requirements at their confluences with the Boise River. However, TMDLs for the segments themselves will be developed in the year 2001.

Pollutant targets are based on upon existing water quality criteria for bacteria, and upon a numeric interpretation of the state narrative standard for sediment. Current pollutant loads are compared to allocated loads to display the reductions necessary to meet water quality goals in the Boise River. Load capacity is divided among load allocations, waste load allocations, background load, and margins of safety.

A wide variety of methods can be utilized to achieve load reductions in the lower Boise River watershed. The methods used to achieve loads will vary by source. For example, the sediment load allocation for a tributary might be met using a suite of cost share projects to implement agricultural best management practices. Any method selected must meet the stated goals and water quality goals for the Boise River. DEQ will evaluate the appropriate method for assessing source loads with respect to allocations, and propose an appropriate methodology for demonstrating that allocations are achieved.

4.1 Sediment

Three segments of the Boise River are listed for sediment. The segments are defined from Barber Diversion to Star, Star to Notus, and Notus to the Snake River. Total suspended sediment concentrations in the upstream segment, as measured at Glenwood Bridge, do not exceed the target criteria discussed below. At Middleton and Parma, suspended sediment concentrations do exceed the 50 mg/l target criterion during some portions of the year. In the watershed, sediments and solids are generated by waste water treatment, agricultural activities, urban storm water, and natural occurrences. Waste water treatment plants are generally small, stable sources of organic suspended solids. Agriculture generates sediment throughout the irrigation season, but much of the load is generated in the early part of the season. When canals are first filled with water and cultivated fields are irrigated before crops have had significant growth, more sediment leaves fields than in the late summer. The TMDL for suspended sediment addresses all sources in the watershed, and establishes loads that will meet the target criteria in the Boise River.

Sediment Targets

The targets for total suspended sediments in the Boise River are 50 mg/l for no more than 60 days, and 80 mg/l for no more than 14 days. The targets are designed to provide protection for the mix of cold and warm water species that inhabit the Boise River downstream of Lucky Peak. A detailed discussion of the selection of the sediment targets is available in Draft Technical Appendix G of the Subbasin Assessment, in the document titled “Selection of a Total Suspended Sediment (TSS) Target Concentration for the Lower Boise River TMDL,” by CH2M Hill.

Suspended Sediment Load Allocations

Twelve Tributaries to the lower Boise River and the riparian corridor receive load allocations for Total Suspended Sediments. The allocations are designed to meet the total suspended sediment goals (TSS) of 50 mg/l and 80 mg/l in the full length of the Boise River, with check points at the Middleton and Parma gage sites. A full definition of the derivation of the riparian corridor sediment load is located in Appendix L. The load allocations presented below are thus portions of the overall sediment load summed at two sites. As shown in Table 14, two monitored tributaries and a portion of the riparian load contribute to the load at Middleton, while the remaining tributaries and riparian load contribute to the load at Parma. Due to the extensive system of diversions along the length of the river, suspended sediments input at any given point do not travel in their entirety to the mouth of the river. The loads presented here are designed using a mass balance of inflows and diversions, with the target criteria as the goals. Two load equations sum the load and waste load allocations derived from mass balance modeling, along with mass balanced point source reserves and background loads. The background and point source reserve loads are reduced according to a mass balance of typical irrigation water withdrawals that remove suspended sediment load.

Derivation of Load Allocations

The goal of load and waste load allocations is to create target loads for tributaries and treatment plants that meet the target criteria for suspended sediment. The load and waste load targets must maintain the 50 mg/l and 80 mg/l criteria in the Boise River, even when flows are very low. Since the loads from tributaries contribute the majority of the suspended sediment to the river, and because those loads are less variable from year to year than river flows, the worst case condition is a large tributary load of sediment that coincides with low flows in the river. This analysis developed loads to ensure that, with a significant margin of safety, the 50 mg/l target could be met at all locations in the Boise River given seasonal 30 day minimum flows.

Fixed load targets are selected, because the management practices that affect sediment loadings to the river are not expected to change on a day to day basis. Thus, the management practices should be developed to meet the load goals, which meet the target criteria even when very low flow conditions occur in the river.

Critical Flow Conditions

Except for the riparian load, the analysis of sediment inputs to the Boise River focuses on a critical condition during the season from February 15 to June 14. Within that season, when the most significant loads of sediment are generated, the 30 day low flows at Middleton (257 cfs) and at Parma (667 cfs) are the critical flow conditions for suspended sediments. Since irrigation return flows from year to year vary less than river flows, the critical condition for suspended sediments is the lowest flow expected to coincide with large sediment inputs to the river. By selecting a 30 day low flow condition (one half of the duration of the 50 mg/l target), the analysis is conservative, since the flow is lower than a minimum over a sixty day period.

Mass Balance Derived Load Reduction

The mass balance analysis for the river shows that 1992 tributary loads of suspended sediment must be reduced by 37% in order to meet the 50 and 80 mg/l target criteria (Miller, July 27, 1998). Since 1992 had the lowest flows on record since 1928, it represents an extreme, and rare low flow condition that creates stringent reduction requirements The reduction percent (37) was applied to median year (1995) total suspended sediment loads for each tributary to create a set of load allocations. The load calculated for the 30 day low flow in 1995 is a critical condition that is conservative but likely to occur relatively frequently in comparison to the most extreme conditions, and thus is a better basis for establishing load targets than the most extreme condition on record. Table 14 displays the 1995 loads, and the load allocations that represent 37% reductions, however, the 37% reduction was not applied to the riparian corridor load. The loads derived from this process meet the target criteria for suspended sediment even when flows are low, as discussed below.

Table 14. Load Allocations Total Suspended Sediment

Name	Typical Existing Loads, 1995 Tons per day	TSS Allocation, Tons per Day
Eagle Drain	1.61	1.61
Thurman Drain	0.34	0.34
Riparian Load #1	2.45	2.45
Allocations to Middleton		**4.40**
Fifteenmile Creek	28.6	18.02
Star Feeder	2.75	1.73
Long Feeder	0.56	0.35
Watts Creek	0.45	0.28
Mill Slough	11.24	7.08
Willow Creek	3.62	2.28
Mason Sough	1.91	1.20
Mason Creek	34.1	21.48
East and West Hartley Gulch	8.43	5.31
Indian Creek	9.11	5.74
Conway Gulch	11.34	7.14
Dixie Drain	41.12	25.91
Riparian Load #2, #3	4.90	4.90
Allocations to Parma		**101.42**
WATERSHED TOTAL	**162.53**	**105.82**

All loads except for the riparian corridor in the existing column are calculated based upon the 30 day low flow for the given tributary from February 15 through June 14, 1995. The riparian corridor load is calculated based on June 6, 1994 data.

Non Point Sources Upstream of Middleton

The loads from the sources upstream of Middleton represent only about 4% of the total allocation of suspended sediments. Mass balance models of suspended sediment movement in the watershed show that the load allocations shown above for Eagle Drain, and Thurman Drain do not increase the concentration of sediment in the mainstem of the Boise River above the target 50 mg/l criterion. The mass balance scenario discussed below in the "Comparison of Allocations to

Capacity" section show that the suspended sediment load arriving at Middleton is well below the capacity. The inputs of the three tributaries and one-third of the riparian load caused changes in the river suspended sediment concentration of less than 1 mg/l.

The portion of the watershed that is upstream of Middleton is dominated by urban and suburban land uses. Rapid development in the West Boise, Eagle, and Meridian areas is changing pasture lands to suburban residential areas. Very few irrigated crop acres are present in the areas drained by Eagle Drain, Thurman Drain, and the various drainages in the Boise metropolitan area. The land uses within the Boise City area of impact will be managed with respect to runoff and suspended sediments by a pending Boise Municipal Storm Water NPDES permit. The permit will require management activities designed to address suspended sediment removal from stormwater runoff using a proposed 80% removal requirement. The Storm Water NPDES permit, when issued, will require management practices on the part of Boise City, Ada County Highway District, Idaho Transportation Department - District 3, Boise State University, Ada County Drainage District No. 3, and new construction. Because the stormwater permits have specific requirements, they represent substantial investments and commitment to containment and treatment by governmental agencies and developers in the private sector. A review of build-out scenarios for the watershed by the Urban / Suburban workgroup shows that with documented and enforcement containment for all urban land uses in Ada County, stormwater loads of total phosphorus may decrease by 27%, while total suspended sediment loads from stormwater may decrease by 26%. The small size of these three sources in combination with the permit obligations applied to the dominant land uses make the allocation of the 1995 loads sufficient to meet the goals of the TMDL suspended sediments.

Suspended Solids Waste Load Allocations

The point source dischargers in the lower Boise River watershed contribute suspended solids to the river. Relative to the mass of sediment entering the river through tributaries, the point source discharges are quite small. All of the treatment plants in the valley are expected to grow in flow volume over time due to increasing numbers of service connections. As flows expand, suspended solids discharges expand as well. Changes in loads from treatment plants have negligible effects on the Boise River itself, since sediment contributions come largely from tributaries. For example, a 35 percent reduction in suspended solids loads from the two City of Boise facilities results in only a 1 percent net change in the river. Since most of the treatment plants in the valley already remove 85 percent or more of suspended solids, further treatment at this time would result in high costs with little tangible benefit to the river. The Wasteload allocations for total suspended solids are based upon NPDES permit limitations for each facility, either in current or draft permits. The allocations are displayed in Table 15. All facilities must meet minimum percent removal requirements as stated in their NPDES permits.

Table 15. Waste Load Allocations Total Suspended Solids

Facility Name	Design Flow, MGD	Monthly Average Permit Limit TSS, mg/l	TSS Average Waste Load Allocations lbs/day
Lander Street	15	30	3400 lbs / day monthly[1] 5000 lbs / day weekly[1] 2500 lbs / day monthly[2] 3750 lbs / day weekly[2]
West Boise	24	30	6200 lbs / day monthly 9300 lbs / day weekly
Meridian	2.82	30	710 lbs / day monthly 1065 lbs / day weekly
Nampa	11.76	30	3000 lbs / day monthly 4500 lbs / day weekly
Caldwell	8.48	30	2125 lbs / day monthly 3183 lbs / day weekly
Star	0.33	70	193 lbs / day monthly 290 lbs / day weekly
Middleton	1.83	70	1070 lbs / day monthly 1605 lbs / day weekly
Notus	0.056	70	33 lbs / day monthly 50 lbs / day weekly
Armour	0.475	None	125 lbs / day monthly 154 lbs / day weekly
TOTAL			**8.4 tons/day[3] monthly average**

[1] April 1 - September 30
[2] October 1 - March 31
[3] Using April - September limits Boise City, monthly limits all facilities

Table 16 displays typical existing suspended solids loads in treated effluent, using calendar year 1996 as an example. Note that the suspended solids concentrations in the effluent streams of the major facilities are generally well below the permitted concentrations displayed in Table 15.

Table 16. 1996 Existing Total Suspended Solids Loads

Facility Name	1996 Annual Avg. Flow, MGD	1996 Annual Average TSS, mg/l	1996 Existing Average TSS Loads tons/day
Lander Street	8.2	9.5	0.33
West Boise	12.4	9.1	0.47
Meridian	2.52	10.0	0.11
Nampa	7.7	7.5	0.24
Caldwell	5.27	12.0	0.26
Star	0.08	26.2	0.01
Middleton	0.423	28.3	0.05
Notus	0.056	25.0	0.01
Armour	0.354	17.9	0.027
TOTAL			**1.51 tons /day**

Permitted Sand and Gravel Operations

Sand and gravel operations have strict permit requirements that limit their discharge to storm events only. The implementation of effective management practices to control storm water runoff from such operations should limit any sediment loading. The sand and gravel facilities do have limitations of 30 mg/l monthly average and 45 mg/l total suspended sediments in storm water permits, which satisfy the needs of the TMDL for existing facilities. Since storm water runoff can be highly variable and infrequent, and because only three sand and gravel facilities in the watershed have active NPDES permits, any sediment load generated by such runoff may not even be detectable in comparison to the quantities of sediment entering the river through tributaries. In addition, since the TSS concentration limits incorporated into the permits are below the 50 mg/l criterion, any runoff provides dilution relative to the criterion. New operations should be examined on a case by case basis to determine how any added loads will fit within the overall load capacity for suspended sediments. Both existing facilities and future applicants, the strict non-discharge requirement for process water, along with concentration limits any storm related runoff, are prudent measures.

Fish Hatcheries

The total suspended solids and sediment concentrations generated by the fish hatcheries on Eagle Island and in Nampa are reported according to existing NPDES permit requirements. The fish hatcheries are required to meet an instantaneous maximum limit of 15 mg/l total suspended solids in their effluent. The requirements in the permit are adequate to meet the needs of the TMDL, since effluent at or below 15 mg/l for TSS provides dilution with respect to the criterion, and because the two facilities are quite small in total volume of effluent.

Additional NPDES Permitted Discharges

Certain types of discharge that have active NPDES permits in the watershed are not sources of solids to the river. Non solids producing permit types include groundwater remediation sites, geothermal discharges, and non-contact cooling water sources. For the types of sources just noted, waste load allocations total suspended solids are not required.

Reserve for Growth

The general form of the waste load allocations is a mass limit based on existing flows and currently permitted TSS concentrations. To account growth, a reserve of TSS load is included, based on twenty year build out scenarios for each facility. The reserve for growth for treatment plants is the sum of the expected suspended solids loads that occur in a twenty - year build out scenario, relative to the wasteload allocations. Thus, the size of the reserve represents the difference between current design flows and the flows expected after 20 years of population growth in the Treasure Valley. The reserve, if used by the treatment plants, will not exceed the TSS targets established in the TMDL. The mass balance capacity check described below incorporates the full reserve for growth in addition to the waste loads from Table 15, and shows that a margin of safety still exists with respect to the 50 mg/l, 60 day duration criterion.

How Should the Reserve be Factored Into Permits?

The total reserve is 3.62 tons of total suspended solids, as shown in Table 17, which can be added to existing waste load allocations. Each facility may use its allocated reserve as needed by requesting the incorporation of some portion of its reserve when its permit is re-issued by the EPA. It is expected that permits re-issued in 1998 and 1999, will incorporate the waste load allocations in Table 15. At the next five year permit cycle (after 1999), and in subsequent permit cycles, each facility can seek to incorporate all or part of its TSS reserve in its permit limit for that parameter, not to exceed a maximum of the waste load allocation from Table 15 plus the reserve in Table 17.

Table 17. Total Suspended Solids Reserve Growth

Facility Name	Plan Year	20 Year Additional Flow, MGD	Permit Limit TSS, mg/l	Allocated Reserve, tons/day
City of Boise combined	2015	14.2	30	1.78
Meridian	2015	5.18	30	0.65
Nampa	2015	4.75	30	0.60
Caldwell	2015	2.84	30	0.36
Star	2015	0.323	70	0.09
Middleton	2018	0.415	70	0.12
Notus	?	0.056	70	0.02
TOTAL				**3.62**

? Current design flow of 0.056 MGD, build out projection not available

River Load Capacity

The Boise River load capacities for total suspended sediments given 1995 30 day low flows are 35 tons/day at Middleton and 90 tons per day at Parma. The load capacities are shown in Table 18. The capacities are examples of typical load capacities. The actual capacity will vary with the flow of the river. The interaction of the load and waste load allocations with the capacity of the river are discussed below.

Table 18. Boise River Total Suspended Sediment Load Capacities

Boise River Location	1995 30 day Irrigation Season Low Flow, cfs	TSS, mg/l	Load Capacity, tons/day
Middleton	257	50	35
Parma	667	50	90

Comparison of Allocations to Capacity

To verify that reducing 1995 loads by 37% would meet the target criteria for sediment, DEQ selected a day (June 6, 1994) on which the critical flow condition occurred at Parma when all diversions were operating. A mass balance established for June 6, 1994 with all allocated loads from Table 14, waste loads from Table 15, and the 3.62 tons/day reserve for growth from Table 17 yields a maximum suspended sediment concentration in the river of 30 mg/l, and a mass load at Parma of 53 tons per day. Both the concentration and the mass load from the scenario provide a significant margin of safety. The example condition occurred between April 15 and June 14, coinciding with the time period when large sediment loads are likely to move through tributaries and drains. Table 19 shows the results of the mass balance analyses.

Table 19. Capacity Mass Balance Results

	Date	Flow	TSS Capacity, tons / day	Balanced Load, TSS tons / day	Margin of Safety, percent
Middleton		287	39	6	85%
Parma		667	90	53	41%

The results show that the load allocations will meet instream criteria and provide a good margin of safety with respect to the capacity of the river across a range of flows.

Margin of Safety

- Selection of targets - the target criteria are protective of the most sensitive life stages of the fish present in the Boise River, such as Rainbow / Redband trout, Brown trout, and mountain whitefish.

- Choice of 30 day low flow as the critical flow - the thirty day low flow choice is a lower flow than a 60 day minimum flow (which would be associated with the chronic criterion), and thus adds a significant element of conservatism.

- Load allocations that yield loads in the river that are less than the total capacity, leaving a margin of safety relative to the target concentration, and to the critical flow load capacity.

The loads incorporate a variety of implicit and explicit safety elements that together create a conservative approach to suspended sediment and solids allocations in the lower Boise River watershed. The margin of safety at Parma, given the critical flow condition, is 41% of river capacity, or 37 tons per day. Figure 22, below, shows the mass balance for the 1994 critical flow condition. Please note the “River Concentration” and the “River Load” columns.

Figure 22. Critical Flow Mass Balance, TSS Capacity Check

June 6, 1994 Total Suspended Sediment Mass Balance

Allocated loads, waste loads, and reserve for growth

Lower Boise River

12/18/1998

Gray bars are diversions

-8.4
3.3
3.9

Location	River Mile	Source Flow cfs	In River Flow cfs	GrndH2O Flow cfs	Source [TSS] mg/l	Mixed In River [TSS] mg/l	Main & North Channels Cumulative Load in River tons/day	South Channel Cumulative Load in River tons/day	Load From Source tons/day
BR Below Div Dam	**61.2**		**1720.0**	0.00	**5**	**5**	**23**	**N/A**	
Ridenbaugh	58.3	-496.0	1199.6	-24.42	5	5	17	**N/A**	-6.8
Bubb	57.5	-8.0	1184.8	-6.74	5	5	16	**N/A**	-0.1
Meeves	56.8	-1.0	1178.0	-5.89	5	5	16	**N/A**	0.0
Rossi Mill	56.4	-6.0	1168.6	-3.37	5	5	16	**N/A**	-0.1
River Run Canal	56.1	-18.0	1148.1	-2.53	5	5	16	**N/A**	-0.3
River Run Return	56	18.0	1165.2	-0.84	22	5	17	**N/A**	1.1
Boise City Canal	55.9	-32.0	1132.3	-0.84	5	5	17	**N/A**	-0.5
Settlers	52	-157.0	942.5	-32.84	6	6	14	**N/A**	-2.4
Davis	52	-6.0	936.5	0.00	6	6	14	**N/A**	-0.1
Boise City Parks	51.5	-0.2	932.1	-4.21	6	6	14	**N/A**	0.0
Drainage Dist. #3	51	6.0	933.9	-4.21	22	6	15	**N/A**	0.4
Thurman Mill	51	-27.0	906.9	0.00	6	6	14	**N/A**	-0.4
Boise Water Corp.	50.7	-1.5	902.8	-2.53	6	6	14	**N/A**	0.0
Farmers Union	50.4	-182.0	718.3	-2.53	6	6	11	**N/A**	-2.9
Boise Valley Canal	50.4	0.0	718.3	0.00	6	6	11	**N/A**	0.0
Lander Street	49.9	23.2	737.3	-4.21	30	7	13	**N/A**	1.9
Riparian Corridor #1	49.8	18.2	754.7	-0.84	50	8	16	**N/A**	2.4
BR at Glenwood	**47.4**		**734.5**	**-20.21**		**8**	**16**	**N/A**	
North Channel Flow %		**0.5**							
South Channel Flow %		**0.5**							
New Dry Creek[N]	46	-40.0	331.9	2.34	8	8	7	**N/A**	-0.8
New Union[N]	46	-11.0	320.9	0.00	8	8	7	**N/A**	-0.2
Lemp Ditch[N]	45.4	-3.0	320.0	1.00	8	8	7	**N/A**	-0.1
Warm Springs Ditch[N]	44.8	-3.0	319.0	1.00	8	8	7	**N/A**	-0.1
Graham Gilbert[N]	44.2	-1.0	320.0	1.00	8	8	7	**N/A**	0.0
Ballentyne[N]	43.6	-18.0	304.0	1.00	8	8	6	**N/A**	-0.4
Eagle Drain[N]	43.3	21.0	326.0	0.50	28	9	8	**N/A**	1.6
Conway-Hamming[N]	43	-3.0	324.0	0.50	9	9	8	**N/A**	-0.1
Eagle Island Park[N]	42.4	-0.3	325.7	1.00	9	9	8	**N/A**	0.0
Aiken, Thomas[N]	41.8	0.0	327.8	1.00	9	9	8	**N/A**	0.0
Hart-Davis[N]	40.5	-9.0	323.1	2.18	9	9	8	**N/A**	-0.2
Middleton Irrigation[N]	40.4	-108.3	215.1	0.17	9	9	5	**N/A**	-2.5
Little Pioneer[N]	38	-28.7	194.5	4.02	8	8	4	**N/A**	-0.6
West Boise WWTP[S]	43.5	59.1	439.4	6.53	30	11		13	4.8
Mace-Caitlin[S]	42.5	-7.0	435.7	1.67	11	11		13	-0.20
Mace&Mace[S]	41.1	0.0	440.4	2.34	11	11		13	0.00
Wroten, Jon[S]	40.8	-1.0	440.4	0.50	11	11		13	-0.03
Barber Pumps[S]	40.4	-0.7	441.1	0.67	11	11		13	-0.02
Seven Suckers[S]	40.4	-1.2	439.9	0.00	11	11		13	-0.03
Thurman Drain[S]	40	20.0	461.2	0.67	6	10		13	0.34
Meridian WWTP*	39.5	12.4	462.9	0.84	30	10		13	1.0
Eureka #1[S]	39.2	-31.0	432.9	0.50	10	10		12	-0.9
Phyllis Canal[S]	39.2	-322.9	110.0	0.00	10	10		3	-9.0
Eagle Island Hatchery	38.0	2.4	116.4	2.01	15	10		3	0.1
Canyon County	32.9	-54.4	328.0	17.07	7	7	6	**N/A**	-1.0
Caldwell Highline	32.4	-47.3	282.3	1.67	7	7	5	**N/A**	-0.9
BR near Middleton	**31.2**		**286.4**	**-10.10**		**7**	**6**	**N/A**	
Fifteenmile Creek	27.7	137.9	437.7	13.49	48	20	24	**N/A**	18.02
Riparian Corridor #2	27.6	18.2	456.3	0.39	50	21	26	**N/A**	2.45
Mill Slough	26.4	176.9	637.9	4.62	15	19	33	**N/A**	7.08
Star Feeder	26.4	55.0	692.9	0.00	12	19	35	**N/A**	1.73
Long Feeder	26.4	2.0	694.9	0.00	65	19	35	**N/A**	0.35
Watts Creek	26.4	17.7	712.6	0.00	6	18	36	**N/A**	0.28
Middleton WWTP	25.4	3.50	719.9	3.85	70	19	36	**N/A**	0.66
Willow Creek	24.7	17.6	740.2	2.70	48	19	39	**N/A**	2.28
Mason Slough	23.2	23.6	769.6	5.78	19	19	40	**N/A**	1.20
Mason Creek	23.2	127.6	897.2	0.00	62	25	61	**N/A**	21.48
Riverside Canal	22.6	-208.0	691.5	2.31	25	25	47	**N/A**	-14.1
East Hartley Gulch	22.4	68.0	760.3	0.77	22	25	51	**N/A**	4.06
West Hartely Gulch	22.4	21.0	781.3	0.00	22	25	52	**N/A**	1.25
Sebree Canal	21.9	-239.0	544.2	1.93	25	25	36	**N/A**	-15.95
Campbell	21.9	-25.3	518.9	0.00	25	25	35	**N/A**	-1.69
Siebenberg	21.9	-8.4	510.5	0.00	25	25	34	**N/A**	-0.56
Shipley Pumps	21	-0.2	513.8	3.47	25	25	34	**N/A**	-0.01
Wagner Pumps	20.8	-0.4	514.1	0.77	25	25	34	**N/A**	-0.03
Caldwell WWTP	20.4	17.5	533.2	1.54	30	25	35	**N/A**	1.42
Nampa WWTP**	N/A	25.5	N/A	N/A	30	N/A	N/A	**N/A**	2.07
Indian Creek	19.7	53.6	589.5	2.70	40	26	41	**N/A**	5.74
Simplot Pumps	18.8	-0.6	592.4	3.47	26	26	41	**N/A**	-0.04
Eureka #2	17.9	-106.9	488.9	3.47	26	26	34	**N/A**	-7.37
Upper Center Point	17.6	-17.7	472.4	1.16	25	25	32	**N/A**	-1.22
McManus-Teater	17.6	-3.0	469.4	0.00	25	25	32	**N/A**	-0.21
Atwell Duck Club	17.6	-0.8	468.6	0.00	25	25	32	**N/A**	-0.06
Lower Center Point	16	-32.4	442.3	6.16	25	25	30	**N/A**	-2.20
Bowman Swisher	13.2	-18.3	434.8	10.79	25	25	29	**N/A**	-1.21
Conway Gulch	13.1	67.6	502.8	0.39	39	26	36	**N/A**	7.14
Baxter	12.2	-12.0	494.3	3.47	26	26	35	**N/A**	-0.85
Andrews Ditch	10.4	-16.6	484.6	6.94	26	26	34	**N/A**	-1.16
Dixie Drain	9.4	257.0	745.5	3.85	37	30	60	**N/A**	25.91
Riparian Corridor #3	9.35	18.2	763.9	0.19	50	30	62	**N/A**	2.45
Mammon Pumps	9.3	-7.0	757.1	0.19	30	30	62	**N/A**	-0.57
Hass	8	-9.0	753.1	5.01	30	30	61	**N/A**	-0.73
Parma Ditch	7.5	-26.3	728.7	1.93	30	30	59	**N/A**	-2.12
Island Highline	6.5	-39.6	692.9	3.85	30	30	56	**N/A**	-3.18
Crawforth Pumps	4.3	-0.8	700.6	8.48	29	29	56	**N/A**	-0.06
McConnell Island	4.1	-36.7	664.7	0.77	29	29	53	**N/A**	-2.91
BR near Parma	**3.5**		**667.0**	**2.31**	**29**	**29**	**53**	**N/A**	

*Meridian discharge is included in the Fifteenmile Creek Load, rather than the Boise River

**Nampa discharge is included in the Indian Creek Load

[N] North Channel of the Boise River around Eagle Island

[S] South Channel of the Boise River around Eagle Island

Achieving Loads

The load reductions can be achieved in a number of ways. Treatment methods including, but not limited to, tillage practices, on farm sediment ponds, constructed wetlands, filter strips, and sprinkler irrigation may be utilized. As noted on page 57, DEQ will determine the appropriate methodology for demonstrating that load allocations are achieved.

4.2 Bacteria

Two segments of the Boise River, Star to Notus and Notus to the Snake River require the development of TMDLs for bacteria. The goal of the bacteria TMDLs for the two segments is to meet applicable state criteria for primary and secondary contact recreation.

Bacteria Targets

The targets for bacteria in the Boise River are based upon the state criteria for primary and secondary contact recreation. The compliance points for bacteria loadings are Glenwood Bridge, the Middleton gage site, and the Parma gage site. Both primary and secondary contact recreation beneficial uses have associated numeric criteria in Idaho's Water Quality Standards and Wastewater Treatment Requirements.

primary contact recreation (May 1 - September 30) fecal coliform bacteria colonies:

- may not exceed 500/100 ml at any time;
- may not exceed 200/100 ml in more than 10% of the total samples taken over a thirty day period; and
- may not exceed a geometric mean of 50/100 m/l based on a minimum of five samples taken over a thirty day period (IDAPA 16.10.02.250.01.a).

secondary contact recreation (all year) fecal coliform bacteria colonies:

- may not exceed 800/100 ml at any time;
- may not exceed 400/100ml in more than 10% of the total samples taken over a thirty day period; and
- may not exceed a geometric mean of 200/100 m/l based on a minimum of five samples taken over a thirty day period (IDAPA 16.01.02.250.01.

Bacteria Load Targets

Since contact recreation is presumed to be possible or occurring at any location in the Boise River, during any time of the year, no one flow condition is a critical flow. The load targets bacteria are variable, so long as the criteria displayed above are met. A range of low flow and average loads are included in Tables 20 and 21 as references, but are not fixed load limits for bacteria colonies.

Table 20. Critical Low Flow Bacteria Loads

	1992 30 day low	Primary	Primary	Secondary	Secondary
Location	Flow, cfs	Target, CFU/100 ml	Load Capacity CFU / day	Target, CFU/100 ml	Load Capacity CFU / Day
Glenwood Bridge	110	50	1.35×10^{11}	200	5.38×10^{11}
Middleton	151	50	1.85×10^{11}	200	7.39×10^{11}
Parma	160	50	1.96×10^{11}	200	7.83×10^{11}

CFU = one colony of fecal coliform bacteria

Table 21. Average Condition Bacteria Loads

	1995 Average Flow May -Sept	Primary	Primary	1995 Annual Avg Flow	Secondary	Secondary
Location	Flow cfs	Target, CFU/ 100 ml	Load Capacity CFU / day	Flow cfs	Target CFU/100 ml	Load Capacity CFU / Day
Glen.	2203	50	2.70×10^{12}	1225	200	6.00×10^{12}
Middle.	1641	50	2.01×10^{12}	989	200	4.84×10^{12}
Parma	2277	50	2.79×10^{12}	1603	200	7.85×10^{12}

Bacteria Load Allocations

The tributaries to the lower Boise River can be significant sources of bacteria loading to the river, and generally will have to reduce bacterial counts to levels close to the state criteria in order to protect contact recreation beneficial uses. Since the Boise River near Glenwood Bridge has an approximate geometric mean of just over 50 colonies per 100 milliliters, generally no dilution for the geometric mean is available to downstream sources. The short length of the river and fast travel times for water mean that new dilution does not become available along the length of the river given an approximate die off rate of 0.5 / day for fecal coliform in the Boise River (Tetra Tech, 1975, p. 98). Thus, the tributaries and drains to the lower Boise River must be able to meet a geometric mean of 50 coliform colonies per 100 ml where they enter the river. When dilution is available in the river, tributaries and drains may be able to have slightly more coliform colonies per 100 ml, so long as concentrations of bacteria in the river do not exceed the state criteria. Table 22 shows the primary season (May 1 to September 30) and secondary season geometric mean load allocations for tributaries to the Boise River.

Table 22. Percent Reductions Required to Meet Instream Bacteria Goals

Name	Primary Geo- Mean CFU/100 ml	Primary Load Allocation CFU/100 ml geometric mean	Primary Percent Reduction	Secondary Geo-Mean CFU/100 ml	Secondary Load Allocation CFU/100 ml geometric mean	Secondary Percent Reduction
Eagle Drain	604	50	92	579	200	65
Thurman Drain	758	50	93	512	200	61
Fifteenmile Cr.	992	50	95	612	200	67
Willow Creek	803	50	94	528	200	62
Mill Slough	1282	50	96	556	200	64
Mason Slough	3507	50	99	1422	200	86
Mason Creek	1407	50	97	515	200	61
East and West Hartley Gulch	2296	50	98	565	200	65
Indian Creek	770	50	94	384	200	48
Conway Gulch	723	50	93	144	200	0
Dixie Drain	2987	50	98	1156	200	83
Boise River @ Middleton	208	50	76	106	200	0
Boise River @ Parma	703	50	93	344	200	42

The bacterial reductions for the Boise River at Middleton and Parma, as indicated by the shaded rows in Table 22, are not intended to drive further reductions in the tributaries. The reductions for the Boise River at Middleton and Parma are merely an attempt, due to a lack of data, to describe the bacteria load from the riparian corridor of the river. The listed reductions at Middleton and Parma should not be construed as set "goals", as indicated by the table title. Rather, they should be interpreted as short-term indicators of the level of reductions that may be necessary in the riparian corridor. The Division of Environmental Quality plans to conduct reconnaissance level source identification in the riparian corridor to more accurately identify and characterize riparian bacteria sources to the river. To aid in this process, the Lower Boise WAG has recently (August 1999) entered into a contract with CH2M Hill and the University of Washington to characterize the bacteria sources in the river via DNA ribo-typing. When these data are complete and have been analyzed, actual percent reductions and reduction strategies for riparian corridor sources will be addressed.

Judging Compliance with Bacteria Load Allocations

The bacteria load allocations are designed to target the geometric mean criteria for fecal coliform, but compliance with those criteria must be judged using an appropriate number of samples and averaging. Tributaries should discharge bacteria in quantities that do not exceed state criteria for bacteria assuming little likelihood for dilution and minimal die-off. Thus, one measurement of bacteria at the mouth of a tributary that is greater than 50 colonies per 100 ml does not constitute a violation of the allocation. Compliance is judged when a tributary does not cause exceedences of the seasonally applicable criteria in the Boise River. The load allocations are thus flow variable, and the geometric mean targets shown in table 22, above are the most stringent case within the variable scenario.

Non Point Source Loads

Non point sources of bacteria loading to the river, such as pasture lands in the Boise River floodplain, should be managed to prevent the movement of bacteria into the river.

Bacteria Waste Load Allocations

Waste load allocations for bacteria in general form contain a concentration requirement equal to existing permit limits, and flow variable loads of coliform units per day. The limits are designed to ensure that instream criteria for bacteria are always met, expressed in colonies of fecal coliform per 100 milliliters of water. Actual loads and loading capacity will change based on daily discharge variability. No reductions are necessary for the NPDES permitted facilities, as shown by comparing the effluent geometric mean values in column two of Table 23 to the permit limits column.

Table 23. Bacteria Wasteload Allocations

Site	Average of Effluent Fecal Coliform Geometric Mean CFU / 100 ml	Fecal Coliform Wasteload* Allocations CFU / 100 ml May 1 - Sept 30	Fecal Coliform Wasteload* Allocations CFU / 100 ml Oct 1 - April 30
Lander Street	12	Monthly 50 Weekly 100 Daily 500	Monthly 100 Weekly 200 Daily 800
West Boise	16	Monthly 50 Weekly 100 Daily 500	Monthly 100 Weekly 200 Daily 800
Meridian Discharge to Fivemile Creek	9	Monthly 100 Weekly 200 Daily 800	Monthly 100 Weekly 200 Daily 800
Meridian Discharge to Boise River	9	Monthly 50 Weekly 100 Daily 500	Monthly 100 Weekly 200 Daily 800
Nampa	65	Monthly 200 Weekly 200 Daily 800	Monthly 200 Weekly 200 Daily 800
Caldwell	4	Monthly 50 Weekly 100 Daily 500	Monthly 100 Weekly 200 Daily 800
Middleton	21	Monthly 50 Weekly 100 Daily 500	Monthly 100 Weekly 200 Daily 800
Star	24	Monthly 50 Weekly 100 Daily 500	Monthly 100 Weekly 200 Daily 800
Notus	47	Monthly 50 Weekly 100 Daily 500	Monthly 100 Weekly 200 Daily 800
Wilder	16	Monthly 100 Weekly 200 Daily 500	Monthly 100 Weekly 200 Daily 800
Armour	10	Monthly 50 Daily 400	Monthly 200 Daily 400

*Monthly and weekly values are averages; daily is the instantaneous maximum

Sand and Gravel Operations

Sand and gravel operations that fall under general permits are not dischargers of fecal coliform bacteria, and do not receive waste load allocations for bacteria. All sand and gravel operations in the Treasure Valley have NPDES permits issued by the Environmental Protection Agency that specify a strict non-discharge requirement for all operational activities. Storm water runoff from these facilities is the only permitted discharge of water, and is required to meet concentration limits for total suspended sediments that are less than the criteria developed for the Boise River by DEQ. The TMDL cannot issue waste load allocations for sand and gravel, since those facilities are already required to have no operational discharge. Performance based permitting is the appropriate method for controlling storm water runoff. Waste load allocations would contradict the non-discharge requirements already in place.

Fish Hatcheries - Eagle Island and Nampa

Coliform bacteria inhabit the intestinal tracts of warm blooded animals such as livestock, geese, and humans. Fish, such as trout in the two hatcheries operated by the Idaho Department of Fish and Game, are not sources of coliform bacteria (Geldreich, 1967). Since the hatcheries are not sources of coliform bacteria, (as recognized by the EPA in its NPDES permits for the hatcheries, which do not include fecal coliform limits), no waste load allocations for bacteria are proposed for the hatcheries.

Background

The average count of fecal coliform bacteria in the Boise River near Diversion Dam since November of 1993 is 2 / 100 ml, which constitutes the background concentration of bacteria entering the watershed. Expressed as a load, using the 1995 annual average flow, the background load of organisms is roughly 1588 cfs * 2 CFU/100 ml * 24.47 x 10^6 = 7.8 x 10^{10} CFU / day. For the primary contact recreation season, the approximate background coliform load is 2934 cfs * 2 CFU/100 ml * 24.47 x 10^6 = 1.4 x 10^{11} CFU / day.

Margin of Safety for Bacteria

An implicit margin of safety is built into the analysis of fecal coliform bacteria. The margin is based primarily upon the way in which the load reduction requirements are calculated. Because the data used to evaluate tributary loads are widely spaced instantaneous samples (fewer than five in a 30 day period), the geometric mean values calculated to develop load reduction goals are likely to be more stringent than true geometric mean values. The analysis also assumed no dilution available to the tributaries, and estimated load capacities based on 30 day minimum flows for 1992, which was the lowest flow year on record for the lower Boise River. Thus, the reductions needed to meet the calculated capacities are large and conservative. For treatment plants, disinfection and management of effluent is expected to be relatively stable over time, and generally provides fecal coliform counts well below permit requirements.

The standards for fecal coliform maintained by the State of Idaho are more stringent than the criteria developed by the National Technical Advisory Committee. That committee recommended a geometric mean count of no more than 200 colonies per 100 ml of fecal coliform in order to protect primary contact recreation uses (EPA, 1992). The State of Idaho relies upon a geometric mean value of 50 colonies per 100 ml for the primary season, which is four times more stringent than the Federal recommendation. Thus, the use of that standard has already built in a considerable margin of safety into the analysis.

Potential Change of Criteria

The Negotiated Rulemaking Committee for the State of Idaho has proposed E. Coli criteria to be used as the basis for assessing support of contact recreation beneficial uses. Should the E. Coli criteria be approved by the legislature and codified in the Water Quality Standards and Wastewater Treatment Requirements for Idaho (IDAPA 16.01.02), compliance with the load allocations in this TMDL could be demonstrated using E. Coli samples, rather than fecal coliform. The intent of the TMDL is to protect contact recreation beneficial uses, as demonstrated by bacteria criteria, whatever the most current bacteria criteria may be. For waste load allocations that are part of NPDES permits, the waste loads for fecal coliform should remain through the duration of a five year permit cycle. If E. Coli are used as the new Idaho criteria for contact recreation when the permits are re-issued, the new E. Coli criteria should be incorporated into the permits in place of fecal coliform requirements.

4.3 Temperature

Two segments of the Boise River have temperature listed as a pollutant on the 1996 303(d) list Idaho. The first segment extends from Star to Notus, while the second extends from Notus to the Snake River. The Boise River has water temperature criteria applicable to segments designated for salmonid spawning, as well as for cold water biota. The water temperature criteria for cold water biota and salmonid spawning are shown in Table 24, below.

Table 24. Water Temperature Criteria

Criteria	Cold Water Biota	Salmonid Spawning
Daily Maximum	22 deg C.	13 deg C.
Maximum Daily Average	19 deg C.	9 deg C.

The cold water biota criteria apply from Lucky Peak Dam to the Snake River, including the two river segments listed temperature downstream of Star. Salmonid spawning criteria apply from Diversion Dam to Caldwell, and include part of the segment from Star to Notus that is listed for temperature. Since mountain whitefish are the only salmonids known to inhabit the Boise River downstream of Star, the water temperature criteria for spawning apply from October 15 to March 15.

Temperature Source Analyses

Analyses of summer and winter temperatures in the lower Boise River identify the sources of heat load that influence river temperatures. The size of the heat load contribution from each source defines which sources are the most significant. Sources of heat include the groundwater, air temperature, sunlight, wastewater treatment plant effluent, and tributaries.

Cold Water Biota Criteria

Water temperature criteria for cold water biota are not fully supported during the summer months from Middleton to the mouth of the Boise River. Water temperatures in excess of the state criteria occur occasionally at Middleton and Caldwell, and very frequently in the vicinity of Parma. The majority of criteria exceeding water temperatures occur in June, July, and August. A few exceedences may occur during May and September of especially hot years. Both the daily maximum criterion and the maximum daily average criterion for water temperature with respect to cold water biota are not met downstream of Middleton.

Salmonid Spawning Criteria

Water temperature data from the Parma gage site show that the Boise River exceeded the salmonid spawning daily maximum criterion in 3.5 percent of the samples between 1986 and

1997, generally in October and March. Water temperatures in excess of the daily average salmonid spawning criterion occurred in 18.5 percent of the samples between 1986 and 1997, and were clustered in October, November, February, and March. Only two daily average exceedences occurred in December and January since 1986.

Sources of Heat Load to the River

During the salmonid spawning time period for the Boise River downstream of Middleton, from October 15 to March 15, the anthropogenic sources of heat load do not contribute nearly as much heat to the river as do the natural sources. The Caldwell waste water treatment plant adds heat load to the river that is an order of magnitude less than the total heat load needed to raise the water temperature of the river by one degree Celsius. Since the size of the water temperature criteria exceedences can be from one to five degrees, the natural sources of heat are causing the majority of the temperature change The pattern of water temperatures in the river closely track air temperatures. The average air temperatures on days when the river water exceeds the 9 degree Celsius average criterion salmonid spawning range from 2.5 to 6.7 degrees Celsius warmer than the air temperatures on days when the river meets the criterion. The causes of cold water biota temperature criteria exceedences are very similar. Detailed discussions of the temperature analyses are available in Appendix F.

The climate of the lower Boise river valley has a strong controlling influence on the temperature of the water in the Boise River during the summer months. Other inputs of heat load to the river, such as tributaries and waste water treatment plants, contribute only modest percentages of the total temperature increases that occur in the river.

Temperature Recommendations

Load allocations for temperature are not recommended for the lower Boise River segments listed temperature. Instead, the finding that atmospheric conditions preclude compliance with cold water biota temperature criteria during June, July and August should be reviewed and supported with additional analysis as needed. A variety of regulatory options should be explored to address only the lower Boise River segments from Star to Notus and Notus to the Snake River, in which a mix of aquatic species, such as mountain whitefish, suckers, shiners, and bass exist despite temperatures that sometimes exceed state criteria. The options for addressing the temperature regime of the Boise River downstream of Star may include site specific criteria or a use attainability analysis to suggest an alternative set of criteria applicable to the suite of biota present in that portion of the river. In addition, a Cool Water Biota beneficial use containing temperature criteria between the cold and warm water uses has been proposed by the state negotiated rule making committee and represents a potential alternative for the lower Boise River downstream of Star.

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Acronyms

(Ag Plan)	Agricultural Pollution Abatement Plan
(BAG)	Basin Advisory Group
(BMP)	Best Management Practices
(CAFO)	Confined Animal Feeding Operation
(CFA)	Confined Feeding Areas
(CWB)	Cold Water Biota
(DEQ)	Idaho Division of Environmental Quality
(DO)	Dissolved Oxygen
(EPA)	Environmental Protection Agency
(EPT Taxa)	Ephemeroptera, Plecoptera, and Tricoptera
(EQIP)	Environmental Quality Incentive Program
(HUC)	Hydrologic Unit Code
(IDA)	Idaho Department of Agriculture
(IDAPA)	Idaho Administrative Procedures Act
(IDFG)	Idaho Fish and Game
(IDHW)	Idaho Department of Health and Welfare
(IDL)	Idaho Department of Lands
(IDWR)	Idaho Department of Water Resources
(IPC)	Idaho Power Company
(IRI)	Idaho River Index
(LBRWQP)	Lower Boise River Water Quality Plan
(MOU)	Memorandum of Understanding
(NRCS)	Natural Resource Conservation Service
(NPDES)	National Pollutant Discharge Elimination System
(NTU)	Nephelometric Turbidity Units
(SAWQP)	State Agricultural Water Quality Program
(SCC)	Soil Conservation Commission
(SCD)	Soil Conservation District
(SS)	Suspended Solids
(TMDL)	Total Maximum Daily Load
(USBR)	The U.S. Bureau of Reclamation
(USGS)	United States Geological Survey
(WAG)	Watershed Advisory Group
(WLA)	Wasteland Allocation
(WWTP)	Wastewater Treatment Plants

Abbreviations

ºC	degrees Celsius
cfs	cubic feet per second
ft	foot
ha	hectare
kg	kilogram
km	kilometer
l	liter
m	meter
mg	milligram
mgd	million gallons per day
mgll	milligrams per liter
mi	mile
ml	milliliter
T	ton
ug	microgram
yr	year

Appendices

APPENDIX A

Proposed Changes to the 1998 303(d) List for the Lower Boise River

December 22, 1997

MEMORANDUM:

TO: Bill Clark, DEQ Central Office

FROM: Sally Goodell, Boise Regional Office

THROUGH: Craig Shepard, Boise Regional Office
Steve West, Boise Regional Administrator

SUBJECT: Proposed Changes To The 1998 303(d) List For The Lower Boise River

The Boise Regional Office has been reviewing data in detail as part of our development of a draft problem assessment for the lower Boise River. Based on our review of the available data we recommend the following changes to the 1998 303(d) list for the Boise River:

Segment	Change
Boise River, Barber Diversion to Star	Delete dissolved oxygen(DO) Delete oil and grease
Boise River, Star, to Notus	Delete DO
Boise River, Notus, to Snake River	Delete DO

These recommendations were reviewed by the lower Boise River Watershed Advisory Group (WAG) in October 1997.

Oil and Grease

These pollutants were originally listed for the Boise River from Barber Diversion to Star based on the 1992 305(b) report, "The 1992 Idaho Water Quality Status Report". Oil and grease was identified in the 305(b) report as a potential pollutant based on the best professional judgement of DEQ staff. It is our opinion that the data not substantiate that oil and grease are impairing uses in the River. The U.S. Geological Survey (USGS) under contract to the City of Boise, has collected oil and grease data at stormwater outfalls in Boise, and Garden City, during several stormwater events. The Bureau of Reclamation has collected oil and grease data in selected drains and streams in the Boise area that discharge to the Boise River. An analysis of the data supporting de-listing of this pollutant is attached for your review.

The USGS collected and analyzed their samples using standard USGS quality assurance methods that are described in the report "Data and Adjusted Regional Regression Models of Volume and Quality of Urban Storm-Water Runoff in Boise and Garden City, Idaho", USGS Water

Resources Investigation Report 95-4228. Quality assurance methods used by the Bureau of Reclamation for sampling and analysis are described in the report "Five Mile Drain Storm Water Quality Study, Draft Scope of Work".

DEQ's recommendation to de-list oil and grease for the Boise River was presented to the stormwater work group that supports the lower Boise River WAG. The work group supports the recommendation and further recommends that oil and grease in stormwater discharge to the Boise River be monitored in the future to detect any changes in conditions.

Dissolved Oxygen

All three of the segments of the Boise River that are currently listed for DO are designated for cold water biota. The DO criteria for cold water biota in the Idaho Water Quality Standards and Wastewater Treatment Requirements requires that DO remain above 6.0 mg/l at all times. DO has been measured by the USGS at four sites in the Boise River during synoptic sampling conducted between May 1994 and August 1997. DO data for earlier dates is available for three of the four sites (Boise River below Diversion Dam, at Glenwood Bridge, and near Parma). We confined our analysis to data available from the last five years. In addition, the USGS collected diel DO data at five sites in August and early September 1997. All data were collected using standard USGS methods for quality assurance.

Tables showing the synoptic DO data at the four major river sites and tables and graphs of the diel DO measurements are attached for your review. The sampling sites relate to listed segments as follows:

Boise River, above Barber Diversion	Boise River below Diversion Dam (13203510)
Boise River, Barber Diversion to Star	Boise River at Glenwood Bridge (13206000) Boise River at Eckert Road
Boise River, Star, to Notus	Boise River near Middleton (13210050) Boise River near Caldwell
Boise River, Notus, to Snake River	Boise River near Parma (13213000)

In all of these samples, there has not been a single measurement that did not meet the applicable DO criteria. Based on these data the Boise Regional Office recommends removing DO from the 303(d) list for all three segments of the lower Boise River.

If you have any questions or need additional information, please contact me at 373-0575, or Paul Schinke at 373-0589.

SG:cm h:\98-303d.wpd

Draft Oil and Grease Sampling Summary
Lower Boise River Watershed

Idaho Division of Environmental Quality, Boise Regional Office 11/18/97

The data summarized below were collected by the US Geological Survey (USGS) for the City of Boise in support of an NPDES storm water permit application, and by the Bureau of Reclamation (BOR) on selected drains. The USGS monitored the runoff from three storm events that caused precipitation over the watersheds of the outfalls in Table 1, below.

Table 1. Concentrations of Total Recoverable Oil and Grease in mg/l from WRI Report 95-4228, USGS

Outfall Location	Storm 1	Storm 2	Storm 3
Walnut Street	<1	<1	<1
Boise State University	5	2	3
9th Street	1	2	1
Americana Blvd.	2	2	2
43rd Street - Davis Drain	3	4	>1

The storm events that caused runoff ranged in size from 0.03 inches to 0.34 inches of precipitation, and cover a good cross section of storm sizes when compared to events recorded in Boise from 1976 - 1993. A precipitation event larger than 0.50 inches did not occur in Boise during the USGS study, but events of that size represent only 10 percent of the storms in the historical record (USGS, 1995).

The water quality samples collected for the City of Boise were all gathered during the "first flush," and thus may represent concentrations of oil and grease that are higher than the average for the entire runoff event. The estimated concentrations of oil and grease in the Boise River after mixing of the storm water runoff with the river water are shown in Table 2, below. In the table, all estimated concentrations are reported only to four decimal places, and all are well below 1 mg/l. Since the 43rd Street outfall in Garden City enters the Davis Drain, for which flow data are not available, its contribution is assumed to enter the Boise River directly without the benefit of dilution in the drain. The spreadsheet and statement of assumptions used in the calculations shown in Table 2 is available from DEQ upon request.

Table 2. Estimated Concentrations of Oil and Grease in the Boise River after Mixing*, mg/l
(R) indicates runoff from an outfall on a given date.

Storm Date	Downstream of Walnut Street	Downstream of Boise State	Downstream of 9th Street	Downstream of Americana	Downstream of 43rd Street
10/7/93	0.0001 (R)	0.0004 (R)	0.0006 (R)	0.0006	0.0006
12/7/93			0.0007 (R)	0.0023 (R)	0.0023
12/11/93	0.0006 (R)	0.0025 (R)	0.0025	0.0025	0.0025
4/23/94		0.0011 (R)	0.0011	0.0019 (R)	0.0019
5/4/94			0.0000 (R)	0.0000	0.0000
5/17/94	0.0002 (R)	0.0002	0.0002	0.0002	0.0002
6/1/94				0.0005 (R)	0.0005
9/13/94					0.0019 (R)
10/4/94					0.0285 (R)
10/14/94					0.0012 (R)

*Not every drainage area received precipitation during every storm. Concentrations are carried downstream from the first date when and location where runoff occurred.

Bureau of Reclamation Sampling in Drains

The Bureau of Reclamation has developed a study plan to monitor a group of pollutants during four storm events over the course of one year. Sampling sites are spaced along Fivemile Creek, Ninemile Creek, South Slough, Sky Pilot Drain, and Solomon Drain. One data set is available at present, and oil and grease concentrations at all sites are less than the detection limit (Table 3).

Table 3. Bureau of Reclamation Oil and Grease Sampling Results

Parameter	Fivemile Franklin	Fivemile Ustick	North Slough Fry St.	North Slough Eagle Road
Oil & Grease, mg/l	< 5.0	< 5.0	< 5.0	< 5.0
Parameter	**South Slough**	**Ninemile Creek**	**Solomon Drain**	**Sky Pilot Drain**
Oil & Grease, mg/l	< 5.0	< 5.0	< 5.0	< 5.0

Typical Oil and Grease Content of Urban Runoff

Oil and grease data from the Federal Highway administration indicate that typical concentrations in runoff range from 6 to 16 mg/l. A report from the Watershed '96 Conference in Washington, D.C., indicates that oil and grease in storm water derived from roads and parking lots may range from 0.7 to 6.6 mg/l. In comparison, the City of Boise storm water drains all have measured concentrations less than 6.0 mg/l, and are within normal the normal range for oil and grease.

Impacts of Oil and Grease

The concentrations of oil and grease that cause negative impacts on aquatic life are widely variable depending upon the specific petroleum hydrocarbon of interest. Given that oil and grease are washed into the Boise River at the low concentrations measured, and that runoff volumes are not large in comparison to the flow of the river itself, aquatic life forms are not exposed to concentrations that cause impairment.

Conclusions

- The 1996 303(d) listings of oil and grease as pollutants of concern for the Boise River from Barber Diversion to Star are incorrect and should be removed when the 1998 303(d) list is prepared.
- Storm water management activities already in place are sufficient to manage oil and grease runoff from the Boise urban area.

References

Bureau of Reclamation, Five Mile Drain Storm Water Quality Study, Draft Scope of Work, March, 1997.

Constituents of Highway Runoff, Vol. IV, Characteristics from Operating Highways, Research Report, Federal Highway Administration, Office of Research and Development, Washington, D.C., February, 1981.

Dupuis, Tom, CH2M Hill Consulting, Milwaukee, Wisconsin. Personal communication on May 13, 1997.

Kjelstrom, L.C., "Data for and Adjusted Regional Regression Models of Volume and Quality of Urban Storm-Water Runoff in Boise and Garden City, Idaho, 1993-94," US Geological Survey, Water Resource Investigations Report 95-4228.

Shepp, David L., "Petroleum Hydrocarbon Concentrations Observed in Runoff from Discrete, Urbanized, Automotive-Intensive Land Uses," Watershed '96 Conference Proceedings, pp. 220-223.

ALL DATA
AFTER SEP. 96 A[illegible]
PROVISIONAL RECO[illegible]

WATER-QUALITY DATA

DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	TEMPER-ATURE AIR (DEG C) (00020)	TEMPER-ATURE WATER (DEG C) (00010)	TUR-BID-ITY (NTU) (00076)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)
NOV 1993									
03...	1530	258	72	7.5	16.5	11.5	0.70	12.3	126
JAN 1994									
18...	1300	210	76	7.7	3.0	2.5	--	12.7	100
MAR									
10...	1215	245	86	8.1	6.5	3.0	1.0	12.4	101
MAY									
11...	1530	1770	90	7.8	28.0	9.0	0.40	11.0	106
JUL									
20...	1245	2010	76	7.6	29.5	15.5	--	9.6	106
SEP									
13...	1500	620	101	7.9	19.0	17.0	1.0	9.1	105
NOV									
14...	1400	161	109	8.4	5.5	8.5	--	12.7	118
APR 1995									
13...	1100	1420	92	6.7	--	6.0	--	12.1	108
26...	0930	4640	87	7.5	--	7.0	--	11.5	104
MAY									
16...	0940	4610	77	7.8	21.5	7.5	--	12.4	115
JUN									
12...	0905	2620	60	7.7	18.0	10.5	--	10.7	107
AUG									
14...	0525	1830	62	6.9	20.0	14.0	--	13.9	114
OCT									
19...	1400	337	73	7.6	16.0	14.5	--	9.4	101
DEC									
07...	1045	200	73	7.1	1.5	8.0	--	10.8	101
FEB 1996									
13...	1500	4000	81	7.8	11.0	2.0	--	13.3	106
APR									
11...	1005	5900	77	7.4	7.5	7.0	--	11.5	105
22...	0950	5400	74	7.7	14.0	7.5	--	14.0	120
MAY									
15...	1215	4650	71	7.7	22.0	8.0	--	12.2	116
JUN									
12...	1010	7800	59	7.8	20.5	10.5	--	10.6	104
AUG									
21...	0910	2100	61	6.6	16.0	14.5	--	9.5	102
OCT									
21...	1115	321	69	7.3	8.0	12.0	--	10.2	105
DEC									
16...	1330	240	74	8.0	10.0	6.0	--	12.1	107
FEB 1997									
[illegible]...	1000	7010	71	7.4	4.5	2.5	--	13.9	113
APR									
14...	1325	--	75	7.6	16	6.5	--	11.2	100
JUN									

PROVISIONAL RECORDS

PROVISIONAL RECORDS

AUG	1230	--	51	7.8	[illegible].0	14.0	SS --	13.4	145
11...	1525	--	56	7.8	[illegible].0	15.0	--	12.0	132

Diversion Dam

13206000 - BOISE RIVER AT GLENWOOD BRIDGE NR BOISE ID

WATER-QUALITY DATA

DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	TEMPER-ATURE AIR (DEG C) (00020)	TEMPER-ATURE WATER (DEG C) (00010)	TUR-BID-ITY (NTU) (00076)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)
NOV 1992									
02...	1345	83	198	7.9	11.5	12.0	1.2	10.9	111
JAN 1993									
07...	1345	71	274	7.4	-3.5	3.5	--	11.1	121
MAR									
10...	1245	120	251	8.0	6.5	8.0	3.3	10.8	101
MAY									
12...	1130	2570	99	8.1	28.5	8.5	6.2	12.3	116
AUG									
06...	1050	1130	71	7.3	22.5	14.0	--	9.7	102
SEP									
14...	1245	626	82	8.1	25.0	17.0	1.2	10.3	117
NOV									
01...	1630	240	127	7.8	12.0	10.5	0.60	15.4	152
JAN 1994									
19...	1345	336	116	7.8	-1.5	3.0	--	13.0	104
MAR									
04...	1145	248	143	8.3	17.0	7.0	0.60	13.6	124
MAY									
13...	1500	806	98	8.8	22.0	13.0	0.40	12.0	123
JUL									
12...	1345	1260	84	8.3	32.0	16.5	--	10.5	118
SEP									
09...	0930	398	116	7.8	17.0	17.0	0.90	8.4	96
NOV									
10...	1115	188	163	--	6.5	8.5	1.2	10.9	104
JAN 1995									
17...	1345	100	226	7.6	4.0	5.5	--	13.7	122
FEB									
14...	1500	195	174	8.7	4.5	4.0	--	14.3	121
MAR									
20...	1230	167	175	8.4	12.5	9.0	4.6	11.3	111
APR									
13...	1500	923	104	7.1	12.0	7.5	--	11.5	106
26...	1245	3450	90	7.4	--	8.0	--	10.2	102
MAY									
16...	1315	3990	80	8.2	15.5	8.0	2.0	11.2	106
JUN									
12...	1125	1710	70	8.0	28.0	12.0	--	10.0	101
JUL									
21...	1255	1040	70	7.9	26.5	16.0	--	10.0	111
AUG									
14...	1220	790	73	7.0	24.5	15.0	--	10.0	108
SEP									
19...	0930	811	86	7.6	16.5	16.0	13	11.1	124
OCT									
19...	1130	[illegible]	[illegible]	[illegible]	[illegible]				

DEC									
07...	0850	235	109	7.2	1.0	5.0	--	11.0	95
FEB 1996									
13...	1540	3760	84	7.9	9.0	3.0	--	12.3	99
APR									
11...	1200	5690	83	7.9	10.0	7.5	2.9	11.6	108
22...	1300	4910	78	8.0	16.0	8.0	--	13.7	130
MAY									
16...	1130	3790	78	7.8	14.5	8.5	2.0	10.8	104
JUN									
11...	1350	5060	64	7.6	21.5	11.5	2.0	10.9	109
JUL									
12...	1340	1340	72	8.1	30.0	15.5	0.60	11.0	121
AUG									
21...	1025	1250	76	7.7	15.0	14.5	1.1	9.5	102
SEP									
24...	1354	743	91	8.1	16.0	16.0	1.5	10.7	120
OCT									
21...	1335	386	106	8.2	9.5	11.0	--	11.8	116
DEC									
16...	1205	446	126	7.9	4.5	5.0	--	13.3	115
FEB 1997									
10...	1300	6860	77	7.5	11.0	3.0	--	12.3	101

PROVISIONAL RECORDS

Glenwood

DISTRICT CODE 16

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY   PROCESS DATE 10-16-97
13210050   - BOISE RIVER NR MIDDLETON ID

WATER-QUALITY DATA

Spawning Window Oct 15 – March 15
Mountain whitefish

DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	TEMPER-ATURE AIR (DEG C) (00020)	TEMPER-ATURE WATER (DEG C) (00010)	TUR-BID-ITY (NTU) (00076)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)
MAY 1994									
12...	1045	234	177	8.1	20.5	16.0	--	10.6	119
NOV									
09...	1215	258	293	--	5.0	7.0	1.2	10.9	100
JAN 1995									
18...	1400	206	347	8.3	4.5	5.5	--	12.9	110
FEB									
14...	1130	271	298	8.9	4.0	3.0	--	13.1	108
MAR									
10...	1350	224	314	8.5	15.5	9.5	1.4	12.7	119
APR									
13...	1745	765	136	6.7	8.0	8.5	--	11.0	104
28...	1415	3630	105	8.0	16.0	9.0	--	11.0	105
MAY									
17...	1320	3760	97	8.0	19.0	13.0	2.7	10.3	109
JUN									
13...	1215	1160	96	8.4	--	13.5	--	11.5	121
JUL									
20...	1500	871	105	8.1	31.0	18.5	--	10.6	124
AUG									
15...	1415	573	122	8.0	29.0	18.0	--	12.5	145
SEP									
11...	1440	417	148	8.8	20.0	18.5	1.0	11.6	134
OCT									
19...	0930	356	219	7.5	5.0	10.0	--	10.8	104
DEC									
05...	1420	382	222	7.5	0.0	4.5	--	14.1	116
FEB 1996									
14...	1335	4000	101	7.6	16.0	3.0	--	13.2	105
APR									
11...	1140	4800	93	7.5	15.0	7.0	--	10.6	93
23...	1235	4200	91	7.7	14.0	8.5	--	13.7	130
MAY									
15...	1330	3240	90	8.2	22.0	11.0	--	--	--
JUN									
13...	1225	4690	74	7.9	26.5	12.0	--	9.7	97
AUG									
22...	1030	620	121	7.9	19.0	15.5	--	9.6	105
OCT									
24...	1310	412	179	8.3	11.5	11.5	--	11.5	115
DEC									
16...	1005	342	233	7.6	4.0	5.0	--	11.3	95
APR 1997									
16...	1130	--	91	7.9	22.0	7.5	--	11.5	103
JUN									
12...	1230	--	281	7.7	16.0	12.5	--	10.4	106
JUL									

15...	1020	--	101	7.7	22.5	17.5	--	11.3	125
AUG 11...	1200	--	102	7.9	24.0	17.5	--	11.3	130

Middleton

DISTRICT CODE 16 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10-16-97

13213000 - BOISE RIVER NR PARMA ID

WATER-QUALITY DATA

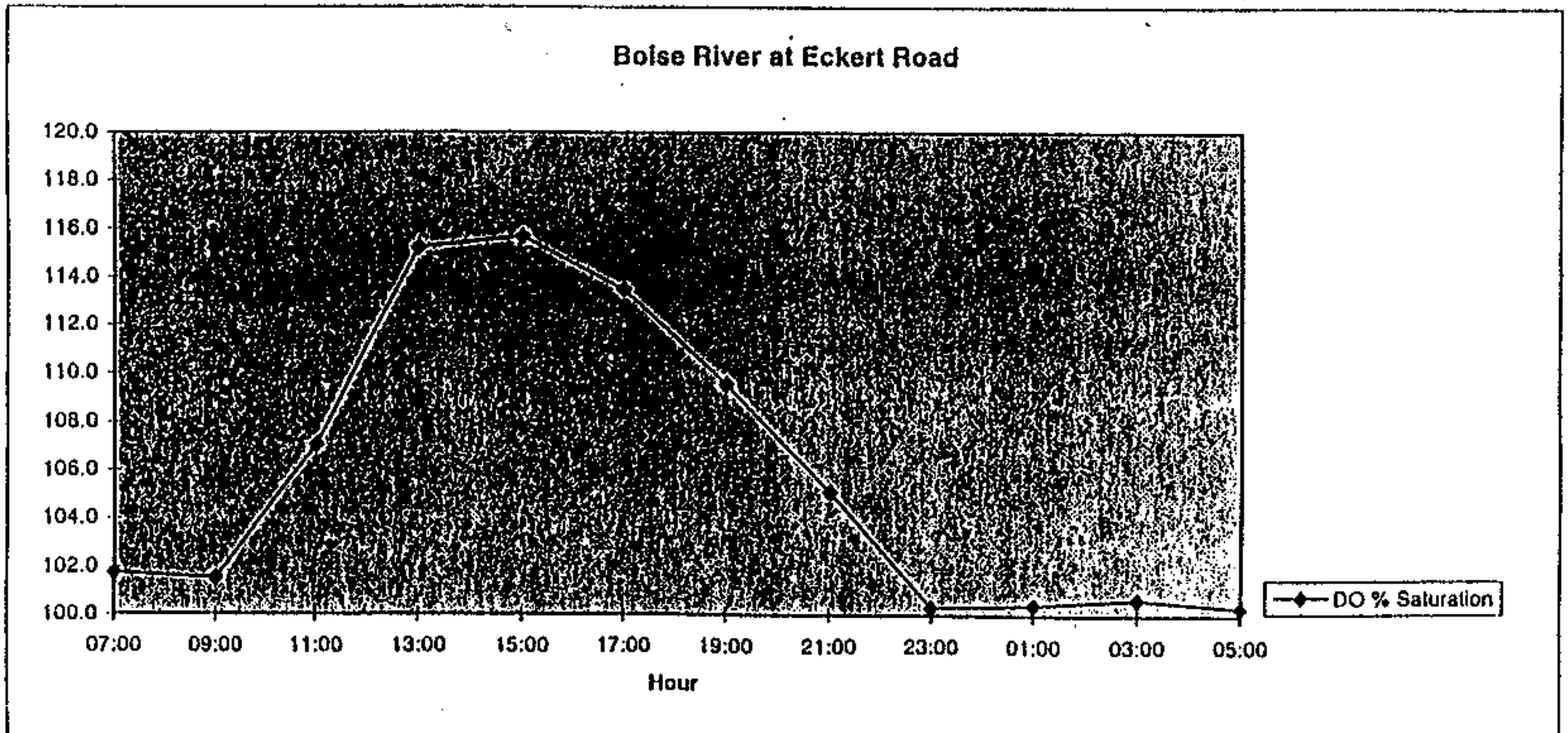
DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	TEMPER-ATURE AIR (DEG C) (00020)	TEMPER-ATURE WATER (DEG C) (00010)	TUR-BID-ITY (NTU) (00076)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)
NOV 1992									
03...	1030	648	591	8.3	10.5	9.5	4.5	10.4	96
JAN 1993									
05...	1245	576	604	8.1	-2.5	1.5	3.5	9.5	96
MAR									
11...	1330	723	577	8.6	9.5	8.5	8.0	13.7	126
MAY									
13...	1330	2170	203	8.0	29.0	15.5	15	9.8	107
SEP									
08...	1320	772	451	8.5	30.5	18.5	4.4	11.8	137
NOV									
02...	1200	981	537	8.6	15.0	9.0	0.80	17.3	161
JAN 1994									
04...	1330	859	507	8.2	5.0	6.5	--	13.2	118
19...	0930	870	515	7.9	-2.0	4.5	3.7	11.5	96
MAR									
01...	1430	800	509	8.7	21.5	9.0	2.8	13.7	135
MAY									
10...	1145	587	420	8.0	27.0	18.5	34	8.7	100
SEP									
07...	1230	444	536	8.3	16.0	17.0	2.2	12.0	138
NOV									
08...	1330	779	559	--	1.5	8.0	3.2	12.4	114
FEB 1995									
15...	1520	686	585	8.8	3.5	4.5	4.5	14.3	121
MAR									
21...	1200	757	540	8.9	13.0	9.5	--	9.9	98
APR									
14...	1200	1270	294	8.5	10.0	8.5	--	10.7	101
27...	1020	3560	163	7.7	20.0	10.5	--	9.4	92
MAY									
18...	1500	4380	159	8.3	22.0	13.0	5.1	10.5	108
JUN									
14...	0915	1010	301	8.1	17.5	16.5	--	8.3	93
JUL									
19...	1300	1420	308	8.0	29.0	21.0	12	8.3	102
AUG									
16...	0920	1080	361	7.6	22.0	18.0	--	6.9	78
OCT									
18...	0920	942	491	7.9	10.0	12.5	--	9.1	92
DEC									
05...	1130	935	501	7.9	-1.0	6.0	--	11.3	102
FEB 1996									
15...	1015	5360	174	7.7	3.5	3.5	--	11.7	95
APR									
10...	1015	6320	138	7.3	12.5	10.5	--	9.2	90
24...	1015	5040	139	7.8	11.0	[illegible]	[illegible]	[illegible]	[illegible]

MAY									
17...	1055	5320	171	7.8	21.5	12.0	--	10.3	103
JUN									
10...	1415	5100	136	7.8	25.5	15.0	--	9.1	97
AUG									
21...	1235	1140	331	7.5	23.5	17.5	--	8.9	102
OCT									
23...	1215	1190	491	8.0	9.5	10.0	--	11.1	106
DEC									
17...	1015	929	515	8.3	-1.0	4.0	--	13.6	111
FEB 1997									
11...	1025	8000	144	7.8	9.0	3.5	--	11.7	96
APR									
17...	1120	6340	127	7.9	19.0	9.5	--	10.5	100
MAY									
22...	1025	4760	145	7.8	17.0	13.5	--	9.7	101
JUN									
10...	1115	4540	154	7.8	25.0	15.0	10	7.1	79
JUL									
18...	1035	1420	317	8.0	20.0	18.0	20	6.7	77
AUG									
12...	1227	1580	314	8.1	25.0	19.0	6.2	8.6	100

Parma

Eckert Road 8/21-22/1997

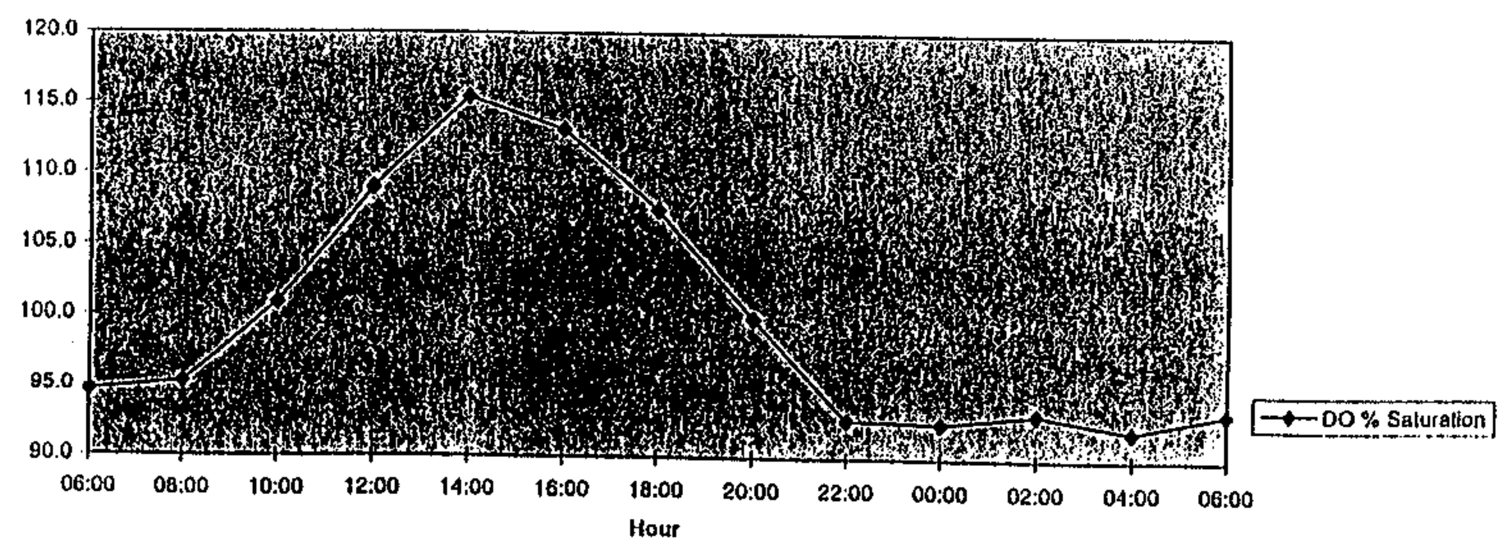
Time (24hr)	DO % Saturation	H20 Temp	Air Temp	pH	DO-Meas	Cond-True	Cond-Meas	Barometer
07:00	101.8	14.7	15.0	7.41	9.28	58.4	292	686
09:00	101.5	15.0	19.0	7.48	9.26	58.6	293	687
11:00	107.1	15.7	26.4	7.68	9.55	58.2	291	687
13:00	115.2	16.7	31.2	7.87	9.77	58.4	292	674
15:00	115.7	17.1	33.0	7.99	9.81	58.6	293	674
17:00	113.5	17.1	35.2	7.99	9.77	58.6	293	685
19:00	109.6	16.4		7.83	9.63	58.4	292	684
21:00	105.1	15.6	21.5	7.54	9.24	58.8	294	684
23:00	100.3	15.0	21.0	7.39	9.01	58.6	293	684
01:00	100.4	14.8	16.5	7.34	9.02	58.6	293	684
03:00	100.7	14.7	16.0	7.32	9.04	58.8	294	684
05:00	100.3	14.7	14.5	7.31	9.01	58.8	294	685



Glenwood Road 8/21-22/1997

Time (24hr)	DO % Saturation	H20 Temp	Air Temp	pH	DO-Meas	Cond-True	Cond-Meas	Barometer
06:00	94.6	15.0	16.0	7.55	8.63	62.0	310	691
08:00	95.3	14.8	17.0	7.45	8.69	61.8	309	691
10:00	100.9	15.3	24.0	7.63	9.20	67.4	337	691
12:00	109.0	16.4	28.0	8.07	9.58	69.2	346	677
14:00	115.4	17.6	27.5	8.37	9.58	69.8	349	674
16:00	113.1	18.4	32.0	8.43	9.39	70.0	350	674
18:00	107.5	18.7		8.21	9.01	70.0	350	688
20:00	99.9	18.2	22.0	7.81	8.54	64.0	320	687
22:00	92.7	17.4	23.0	7.50	8.10	78.0	390	687
00:00	92.5	16.5	17.5	7.40	8.25	68.2	341	688
02:00	93.2	15.8	18.0	7.35	8.31	68.4	342	688
04:00	92.0	15.2	16.0	7.34	8.39	66.8	334	688
06:00	93.3	14.9	14.5	7.33	8.51	65.8	329	689

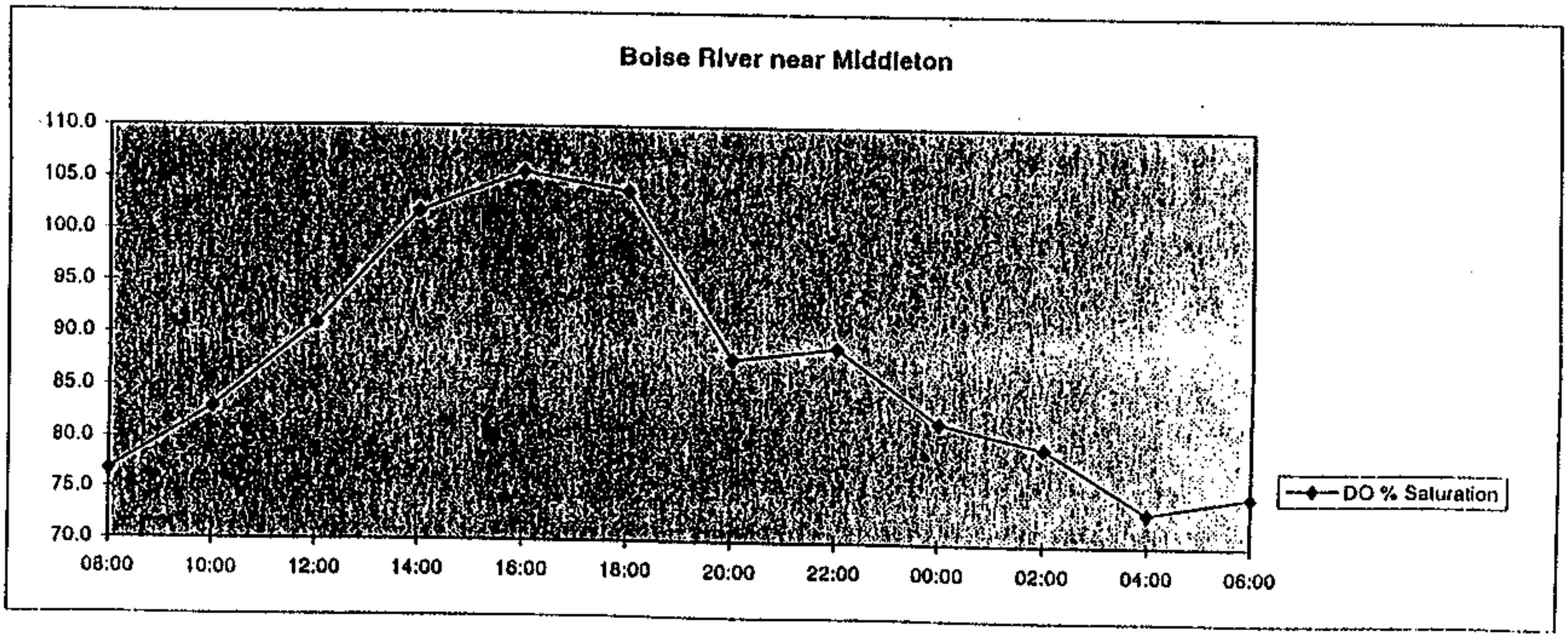
Boise River at Glenwood Road



Middleton 8/28-29/1997

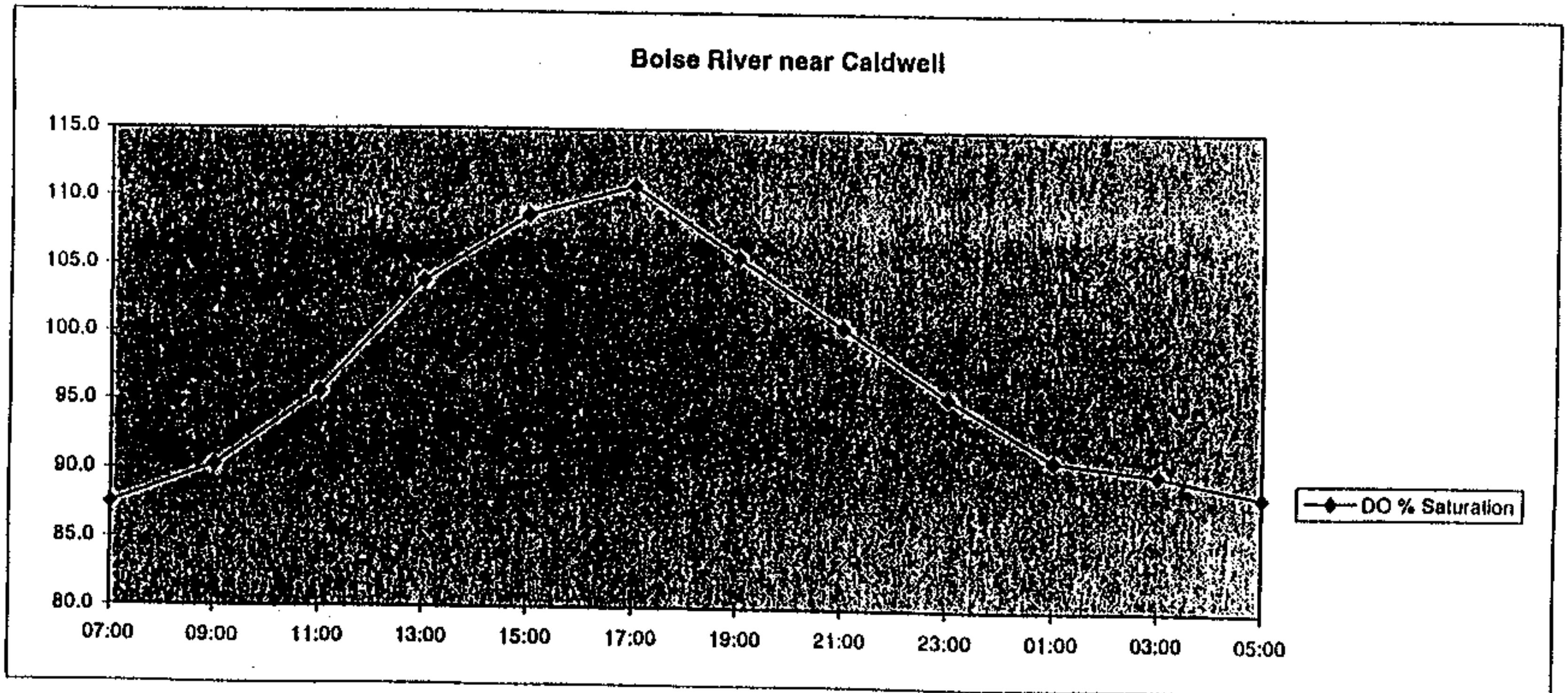
Time (24hr)	DO % Satur	H20 Temp	Air Temp	pH	DO-Meas*	Cond-True	Cond-Meas	Barometer
08:00:00	76.8	16.5	16.5	7.08	6.71	63	63	692
10:00:00	83.0	16.5	18.0	7.00	7.40	60	60	692
12:00:00	91.0	17.0	25.0	7.25	7.95	62	62	692
14:00:00	101.8	17.5	26.5	7.37	8.70	63	63	691
16:00:00	105.6	18.5	31.0	7.50	8.85	63	63	691
18:00:00	103.8	18.8	30.0	7.40	8.70	60	60	690
20:00:00	87.7	18.6	24.5	7.25	7.35	60	60	690
22:00:00	88.9	18.4	18.5	7.25	7.60	59	59	690
00:00:00	81.9	18.0	17.0	7.08	7.00	60	60	690
02:00:00	79.5	17.7	15.0	7.05	6.80	60	60	692
04:00:00	73.2	17.3	15.5	6.95	6.40	60	60	692
06:00:00	74.9	16.9	13.5	6.94	6.55	61	61	693

*Mean



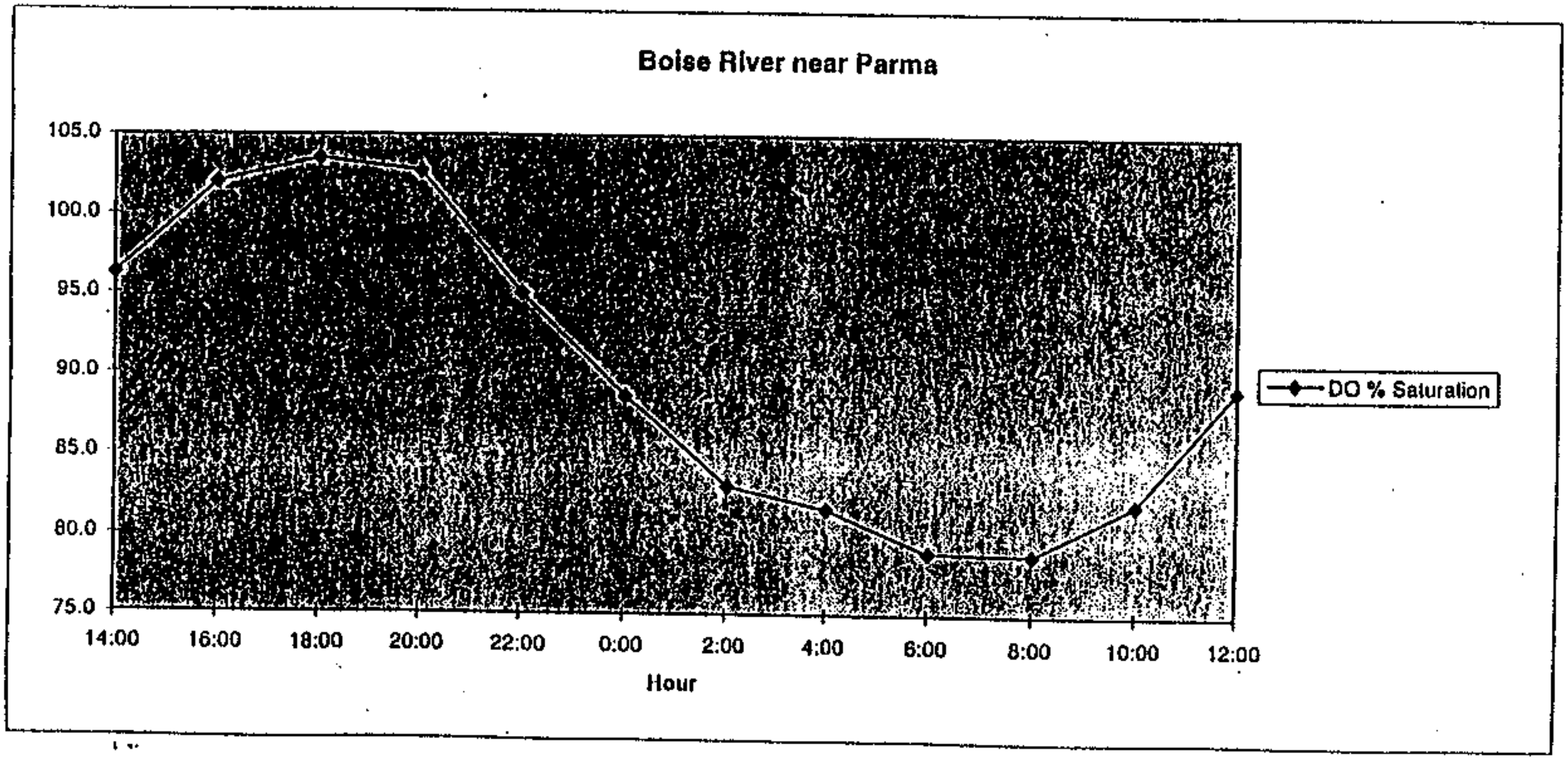
Caldwell 8/28-29/97

Time (24hr)	DO % Satur	H20 Temp	Air Temp	pH	DO-Meas	Cond-True	Cond-Meas	Barometer
07:00	87.5	17.4	14.0	7.52	7.65	105.4	105.400	694
09:00	90.3	17.0	17.5	7.48	7.89	105.5	105.500	694
11:00	95.7	17.1	24.5	7.55	8.36	105.4	105.400	694
13:00	103.7	17.5	28.0	7.69	8.87	105.0	105.000	694
15:00	108.7	18.3	28.5	7.86	9.29	103.7	103.700	694
17:00	110.9	19.0	29.0	7.99	9.29	102.4	102.400	692
19:00	105.6	19.2	28.0	7.87	8.85	101.5	101.500	692
21:00	100.5	19.0	23.5		8.42	102.6	102.600	692
23:00	95.5	18.6	23.5	7.60	8.00	102.1	102.100	693
01:00	91.0	18.2	18.0	7.51	7.78	103.6	103.600	693
03:00	90.1	17.7	16.0	7.45	7.70	104.5	104.500	693
05:00	88.6	17.3	16.5	7.42	7.74	105.3	105.300	694



Parma 9/4-5/1997

Time (24hr)	DO % Saturation	H20 Temp	Air Temp	pH	DO-Meas	Cond-True	Cond-Meas	Barometer
14:00	96.3	20.2	27.0	7.91	8.78	58.4	292	701
16:00	102.0	20.8	26.0	7.95	9.30	58.4	292	699
18:00	103.5	21.3	24.0	8.01	9.23	58.6	293	698
20:00	102.7	21.2	19.5	7.98	8.71	59.0	295	697
22:00	95.0	20.8	12.5	7.90	8.06	59.0	295	697
0:00	88.6	20.4	14.5	7.81	7.63	59.0	295	697
2:00	83.0	20.0	12.0	7.72	7.30	58.6	293	697
4:00	81.7	19.6	10.5	7.68	7.18	58.6	293	697
6:00	79.0	19.3	9.5	7.64	7.09	58.6	293	697
8:00	78.8	18.9	10.5	7.64	7.08	58.6	293	697
10:00	82.1	18.9	21.5	7.65	7.37	59.0	295	698
12:00	89.2	19.4	29.0	7.73	8.01	59.2	296	698



APPENDIX B

A Review of Primary and Secondary Contact Recreation Beneficial Uses
Third Draft Technical Memorandum
Lower Boise River Watershed

A Review of Primary and Secondary Contact Recreation Beneficial Uses

Third Draft Technical Memorandum

Lower Boise River Watershed

Prepared for
State of Idaho

by
Idaho Division of Environmental Quality, Boise Regional Office
December 18, 1998

Table of Contents

Introduction

This draft is the first of three technical memoranda that will be used to develop problem assessments for the Lower Boise River watershed, U.S. Geological Survey (USGS) hydrologic cataloging unit 17050114. The document is a technical review of recent water quality conditions with respect to the contact recreational uses of two water quality limited (WQL) stream segments in the watershed on the Boise River that are listed for bacteria or pathogens. The segments are the Boise River from Star to Notus, and from Notus to the Snake River. Those segments that are WQL and have been found to be impaired for recreational uses will require the development of a Total Maximum Daily Load (TMDL) allocation. Segments other than those that are WQL that have bacteria counts exceeding state criteria should also be addressed. For a small group of segments, no information is available, and monitoring is recommended.

Pollutants of Concern

Fecal coliform bacteria in a stream are the result of wastes from warm blooded animals. While fecal coliform bacteria are not a direct threat to health, fecal coliform concentrations have been demonstrated to correspond with pathogens in the water that threaten human health. Toxic substances may also impair recreational uses, and where data exist that substantiate such impairment, corrective action may also be necessary. The EPA suggests that a greater illness rate in swimmers is associated with median fecal coliform bacteria densities of greater than 400 colonies per 100 ml (EPA, 1992). The EPA recommendation is tempered by other studies in which fecal coliform bacteria densities are not well correlated with the incidence of illness in humans (Slaughterbeck and Trial, 1993). Thus, the risk potential of fecal coliform bacterial densities that slightly exceed the existing state criteria may only be moderate. The exact characterization of the risk associated with fecal coliform bacteria is not possible, and the interpretation of data demands appropriate professional judgement.

Both Primary (PCR) and Secondary (SCR) Contact Recreation beneficial uses have associated numeric criteria in Idaho's Water Quality Standards and Wastewater Treatment Requirements (IDHW, 1996). Loading allocations for recreation impaired WQL stream segments will be developed with criteria for fecal coliform bacteria as the targets.

Contaminant Behavior in Streams

Fecal coliform bacteria are derived from the intestines of warm blooded animals, and are commonly found in animal feedlot runoff and municipal waste water treatment plant effluents. Wildlife, pastures, and urban storm-water can also be sources of bacteria.

It is possible that under the right combination of warm water temperatures and high organic loading, bacterial colonies may increase in number. However, the Boise River's water temperatures, low organic loads, and lack of shading are likely to preclude growth of bacteria. In the Boise River, bacteria generally die at an exponential rate that varies with water temperature and the intensity of sunlight. (Geldreich, et al., 1980). Most observers note that fecal coliform bacteria die at about twice the rate of fecal streptococci bacteria, which are also common in human and animal waste (Tetra Tech, 1985). One rate of die-off suggested for fecal coliform bacteria in the Boise River is 0.02 per hour in 68 degrees Fahrenheit water (Tetra Tech, 1985). As an example, that rate suggests that 1000 fecal coliform colonies per 100 ml of water would decline to a number just less than 500 colonies per 100 ml in 35 hours (about one and one half days).

State of Idaho Criteria for Contact Recreation

The recreational criteria of the state of Idaho are listed in IDAPA 16.01.02, section 250.01 of the current regulations (IDHW, 1996). For both Primary and Secondary Contact Recreation, all of the toxic substance criteria described in 40 Code of Federal Regulations (40 CFR), column D2 are applicable, with selected modifications specific to the state of Idaho.

Primary Contact Recreation (May 1 - September 30)

Defined as "surface waters which are suitable or intended to be made suitable for prolonged and intimate contact by humans or for recreational activities when the ingestion of small quantities of water is likely to occur. Such waters include, but are not restricted to, those used for swimming, water skiing, or skin diving." (IDHW, 1996)

Fecal coliform bacteria colonies:

- may not exceed 500/100 ml at any time
- may not exceed 200/100 ml in more than ten percent of the total samples taken over a thirty day period
- may not exceed a geometric mean of 50/100 ml based on a minimum of five samples taken over a thirty day period

Secondary Contact Recreation (All year)

Defined as: "surface waters which are suitable or intended to be made suitable for recreational uses on or about the waters and which are not included in the primary contact category. These waters may be used for fishing, boating, wading, and other activities where ingestion of raw water is not probable." (IDHW, 1996)

Fecal coliform bacteria colonies:

- may not exceed 800/100 ml at any time
- may not exceed 400/100ml in more than ten percent of the total samples taken over a thirty day period
- may not exceed a geometric mean of 200/100 ml based on a minimum of five samples taken over a thirty day period

Conclusions and Recommendations

The Division of Environmental Quality recommends that TMDLs for bacteria be developed for the lower Boise River segments from Star to Notus and Notus to the Snake River. In the segments just mentioned, ongoing measurements of fecal coliform bacteria denote recurring exceedences of state water quality criteria. Indian Creek downstream of New York Canal also has significant exceedences of contact recreation criteria. DEQ recommends that appropriate corrective actions should be identified and implemented to restore full support of primary and secondary contact recreation in Indian Creek. Two streams not listed as Water Quality Limited have quantities of fecal coliform bacteria greater than the contact recreation criteria, and should be addressed when management strategies for bacteria are developed.

Summary of Stream Segments

Stream Segment	Description	Listed for Bacteria?	Designation	Recommendation
Boise River	Lucky Peak Dam to Barber Diversion	NO	Primary and Secondary Contact Recreation	NO action required
Boise River	Barber Diversion to Star	NO	Primary and Secondary Contact Recreation	NO action required
Boise River	Star to Notus	YES	Primary and Secondary Contact Recreation	Develop TMDL for bacteria
Boise River	Notus to the Snake River	YES	Primary and Secondary Contact Recreation	Develop TMDL for bacteria
Blacks Creek	Headwaters to Boise River	NO	Unclassified Default Secondary Contact Recreation	Monitoring and possible corrective action for bacteria
Fivemile Creek	Headwaters to Fifteenmile Creek	NO	Secondary Contact Recreation	Additional monitoring
Tenmile Creek	Headwaters to Fifteenmile Creek	NO	Secondary Contact Recreation	NO action required

Mason Creek	Headwaters to the Boise River	NO	Unclassified Man Made Waterway	No action required
Upper Indian Creek	Headwaters to New York Canal	NO	Primary (to Sugar Avenue) and Secondary Contact Recreation	Monitoring
Lower Indian Creek	New York Canal to Boise River	NO	Primary and Secondary Contact Recreation	Corrective action for bacteria
Sand Hollow	Headwaters to the Snake River	NO	Unclassified Man Made Waterway	NO action required

Non-Listed Stream Segments

The following streams have fecal coliform bacteria problems that should be addressed when developing control strategies:

- Indian Creek, New York Canal to the Boise River
- Willow Creek
- Fifteenmile Creek

Characterization of Fecal Coliform Densities

Fecal Coliform bacteria occur in the Boise River during a wide variety of flow and water temperature conditions. High densities of bacteria are not limited to extremely high flows nor to very cold temperatures, and thus contact recreation may coincide with bacterial conditions that are in excess of state criteria.

Fecal Coliform Exceedences - Boise River, Star to Notus

Fecal coliform bacteria densities in excess of state criteria included three primary exceedences and one secondary exceedence. The measure values ranged from 630 / 100 ml to 830 / 100 ml. The flows associated with the exceedences are slightly less to slightly above the long term average flows for the months during which they occurred. The water temperatures associated with the exceedences ranged from 52 to about 64 degrees, which do not preclude contact recreation.

Fecal Coliform Exceedences - Boise River, Notus to the Snake

Fecal coliform densities in excess of state criteria ranged from 510 / 100 ml (only slightly above the primary contact instantaneous criterion) to 3600 / 100 ml. Eleven of the exceedences are between 500 and 1500 colonies per 100 ml, and the remaining exceedences are 2000, 3000, and 3600 colonies per 100 ml.

The flows associated with the coliform bacteria problems were predominantly lower than the long term average flow at the Parma gage for the month in which the exceedence occurred. Ten of the flows in which exceedences occurred were less than the long term monthly average flow at Parma, while the remaining four exceedences occurred during higher than long term average flow conditions. Water temperatures that associated with the fecal exceedences probably did not preclude contact recreation. Six of the primary exceedences were associated with water temperatures between 60 and 70 degrees Fahrenheit (F), one with a temperature greater than 70 degrees F, and the remaining six with temperatures between 50 and 60 degrees F.

Fecal Coliform Exceedences - Lower Indian Creek

Three sets of weekly fecal coliform bacteria measurements are available on Indian Creek, one upstream of the Nampa Waste Water Treatment Plant (WWTP) outfall, downstream of the Nampa outfall, and upstream of the Armour Fresh Meats facility. The Nampa data are collected downstream of Sugar Avenue, where Secondary Contact Recreation is designated. The range of secondary exceedences upstream is 900 to 5,700 colonies per 100 ml, while the downstream range of secondary exceedences is 900 to 14,300 colonies per 100 ml. The average density of coliform organisms upstream is 1167 per 100ml, and the downstream average is 1307 colonies per 100 ml. Bacteria counts in excess of state criteria have occurred in many months year after year. The Nampa data show that Indian Creek has on-going conditions that pose a risk of illness from ingestion of the water. Summary information related to the bacteria measurements in Indian Creek can be found in tables 18 and 19 in Appendix A. The Armour data show numerous exceedences of both the secondary and the primary instantaneous criteria for bacteria.

Boise River Segment One

Lucky Peak Dam to Barber Park

Contact Recreation Use Designations

Primary and Secondary

Available Data

One U.S. Geological Survey synoptic monitoring station, 13203510, located just downstream of the Diversion Dam, has data applicable to the segment. Thirty - seven (37) measurements of fecal coliform bacteria are available, spanning a time period from November 20, 1990 to August 17, 1998.

Coliform Measurements

All of the measured values are quite low, and no impairment of primary or secondary contact recreation is evident. No exceedences of applicable toxic substance criteria are evident

Recommendation

This segment's status is "Full Support" for both Primary and Secondary Contact Recreation.

Boise River Segment Two

Barber Diversion to Star

This segment extends from the Barber diversion to a point just upstream of the diversion near Star Road.

Contact Recreation Use Designations

Primary and Secondary

Available Data

Three USGS synoptic monitoring stations are applicable to the segment, one in the Boise River itself, and two in agricultural drains that flow into the river. Each of the three stations has fecal coliform measurements, but toxic substances are not monitored at any of the three sites. The number of measurements for a site is shown in parentheses ().

13206000	Glenwood Bridge	(55)	11/22/89	to	09/08/98
13206400	Eagle Drain	(6)	05/03/94	to	06/09/97
13208750	Thurman Drain	(6)	5/3/94	to	6/9/97

Coliform Measurements

One exceedence of both the primary and secondary instantaneous standards occurred on September 9, 1994 in the Boise River at the Glenwood Bridge site. Since all of the other measurements made at the site are less than state criteria, the single exceedence seems to be an anomaly.

Recommendation

This segment's status is "Full Support" for Primary and Secondary contact recreation.

Boise River Segment Three

Star to Notus

This segment of the lower Boise River begins at the diversion dam near Star Road, and extends to Notus.

Contact Recreation Use Designations

Primary and Secondary

Available Data

Nine USGS synoptic sites are applicable to the segment, including one site in the Boise river and eight sites in tributaries. Like the other stations noted above, the monitoring sites along this segment collect fecal coliform data, but no information on toxic substances. The number of measurements for a site is shown in parentheses ().

13210050	Boise River near Middleton	(34)	11/31/91	to	08/18/98
132108247	Mill Slough near Middleton	(11)	05/03/94	to	08/19/98
13210815	Fifteenmile Creek	(23)	05/04/94	to	08/19/98
13210835	Willow Creek at Middleton	(18)	05/02/94	to	06/10/97
13210850	Mason Slough	(6)	05/04/94	to	06/18/97
13210985	Mason Creek	(23)	05/04/94	to	08/19/98
13210986	West Hartley Gulch	(18)	05/05/94	to	06/10/97
13210987	East Hartley Drain	(18)	05/05/94	to	06/10/97
13211445	Indian Creek	(24)	05/05/94	to	08/17/98

Coliform Measurements

Three exceedences of the primary instantaneous criterion (500/100 ml), and one secondary exceedence (800/100 ml) are evident in the data for the Boise River near Middleton. West Hartley Gulch, East Hartley Drain, Mason Slough, Mason Creek, and Indian Creek all have multiple exceedences of both the primary and the secondary instantaneous criteria. The presence of so many drains and tributary confluences with very high fecal coliform counts along such as short length of the river suggests a possibility for exceedences in the Boise River near Caldwell.

Recommendation

This segment's status is "Not Full Support" for Primary and Secondary contact recreational uses. A TMDL for bacteria is needed for this segment.

Fifteenmile Creek, Willow Creek, and Indian Creek all have fecal coliform problems that should be addressed when developing bacteria management plans.

Boise River Segment Four

Notus to the Snake River

Contact Recreation Use Designations

Primary and Secondary

Available Data

Three USGS synoptic monitoring sites are applicable to the segment. One site is located in the Boise River near Parma, and two sites are located in tributaries. Fecal coliform bacteria data are available for the tributaries. The Boise River site near Parma includes both fecal coliform data and toxic substances data. The number of measurements for a site is shown in parentheses ().

13213000	Boise River near Parma	(74)	11/12/86	to	08/18/98
13212550	Conway Gulch	(23)	05/06/94	to	08/18/98
13212890	Dixie Drain	(23)	05/06/94	to	08/19/98

Coliform Measurements

Twenty-one (21) exceedences of the primary contact recreation criteria occur in the Boise River near Parma, and fourteen (14) exceedences of the secondary instantaneous criterion are evident in the data.

Recommendation

This segment's status is "Not Full Support" for both Primary and Secondary contact recreational uses. A TMDL for bacteria is needed for this segment.

Black's Creek

Headwaters to Black's Creek reservoir

Contact Recreation Use Designations

Black's Creek is an unclassified water body. The flow conditions of the stream during the primary contact recreation period are unlikely to allow full body immersion. On June 11, 1997, an unusually wet year, measured flow was 0.04 cubic feet per second (cfs). Flows observed on May 15, 1997 were estimated to be 2.0 to 3.0 cfs. The Creek probably dries up in late spring or early summer in all but the wettest years. Flows may be adequate to support secondary contact recreation between February and June.

Available Data

None

Coliform Measurements

None

Recommendation

The status of this segment is needs verification. The area adjacent to the stream is heavily grazed, especially in the lower reaches, and exceedences of secondary contact recreation criteria for bacteria are likely. Monitoring and possible corrective action for bacteria are recommended to support secondary contact recreation.

Fivemile Creek

Headwaters to Fifteenmile Creek

Contact Recreation Use Designations

Secondary. Flow conditions do not preclude Primary Contact Recreation.

Available Data

The data that characterize Fivemile Creek in terms of fecal coliform counts are available in a report prepared by CH2M Hill (1996) for the City of Meridian. Data are available for three sites on Fivemile Creek on April 12, 1995, August 16, 1995, and November 17, 1995. The monitoring sites are located upstream of the Meridian waste water treatment plant outfall, just downstream of the Meridian waste water outfall, and six miles downstream of the outfall.

Coliform Measurements

The data show one exceedence of Primary and one exceedence of Secondary Contact Recreation instantaneous criteria.

Recommendation

This segment's status is "Needs Verification" for both Primary and Secondary contact recreational uses. Additional monitoring is recommended to determine the support status of secondary contact recreation.

Upper Indian Creek

Headwaters to New York Canal

Contact Recreation Use Designations

Primary and Secondary

Available Data

None

Coliform Measurements

None

Recommendation

The status of this segment cannot be determined. Field monitoring is recommended for fecal coliform bacteria and flow.

Lower Indian Creek

New York Canal to the Boise River. Lower Indian Creek flows from Ada into Canyon County, through Nampa and Caldwell before joining the Boise River.

Contact Recreation Use Designations

Primary and Secondary

Available Data

One USGS synoptic monitoring site is located near the mouth of Indian Creek. The City of Nampa measures fecal coliform bacteria upstream and downstream of its WWTP outfall.

Coliform Measurements

- **13211445 Indian Creek at Mouth** (21) 5/4/94 to 8/13/97
- **Division of Environmental Quality** - 3 Samples on 7/11/94; upstream of Armour effluent, downstream of Armour effluent, and near Amity Road.
- **Armour Fresh Meats** - Reports weekly average upstream fecal Coliform, 6/92 - May 97. Samples are collected upstream of Sugar Avenue, where both primary and secondary contact recreation are designated.
- **City of Nampa** - weekly sampling upstream and downstream of the WWTP outfall, January, 1990 to the present.

Four values in the USGS data are in excess of both the Primary and Secondary instantaneous criteria. All three DEQ samples from July of 1994 revealed primary exceedences, two of which were also exceeded the secondary instantaneous criterion. The data collected by the city of Nampa show ongoing exceedences the secondary instantaneous and geometric mean criteria. The Armour Fresh Meats upstream monitoring data show 36 exceedences of the secondary instantaneous criterion, and 20 exceedences of the primary instantaneous criterion. The exceedences evident in the Nampa data are summarized below:

Upstream, January, 1990 to March, 1997
113 exceedences of the Secondary instantaneous criterion
26 exceedences of the Secondary geometric mean

Downstream, January, 1990 to March, 1997
95 exceedences of the Secondary instantaneous criterion
23 exceedences of the Secondary geometric mean

Recommendation

This segment's status is "Not Full Support" for both Primary and Secondary contact recreational uses. Corrective actions for bacteria problems are recommended to support Primary and Secondary Contact Recreation.

Mason Creek

Mason Creek is a highly manipulated channel that crosses the New York and Ridenbaugh canals, flows through Nampa, and eventually joins the Boise River just upstream of Caldwell. This segment is a man made waterway protected only for agricultural water use.

Contact Recreation Use Designations

This segment is unclassified.

Available Data

One USGS synoptic monitoring site is located near the mouth of Mason Creek.

13210985 Mason Creek at Mouth (20) 5/4/94 to 8/13/97

Coliform Measurements

Not relevant to a man made waterway

Recommendation

No action is required with respect to contact recreation.

Tenmile Creek

Headwaters to Fifteenmile Creek

Tenmile Creek flows past the City of Meridian and later joins Fivemile Creek to form Fifteenmile Creek.

Contact Recreation Use Designations

Secondary, but flows do not preclude Primary Contact Recreation

Available Data

Three measurements of fecal coliform bacteria are available from the same CH2M Hill (1996) study referenced on the Fivemile Creek summary page. The measurements were collected on August 12, 1995, August 16, 1995 and November 17, 1995.

Coliform Measurements

None of the values exceed the instantaneous criteria for Primary and Secondary contact recreation.

Recommendation

This segment's status is 'Full Support" for Secondary Contact Recreation.

Sand Hollow

Sand Hollow flows from the foothills north of the Boise River to a point in between Notus and Parma, where it turns west - northwest and flows into the Snake River. This segment is a man made waterway protected only for agricultural water use.

Contact Recreation Use Designations

This segment is unclassified

Available Data

None

Coliform Measurements

None

Recommendation

No action is required with respect to contact recreation.

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Appendix A - Fecal Coliform Data

All data displayed are from U.S. Geological Survey synoptic monitoring sites.

K = estimated value

Table I. Boise River below Diversion Dam

Boise River Below Diversion Dam			
USGS 13203510			
Date	Discharge cfs	Fecal Coliform # / 100 ml	Fecal Streptococci # / 100 ml
11/20/90	175	<1	k3
01/18/91	160	<1	k3
03/28/91	177	<1	k4
05/22/91	1350	k1	k4
07/23/91	737	k1	k1
09/11/91	1640	k5	150
11/03/93	258	<1	80
01/18/94	245	k4	k4
03/10/94	210	k12	k6
05/11/94	1770	k1	k3
07/20/94	620	k1	k3
09/13/94	2010	k2	N/A
11/14/94	161	k2	N/A
04/13/95	1420	k2	N/A
04/26/95	4640	<1	N/A
05/16/95	4610	<1	N/A
06/12/95	2610	k1	N/A
08/14/95	1830	<1	N/A
10/19/95	337	<1	N/A
12/07/95	200	k5	N/A
02/13/96	4000	<1	N/A
04/11/96	5900	<1	N/A
05/15/96	4630	<1	N/A
06/12/96	7800	k3	N/A
08/21/96	2100	<1	N/A
10/21/96	321	k3	N/A
12/16/96	240	k1	N/A
02/10/97	7010	k2	N/A
04/14/97	N/A	<1	<1
06/09/97	N/A	k2	>2
07/14/97	N/A	k1	0
08/11/97	N/A	<1	<1
10/20/97	306	k2	k3
12/15/97	249	<1	<1
4/6/98	1630	k2	k3
5/11/98	3930	k1	k3
7/13/98	N/A	N/A	N/A
8/17/98	N/A	k1	k4

Table 2. Boise River at Glenwood Bridge

Boise River at Glenwood Bridge				
USGS 13206000				
Date	Flow cfs	Fecal Coliform # / 100 ml	Fecal Streptococci # / 100 ml	
11/22/89	185	25	k17	
01/16/90	167	k2	k3	
03/16/90	147	k4	k16	
05/29/90	850	>200	>330	
07/09/90	736	49	44	
09/21/90	491	70	68	
11/19/90	169	29	40	
01/17/91	154	37	350	
03/28/91	157	k7	42	
05/22/91	602	k9	26	
07/23/91	944	41	73	
09/11/91	574	k310	98	
11/12/91	153	27	210	
01/21/92	134	k18	260	
03/18/92	114	k10	46	
05/14/92	732	22	50	
07/20/92	608	54	170	
09/11/92	287	180	k1200	
11/02/92	83	190	350	
01/07/93	71	44	130	
05/12/93	2570	k9	29	
08/06/93	1130	100	100	
09/14/93	626	k5	160	
01/19/94	336	140	k15	
03/04/94	248	140	59	
05/13/94	806	k20	110	
07/12/94	1260	k28	k22	
09/09/94	398	**k1000**	k1200	Primary Secondary
11/10/94	188	42	150	
03/20/95	167	41	78	
04/13/95	923	k22	N/A	
04/26/95	3450	26	N/A	
05/16/95	3990	62	91	
06/12/95	1710	k33	N/A	
07/21/95	1040	57	31	
08/14/95	790	45	N/A	
09/19/95	811	100	110	
10/19/95	337	68	N/A	
12/07/95	235	58	N/A	

Two Primary exceedences
One Secondary exceedence

Time:	Boise River at Glenwood Bridge				
	USGS 13206000				
	Date	Flow cfs	Fecal Coliform # / 100 ml	Fecal Streptococci # / 100 ml	
	02/13/96	3760	k12	N/A	
	04/11/96	5960	k7	k18	
	05/16/96	3790	100	350	
	06/11/96	5060	k14	31	
	07/12/96	1340	20	42	
	08/21/96	1250	47	35	
	09/24/96	743	45	61	
	10/21/96	386	k40	N/A	
	12/16/96	446	k42	N/A	
	02/10/97	6860	k4	N/A	
	4/15/97	6900	k8	k12	
	5/23/97	N/A	45	56	
	6/9/97	4320	30	72	
	7/16/97	1320	95	k7	
	8/11/97	1840	92	73	
	9/8/97	1420	400	620	
	10/20/97	446	75	k40	
	12/15/97	264	26	360	
	4/6/98	1940	k5	11	
	5/11/98	3290	300	980	
	6/12/98	5540	32	k3	
930	7/13/98	2360	<1	<1	
1335	7/13/98	1200	k16	k11	
	8/17/98	N/A	640	55	Primary
	9/18/98	N/A	290	760	

Tables 3 & 4. Eagle Drain and Thurman Drain

Eagle Drain at Eagle			
USGS 13206400			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/03/94	39	k370	N/A
11/15/94	13	k81	N/A
05/17/95	29	240	N/A
12/05/95	11	k3500	N/A
05/14/96	29	3400	N/A
06/09/97	N/A	440	>750

Thurman Drain at Mouth near Eagle			
USGS 13208750			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/03/94	29	2800	N/A
11/15/94	10	160	N/A
05/18/95	14	280	N/A
12/07/95	14	340	N/A
05/14/96	14	3500	N/A
06/09/97	N/A	k120	>250

Table 5. Boise River near Middleton

Boise River near Middleton				
USGS 13210050				Three Primary exceedences One Secondary exceedence
Date	Flow cfs	Fecal Coliform # / 100 ml	Fecal Streptococci # / 100 ml	
11/13/91	241	37	400	
01/23/92	212	51	370	
03/18/92	174	k350	190	
05/11/92	169	97	130	
07/21/92	178	<190	k1000	
09/11/92	161	99	k2700	
05/12/94	234	200	300	
11/09/94	258	48	350	
03/10/95	224	33	58	
04/13/95	765	100	N/A	
04/28/95	3630	290	N/A	
05/17/95	3760	120	71	
06/13/95	1160	140	N/A	
07/20/95	871	54	72	
08/15/95	573	270	N/A	
09/11/95	417	100	44	
10/19/95	356	76	N/A	
12/05/95	382	k36	N/A	
02/14/96	4000	k15	N/A	
04/11/96	4800	k31	N/A	
05/15/96	3240	**k630**	N/A	Primary
06/13/96	4690	240	N/A	
08/22/96	620	**640**	N/A	Primary
10/24/96	412	k64	N/A	
12/16/96	342	46	N/A	
04/16/97	N/A	k43	k47	
06/12/97	N/A	300	300	
07/15/97	N/A	270	90	
08/11/97	N/A	**830**	470	Primary Secondary
10/21/97	321	70	k140	
12/16/97	360	96	k57	
4/7/98	1840	38	89	
7/14/98	680	k39	90	
8/18/98	N/A	110	190	

Table 6. Fifteenmile Creek near Eagle

Fifteenmile Creek at Mouth near Middleton			
USGS 13210815			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/04/94	116	700	N/A
11/16/94	23	600	N/A
04/11/95	83	1700	N/A
04/24/95	110	1400	N/A
05/17/95	119	650	N/A
06/15/95	89	k770	N/A
08/17/95	99	560	N/A
10/17/95	62	200	N/A
12/05/95	36	610	N/A
02/14/96	37	k63	N/A
04/11/96	118	940	N/A
05/16/96	199	k7100	N/A
06/13/96	104	k400	N/A
08/20/96	147	660	N/A
10/21/96	60	210	N/A
12/19/96	33	180	N/A
02/13/97	51	150	N/A
06/12/97	N/A	2100	2600
07/16/97	N/A	k800	k34
08/13/97	N/A	k1500	7700
12/18/97	29	k120	450
5/12/98	N/A	1300	4900
8/19/98	N/A	1400	8100

Tables 7 & 8. Mill Slough and Willow Creek

Mill Slough below Grade Ditch near Middleton			
USGS 132108247			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/03/94	139	620	N/A
11/15/94	66	140	N/A
05/12/95	157	1000	N/A
12/05/95	65	160	N/A
05/13/96	116	1700	N/A
06/10/97	N/A	630	>800
07/15/97	N/A	k750	k40
08/12/97	N/A	540	k3200
12/18/97	54	200	1100
5/11/98	207	1300	4200
8/19/98	N/A	250	1000

Willow Creek at Middleton			
USGS 13210835			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
5/2/94	75	k1300	N/A
11/17/94	2	k5600	N/A
4/18/95	82	500	N/A
4/26/95	56	2200	N/A
5/12/95	118	860	N/A
6/7/95	46	780	N/A
8/14/95	18	1300	N/A
10/16/95	33	230	N/A
12/4/95	2	280	N/A
2/12/96	41	k110	N/A
4/8/96	20	350	N/A
4/25/96	121	1400	N/A
5/13/96	27	2600	N/A
6/11/96	42	4500	N/A
10/22/96	32	210	N/A
12/18/96	939	k10	N/A
2/12/97	299	100	N/A
6/10/97	N/A	430	>650

Tables 9 & 10. Mason Slough and Mason Creek

Mason Slough at Mouth near Caldwell			
USGS 13210850			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/04/94	21	860	N/A
11/16/94	12	780	N/A
05/15/95	15	2300	N/A
12/07/95	9	k70	N/A
05/14/96	42	45000	N/A
06/18/97	N/A	k1700	1200

Mason Creek at Mouth near Caldwell			
USGS 13210985			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/04/94	126	100	N/A
11/16/94	47	k86	N/A
04/12/95	28	88	N/A
04/24/95	75	280	N/A
05/15/95	116	680	N/A
08/17/95	168	630	N/A
10/17/95	84	k78	N/A
12/07/95	61	2200	N/A
02/16/96	62	k180	N/A
04/09/96	59	550	N/A
04/26/96	92	450	N/A
05/14/96	121	2100	N/A
06/12/96	124	2200	N/A
08/20/96	139	k6800	N/A
10/24/96	93	k300	N/A
12/18/96	58	k33	N/A
02/12/97	77	330	N/A
06/11/97	N/A	3100	3500
07/16/97	N/A	k1200	830
08/13/97	N/A	k640	9900
12/18/97	65	k240	690
5/12/98	208	2600	>2700
8/19/98	N/A	880	4900

Table II. West Hartley Gulch

West Hartley Gulch near Caldwell			
USGS 13210986			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/05/94	30	720	N/A
11/17/94	8	170	N/A
04/11/95	5	150	N/A
04/25/95	11	560	N/A
05/11/95	23	320	N/A
06/07/95	40	1900	N/A
08/15/95	44	1000	N/A
10/16/95	14	k76	N/A
12/04/95	7	140	N/A
02/12/96	8	k110	N/A
04/08/96	5	k47	N/A
04/25/96	22	510	N/A
05/13/96	28	5100	N/A
06/11/96	31	1000	N/A
10/22/96	15	210	N/A
12/18/96	8	k59	N/A
02/12/97	8	240	N/A
06/10/97	N/A	510	>1100

Table 12. East Hartley Gulch

East Hartley Drain near Caldwell			
USGS 13210987			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/05/94	64	1100	N/A
11/18/94	23	150	N/A
04/11/95	16	280	N/A
04/25/95	25	1000	N/A
05/11/95	50	2300	N/A
06/07/95	66	3800	N/A
08/15/95	95	1900	N/A
10/16/95	63	k200	N/A
12/04/95	25	210	N/A
02/12/96	22	k18	N/A
04/08/96	17	k67	N/A
04/25/96	34	590	N/A
05/13/96	63	5000	N/A
06/11/96	71	2600	N/A
10/22/96	40	k100	N/A
12/18/96	22	k69	N/A
02/12/97	13	k6	N/A
06/10/97	N/A	4600	>2500

Table 13. Indian Creek at Mouth near Caldwell

Indian Creek at Mouth near Caldwell			
USGS 13211445			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/05/94	75	1300	N/A
11/17/94	162	220	N/A
04/12/95	92	370	N/A
04/24/95	100	240	N/A
05/16/95	167	280	N/A
06/12/95	83	440	N/A
08/17/95	33	1200	N/A
10/17/95	150	k130	N/A
12/06/95	201	260	N/A
02/13/96	207	k110	N/A
04/09/96	102	290	N/A
04/26/96	101	190	N/A
05/16/96	151	3000	N/A
06/11/96	55	680	N/A
08/20/96	76	920	N/A
10/22/96	256	370	N/A
12/17/96	204	k130	N/A
02/11/97	214	130	N/A
06/11/97	N/A	590	850
07/16/97	N/A	k540	k140
08/13/97	N/A	640	2100
12/17/97	213	k220	k18000
5/13/98	206	640	1500
8/17/98	N/A	67	430

Table 14. Conway Gulch

Conway Gulch at Notus			
USGS 13212550			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/06/94	40	440	N/A
11/18/94	23	100	N/A
04/12/95	17	k44	N/A
04/25/95	31	k110	N/A
05/18/95	42	540	N/A
08/16/95	47	1600	N/A
10/18/95	27	k43	N/A
12/06/95	19	k17	N/A
02/15/96	31	k8	N/A
04/09/96	14	160	N/A
04/24/96	40	150	N/A
05/16/96	52	2900	N/A
06/10/96	52	640	N/A
08/20/96	50	k460	N/A
10/23/96	33	k53	N/A
12/17/96	20	k43	N/A
02/10/97	19	440	N/A
06/18/97	N/A	k490	1900
07/15/97	N/A	k470	390
08/12/97	N/A	440	k14000
12/16/97	21	k27	9600
5/13/98	43	230	930
8/18/98	N/A	>4000	8600

Table 15. Dixie Drain

Dixie Drain near Wilder			
USGS 13212890			
		Fecal	Fecal
Date	Flow	Coliform	Streptococci
	cfs	# / 100 ml	# / 100 ml
05/06/94	219	k6100	N/A
11/18/94	81	270	N/A
04/18/95	162	420	N/A
04/27/95	183	6400	N/A
05/19/95	182	k9000	N/A
08/16/95	222	k1500	N/A
10/18/95	196	370	N/A
12/06/95	81	320	N/A
02/15/96	85	2200	N/A
04/10/96	166	1300	N/A
04/24/96	240	k3000	N/A
05/17/96	370	5900	N/A
06/10/96	219	2300	N/A
08/21/96	154	k1000	N/A
10/23/96	166	k210	N/A
12/17/96	76	k160	N/A
02/11/97	92	260	N/A
06/18/97	N/A	1900	1800
07/16/97	N/A	1400	k120
08/12/97	N/A	1200	k3300
12/17/98	85	160	1800
5/14/98	349	1800	1300
8/19/98	N/A	900	1800

Table 16. Boise River near Parma

Boise River near Parma					
USGS 13213000				21 Primary exceedences	
				14 Secondary exceedences	
		Fecal	Fecal		
Date	Flow	Coliform	Streptococci		
	cfs	# / 100 ml	# / 100 ml		
11/12/86	2250	100	410		
01/22/87	827	k27	k300		
03/19/87	929	220	1100		
05/28/87	1270	2000	1500	Primary	Secondary
07/27/87	549	k320	900		
09/09/87	733	400	1400		
11/23/87	906	76	480		
01/13/88	761	250	2900		
03/14/88	667	43	k150		
05/23/88	380	1000	1900	Primary	Secondary
07/20/88	258	k1000	3400	Primary	Secondary
09/21/88	514	480	2400		
11/10/88	842	190	1600		
01/20/89	723	530	k11000		
03/13/89	1130	210	3100		
05/08/89	1390	1100	770	Primary	Secondary
07/05/89	543	240	470		
08/29/89	1100	270	2100		
11/16/89	950	150	290		
01/30/90	1420	180	430		
03/26/90	323	k49	k97		
05/21/90	830	980	1400	Primary	Secondary
07/12/90	309	510	1200	Primary	
09/17/90	784	350	1300		
11/21/90	888	400	510		
01/16/91	932	1000	k54000		Secondary
03/25/91	587	300	650		
05/20/91	1400	540	1000	Primary	
07/22/91	608	N/A	970		
09/10/91	796	620	6700	Primary	
11/14/91	808	k62	370		
01/22/92	660	260	590		
03/17/92	564	220	350		
05/12/92	308	780	380	Primary	
09/08/92	170	220	k7800		
11/03/92	648	k74	260		
01/05/93	576	k35	290		
05/13/93	2170	590	240	Primary	
09/08/93	772	260	1900		

Boise River near Parma					
USGS 13213000					
Date	Flow cfs	Fecal Coliform # / 100 ml	Fecal Streptococci # / 100 ml		
11/02/93	981	k70	1500		
01/04/94	859	550	2400		
03/01/94	800	**k1000**	k25		Secondary
05/10/94	587	**1000**	610	Primary	Secondary
09/07/94	444	330	1700		
11/08/94	779	420	k140		
02/15/95	686	92	200		
04/14/95	1270	250	N/A		
04/27/95	3560	k750	N/A		
05/18/95	4380	k400	120		
07/19/95	1420	270	1300		
08/16/95	1080	**k670**	N/A	Primary	
10/18/95	942	150	N/A		
12/05/95	935	190	N/A		
02/15/96	5360	250	N/A		
04/10/96	6360	260	N/A		
04/24/96	5110	420	N/A		
05/17/96	5080	**3000**	N/A	Primary	Secondary
06/10/96	5040	**k3600**	N/A	Primary	Secondary
08/21/96	1140	**k2400**	N/A	Primary	Secondary
10/23/96	1190	k390	N/A		
12/17/96	929	k160	N/A		
02/11/97	8000	80	N/A		
04/17/97	6340	140	150		
05/22/97	4760	**960**	390	Primary	Secondary
06/10/97	4540	460	400		
07/18/97	1420	**610**	320	Primary	
08/12/97	1580	**1100**	1600	Primary	Secondary
9/9/97	1510	500	1300		
10/21/97	1000	260	130		
12/16/97	942	440	280		
4/8/98	2350	600	>2100		
5/13/98	4680	**>3400**	3000	Primary	Secondary
7/15/98	1430	**640**	1000	Primary	
8/18/98	N/A	**510**	1100	Primary	

Table 17. Flow and Water Temperature Data Associated with Fecal Coliform Exceedences Near Parma

DATE	Fecal Coliform # / 100 ml	Flow cfs	Water Temperature degrees F	Flow % of Long Term Monthly Mean
6/10/96	K 3600	5040 (>)	59.0	254%
5/17/96	3000	5080 (>)	53.6	173%
8/16/95	K 670	1080 (>)	64.4	146%
5/10/94	1000	587 (<)	65.3	20%
5/12/92	780	308 (<)	59.0	11%
1/16/91	1000	932 (<)	39.2	70%
5/20/91	540	1400 (<)	56.3	48%
9/10/91	620	796 (<)	61.7	82%
5/21/90	980	830 (<)	59.0	28%
7/12/90	510	309 (<)	73.4	32%
5/8/89	1100	1390 (<)	59.9	47%
5/23/88	1000	380 (<)	68.0	41%
7/20/88	K 1000	258 (<)	71.6	26%
5/28/87	2000	1270 (<)	62.6	43%

(>) Flow is greater than long term monthly mean flow, cfs
(<) Flow is less than long term monthly mean flow, cfs

Summary Information, lower Boise River near Parma

- Ten of the primary contact recreation exceedences coincide with flows that are less than the long term monthly average for the month in which they occur.

- The water temperatures associated with the primary contact recreation exceedences are as follows:

0 - 50 degrees F	none
50 - 60 degrees F	six exceedences
60 - 70 degrees F	six exceedences
70 - 80 degrees F	one exceedence

- The flows and temperatures described above would not preclude the possibility of contact recreation in the lower Boise River near Parma.

Table 18. Indian Creek Upstream Descriptive Statistics

Secondary Contact Recreation

Statistic	Secondary Fecal Exceedences #/100 ml	Water Temperature degrees F	Flows cfs
Maximum	5700	69	120.9
Minimum	900	48	26.6
Average	1522	59	54.1
Median	1200	60	46.2
Std. Deviation	933	6.2	22.3

The water temperatures associated with the upstream fecal coliform problems, like the flows, do not preclude the possibility of contact recreation. The mean and median fecal coliform measurements show that the risk of illness from ingestion of Indian Creek water is moderate.

Table 19. Indian Creek Downstream Descriptive Statistics

Secondary Contact Recreation

Statistic	Secondary Fecal Exceedences #/100 ml	Water Temperature degrees F	Flows cfs
Maximum	14300	71	120.9
Minimum	900	50	18.1
Average	1852	60.1	54.6
Median	1200	60	46.0
Std. Deviation	2157	5.3	25.2

Due to the small size of the Nampa waste water discharge and the proximity of the upstream and downstream monitoring site on Indian Creek, the flows associated with the downstream fecal coliform bacteria problems are quite similar to the upstream flows. Again, contact recreation is not precluded by the size of the flows, nor by the water temperatures.

APPENDIX C

A Review of Aquatic Life Conditions
Draft Technical Memorandum
Lower Boise River

A Review of Aquatic Life Conditions

DRAFT Technical Memorandum

Lower Boise River

Prepared for
State of Idaho

by
Idaho Division of Environmental Quality, Boise Regional Office
June 6, 1998

Table of Contents

List of Illustrations

List of Tables

List of Figures

Introduction

The following technical review evaluates water quality conditions with respect to the aquatic life beneficial uses in the four water quality limited (WQL) stream segments in the lower Boise River (Table 1). Aquatic life beneficial uses encompass aquatic organisms, including fish, that live or reproduce within the river and some of its tributaries. The watershed is defined as U.S. Geological Survey (USGS) hydrologic cataloging unit 17050114 and extends from Lucky Peak Dam to the mouth of the Boise River. Those stream segments that are water quality limited and have been found to be impaired for one or more beneficial uses will require the development of an appropriate total maximum daily load (TMDL) allocation. Stream segments that have conditions exceeding aquatic life criteria, but are not listed as WQL, should also be addressed when developing pollution control strategies for the watershed.

This document describes physical and chemical water quality conditions in the Boise River. The status and distribution of aquatic communities, such as fish and aquatic insects, are also described to evaluate water quality conditions, habitat conditions, and beneficial use status. The Division of Environmental Quality (DEQ) evaluates impairment in streams using applicable criteria (from designated and existing uses) and alternate measures of aquatic life status. Alternate measures include the presence of fish, available habitat, flow conditions and aquatic insects. The combined physical, chemical, and biological indicators are used to develop management recommendations, including TMDLs where needed.

Table 1. October, 1996 list of water quality limited segments in the lower Boise River.

Name	Boundaries	Listed Pollutants	Priority
Boise River	Lucky Peak Dam to Barber Diversion	Flow Alteration	low
Boise River	Barber Diversion to Star	Sediment, Dissolved Oxygen, Oil & Grease	low
Boise River	Star to Notus	Nutrients, Sediment, Dissolved Oxygen, Temperature, Bacteria	HIGH
Boise River	Notus to Snake River	Nutrients, Sediment, Dissolved Oxygen, Pathogens, Temperature	HIGH

Condition of Aquatic Life Communities

DEQ is in the process of developing a standardized approach for evaluating the status of beneficial uses on large rivers at the reconnaissance level. A standard approach is not available at this time and the TMDL schedule for the lower Boise River requires use of other methods for evaluating aquatic life beneficial uses. A substantial amount of data is available for the Boise River that allows for evaluation of the status of uses based on the condition of aquatic life communities and water quality conditions in relation to appropriate water quality criteria. The condition of aquatic life communities in the Boise River has been evaluated by looking at both the benthic macroinvertebrate and fish populations in the River.

Description of Fish Populations

Fish in the Boise River are an important part of the river system, as well as a significant recreational resource. Much of the information available about the status and distribution of fish in the Boise River and its tributaries comes from the Idaho Department of Fish and Game (IDFG). The professional opinions of the IDFG with respect to the distribution of fish and status of cold water biota, warm water biota and salmonid spawning in the lower Boise River are included in Appendix D.

Brown Trout, Rainbow Trout, and Mountain Whitefish are the dominant cold water game fish in the upper part of the River. Most of the trout found in the reach above Star Diversion are hatchery fish but wild trout are present. IDFG has documented limited natural reproduction of wild trout occurring in the Boise River or its tributaries in this part of the river. Trout are essentially absent downstream of the Star Diversion. Sculpin, another cold water fish, are found in the river from Lucky Peak to the Lander Street area. Mountain Whitefish are found in the rest of the river, to the confluence with the Snake.

Gibson (1975) sampled fish in the Boise River in the winter, summer and fall of 1974. He found a similar pattern, trout in the reach above Star and Mountain Whitefish along the entire length of the river. Gibson's catch rate for Mountain Whitefish was significantly higher in the fall and winter than in the summer.

The USGS sampled fish in the Boise River in December 1996 and August 1997. Mountain Whitefish were found in all reaches of the River in both sampling events, although their frequency decreased significantly at the mouth (W. Mullins, USGS, written commun., 1997). Mountain Whitefish appear to be reproducing along the entire river, based on the presence of juvenile and adult fish at each sampling location. Warm water species such as Largemouth Bass, Smallmouth Bass and Channel Catfish were found from Middleton to the mouth of the River.

Status of Fish Populations

At DEQ's request, the IDFG evaluated the status of cold water biota (CWB), warm water biota (WWB) and salmonid spawning (SS) along the length of the Boise River (Appendix D). A summary of IDFG's opinions is shown in Table 2. IDFG considers cold water biota to be impaired in all segments of the River. Salmonid spawning is impaired from Diversion Dam to Notus. IDFG believes that Mountain Whitefish spawning in the reach from Notus to the Snake River is likely, but the available information is insufficient to determine the status of the salmonid spawning use based on fish data alone.

Table 2. Status of fish populations in the lower Boise River.

Segment	Designated Uses	Existing Uses	Impaired Uses	Causes of Impairment
Boise River Lucky Peak Dam to Barber Park	CWB, SS	CWB, SS Trout, Mountain Whitefish	CWB, SS	Flow, lack of cover, sediment, toxins, lack of gravel, channelization, temperature armored substrate
Boise River Barber Park to Veterans Park	CWB, SS	CWB, SS Trout, Mountain Whitefish	CWB, SS	SAME as ABOVE
Boise River Veterans Park to Star	CWB, SS	CWB, SS Trout, Mountain Whitefish	CWB, SS	SAME as ABOVE, plus flood control, gravel mining, unscreened diversions, barriers, low flow
Boise River Star to Caldwell	CWB, SS	CWB, SS Trout, Mountain Whitefish	CWB, SS	SAME as ABOVE
Boise River Caldwell to Snake River	CWB	CWB, WWB, SS Mountain Whitefish (Seasonal)	CWB	SAME as ABOVE but temperature and sediment more significant

Description of Aquatic Insect Populations

Aquatic insects, known as benthic macroinvertebrates, serve as important consumers of organic material in streams, as well as food sources for fish. Insect populations are very useful indicators of the overall health of streams. When insects are diverse and abundant, streams are in good health. Small numbers of insects, lack of diversity, and dominance by pollution tolerant insects are indicative of streams that are degraded.

The benthic macroinvertebrate data collected by the USGS in the Boise River span five sites from Lucky Peak to the confluence with the Snake River. The data were collected on two sampling dates, in October of 1995 and October of 1996. A technical memorandum interpreting the data is included as Appendix E. DEQ collected three sets of benthic macroinvertebrate samples on August 18, 1995 in the Boise river near Star, Caldwell, and Notus. A more detailed review of the dominant and pollution tolerant species helps to further characterize the overall quality of the Boise River.

Organisms that are tolerant of degraded conditions generally increase from Lucky Peak toward the mouth of the Boise River, with the highest proportion of tolerant taxa generally found in the Middleton and Caldwell area.. For example, *Tricorythodes minutus*, a mayfly that is highly tolerant of degraded conditions, is only about two tenths of one percent of the total population at Barber Park, but represents 42 percent of the insect population at the mouth of the river. Tolerant mayflies in high percentages, such as the *Tricorythodes*, indicate nutrient enriched streams with high summer water temperatures (Wisseman, 1996). In similar fashion, pollution tolerant midges increase from roughly 5 percent of the population at Barber Park to about 26 percent of the population near Caldwell. Scrapers, insects that consume algae attached to hard surfaces, represent about five percent of the population at Barber Park, and about seven percent at Glenwood Bridge. Near Middleton and Caldwell, both the abundance of scrapers and the percentage of the total population represented by scrapers decline (about 2 percent and less than one percent, respectively), indicating degraded conditions (Wisseman, 1996).

Organisms that favor good conditions decline in numbers toward the mouth of the Boise River. Stoneflies, characteristic of good water quality and clean gravel substrates, are present in very small numbers at Barber Park and Glenwood Bridge. Stoneflies are completely absent in the reach of the river from Middleton to the Snake. Moderately tolerant caddisflies fluctuate as a percentage of the total population from Barber Park to Middleton, but decline significantly downstream of Middleton. Another moderately tolerant organism, *Baetis tricaudatus* (a mayfly), represents twenty percent of the total insect population at Barber Park, and 17 percent of the population at Glenwood Bridge. *Baetis tricaudatus* drops to about six percent of the total population at Middleton, and drops again to about 1.3 percent at Caldwell. Near the mouth of the Boise River, *Baetis tricaudatus* increases to 8.5 percent of the total population. The decline of the mayfly indicates that conditions at Middleton and Caldwell are degraded relative to Barber Park and Glenwood Bridge.

Naididae, worms tolerant of fine sediment, increase measurably from Glenwood Bridge (7.3% of the population) to Caldwell (17%). Similarly, *Plecoptera*, organisms intolerant of fine sediment and warm temperatures, are few to zero at Middleton and Caldwell. W. Mullins (USGS, personal commun., 1997) has suggested that changes in benthic macroinvertebrates along the River indicate altered substrate may be a significant cause impairment. Altered substrate is a common result of excess sediment.

Evaluation of Applicable Water Quality Criteria

Pollutants of Concern

A variety of pollutants may impair aquatic life beneficial uses when present in significant quantities or concentrations. Pollutants of concern include sediment, nutrients (nitrogen and phosphorus), dissolved gasses, temperature, and toxic materials such as chlorine, metals, or organic chemicals. Some impairments of aquatic life are due to factors not normally considered to be "pollutants." Gravels for spawning, cover elements for trout, recreational fishing pressure, channelization, flow regulation, and the loss of tributary spawning areas can also limit the abundance and health of fish populations.

Sediment

Sediments are suspended when water velocities are high enough to carry solids along with the flow of the stream. When sediments are suspended in flowing water, the light available for aquatic life is limited. Fish that feed by sight may have difficulty finding prey, or may avoid streams that are extremely turbid. At concentrations of about 50 to 100 mg/l for periods of 30 to 60 days sublethal and lethal affects on salmonid reproduction are observable (Newcombe and Jensen, 1996). At extremely high concentrations, suspended sediments may interfere with the function of fish gills. In areas where currents are normally slow, or during low water conditions, sediments fall out of suspension and settle on the stream bed.

Solids may remain on the stream bed until the spring when flows increase, or may remain for years. Sediments can cause impairment by settling and altering habitat, and by carrying nutrients such as phosphorus. Attached phosphorus may serve as a reservoir of nutrients that can later be released into the water. On the stream bed, sediments (especially sand size and smaller particles) can limit the oxygen available to fish eggs, and can increase the mortality of emerging embryos. In addition, excessive fine sediments may limit the growth and movement of aquatic insects that are an important part of the food web in streams.

Nutrients

Within this document, the term nutrients refers to all the species of nitrogen and phosphorus. Phosphorus can enter a stream either as dissolved ortho-phosphate in the water or bound to sediment particles. Once in a stream, dissolved phosphorus may be transported along with the river flow, may be utilized by plants or algae, or may adsorb to solids in the water. Sediment attached phosphorus is likely to remain bound to solids, and is likely to be released only at a very slow rate. Thus, significant quantities of phosphorus may move slowly downstream in conjunction with sediment movement.

Nitrogen is highly soluble in water and moves easily through surface runoff or ground water to enter streams. In stream, nitrate is the most stable and readily transported form of nitrogen. Ammonia that enters well oxygenated streams like the Boise River is very quickly oxidized to become nitrate. Ammonia in small concentrations can be assimilated by streams. However, if ammonia enters a stream in high concentrations, it can have a toxic impact on fish and other aquatic life.

Organic sources of nitrogen often hydrolyze quickly to ammonia, and then in turn to nitrate. As nitrogen moves with a stream, its various forms may be utilized for growth by algae or plants. Nitrogen may also leave the water as dinitrogen gas where sufficient organic carbon and facultative bacteria are present in the stream bed. Unlike phosphorus, nitrogen is probably not stored for any significant length of time in sediments.

When nitrogen and phosphorus are combined in slow moving, warm waters with plenty of available light, algal blooms may occur. When algae die, decay of organic matter may reduce dissolved oxygen (DO) to levels that adversely affect fish. Very low DO levels can cause fish kills. The growth of algae is most significant when both nitrogen and phosphorus are present in solution in high concentrations. Either nitrogen or phosphorus may be a "trigger", or limiting factor on algal growth, making growth more likely when high concentrations of dissolved phosphorus and nitrogen are present.

Dissolved Gasses

Dissolved gasses, such as oxygen and nitrogen, are essential to aquatic life, but can be harmful if present in excessive concentrations. When dissolved gasses become super-saturated at greater than 110% of the normal saturation for a given water temperature, fish may be harmed. The primary risk for fish is caused by dissolved nitrogen, a problem caused primarily by large spillways at dam sites. Gasses enter the water through equilibrium with the atmosphere, aeration by features such as dams and riffles, or by the release of oxygen from photosynthesis. Supersaturation may often dissipate quickly downstream of some sources, or may persist for hours in areas where plants and algae are growing.

Very low DO, less than 6.0 mg/l for cold water biota, can also be a problem, because fish and other aquatic organisms will be stressed. High water temperature or inputs of oxygen consuming wastes can cause DO concentrations to decrease. Excessive quantities of algae can consume oxygen when they die and decompose.

Temperature

The temperature of the water in streams can impact fish and other aquatic life. As the temperature goes up, the water holds less oxygen. In addition, many species of fish are best adapted to a particular range of temperatures. If temperatures are too high for a period of time, fish are placed in stress. At higher than optimal temperatures, the growth rates of juvenile fish may be reduced, the success of feeding declines, and fish may be more susceptible to predation.

pH

The pH of a stream describes whether the water is acid, neutral, or basic. Fish and other aquatic organisms are generally adapted to survive within a limited range of acid or basic waters. An acidic or basic condition in a stream may persist until some type of natural buffering becomes available.

Metals and Toxic Substances

Metals and toxic substances are a concern for aquatic life in two respects. First, such materials may cause direct harm to fish and other aquatic organisms through either acute or chronic affects. Second, since the Boise River is a significant recreational fishery, materials that can accumulate in tissues of fish that may be eaten are a significant concern for human health. The applicable criteria are designed to protect aquatic life directly and to protect human health for the consumption of organisms.

Applicable Water Quality Criteria

The State of Idaho Water Quality Standards and Waste Water Treatment Requirements establish a set of criteria designed to protect aquatic life in streams, lakes, and reservoirs. The numeric and narrative criteria that apply to the lower Boise River are summarized below.

Numeric Criteria

The criteria listed in Table 5 below are summarized from a complete description in the State of Idaho Water Quality Standards and Wastewater Treatment Requirements, IDAPA 16.01.02 250.02.

Table 3. Summary of aquatic life numeric water quality criteria.

Criteria	Cold Water Biota	Salmonid Spawning*
pH	6.5 - 9.5	6.5 - 9.5
Total Dissolved Gas	≤ 110 % of saturation	≤ 110 % of saturation
Residual Chlorine	1 hour average ≤ 19 μg/l 4 day average ≤ 11 μg/l	1 hour average ≤ 19 μg/l 4 day average ≤ 11 μg/l
Metals and Toxic Substances	Set of limits described in IDAPA 16.01.02.250.07	Set of limits described in IDAPA 16.01.02.250.07
Dissolved Oxygen	≥ 6.0 mg/l	Water Column: greater of: ≥ 6.0 mg/l or 75% of saturation** or 90%of saturation*** Intergravel: 1 day minimum ≥ 5.0 mg/l 7 day average ≥ 6.0 mg/l
Temperature	Daily Maximum ≤ 22° C Max. Daily Avg.≤ 19° C	Daily Maximum ≤ 13° C Max. Daily Avg.≤ 9° C
Ammonia	Not to exceed one hour and four day averages calculated according to IDAPA 16.01.02 250.02.c.iii	Not to exceed one hour and four day averages calculated according to IDAPA 16.01.02 250.02.c.iii
Turbidity	Below any applicable mixing zone: 1) Shall not exceed background by more than 50 NTU instantaneously 2) Shall not exceed background by more than 25 NTU for more than 10 consecutive days	Below any applicable mixing zone: 1) Shall not exceed background by more than 50 NTU instantaneously 2) Shall not exceed background by more than 25 NTU for more than 10 consecutive days

*Applicable only during the time period listed for given species in IDAPA 16.01.02.250.02.d.iv; Rainbow Trout, January 15 to July 15; Mountain Whitefish, October 15 to March 15.
**IDAPA 16.01.02.278 - Site specific criterion for Boise River from Veteran's State Park to mouth.
***General aquatic life criterion that applies to Boise River from Lucky Peak Dam to Veterans State Park.

Narrative Criteria

In addition to numeric criteria, the following narrative criteria were evaluated to identify possible impairment of aquatic life uses in the Boise River.

Toxic Substances

Surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses. These substances do not include suspended sediment produced as a result of nonpoint source activity (IDAPA 16.01.02.200.02).

Excess Nutrients

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 16.01.02.200.06).

Sediment

Sediment shall not exceed quantities specified in Section 250., or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350.02.b (IDAPA 16.01.02.200.08).

Description of Criteria Exceedences

The lower Boise River exhibits few significant exceedences of aquatic life criteria, with the exception of temperature and sediment. From Lucky Peak to the mouth of the Boise River, pH, dissolved oxygen, chlorine, and ammonia meet the requirements listed in the table above, and do not impair aquatic life. Temperatures exceed the state criteria for cold water biota and salmonid spawning frequently.

Sediment

Sediment impairs aquatic life beneficial uses throughout the river, from Lucky Peak Dam to the confluence with the Snake River. Near the City of Boise, flow regulation by Lucky Peak, Diversion Dam, and Barber Diversion creates significant accumulations of sand that damage fish habitat behind each dam. As the sand washes downstream, it contributes to high levels of embeddedness in the stream bed from Diversion Dam to Star, limiting the spawning of trout and whitefish. Downstream of the Star Road diversion, sediment load from agricultural drains increases significantly. Sands continue to contribute to high levels of embeddedness, the proportion of fine sediment in the substrate increases and the concentration of suspended sediments in the water column increases. Increased turbidity has often been noted in the Boise River downstream of Middleton.

The condition of benthic macroinvertebrates also indicates that sediment is a significant cause of impairment, particularly in the River below Middleton. The presence and abundance of species requiring clean substrate decreases and species that are more tolerant of sediment increase.

Sediment Impacts on Substrate

In general, the portion of the Boise River near the city has an armored substrate that consists primarily of large cobbles. Of the cobbles, pebbles, and gravel present, more than 60 percent were embedded in the 25 to 49 percent range during a 1987 survey (Asbridge and Bjorn, 1988). Embeddedness exceeding 32 percent is generally considered to indicate impaired habitat. Most pea gravels in Loggers Creek were also embedded in the 25 to 49 percent range during the same study, limiting the value of the substrate for salmonid spawning. Cover elements for salmonids are also in short supply, with over 70 percent of the areas studied by Asbridge and Bjorn (1988) having only depth as a source of cover for fish.

More recently, the USGS has measured embeddedness and substrate particle size at Eckart Road and near Middleton in November 1997 (W. Mullins, USGS, written commun., 1997). Ocular embeddedness estimates at Eckart Road ranged from 2 (50 - 75% embedded) in a deep run to 4 (25 - 50% embedded) in riffles. All embeddedness observations at the site near Middleton were rated as 1 (≥ 75%) or 2. Pebble count data from the same sites indicate a much higher proportion of sand and silt (about 48% compared to about 18%) near Middleton than at Eckart Road. Gravels were found at both sites, although the proportions were greater at Middleton than Eckart Road. The substrate at Eckart Road is dominated by cobbles, very coarse gravels and sand.

Suspended Sediment

Sediment suspended in the water column can adversely affect aquatic life. Many fish species are adapted to high suspended sediment levels for short durations that commonly occur during natural spring runoff events. However longer durations of exposure can interfere with feeding behavior, damage gills, reduce available food, reduce growth rates, smother eggs and fry in the substrate, damage habitat and induce mortality. Eggs, fry and juveniles are particularly sensitive to suspended sediment, although at high enough concentrations adult fish are affected as well. Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on suspended sediments in streams and estuaries. For Rainbow Trout, lethal effects, which include reduced growth rate, begin to be observed at concentrations of 50 to 100 mg/l when those concentrations are maintained for 20 to 60 days. Similar effects are observed for Brown Trout at 100 mg/l suspended sediment for a duration of 30 - 60 days and for Largemouth Bass at 63 mg/l for 30 days. Adverse effects on habitat, especially spawning and rearing habitat were noted at similar concentrations. In an earlier report, Newcombe and MacDonald (1991) observed that benthic macroinvertebrate populations were significantly reduced and sensitive species eliminated at similar concentrations when duration ranged from 30 to 100 days.

From 1994 through 1997, when the USGS sampled the four main river stations, suspended sediment concentrations in the lower Boise River occasionally exceed 50 mg/l at Glenwood

Bridge (4 out of 29 measurements) and Middleton (1 out of 22 measurements) and more frequently at Parma (10 out of 26 measurements). Concentrations ranged as high as 245 mg/l at Parma. Highest concentrations are generally observed during spring runoff, although 245 mg/l of suspended sediment was measured at Parma on July 19, 1995 and concentrations exceeding 50 mg/l have been observed in every month from February to August. The data is insufficient to determine the duration of high suspended sediment concentrations.

Lack of Spawning Gravels

IDFG has identified lack of spawning gravels as a significant cause of impairment of cold water biota in the Boise River. Rainbow and Brown Trout, in particular, need clean gravels for spawning. The presence of the dams in the upper part of the River has severely limited recruitment of new gravels. The potential spawning gravels that are in place are both embedded and are frequently dry during low flow conditions.

Nutrients and Nuisance Aquatic Growth

Algae of various types grow in the water and on the bed of the Boise River. Algae provide a food source for many aquatic insects, which in turn serve as food for fish. Algae grow where sufficient nutrients (nitrogen, phosphorus) are available to support growth. Flows, temperatures, and sunlight penetration into the water all must combine with nutrient availability to produce optimum conditions for photosynthetic growth. When nutrients exceed the quantities needed to support primary productivity, algae blooms may develop. Algae blooms can adversely impact aquatic life. Death and decomposition of algae creates an oxygen demand. If the demand is high enough, DO levels in the water body may decline to low levels that harm fish.

Nutrients in the Boise River are significantly enriched (Figures 1 and 2). Under the right conditions, algae blooms are possible. Total phosphorus concentrations in samples collected by the USGS range from well below the EPA recommended criterion for flowing waters of 0.1 mg/l at Diversion Dam to as high as 0.8 mg/l at Middleton and 0.5 mg/l at Parma. The highest concentrations occur during low flow conditions, which are generally in the winter when aquatic plant growth is less of a concern. However, total phosphorus concentrations during the growing season at Middleton and Parma are more than sufficient to support algae growth.

Ortho-phosphate concentrations follow a similar pattern to total phosphorus with respect to flow conditions and location. Highest concentrations are during low flow periods, concentrations increase downstream, and ortho-phosphate is more than adequate to support nuisance aquatic growth under the right conditions. Bothwell (1988, 1989) and Horner, Welch and Veenstra (1983) have shown that phosphorus concentrations as low as 25 to 50μg/l are sufficient to support growth of periphyton communities. Generally, ortho-phosphate concentrations are 75 to 80 percent of total phosphorus concentrations in the Boise River (Table 6).

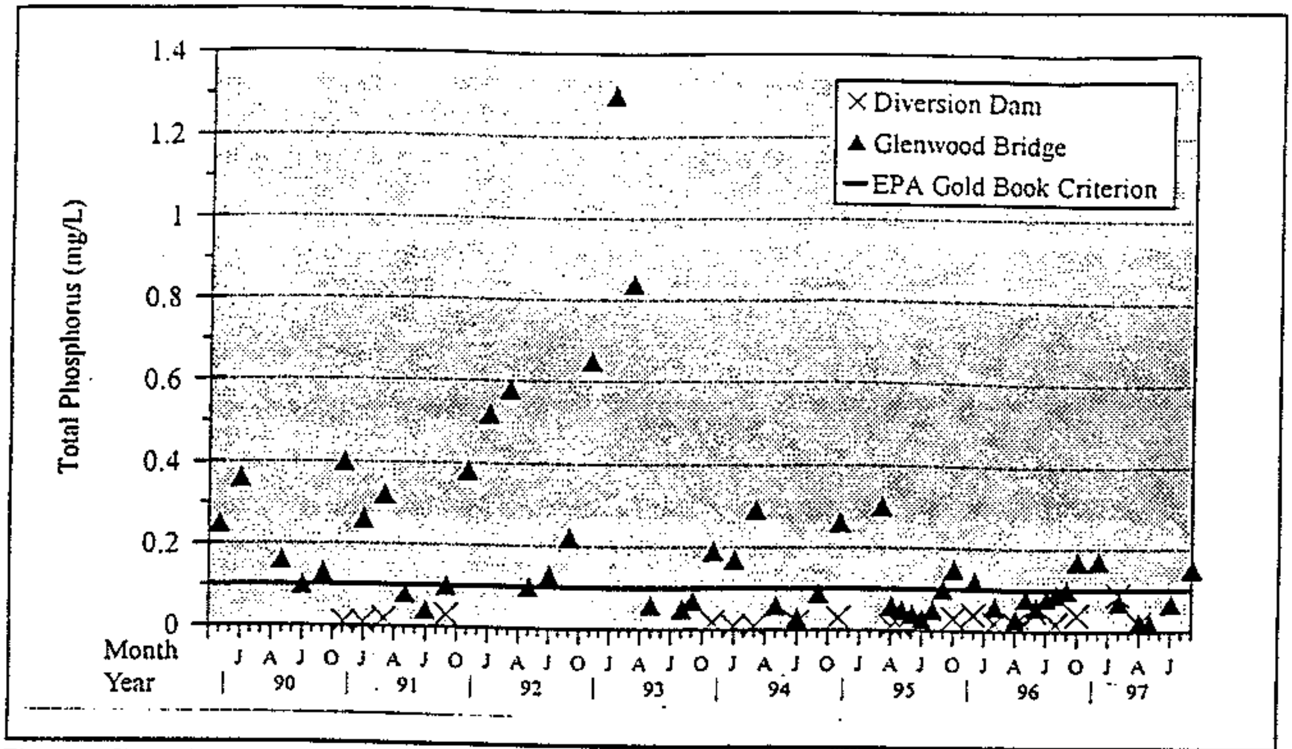

Figure 1. Total phosphorus concentrations on the lower Boise River Diversion Dam and Glenwood Bridge.

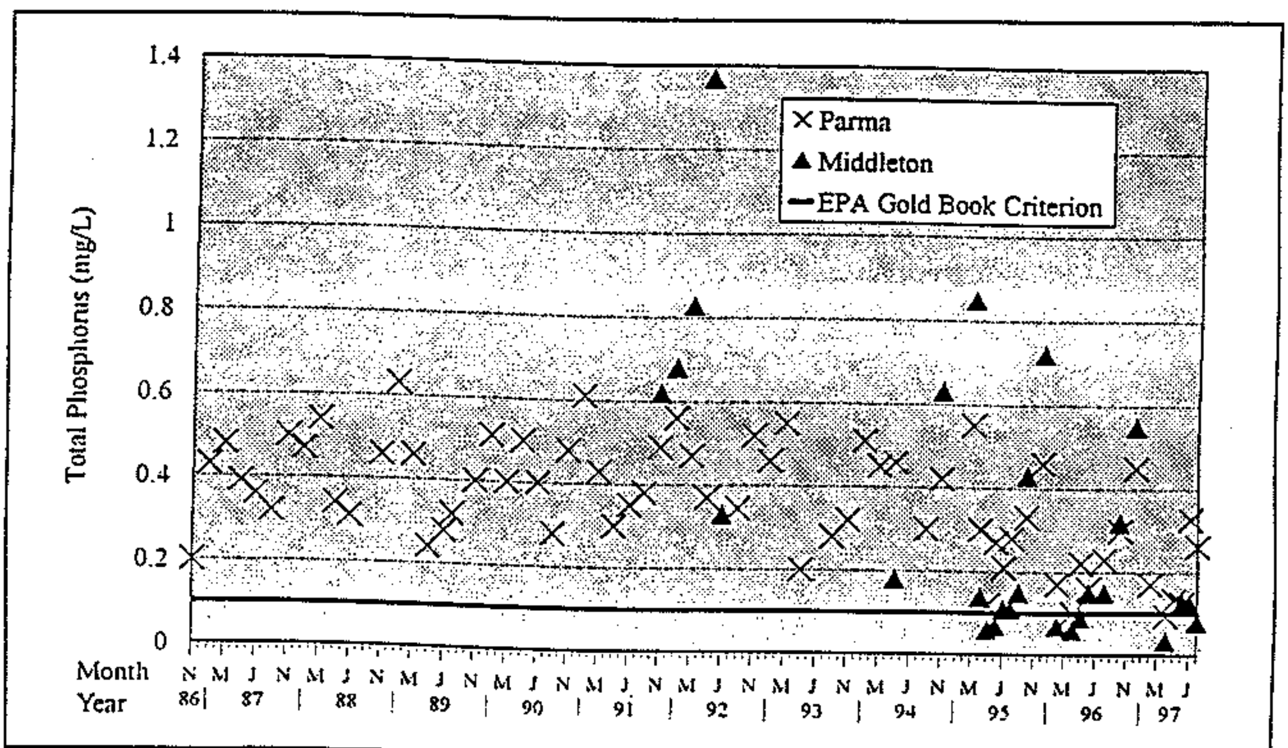

Figure 2. Total Phosphorus Concentrations in the Boise River near Middleton and Parma.

Table 4. Average percent of total phosphorus that is ortho-phosphate in the Boise River based on USGS synoptic data.

Station	Percent Ortho Phosphate/Total Phosphorus
Diversion Dam	73
Glenwood Bridge	78
Middleton	81
Parma	77

Chlorophyll-a in algae in the water column and in the algae attached to rock (periphyton) are commonly used to measure algal productivity. The USGS measured chlorophyll-a in the water column in the Boise River at Diversion Dam, Glenwood Bridge, Middleton, and Parma ten times in 1995 and 1996 (Figures 3 and 4). None of the measured values exceed 20 μg/l. Idaho does not have a numeric criterion for chlorophyll-a. Oregon's criterion is 15 μg/l. An exceedence of the Oregon criterion triggers a determination whether a beneficial use is adversely impacted. North Carolina has a chlorophyll-a criterion of 40 μg/l. Comparing the USGS data to these criteria, and considering that the USGS has not measured single exceedence of the DO criteria for aquatic life DEQ has concluded that nutrients are not causing excessive growth of water column algae.

Chlorophyll-a data from periphytic algae do not provide for an equally clear conclusion. Periphyton grow on pebbles and cobbles along the stream bed. In streams that are not impacted by an over abundance of nutrients, the periphytic algae grow as single celled organisms called diatoms that are kept in check by the grazing of aquatic insects. When nutrient availability exceeds the basic needs of diatoms, other species, including bulky, filamentous algae such as *Cladophora* may grow on the stream bed. The bulky filamentous algae can cause significant aesthetic and water quality impairments.

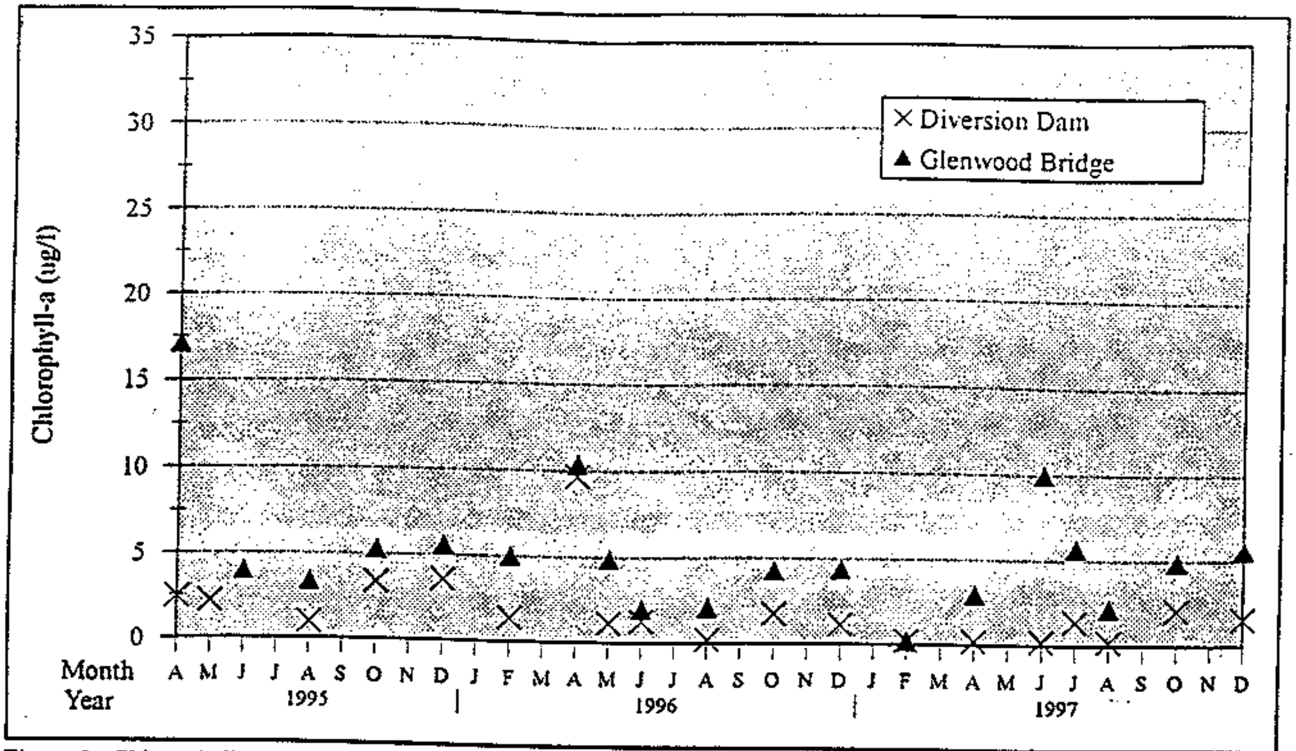

Figure 3. Chlorophyll-a concentrations in the lower Boise River at Diversion Dam and Glenwood Bridge.

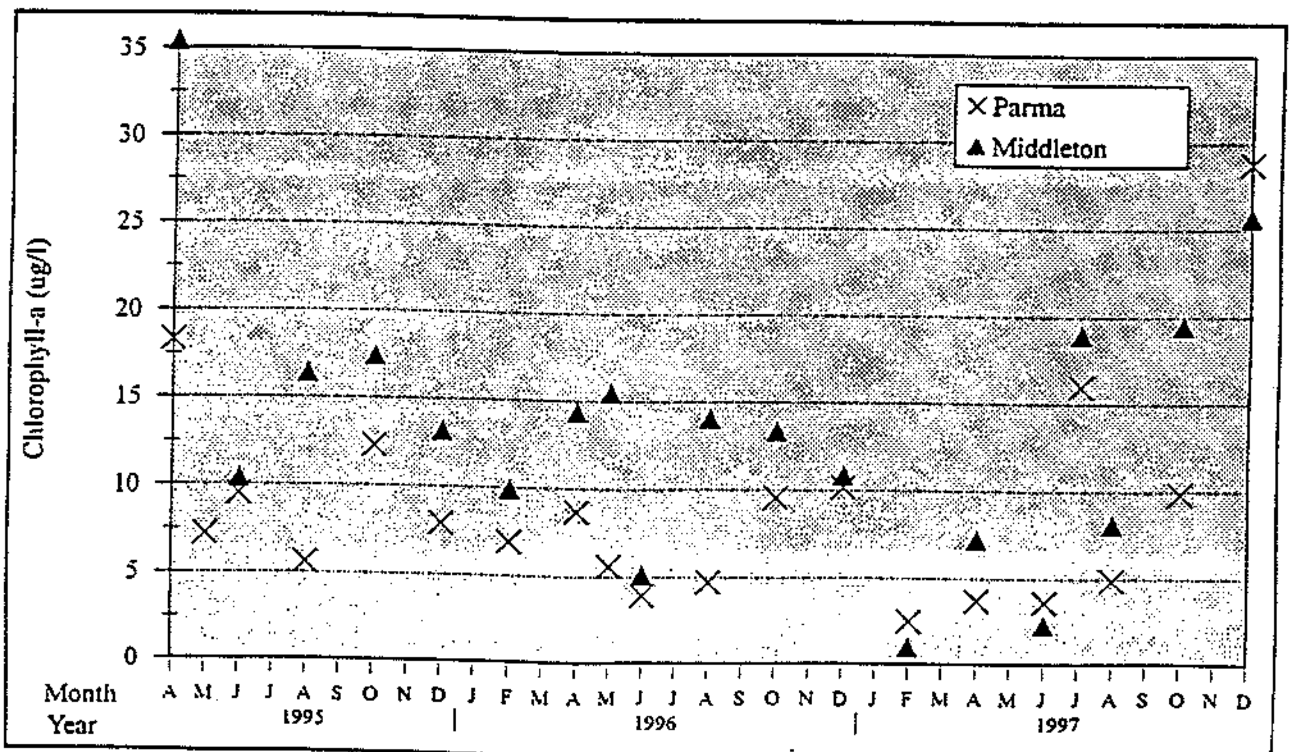

Figure 4. Chlorophyll-a concentrations in the Boise River near Middleton and Parma.

DEQ does not have numeric criterion for periphytic chlorophyll-a. Several authors have suggested that periphyton chlorophyll-a values from 100-200 mg/m2 constitutes a nuisance threshold, above which aesthetics are impaired (Horner and others, 1983, Watson and Gestring, 1996; Welch, Horner and Patmont, 1989; Welch, Jacoby, Horner and Seeley, 1988). However, no thresholds have been proposed for adverse impacts to aquatic life. Impacts to aquatic life would generally be identified based on DO problems.

The USGS collected periphyton samples in the Boise River at Eckert Road, Glenwood Bridge, Middleton, Caldwell and the mouth in October of 1995 and 1996. Chlorophyll-a in periphyton ranges from a low of .025 mg/m2 at Eckert Road to a high of 933 mg/m^2 at Caldwell (Figure 5). The highest values are consistently found at Middleton and Caldwell, where diversions result in lower flows and water temperatures begin to increase.

While periphyton chlorophyll-a values exceed suggested nuisance thresholds in these segments, the absence of DO problems indicates that nutrients were not causing impairment of aquatic life in the Boise River during the sampling periods. However, the high nutrient concentrations and low flow conditions in the Middleton and Caldwell reaches suggests that in drought years, if flows are low enough, conditions in the River could support sufficient algae growth to impair aquatic life. This possibility is supported by the presence of masses of filamentous algae and rooted aquatic macrophytes in canals in the Boise River valley. When the enriched river water is diverted into unshaded, low gradient canals with slower flow velocities, algae and rooted aquatic macrophytes grow freely.

It is also possible that high sediment concentrations in the River below Caldwell are preventing algae growth by limiting the amount of light that penetrates the water column. If sediment concentrations in the summer are reduced, algae growth in the reach of the River below Caldwell may increase.

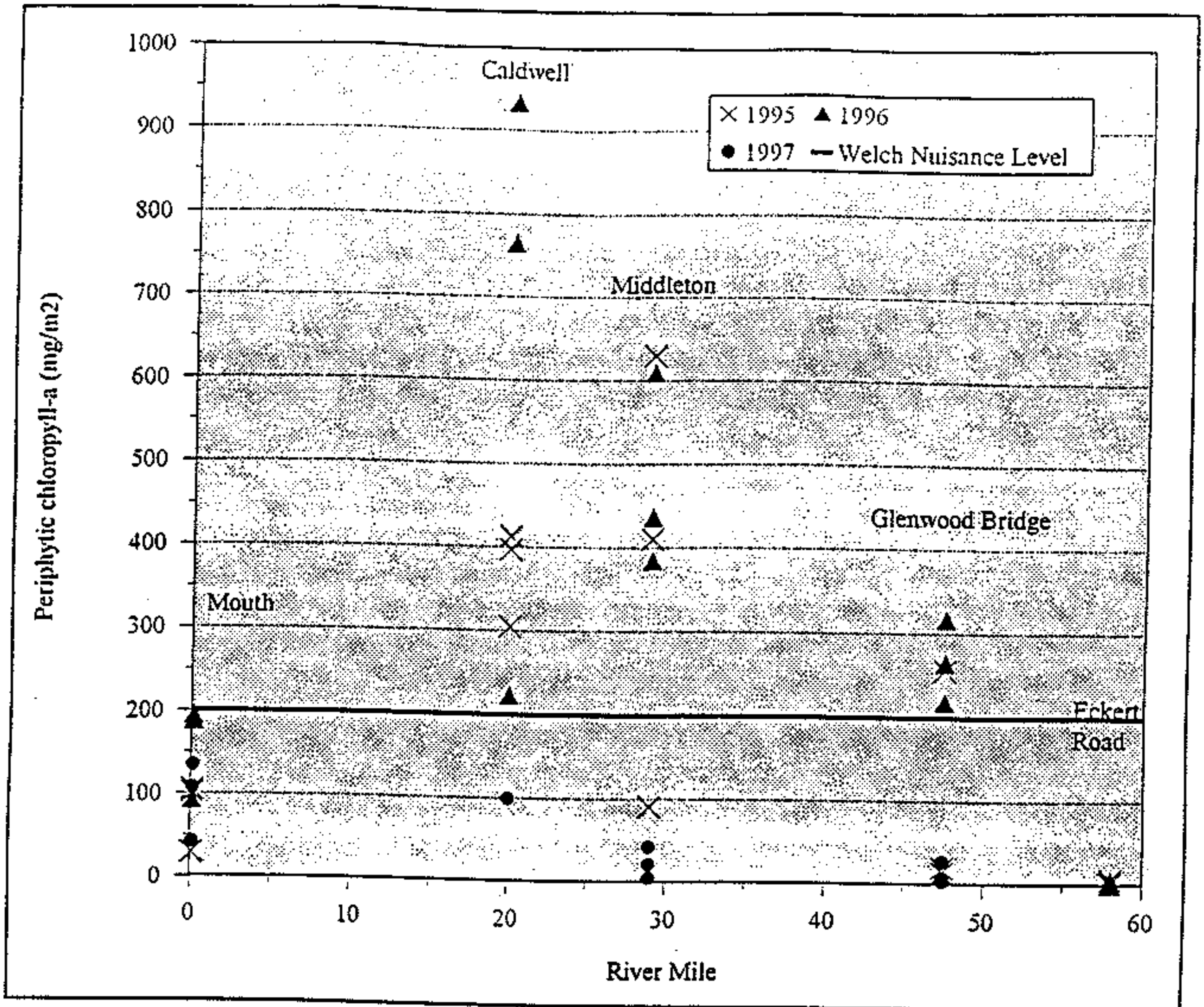

Figure 5. Periphytic chlorophyll-a in the lower Boise River.

Dissolved Gasses

The USGS measured DO in the Boise River at four sites. Start dates for sampling range from November 1992 at Glenwood Bridge and Parma through May 1994 at Middleton. DEQ has evaluated data through August 1997 at each of the four sites. During this period, no DO concentrations were measured that were lower than the applicable criteria. The data that were collected are limited to dissolved oxygen, and thus are insufficient to evaluate the percent saturation for total dissolved gasses.

Temperature

A complete review of water temperatures in the lower Boise River with respect to existing cold water biota and salmonid spawning criteria is available in Appendix F. The following section summarizes the important conclusions regarding water temperatures in the Boise River.

Cold Water Biota Criteria

The daily maximum (22 ° C) and maximum daily average (19° C) criteria for cold water biota are occasionally exceeded at Middleton. Upstream of Middleton, water temperature have not exceeded the two criteria in the available data. The frequency of water temperatures in excess of cold water biota criteria increases at Caldwell and increases more at Parma. USGS data from Parma show water temperatures in the river exceeded both the daily maximum and daily average criteria for cold water biota every July and August from 1987 to 1997 (except for 1995, for which no data are available). Temperatures in the 23 to 25° C range are not uncommon at Parma during July and August. In hot, dry years temperature criteria may be exceeded for virtually all of the days in July and August.

Salmonid Spawning Criteria

The daily maximum (13 ° C) criterion associated with salmonid spawning is exceeded in the Boise River from Diversion Dam to Middleton. The salmonid spawning criteria apply in this reach from October 19 to July 15 each year because of the spawning periods for Mountain Whitefish (October 15 to March 15) and Rainbow Trout (January 15 to July 15). Most of the criteria exceedences occur in October, June and July when the weather is warmer.

The frequency with which the daily maximum water temperature exceeds 13° C seems to increase downstream of Boise, beginning near Eagle Island. However, the large amount of daily data available for the south channel of the Boise River around Eagle Island, compared to other sites in this reach which have bimonthly data, may provide a false impression.

The USGS is currently measuring water temperatures hourly for one full year in the Boise River at Diversion Dam, Glenwood, Middleton, Caldwell and Parma and also in Dixie Drain, Conway Gulch and Willow Creek. When these data are available in the spring of 1998, DEQ will be better able to characterize the extent of salmonid spawning temperature problems in the river.

pH

The USGS measured pH in the Boise River at the same time as DO at the four main river sampling sites. The pH criteria for aquatic life were not exceeded in any of the samples.

Metals

Metals for which data are available are in most cases well below state limits. For certain parameters, such as selenium, the data reported are not directly comparable to the state criteria, but appear to be quite low. In addition, some samples were analyzed with detection limits higher than the state criteria, and thus cannot be evaluated. For example, a value for cadmium reported as less than 1 μg/l on 5/14/92 at Glenwood bridge cannot be compared to the applicable chronic criterion of 0.409 μg/l dissolved cadmium. The concentration in the water may be either less than or greater than the limit.

A few USGS samples from the 1980's have shown exceedences of the aquatic life criteria for mercury and cadmium. However, based on more recent evaluation of sampling and analytical techniques (M. Hardy, USGS, oral commun., 1997), proximity to detection limits and the lack of recent criteria exceedences, DEQ concluded that these data do not indicate mercury or cadmium contamination problems.

Other Causes of Impairment

The components of habitat needed for cold water fish in the lower Boise River include cover elements, gravels for spawning, clean substrate to support insects, and moderate summer water velocities. In the Boise River, most of these habitat elements are absent or are not optimal for a healthy fishery. Only one trout spawning redd has been observed by IDFG, in Logger's Creek. Many of the tributaries that at one time supported trout spawning are now piped beneath the City of Boise. Low winter flows may effectively isolate fish from any remaining spawning habitat in the tributaries.

Flows and Water Velocity

The annual hydrograph of the Boise River, that is, the flow of water in the river over one year, has been significantly altered by flow management for flood control and irrigation. Flows in the Boise River do not reach the peaks that occurred prior to dam construction and flood control. Spring flood flows that used to occur in short peaks are now distributed more evenly across several months, the duration depending on the total water available in the basin and the timing and rate of snowmelt in the spring. Low summer flows characteristic of natural streams have been replaced with higher irrigation flows across the summer. The spring of 1997, a higher than average water year, is an example of a year in which controlled flow prevents flooding, but exposes fish to high velocity water for prolonged periods of time. Low flow conditions occur in the late fall and winter, during spawning periods for Brown Trout and Mountain Whitefish and during the early part of the spawning period for Rainbow Trout.

Velocities in parts of the Boise River between Lucky Peak and Star are often too fast for adult and juvenile trout during the summer months. The velocities observed are high enough to limit trout to the river banks and bottom. Asbridge and Bjorn (1988) found that when flows averaged 4400 cubic feet per second (cfs), high velocity runs are the dominant habitat type in both the Boise River and Loggers Creek.

Minimum Flows and Habitat

In the fall and winter, flows drop far below typical natural flows, stressing fish by limiting their access to cover near banks and tributary spawning grounds. After construction of Lucky Peak Dam, winter time flows in the Boise River occasionally dropped to 80 cfs or less, severely limiting the pools available for fish survival. IDFG holds contracts for 50,000 acre-ft of storage water in Lucky Pear Reservoir. IDFG's storage water, combined with uncontracted storage space held by the U.S. Bureau of Reclamation, provides a minimum flow of 150 cfs during winter low flow periods to provide better winter time support for fish. However, a flow of 240 cfs is more beneficial as a minimum needed to support spawning during the winter months (Jarvis, 1985). The monthly average flow near Boise limits Brown Trout spawning, which occurs primarily in October and November and requires a minimum flow of 225 cfs (Figure 6). Rainbow Trout spawning, requiring a minimum flow of 255 cfs, probably is supported by typical regulated flows, because sufficient average and minimum flows occur in the Rainbow Trout spawning months of April, May and June (Jarvis, 1985). Mountain Whitefish spawning may also be limited by low November and December flows.

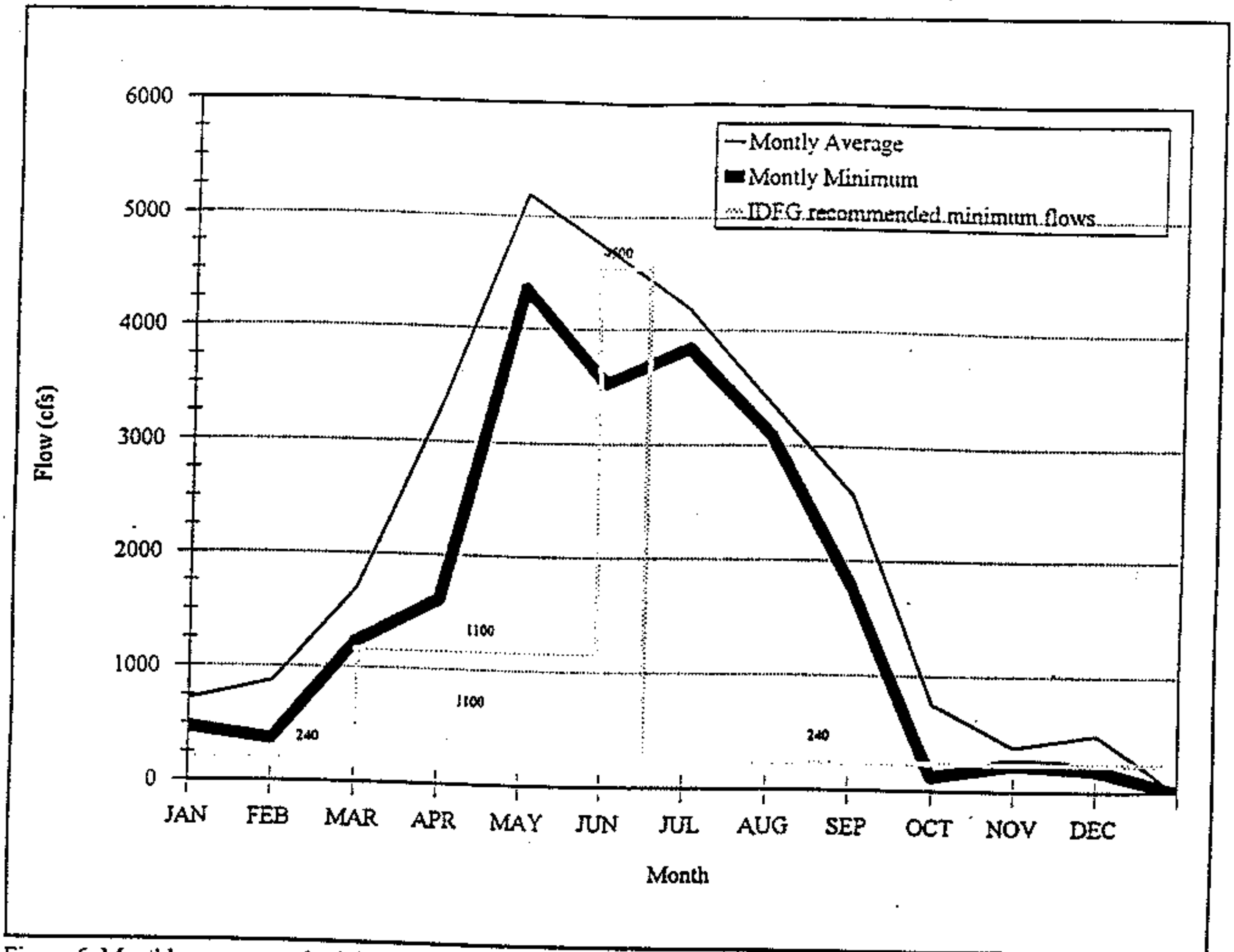

Figure 6. Monthly average and minimum regulated flows in the Boise River at Boise, USGS gaging station 13202000.

The US Fish and Wildlife Service concluded that most of the remaining spawning gravel between Lucky Peak Dam and Star is contained in tributaries, that the gravel is only amenable to spawning when Boise River flows are greater than or equal to 1100 cfs, and is only amenable to rearing at flows greater than or equal to 900 cfs (Pruitt and Nadeau, 1978). The minimum flow requirements for the Boise River are summarized in a letter sent to the Idaho Water Resources Board from Mr. Cal Groen, Natural Resources Policy Bureau Chief at the IDFG (1993). IDFG, based upon the work of Pruitt and Nadeau (1978), suggest a minimum of 240 cfs from June 16th to the last day of February, 1100 cfs from March 1 to May 31, and 4500 cfs from June 1 to June 15.

Status of Aquatic Life Uses

Aquatic life uses are impaired along the entire length of the lower Boise River from Lucky Peak Dam to the mouth of the River. Data on fish populations, aquatic insects and chemical and physical characteristics of the River all indicate impairment. Major causes of impairment include the listed pollutants sediment, temperature. Other causes of impairment include flow management and habitat alteration. A reach by reach summary of the status of aquatic life is shown in Table 7.

Table 5. Status of aquatic life beneficial uses in the lower Boise River by stream segment.

Segment	Designated Uses	Existing Uses	Status	Listed Causes of Impairment	TMDL Required	Other Factors Contributing to Impairment
Boise River, Lucky Peak to Barber Diversion	CWB SS*	CWB SS	Not Full Support	Flow	No	Sediment
Boise River, Barber Diversion to Star	CWB SS	CWB SS	Not Full Support	Sediment	Yes	Flow Habitat Temperature(SS)
Boise River, Star to Notus	CWB SS to Caldwell	CWB SS	Not Full Support	Temperature Sediment	Yes	Flow Habitat
Boise River, Notus to Snake	CWB	CWB WWB SS likely	Not Full Support for CWB, SS	Temperature Sediment	Yes	Flow Habitat

* SS excluded from Lucky Peak Dam to Diversion Dam (IDAPA 16.01.02.140.03).

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APPENDIX D

Status of Fisheries in the Lower Boise River

IDAHO FISH & GAME
SOUTHWEST REGION
3101 South Powerline Road
Nampa, Idaho 83686

Philip E. Batt / Governor
Stephen P. Mealey / Director

February 18, 1997

Mr. Steve West, Administrator
Division of Environmental Quality
Boise Regional Office
1445 North Orchard Street
Boise, ID 83706-2239

RE: Letter of December 31, 1996 Requesting Information on Status of Fish Populations in Boise River Drainage

Dear Mr. West:

The Idaho Department of Fish and Game (IDFG) is responding to the Division of Environmental Quality (DEQ) information request about the current status of fish populations in the lower Boise River mainstem and tributaries and Lake Lowell. We understand this knowledge is critical for the process of preparing Total Maximum Daily Load (TMDL) allocations for water quality limited segments. To summarize, the questions posed to us by the (DEQ) in the December 31, 1996 letter were:

1) Do cold water biota currently exist in the water quality limited segments in the Boise River watershed?

2) Are any salmonids known to spawn in the water quality limited segments in the Boise River watershed?

3) Do warm water biota currently exist in the water quality limited segments in the Boise River watershed?

4) Are the warm water biota, cold water biota, or salmonid spawning uses impaired in the water quality limited segments?

5) For those uses that are impaired in the lower Boise River drainage and Lake Lowell, what are the primary causes of impairment for each use (i.e. lack of habitat, temperature, toxins, flow, sediment...)?

6) The Water Quality Standards and Wastewater Treatment Requirements provide numerical criteria to support aquatic life

uses for temperature, water column dissolved oxygen, intergravel dissolved oxygen, turbidity, and ammonia. For those aquatic life uses that you believe are impaired by other factors, can you recommend target in stream conditions, such as percent surface fines or suspended sediment level, that if achieved would correct the impairment?

At a January 14, 1997 meeting attended by DEQ and IDFG staff, and Lower Boise River WAG participants, two additional questions arose for IDFG. They were:

7) What are the IDFG's goals for fish populations and fisheries in water quality limited segments of the Boise River drainage below Lucky Peak? For Lake Lowell?

8) What additional information needs exist if any that could help in this determination for water quality limited segments of the Boise River below Lucky Peak? Lake Lowell?

We'll attempt to answer your questions separately for the Boise River drainage and Lake Lowell. Fish and Game also believes it is appropriate to include a brief discussion of mountain whitefish (*Prosopium williamsoni*) since many questions have arisen from Lower Boise River WAG members regarding its general biology and behavior.

Mountain Whitefish

Whitefishes are members of the family Salmonidae which also includes trouts, chars, salmons, and graylings. Mountain whitefish are widely distributed over the western United States in many cold water bodies, both east and west of the Continental Divide. It occurs in streams, large rivers, and lakes but seems to prefer large rivers. Trout and various coldwater sculpins, suckers, and minnows are their principal associates (McAfee 1966). In the Logan River, Utah the mountain whitefish prospers in waters with a mean temperature of 9° C to 11° C, a near saturation of oxygen, and a pH of 8.1 to 8.4 (Sigler and Sigler 1987). In the Logan River, they are found anywhere where pools are at least 5 m wide and 0.9 m to 1.2 m feet deep during base flow conditions.

The mountain whitefish is primarily a bottom feeder consuming a variety of organisms, especially aquatic insect larvae such as mayflies, stoneflies, caddisflies and midges, small molluscs, and occasionally fish (Scott and Crossman 1973). Mountain whitefish typically feed more actively in the cold winter months than in some of the warmer summer months (Sigler and Sigler 1987). Like most bottom feeding fish, the mountain whitefish opportunistically will eat the eggs of its own species and other species (Foerster 1925; Simon 1946--from Scott and Crossman 1973). It is doubtful that predation by whitefish on the eggs of other salmonids is harmful to these species (Scott and Crossman 1973).

Spawning by mountain whitefish occurs in late fall through early winter (mid to late November or early December) but this depends on latitude and temperature (Sigler and Sigler 1987). Whitefish in streams and rivers move from pool areas to riffles to spawn; those present in lakes typically move into tributary streams. Whitefish do not build redds. In northern Idaho, they spawn during late October and early November when water temperatures range between 4° C and 7° C. Spawning occurs over gravel or gravel and rubble in streams and rivers where there is adequate current to remove silt from the eggs (Scott and Crossman 1973; Sigler and Sigler 1987). They have also been known to spawn in shallow water along the gravel shores of lakes. The eggs are adhesive and stick to the stream bottom substrate. Eggs require low temperatures for optimum development, generally 6° C or less (Rajagopal 1979). The growth of larval and juvenile mountain whitefish has been found to be greater at 9° C and 12° C , than at 6° C (Stalnaker and Gresswell 1974)--from Rajagopal 1979. Whitefish eggs will typically hatch in March. Newly hatched fry are generally found in stream shallows for a few weeks but then move offshore. Sexual maturity is typically reached at age 3 or 4.

Mountain whitefish are an important game fish in Idaho including locally in the Boise area. During a March 1994 to February 1995 creel survey conducted on the Boise River from Eckert Road downstream to Glenwood Bridge, anglers caught an estimated 10,000 whitefish (Allen et al., in press). This represented nearly 20% of the total catch.

Boise River Drainage

Mainstem Boise River Water Quality Limited Segments

Question 1) Based on the most current information collected by the U.S. Geological Survey (USGS) and IDFG (December 1996), cold water biota are documented to exist in all four mainstem water quality limited segments (WQLS) albeit seasonally for the lower two segments.

Wild rainbow trout (*Oncorhynchus mykiss*) and naturalized brown trout (*Salmo trutta*) were present in the following sections: Lucky Peak Dam to Veteran's Park and Veteran's Park to Caldwell. These two species were not collected in the two most downstream WQLS's (Caldwell to Notus; Notus to Snake River). Mountain whitefish were the most prevalent salmonid species found in all four WQLS's of the mainstem Boise River. As a percent of total numbers of fish collected, they ranged from 9% to 39% of samples. Sculpin (*Cottus* spp.), also cold water biota, were collected from the upper two WQLS's but were absent in the two lower segments. Sculpin exhibited a dramatic decline in abundance between the upper two sampling locations.

While salmonids are known to be year-around residents in the upper two mainstem WQLS's, it appears questionable at this time whether or not trout species are found in the lower two WQLS's. Whitefish distribution is year-around in the upper two WQLS's with apparent seasonal distribution (fall-winter) in the lower two reaches due to environmental influences. Sculpin distribution seems to mirror that of trout species. Gibson (1975) found rainbow trout and brown trout year-around in the upper two reaches, but not below the Eagle to Star area during any of his three sampling periods (winter, summer, fall). Mountain whitefish were the predominant coldwater game fish collected in the 1974 survey again displaying seasonal distribution patterns. They were found year-around in the upper two WQLS's and during the fall-winter period in the lower two segments (Gibson 1975; Will Reid, IDFG, personal communication). Gibson (1975) reported collecting sculpin only in the Boise area.

Earlier fish population assessments performed on the mainstem Boise River by Webb and Casey (1961) in February 1960 from Lucky Peak Dam to Parma showed mostly similar trends in species presence/absence, distribution, and abundance. They documented the presence of rainbow trout and whitefish as far downstream as Middleton. However, of note was the general lack of trout species and low numbers of whitefish documented in the upper Boise River above the Eagle Fish Hatchery. Webb and Casey (1961) noted the presence of sculpin in the Boise River in sampling stations located five miles below Lucky Peak Dam (approximately 3/4 miles below Barber Bridge), and 13 miles below the dam directly above the old Strawberry Glen Bridge. Sculpin were not collected at sites located ten miles below Lucky Peak Dam (immediately below Lander Street sewage treatment facility) or at sampling stations near Eagle Island and Middleton. Since trout and whitefish were present at these latter locations, we would also expect sculpin. Their absence could have been the result of sampling inefficiency.

Since 1986, the IDFG has either sponsored or performed semi-annual fish population surveys in the mainstem Boise River from Diversion Dam downstream as far as Eagle Island (Asbridge and Bjornn 1988; Mabbott and Holubetz 1990; Allen et al., *in press*; Allen et al., *in press*). Cold water biota, including trout species, whitefish, and sculpin species, were sporadically found in this river reach in late fall-winter sampling. Salmonid and sculpin abundance and population structure varied depending on environmental factors.

Past creel surveys conducted by the IDFG in the Boise River have documented in angler harvest the presence of wild and natural rainbow trout, brown trout, and mountain whitefish (Reid and Mabbott 1987; Allen et al., *in press*).

Based on past sampling efforts, cold water biota were present in the upper two WQLS's year-around before November 28, 1975 and during the fall-winter period in the lower two WQLS's. Post-1975 sampling efforts have documented similar trends in cold water species distributions.

Question 2) Based on past and recent electrofishing efforts and creel surveys done by the IDFG and others, we know that natural reproduction occurs by wild-natural stocks of rainbow trout, natural brown trout, and mountain whitefish due to the collection and documentation of younger age classes (ages 0-2) of these species. Length-frequency distribution graphs, fish scale analysis, and the separation of hatchery and wild/natural fish are frequently used tools to assist in the process of identifying natural reproduction.

The presence of fish redds (nests) is another obvious sign of natural reproduction, but to the best of our knowledge, redds have not been documented in the mainstem Boise River WQLS's by fishery workers or others. A single brown trout redd was observed in the fall of 1990 in Loggers Creek at Schmeizer Lane by IDFG employees (Scott Grunder, IDFG, personal communication). As previously mentioned, mountain whitefish do not construct redds but spawn over gravel or gravel and rubble. It is apparent, however, that natural reproduction of trout and whitefish is occurring in the system at least in the upper two WQLS's. Otherwise, without suitable annual recruitment of new individuals into populations, they would eventually be extirpated. Natural reproduction by trout species in the upper two segments appears to be limited due to their relatively low abundance and sporadic distribution. It is unlikely that trout spawn in the lower two WQLS's.

Juvenile whitefish were found at three of four sampling locations in 1996 (Glenwood Bridge, Middleton, Parma). They were also documented at Eagle Island in the south channel. It is likely that the presence of juvenile whitefish at these locations indicates successful natural reproduction at the three lower WQLS's. Based on previous IDFG investigations, whitefish also undoubtedly spawn in the uppermost segment.

Question 3) Warm water game fish such as largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*), have infrequently been encountered in sampling efforts over the years in the upper two WQLS's. It is likely that bass, bluegill, and other warm water game fish present upstream of the Star-Eagle reach probably originate from numerous ponds or gravel pits fronting the Boise River. Gibson (1975) collected the greatest number of warm water game fish in the summer downstream of Star and Caldwell. Since the USGS sampled the Boise River in December 1996, it was expected that few if any warm water game fish would be collected. However, we know that cool-warm water game fish are popular with anglers below Caldwell including smallmouth bass, largemouth bass, bluegill, channel catfish, and bullheads. They are typically associated with sloughs or backwaters.

Native cyprinids (minnows) and catostomids (suckers) in the Boise River system are typically eurythermal species. In other words, they have a wide tolerance range between upper and lower avoidance temperatures. Two possible exceptions are longnose dace (*Rhinichthys cataractae*) and mountain sucker (*Catostomus platyrhynchus*). Longnose dace are generally found in swift waters such as turbulent mountain streams and has a preferred temperature range of 12° C to 21° C suggesting it is more cold water oriented (Sigler and Miller 1963; Trautman 1981). Mountain sucker prefer summer water temperature between 12° C and 21° C and suffers when water temperatures reach above 24° C (Sigler and Sigler 1987).

Eurythermic species such as largescale sucker (*Catostomus macrocheilus*), redside shiner (*Richardsonius balteatus*), northern squawfish (*Ptychocheilus oregonensis*), Umatilla dace (*Rhinichthys osculus umatilla*), and chiselmouth (*Acrocheilus alutaceus*) are present throughout the Boise River, but are most abundant in summer downstream of Boise due to higher ambient water temperatures and more desirable habitat conditions. These species are probably more appropriately categorized as warm water biota rather than cold water biota as done in the 1996 Water Body Assessment Guidance document (Idaho DEQ 1996). These species are also more pollution tolerant than obligate cold water fish species (stenotherms) such as trout. Introduced centrarchids (sunfish) and ictalurids (catfish) are typically stenothermic, preferring warmer temperatures, and are most abundant in the lower Boise River system.

Question 4)

Lucky Peak Dam to Veteran's Park: As evidenced from both historical and recent fish population sampling efforts, cold water biota including trout, whitefish, and sculpin are present year-around in this reach of the Boise River. However, they are sporadically distributed in limited numbers. Mountain whitefish appear more resilient than trout but are unquestionably subject to extreme population fluctuations due to environmental conditions. Sculpin are locally abundant but generally disappear below the Lander Street sewage treatment facility. We consider cold water biota and salmonid spawning beneficial uses to be impaired in this WQLS. We do not consider warm water biota to be a viable existing use in this segment because obligate warm water species are not found in appreciable numbers until below Middleton.

Veteran's Park to Caldwell: Cold water biota are found throughout most of this WQLS from Veteran's Park downstream to Middleton, but are most abundant from Eagle Island upstream. They do not appear to be present below Middleton. Again, even where cold water biota are present in any numbers, they are sparsely distributed. Mountain whitefish are most abundant in the Middleton-Caldwell reach in the fall-winter period. Sculpin decline dramatically below Glenwood Street. We consider both cold water biota and salmonid spawning beneficial uses impaired in this WQLS. Warm water biota as represented by game fish species such as sunfish and catfish do not appear in appreciable numbers until below the Middleton-Caldwell area. However, below Star it is probably appropriate to consider warm water biota as an existing beneficial use based on findings of Webb and Casey (1961) and Gibson (1975). The IDFG does not consider a warm water biota designated use entirely appropriate for the Boise River until below Caldwell since environmental and habitat conditions are not optimal until below that point.

Caldwell to Notus: By all accounts, mountain whitefish are the sole cold water fish species present in this WQLS and appear to only inhabit this reach in the fall-winter period. Up until a decade ago, Indian Creek (which drains into the Boise River at Caldwell) supported a healthy native rainbow (redband) trout population which was essentially extirpated by an unfortunate accident at Armour's in the late 1980's and has not recovered. It is probable that Indian Creek trout may have recruited to the lower Boise River system. Based on the more comprehensive findings of Gibson (1975) coupled with the 1996 data, it appears the cold water biota beneficial use is impaired as evidenced by only seasonal distribution and lack of trout species present. We cannot confirm or deny the presence of trout spawning activity but it is unlikely.

At this time, the IDFG cannot make a current status call on the health of the warmwater fish community in this river segment since recent sampling was done in the winter. While the nongame component was well represented by carp (*Cyprinus carpio*), chiselmouth, Umatilla dace, and largescale sucker, game fish species were almost nonexistent since they were in wintering habitats and were difficult to sample. Gibson (1975) found the greatest summer numbers of warm water game fish in the reach below Star.

Notus to Snake River: Mountain whitefish were the only obligate cold water species collected in winter 1996 sampling from this lower-most WQLS. Fewer nongame fish were collected. Based on the rather limited sampling done in the winter of 1996, it is tenuous at best to make a status call on warm water biota. However, for cold water biota, taking into account the recent findings and that of Gibson (1975), it appears that obligate cold water fish use the lower-most river only in the fall-winter period. Additionally, trout species are not present, trout spawning is unlikely based on current conditions, and spawning by whitefish cannot be discounted.

Question 5)

Lucky Peak Dam to Veteran's Park: In our estimation, the causes of impairment for cold water biota in this river segment include altered flow regime, lack of stream bank cover, lack of instream cover (pool depth, woody debris, substrate interstices, etc.), sediment, toxics avoidance (e.g. chlorine), channelization, limited gravel recruitment, and food production. Summer temperatures may be a problem because of the lack of good instream habitat conditions for fish to escape to more suitable locations. Coupled with these limiting factors is high fishing pressure which could effect already suppressed wild fish numbers. However, in this situation, high angling mortality of wild-natural trout may be a function of the cumulatively poor habitat conditions leading to increased vulnerability. The general lack of sufficient habitat renders the remaining wild fish more susceptible to overharvest. A scenario of closing the river to harvest would probably elicit little positive response in wild fish populations due to relatively poor habitat conditions.

Salmonid spawning is impaired by the general lack of suitable particle sizes (gravel of 1-3 inches in diameter), fine sediment, armoring of substrate, lack of sufficient numbers of wild/natural spawning fish, altered flow regime, and lack of suitable escape cover for spawning fish.

Asbridge and Bjornn (1988) cited limiting factors for trout in the Boise River from Barber Dam to Star as summer water velocities, above optimal summer temperature, lack of winter cover, lack of cover, sediment, lack of spawning habitat, and angler harvest.

Veteran's Park to Caldwell: The same factors as above impair cold water biota in this river segment. Other significant limiting factors may be flood control practices (snagging and clearing of vegetation, gravel bar removal), regulated gravel mining, numerous unscreened irrigation diversions, fish passage barriers, low flows during irrigation season below Star, and chemical avoidance/toxicity (e.g. chlorine, agricultural chemicals). Below Glenwood Bridge, fishing pressure is much reduced, however, we still observe little recovery in cold water fish species. Temperature limitations may be more pronounced below Star. Below Garden City, there is the transition from urban to rural. This is a highly manipulated river channel.

Salmonid spawning is limited by the same factors as above. For a further discussion on suspected limiting factors, please refer to Asbridge and Bjornn (1988).

Caldwell to Notus/Notus to Snake River: In these two lowest WQLS's, both cold water biota and salmonid spawning are impaired by the same problems as above, however, higher water temperatures, sediment, and chemicals may be larger problems. Water quality concerns are more pronounced in these two segments due to the cumulative effects of intensive agricultural practices.

Although not a designated use for these river segments, warm water biota are the dominant group of fish present. While we do not have enough information to make a status call on warm water biota, we suspect agricultural chemicals and sediment may effect warm water game fish distribution as well.

Many agricultural chemicals, pesticides and herbicides in particular, can have adverse impacts on aquatic organisms (Whitford et al. 1994; State of California 1963). Commonly used herbicides in southwestern Idaho include acrolein and 2,4-D, both of which can be toxic to aquatic organisms (State of California 1963; Eisler 1994). Acrolein kills fish and other aquatic life at recommended treatment concentrations (Bowmer and Smith 1984--from Eisler). In treated irrigation canals, acrolein probably eliminates or seriously depletes all populations of aquatic fauna (Eisler 1994). Acrolein has been used since 1960 to control submerged aquatic weeds in irrigation systems in the United States and elsewhere (Hill 1960; Bartley and Hattrup 1975; Bowmer and Higgins 1976; Reinert and Rodgers 1987). In water, while the half-time persistence is usually less than 50 hours, this is sufficient time to suspect that applications of this substance routinely reach natural surface waters. Frequent applications of acrolein during the growing season could cause chronic suppression or elimination of aquatic fauna. In one Montana stream, acrolein killed all fish in a 4 km reach after application to control aquatic plants and some fish were reported dead as far downstream as 6.4 km (Fritz-

Sheridan 1982). This is just one commonly used compound. There are numerous other chemicals used by the agricultural industry and other interests in southern Idaho which pose hazards to fish and other aquatic life

Question 6) We have little numeric criteria to recommend as a means to resolve impairment issues in WQLS's of the Boise River. However, physical habitat conditions must improve measurably before any resulting change will be observed in cold- and warm-water game fish populations. Due to increasing urbanization of the upper drainage, significant changes in habitat quality may be difficult to achieve. In our opinion, continued urban development of the river floodplain will continue unabated. Unfortunately, the more it is developed, the greater the perceived need to control the river through flood control practices, snagging and clearing, channelization, constructing levies, removing vegetation, etc. These practices have long been destructive to fish and wildlife habitats.

In order to improve conditions for aquatic biota in the Boise River, we offer the following ideas and recommendations. appropriate.

1) Do not remove accumulations of large woody debris in the river channel adjacent streambanks unless it poses a real threat to property, structures, or human safety. The lack of large cover elements in the channel inhibits the production of trout.

2) Regulated gravel mining should be prohibited in the river channel below the ordinary high water mark. Gravel recruitment is already minimal because of upstream reservoirs. Suitable gravel is important for spawning fish and insect production.

3) The sources of human-caused sediment must be identified, captured, and reduced in order to measurably improve the aquatic environment of the lower Boise system. Optimal habitat and reproductive conditions for aquatic macroinvertebrates, trout, whitefish, and other aquatic biota are maintained when surface fine sediment levels are minimal. Waters (1995) provides comprehensive discussions on suspended and bedload fine sediment effects on stream dwelling aquatic biota. There is an extensive volume of literature available on sediment effects on salmonid habitat, salmonid spawning, invertebrate habitat, and behavior, etc. While numeric criteria is available in the literature describing threshold fine sediment levels in pools, egg pockets, interstitial spaces, or the water column, it should be use with caution. Please refer to Waters (1995) for this overview.

Suspended sediment produces little or no direct mortality on adult fish at levels observed in natural, relatively unpolluted streams (Waters 1995). Most early papers were very speculative reporting only visual observations of muddy conditions associated with fish kills, or the result of extreme conditions produced in laboratory tests (Cordone and Kelley 1961). According to Waters (1995), the determination of precise concentrations of suspended sediment that cause acute mortality is difficult and results vary. In a review by Lloyd (1987), discussion focused on sublethal effects of suspended sediment including avoidance and distribution, reduced feeding and growth, respiratory impairment, reduced tolerance to disease and toxicants, and physiological stress. Experiments of sublethal effects tended to be more objective and quantified in nature. This type of literature is much more abundant regarding cold water versus warm water fishes.

In the watershed paper by Cordone and Kelley (1961), they reviewed the effects of sediment on all components of the biological community in streams, including salmonid reproduction. They especially emphasized the importance of fine sediment in salmonid redds and its injurious effect. Their general conclusions were (1) eggs and sac fry are killed as a result of the smothering by suspended sediments entering the redd; (2) sediments obstruct the flow of water and its oxygen supply through the redd, causing asphyxiation; (3) continuous applications of small quantities of sediment into the redd are more detrimental than short-term, sudden flushes; and (4) sediment is one of the most important environmental factors that influence the success of salmonid spawning.

It is well accepted there is an inverse relationship between salmonid egg survival and percentage of fine sediment in spawning gravels. A level of 20% fines less than 0.8 mm became well established and was accepted by many investigators as the criterion above which significant mortality of embryos could be expected (Reiser and White 1988; many others as well). However, other research focused on sediment in the egg pocket and resulted in improved measures over particle-size percentage such as measures of central tendency particularly the geometric mean diameter of substrate particles (Platts et al. 1979) and the fredle index (Lotspeich and Everest 1981; Beschta 1982). The effect of sediment upon reproductive success of warmwater fishes is not well known (Waters 1995). The major publication on this topic including early life of warmwater fishes is by Muncy et al. (1979).

Fine sediment also impacts sac fry emergence from the gravels, the physical habitat of various life stages of fish, and aquatic insect production. According to Waters (1995), the two most important effects of deposited sediment upon the physical habitat of fish are

(1) filling of interstitial spaces of riffles, which reduces or eliminates those spaces essential to fry, especially in winter when fry retreat to coarse riffle bottoms for overwinter cover; and (2) reductions of water depth in pools, including the complete loss of pools and cover with heaviest sedimentation, which decrease physical carrying capacity for juvenile and adult fish during summer growth periods.

4) Minimum flows in the Boise River during the winter (nonirrigation season) should not decrease below 240 cubic feet per second.

5) Water quality standards for certain chemical constituents such as free chlorine need reexamination. Sedentary, bottom-dwelling cold water fishes like sculpin appear to be avoiding sites immediately below both of Boise's water treatment facilities. We do not believe it is related to differences or changes in stream bottom habitats. The literature suggests that trout are also very intolerant of free chlorine (State of California 1963). However, trout are very mobile species and could easily avoid unsuitable conditions unlike less mobile fish like sculpin.

6) There needs to be strong state, federal, and local education programs informing the public and others about the hazards of commonly used herbicides and pesticides to the environment.

Question 7) We are submitting an excerpt from our 1996-2000 Fisheries Management Plan describing our programs and objectives for the Boise River Drainage. Current fishing regulations for the Boise River are the entire mainstem is open to fishing year-around from its mouth upstream to Arrowrock Dam. General regulations apply (6 trout bag & possession limit, no gear restrictions, no size limits) for the entire river except a limited quality trout zone between the United Water Corporation water treatment facility and the Loggers Creek diversion (2 trout bag & possession limits, no trout under 14 inches may be harvested).

Question 8) We believe some of the additional information needs for the Boise River system are as follows.

1) A general, but comprehensive fish population assessment needs to be done on the Boise River mainstem on a four-season basis from Lucky Peak Dam to the mouth. This would provide a more complete picture of species composition and distribution. This type of

survey has not been done since 1974. Recent surveys have been relegated to winter low flow conditions giving a cursory and incomplete picture.

2) Fish populations need to be assessed in tributaries to the mainstem Boise River.

3) Comprehensive riparian and instream physical habitat studies should to be done to assess current and potential conditions for aquatic biota, and to explore realistic opportunities for rehabilitation.

4) The IDFG requests written examples of other state's beneficial use status assessments and how they have dealt with issues such as limited cold water biota criteria, salmonid spawning, nongame species, T & E species, etc.

5) We should identify the sources of sediment to the Boise River below Lucky Peak Dam through Boise-Garden City and Eagle and develop potential containment/abatement measures.

Boise River Tributaries

Unfortunately, there is a paucity of information available on fish species and populations in lower Boise River tributaries. We have nothing of recent vintage to share with you. Most information was collected by the former Department of Health or the DEQ in coordination with the IDFG.

Based on file information from electrofishing samples and fish kill assessments, we know wild rainbow trout were present prior to November 28, 1975 in Indian Creek above and below Sugar Avenue, Seven Mile Creek, Fivemile Creek at Meridian, Tenmile Creek below confluence with Fivemile Creek, and Conway Gulch at Notus (Gibson 1975; unpublished IDFG file information). Wild rainbow trout were collected post-1975 in Sand Hollow Creek (Clark and Bauer 1983). The IDFG estimated upwards of 1,100 wild rainbow trout were killed in Indian Creek below Kings Corner in Nampa on and/or after January 31, 1986 following an accidental discharge of waste from Armour Fresh Meats Company (unpublished IDFG file information). As far as we are aware, it has not recovered. We have no information on Blacks Creek.

It appears likely that designated/potential uses are impaired in Indian Creek (Sugar Avenue to Boise River), Mason Creek (headwaters to New York Canal), Fivemile Creek (headwaters to Boise River), Tenmile Creek (headwaters to Fifteenmile Creek), and Sand Hollow Creek (headwaters to Snake River). The status of salmonid spawning and cold water biota in Indian Creek (headwaters to Sugar Avenue) is unknown at this time. The status of aquatic biota is unknown in Blacks Creek at this time.

In our opinion, impairment of aquatic biota in these systems collectively is caused by historic spills, severe habitat degradation affecting in stream and riparian functions, excess sediment, channelization, irrigation return, pesticides and herbicides, etc.

We do not have detailed management goals for fish or wildlife in most of these tributaries because they are so degraded. Indian Creek has great potential to support wild rainbow trout throughout its length if habitat and water quality issues could be dealt with effectively. Improving the quality of tributary habitat and water quality may not be cheap, but it could be of enormous benefit to wild salmonids by opening up miles of spawning and rearing environments. Restoring stream and riparian environments would be of great benefit to wildlife as well.

Lake Lowell

Lake Lowell was once a premier warm water fisheries in southwestern Idaho, but a number of events since 1990 caused a total collapse of game fish populations. The most critical factors were the prolonged drought, summer evacuation of water from the lake for irrigation and low winter carryover of water; a major rebuild of dams for safety reasons in 1990-1991 with necessary drawdowns; and potential serious water quality problems (Grunder et al. 1993; IDFG file information). The IDFG sampled fish populations in summer 1994 and found that once abundant largemouth and smallmouth bass, crappie, bluegill, and bullhead were at extremely suppressed population levels (Allen et al., *in press*). Sampling performed by IDFG staff in summer 1996 indicates a modest but positive upward direction in population recruitment for game fish species (Allen et al., *in press*). We appear to be observing several year classes of bass species with strong O+ and I+ cohorts.

Currently, Lake Lowell is supporting warm water biota and natural reproduction of game fish species, however, game fish populations have not come close to recovering to pre-1990 levels. This designated use should be considered impaired. Impairment may be a result of cumulative effects of drought and lake drawdowns, poor spawning conditions, poor overwintering conditions, lack of security cover, excessive nutrients (eutrophication), pesticides and pesticides, and other unknown factors.

Fish and Game's goals for the fishery of Lake Lowell can be found in the attached excerpt from our 1996-2000 Fisheries Management Plan for the Boise River Drainage.

In our opinion, water quality should be monitored annually in the Lake Lowell watershed. The fishery will be monitored every two years or as needed.

In closing, the IDFG wishes to emphasize the economic and intrinsic values of these water bodies to local communities and the state. As previously mentioned for the Boise River, the last creel survey conducted by the IDFG in 1994-1995 documented an estimated 70,000 hours of fishing effort in the reach from Eckert Road downstream to Glenwood Bridge (Allen et al., in press). We conservatively estimate the value of this cold water fishery at about $220,000 annually on a 12-hour Recreation Visitor Day (RVD) basis (Sorg et al. 1985). This does not include the fishery value below Glenwood Bridge since angler use is undocumented. The river corridor below Star also receives significant use by waterfowl and upland game hunters.

At its peak in the 1980's, the Lake Lowell fishery supported in excess of 100,000 angler hours. At its nadir in the early 1990's, fishing pressure declined to about 20,000 hours. We conservatively estimate the potential annual value of this warm water fishery at about $276,000 on a 12-hour RVD basis. Based on this value estimate, the collapse of the warm water fishery at Lake Lowell has meant a significant monetary loss to the local and state economy. Waterfowl and upland game hunting are also very significant recreation activities at Lake Lowell.

Both of these water bodies are renowned for their abundant wildlife resources including waterfowl, songbirds, wintering bald eagles, shorebirds, and furbearers. Wildlife viewing is an important and growing recreational opportunity at both areas which contributes significantly to the economy.

Thank you for the opportunity to comment. Questions should be directed to Scott Grunder, Natural Resources Biologist.

Sincerely,

Tracey Trent
Regional Supervisor

TT:sag

(w/attachments)

cc: NRPB (Cal Groen)
Southwest Region (Yundt, Nelson)

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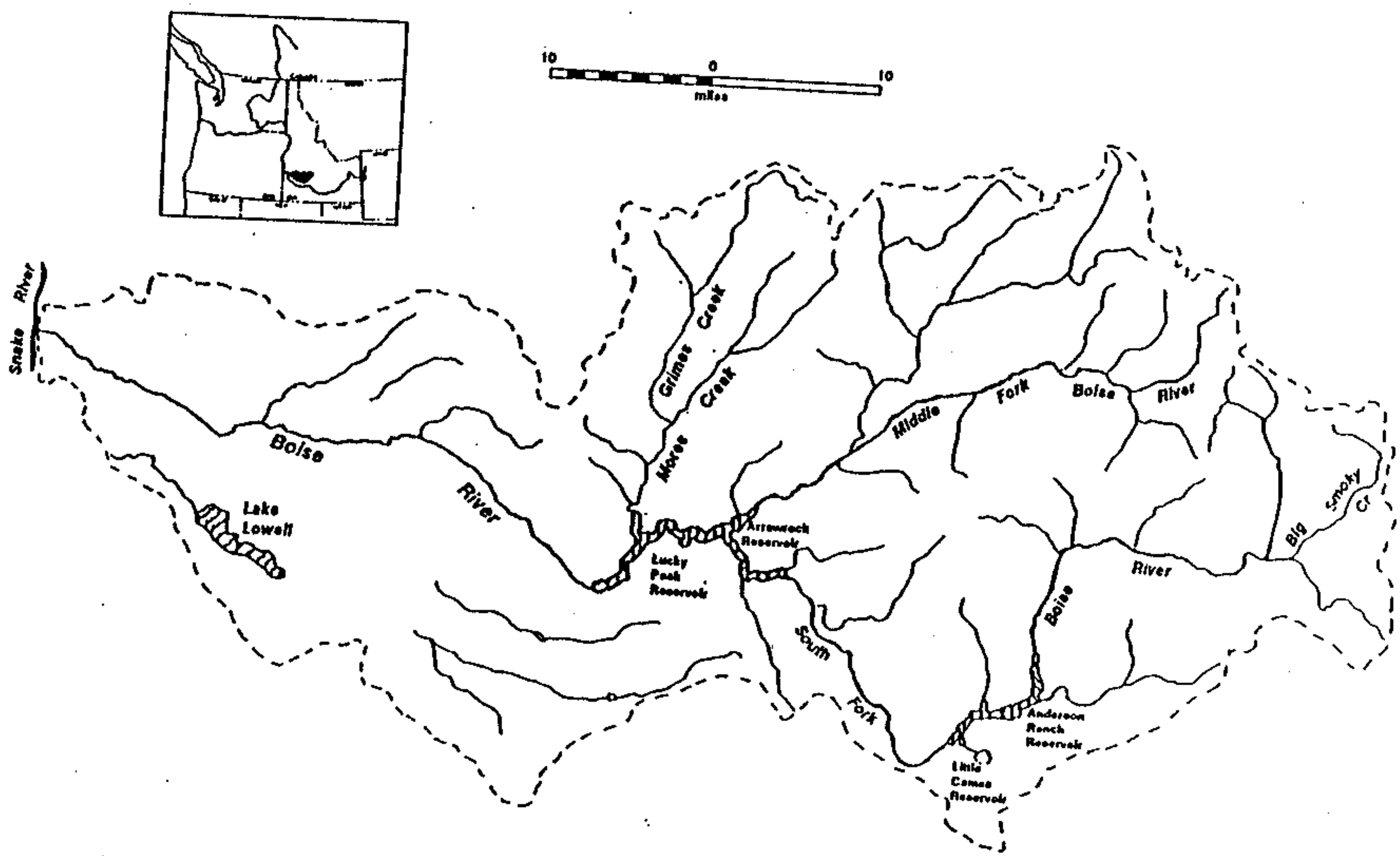
Boise River Drainage



A. Overview

The Boise River basin lies in southwestern Idaho and contains about 4,100 square miles of land. The headwaters of the Boise River originate in the Sawtooth Mountains at elevations in excess of 10,000 feet. It flows in a westerly direction for about 200 miles before emptying into the Snake River near Parma at an elevation of 2,100 feet. Major tributaries to the Boise River include the North Fork Boise River (382 square miles), the South Fork Boise River (1,314 square miles) and Mores Creek (426 square miles). This basin has an average annual runoff of 2,005,000 acre-feet of water.

The Boise River has three major instream impoundments, Anderson Ranch, Arrowrock and Lucky Peak reservoirs, and one large off-stream impoundment, Lake Lowell. The four large reservoirs have a combined storage capacity of 1,143,249 acre-feet of water. The Boise River reservoirs supply water storage for irrigation flood control, recreation, hydropower, and instream flows.

Because of the wide range in elevations, geographic features, and water uses, the Boise River has a great variety of habitat types and fish species. The drainage includes the major population center in the state, has over 250,000 acres of irrigated cropland, and some of Idaho's earliest mining, logging, and hydroelectric developments. Man-caused impacts have severely degraded most habitats over a long period of time creating severe limitation on fishery productivities.

From the mouth of the Boise River upstream to Star, low summer flows and poor water quality limit fishery production. . This section of river supports a fair fishery for largemouth bass, smallmouth bass, and channel catfish. From Star upstream to Lucky Peak Dam, the river changes from a warmwater to a coldwater fishery. Mountain whitefish make up the bulk of the game fish biomass, with hatchery-reared rainbow trout, wild rainbow trout, and fingerling brown trout plants supporting the bulk of the fishing pressure. Upstream from Lucky Peak and Arrowrock reservoirs, rivers and streams contain excellent populations of wild rainbow trout, mountain whitefish, and bull trout. Brook trout, redband trout, and cutthroat trout occur in some tributary streams. Due to the heavy angling pressure exerted on these streams, catchable-size hatchery rainbow trout supplement wild populations in selected heavy use areas.

In 1978, the South Fork Boise River between Arrowrock Reservoir and Anderson Ranch Dam was the first designated quality trout stream segment in southwestern Idaho. Wild rainbow trout and mountain whitefish make up the majority of the fish caught in the South Fork. The rainbow trout fishery there is managed with limit, size, and tackle restrictions. In 1978, anglers caught an estimated 19,150 rainbow trout and released 18,059 (94%). In 1988, anglers caught an estimated 18,400 rainbow trout and released 99%.

A 1988 creel survey of the South Fork Boise River between Featherville and Big Smokey Creek estimated effort at 228 hours/km. Hatchery rainbow trout made up over 80% of fish checked in anglers' creels, but the overall return total creel rate was only 21%, indicating hatchery fish need to be more efficiently utilized.

Popular reservoir fishing within the Boise River drainage exists at Lake Lowell, Lucky Peak, Arrowrock, Anderson Ranch, and Little Camas reservoirs. The Lake Lowell fishery consists primarily of largemouth bass, smallmouth bass, yellow perch, black crappie, bullhead, bluegill, and channel catfish. Lucky Peak and Anderson Ranch reservoirs provide "two-story" fisheries with smallmouth bass occupying the warm, inshore waters and rainbow trout and kokanee dominating the cold, mid-water fishery. The rainbow trout fishery in these reservoirs depends heavily on stocked catchable or fingerling size fish. Little Camas and Arrowrock reservoirs also provide excellent fishing for rainbow trout stocked as catchables and/or fingerlings. Neither of these two reservoirs has a conservation pool, and both have a history of total water evacuation.

Good spawning conditions in tributary streams provide a continuous supply of kokanee in Anderson Ranch Reservoir, but maintenance stocking is required in Lucky Peak and Arrowrock reservoirs. At Anderson Ranch Reservoir, one of the more popular kokanee fisheries in southern Idaho, anglers harvested an estimated 40,000+ kokanee in 1979 and 34,000in 1985. Kokanee populations in the reservoir have fluctuated significantly from 1983 through 1989 due to extreme high and low water conditions in the drainage. Ongoing studies of kokanee populations are being used to develop models to reduce population fluctuations through stocking in low number years. Fall chinook salmon will be considered to crop excess kokanee numbers and to provide a trophy fishery if kokanee numbers become excessive.

Alpine lakes within the Boise River drainage provide anglers with a variety of fishing opportunity. Rainbow, cutthroat, and brook trout are abundant with lesser numbers of golden trout. There are 224 alpine lakes in the Boise drainage. Most of these lakes are too small to support a fishery. The Department presently stocks 68 of the alpine lakes in the Boise River system.

B. Objectives and Programs

1. Objective: Provide a diversity of fishing opportunities within the Boise River drainage.

   Program: Zone the stream areas to concentrate hatchery catchable stocking in the locations where the highest return to the creel will occur.

   Program: Manage for wild trout where habitat and fish populations will sustain acceptable fisheries.

   Program: Manage for increased catch rates and fish size in selected stream reaches with quality and trophy trout regulations.

   Program: Stock appropriate strains of trout and other species to better utilize the rearing capacity and provide larger and more desirable fish to the angler.

   Program: Manage warmwater fisheries to provide a wide variety of sizes and species readily available to the large population of the Treasure Valley area.

   Program: Develop a pond in the Mores Creek drainage for planting catchable rainbows.

Program: Stock alpine lakes with a variety of species including rainbow trout, cutthroat trout, golden trout, and Arctic grayling to provide a variety of fishing experience. Impacts on native species will be considered prior to stocking new species.

2. Objective: Seek better land management practices that significantly improve fishery habitats.

   Program: Provide sediment objectives/standards to land management agencies where sediment is the limiting factor in aquatic habitats.

   Program: Provide riparian vegetation objectives to land management agencies where grazing, development, or other activities have degraded riparian zones.

   Program: Seek to provide habitat necessary to preserve populations of native bull trout and redband trout.

3. Objective: Monitor effects of land management activities, fishery regulations, and other fishery management activities on fish habitat and fish populations.

   Program: Collect common data base information on habitat and fish populations throughout the Boise River drainage.

   Program: Examine changes and trends in common data base information and attempt to determine causes for any changes that are noted.

4. Objective: Seek improved reservoir management and stream flows.

   Program: Pursue development of a minimum pool in Arrowrock Reservoir.

   Program: Study water management at Lake Lowell to determine the relationship between fish production and water levels.

5. Objective: Maintain and improve bull trout populations.

   Program: Maintain "no harvest" rule for bull trout on rivers and tributaries.

   Program: Provide information to public on pressure, how to identify, and how to release bull trout.

   Program: Evaluate bull trout populations in reservoirs to determine if a limited harvest opportunity exists.

Drainage: BOISE RIVER

Water	Miles/acre	Fishery			Management Direction
		Type	Species Present	Management	
Mouth to Star	34/	Mixed	Rainbow trout Mountain whitefish Largemouth bass Smallmouth bass Channel catfish Black crappie	General	Work with state and federal regulatory agencies to improve water quality and habitat condition. Evaluate fish population, species composition, and size structure. Determine angler satisfaction with current fishery.
Star to Barber Dam	25/	Coldwater	Rainbow trout Steelhead Brown trout Mountain whitefish	Put-and-take trout	Work with state and federal regulatory agencies to improve water quality and habitat condition. Stock with rainbow trout, brown trout, and steelhead seasonally. Stock catchable rainbow trout year-round. Manage for high density of anglers.
Barber Dam to Lucky Peak	4/	Coldwater	Rainbow trout Brown trout Mountain whitefish	General	Evaluate potential trophy trout management. Evaluate natural production potential.
Mores Creek		Coldwater	Rainbow trout Mountain whitefish	General	Work with regulatory agencies to enhance habitat. Stock with catchable rainbow trout.
Boise River Drains	92/	Coldwater	Rainbow trout Brown trout Mountain whitefish	General	Work with communities and regulatory agencies to improve water quality and habitat conditions. Improve angler access. Evaluate hatchery fingerling brown trout planting program.
Loggers Creek	2/	Coldwater	Rainbow trout Brown trout Mountain whitefish	General	Manage as a nursery stream to provide catchable size fish to Boise River.
Middle Fork Boise River from Arrowrock Reservoir to North Fork Boise River	11/	Coldwater	Rainbow trout Mountain whitefish	Put-and-take trout	Stock with catchable rainbow trout following high water period until Labor Day. Evaluate return to the creel of hatchery trout. Monitor angler use and satisfaction with current fishery.
			Bull trout	Preservation	Closed to harvest.
From North Fork to Atlanta Power Dam	32/	Coldwater	Rainbow trout Cutthroat trout Mountain whitefish Brook trout	Quality	Manage for high catch rates on wild fish.
			Bull trout	Preservation	Closed to harvest.
From Atlanta Power Dam to Sawtooth Wilderness Boundary	4/	Coldwater	Rainbow trout Cutthroat trout Mountain whitefish Brook trout	Put-and-take trout	Stock with catchable rainbow following high water period until Labor Day. Evaluate return of hatchery trout. Develop catch-out pond for planting catchables to avoid competition with wild trout.
			Bull trout	Preservation	Closed to harvest.

Upstream of Sawtooth Wilderness Boundary and all tributaries	30/	Coldwater	Rainbow trout Cutthroat trout Mountain whitefish Brook trout	Wild trout	Manage for high catch rates and low angler densities. Manage for wild fish.
			Bull trout	Preservation	Closed to harvest.
South Fork Boise River from Arrowrock Reservoir to Neal Bridge		Coldwater	Rainbow trout Mountain whitefish	General	Manage for harvest opportunity for stream trout and mountain whitefish.
			Bull trout	Preservation	Closed to harvest.
South Fork Boise River from Arrowrock Reservoir to Danskin Bridge	18/	Coldwater	Rainbow trout Mountain whitefish	Trophy	Work with USFS to preserve low density angling experience. Manage for high catch rates for large fish.
			Bull trout	Preservation	Closed to harvest.
South Fork Boise River from Danskin to Anderson Ranch Dam	10/	Coldwater	Rainbow trout Mountain whitefish	Trophy	Manage for high catch rates for large fish.
			Bull trout	Preservation	Closed to harvest.
South Fork Boise River from Anderson Ranch Reservoir to Pine Bridge	0.6/	Coldwater	Fall chinook salmon Rainbow trout Kokanee salmon Mountain whitefish	General	Annual river closure to protect spawning kokanee to trap site. Monitor fall chinook salmon runs, if restocked, target fish for harvest.
			Bull trout	Preservation	Closed to harvest.
South Fork Boise River from Pine Bridge to Beaver Creek	25/	Coldwater	Rainbow trout	Put-and-take trout	Good quality habitat with wild trout potential. High accessibility and campgrounds give potential for hatchery return rates of >30%. Consider use of regulation allowing harvest of adipose fin-clipped fish only.
			Mountain whitefish Kokanee salmon	General	
			Bull trout	Preservation	Closed to harvest.
South Fork Boise River from Beaver Creek to Big Smoky Creek	10/	Coldwater	Rainbow trout Mountain whitefish Kokanee salmon	Quality	Good quality habitat for wild trout. Manage for quality >14-inch wild rainbow trout to increase natural reproduction.
			Bull trout	Preservation	Closed to harvest.
South Fork Boise River from Big Smoky Creek to headwaters	15/	Coldwater	Rainbow trout	Put-and-take trout	Good quality habitat, however limited natural productivity limit wild trout in accessible areas. Maintain stocking if return rates meet 40% goals.
			Mountain whitefish Kokanee salmon	General	
			Bull trout	Preservation	Closed to harvest.

Big Smoky Creek from mouth to Calf Creek	4/	Coldwater	Rainbow trout	Put-and-take trout	Good quality habitat with wild trout potential. High accessibility gives potential for >30% return on fish. Consider evaluation of adipose fin regulation to allow wild stocks to rebuild and maintain harvest opportunity on catchable rainbow.
			Mountain whitefish Kokanee salmon	General	
			Bull trout	Preservation	Closed to harvest.
Big Smoky Creek from Calf Creek to headwaters	15/	Coldwater	Rainbow trout Mountain whitefish	Wild trout	Evaluate social and biological potential for quality management. Emphasize bull trout, self-sustaining rainbow populations. Maintain limited harvest opportunity.
			Bull trout	Preservation	Closed to harvest.
Little Smoky Creek	20/	Coldwater	Rainbow trout	Put-and-take trout	Evaluate hatchery program.
			Bull trout	Preservation	Closed to harvest.
All other streams in South Fork Boise River drainage upstream from Anderson Ranch Reservoir	277/	Coldwater	Rainbow trout Mountain whitefish	Wild trout	Investigate potentially unique redband trout and ensure survival. Maintain naturally reproducing populations and harvest opportunity.
			Bull trout	Preservation	Closed to harvest.
North Fork Boise River from mouth to Rabbit Creek	7/	Coldwater	Rainbow trout Mountain whitefish	Wild trout	Manage for high catch rates (3 fish/hour) and low angler densities.
			Bull trout	Preservation	Closed to harvest.
Rabbit Creek to Deer Park (Hunter Creek)	13/	Coldwater	Rainbow trout Mountain whitefish	Put-and-take trout	Manage for high yield and moderate angler densities.
			Bull trout	Preservation	Closed to harvest.
Deer Park to headwaters and all tributaries	41/	Coldwater	Rainbow trout Mountain whitefish	Wild trout	Manage for high catch rates (3 fish/hour) and low angler densities.
			Bull trout	Preservation	Closed to harvest.
Lucky Peak Reservoir	/2,850	Mixed	Smallmouth bass Yellow perch Rainbow trout Kokanee salmon Mountain whitefish	General	Evaluate status of smallmouth bass fishery. Provide an attractive kokanee salmon fishery for large fish. Investigate feasibility of providing a trout fishery by stocking large numbers of fingerling rainbow in Lucky Peak Reservoir to avoid excessive competition for plankton and jeopardizing quality of kokanee salmon fishery. Continue to stock catchable rainbow trout. Investigate feasibility of introducing lake trout.
			Bull trout	Preservation	Closed to harvest.

Arrowrock Reservoir	/4,000	Mixed	Smallmouth bass Yellow perch Rainbow trout Mountain whitefish	General	Seek minimum pool through federal government. Stock annually with fingerling rainbow trout.
			Bull trout	Preservation	Closed to harvest.
Lake Lowell	/10,000	Mixed	Largemouth bass Smallmouth bass	Quality	Determine angler use and harvest rates. Manage bass with primary emphasis on quality fishery. Investigate feasibility of planting Lahontan cutthroat trout.
			Channel catfish Bluegill Yellow perch Black crappie Pumpkinseed Rainbow trout Cutthroat trout	General	
Anderson Ranch Reservoir	/4,740	Mixed	Rainbow trout Bull trout Mountain whitefish Kokanee salmon Fall chinook salmon Yellow perch Smallmouth bass	General	Emphasize kokanee. Continue developing model to evaluate potential. Goal of 1.0 kokanee/hour with mean size of 12 to 14 inches if productivity allows. Consider fall chinook salmon if kokanee numbers are excessive. Improve trout fishing through hatchery program and public awareness. Maintain smallmouth bass to diversify fishing opportunity.
Little Camas Reservoir	/1,456	Mixed	Rainbow trout Smallmouth bass	General	Use fall fingerling plants to improve carryover in high water years.
Mountain Home Reservoir		Mixed	Rainbow trout Largemouth bass	General	Stock with rainbow trout when water levels allow. Work with irrigation companies to leave conservation pool so trout can overwinter.
Long Tom Reservoir		Coldwater	Rainbow trout	General	Work to secure minimum pool. Establish trophy lake when conservation pool is secure.
Featherville dredge ponds	/3	Coldwater	Rainbow trout	Put-and-take trout	Continue stocking hatchery rainbow trout. Increase numbers to provide 1.0 fish/hour.
Big Trinity Lake	/12	Coldwater	Rainbow trout	Put-and-take trout	Accessible by road. Stock annually with catchables. Stock cutthroat trout fingerlings for diversity.
Little Trinity Lake	/3	Coldwater	Rainbow trout	General	Accessible by road. Stock annually with catchables. Stock cutthroat trout fingerlings for diversity.
Other alpine lakes	/801	Coldwater	Rainbow trout Cutthroat trout Golden trout Brook trout Arctic grayling	General	Put-and-grow for trout and char.

APPENDIX E

Draft Interpretation of Benthic Macroinvertibrate Data

The Lower Boise River from Lucky Peak Dam to the Confluence with the Snake River

Draft Interpretation of Benthic Macroinvertebrate Data

The Lower Boise River from Lucky Peak Dam to the Confluence with the Snake River

PDS 6/6/98

Introduction

This document provides a brief summary of conclusions that stem from the interpretation of benthic macroinvertebrate data collected in the Boise River by the US Geological Survey (USGS). Bill Mullins of the USGS and staff members at the Idaho Division of Environmental Quality (DEQ) provided valuable assistance with interpretation. The draft guidance document published by Aquatic Biology Associates, Inc., of Corvallis, Oregon, contains many concepts that are important for the interpretive process. The conclusions that follow evaluate the health of the benthic community, and relate the condition of that community to water quality and habitat conditions in the lower Boise River.

Data Sources

- US Geological Survey, Boise Idaho, collection at five sites in October, 1995 and October, 1996.
- Todd V. Royer and G. Wayne Minshall, Idaho River Index (IRI)
- Aquatic Biology Associates - identification and quantification of all USGS samples

Interpretation Sources

DEQ

- Bill Clark
- Bryan Horsburgh
- Bob Steed
- Erica Anderson

Other Sources of Interpretation Guidance

- Bill Mullins - USGS, Boise
- Aquatic Biology Associates, Corvallis, Oregon

Summary of Conclusions

General Conclusions

- The lower Boise River is sub-optimal in terms of habitat and temperature, as indicated by the structure of the benthic communities sampled in 1995 and 1996.
- Habitat and temperature probably become more strongly limiting to the benthos at Middleton and Caldwell
- Benthic data at the mouth of the river does not consistently indicate conditions that are more or less degraded than at the Middleton and Caldwell sites.
- The very limited plecoptera populations probably point to fine sediment and warm summer water temperatures as limiting factors in the Boise, especially near Middleton and Parma
- The limited number of EPT taxa at all five sites, along with indicator organisms that increase or decline from upstream to downstream show that conditions are degraded (Table One, Selected Indicator Macroinvertebrates, page 1 & 2)

Indicators of Degraded Habitat Conditions

- Naididae, worms tolerant of fine sediment, increase dramatically to 17% of the total population at Caldwell in 1996, and are somewhat elevated as a percent of the total population (7.3%) at Glenwood Bridge in 1995.
- Plecoptera, organisms intolerant of fine sediment and warm temperatures, are few or zero at Middleton, Caldwell, and the mouth of the River (Chart 1)
- Predators are lower in a given year at Middleton, Caldwell, and the mouth than upstream (Table Two, pages 1 and 2)
- The numbers of tolerant taxa are greater at Middleton, Caldwell, and the mouth than upstream (Table Two, pages 1 and 2)
- Tricorythodes minutus and tolerant midges increase as percents of the total population at Middleton and Caldwell (Chart 2)
- Baetis Tricaudatus, an Ephemeroptera, declines near Middleton and Caldwell (Chart 3)

Annual Change Between 1995 and 1996 at the Five Lower Boise River Sites

DEQ is not certain whether changes from 1995 to 1996 can be considered significant in terms of habitat or water quality. The 1996 data are primarily a source of confirmation for the general conclusions indicated by the 1995 data. The benthic community in the lower Boise River is probably lower than the ABA "optimal" stream in part due to its nature as a large Snake River Plain river, and in part due to poor quality habitat. Like the 1995 data, the 1996 data seem to show again that Middleton and Caldwell are particular problem areas where habitat and temperature for benthos are probably even less favorable than at Eckert Road and Glenwood Bridge.

Tle One

Comparison of Selected Indicator Macroinvertebrates in the Lower Boise River

All data collectedby the USGS and analyzed by ABA in Corvallis

PDS 6/6/98

Tricorythodes minutus — Tolerant

Mean number of individuals

	Barber Park	Glenwood	Middleton	Caldwell	Fort Boise
1995	18	260	2714.4	1219.3	7519.2
1996	2.7	2.7	132.7	27.8	1056

Tricorythodes minutus — Tolerant

Percent of Total Population

	Barber	Glenwood	Middleton	Caldwell	Fort Boise
1995	0.17	1.78	21.67	10.13	42.09
1996	0.04	0.06	3.47	1.84	19.1

Total Plecoptera — Intolerant - need gravel and cold water

Mean Number of Individuals

	Barber Park	Glenwood	Middleton	Caldwell	Fort Boise
1995	16	27	0	0	0
1996	13.3	85.3	8	0	0

Total Plecoptera — Intolerant - need gravel and cold water

Percent of Total Population

	Barber	Glenwood	Middleton	Caldwell	Fort Boise
1995	0.05	0.06	0	0	0
1996	0.22	1.99	0.21	0	0

Total Chironomidae — Tolerant Midges

Mean Number of Individuals

	Barber Park	Glenwood	Middleton	Caldwell	Fort Boise
1995	544.8	1193.4	1205.7	3248	2158.8
1996	298.7	338.7	652	640.7	1402.7

Total Chironomidae — Tolerant Midges

Percent of Total Population

	Barber	Glenwood	Middleton	Caldwell	Fort Boise
1995	5.12	8.14	9.62	26.98	12.08
1996	4.91	7.89	17.04	42.34	25.37

Table One

Cheumtopsyche - caddisfly
Mean Number of Individuals

	Barber Park	Glenwood	Middleton	Caldwell	Fort Boise
1995	327.6	394.9	712.4	82	34
1996	90.7	157.3	87.3	0	16

Cheumtopsyche - caddisfly
Percent of Total Population

	Barber	Glenwood	Middleton	Caldwell	Fort Boise
1995	3.08	2.69	5.69	0.68	0.06
1996	1.49	3.66	2.28	0	0.29

Baetis Tricaudatus Moderately Tolerant
Mean Number of Individuals

	Barber Park	Glenwood	Middleton	Caldwell	Fort Boise
1995	2152.8	2584.4	787.1	158	1518.7
1996	1178.7	261.3	221.3	6.7	178.7

Baetis Tricaudatus Moderately Tolerant
Percent of Total Population

	Barber	Glenwood	Middleton	Caldwell	Fort Boise
1995	20.23	17.63	6.28	1.31	8.5
1996	19.37	6.09	5.78	0.44	3.23

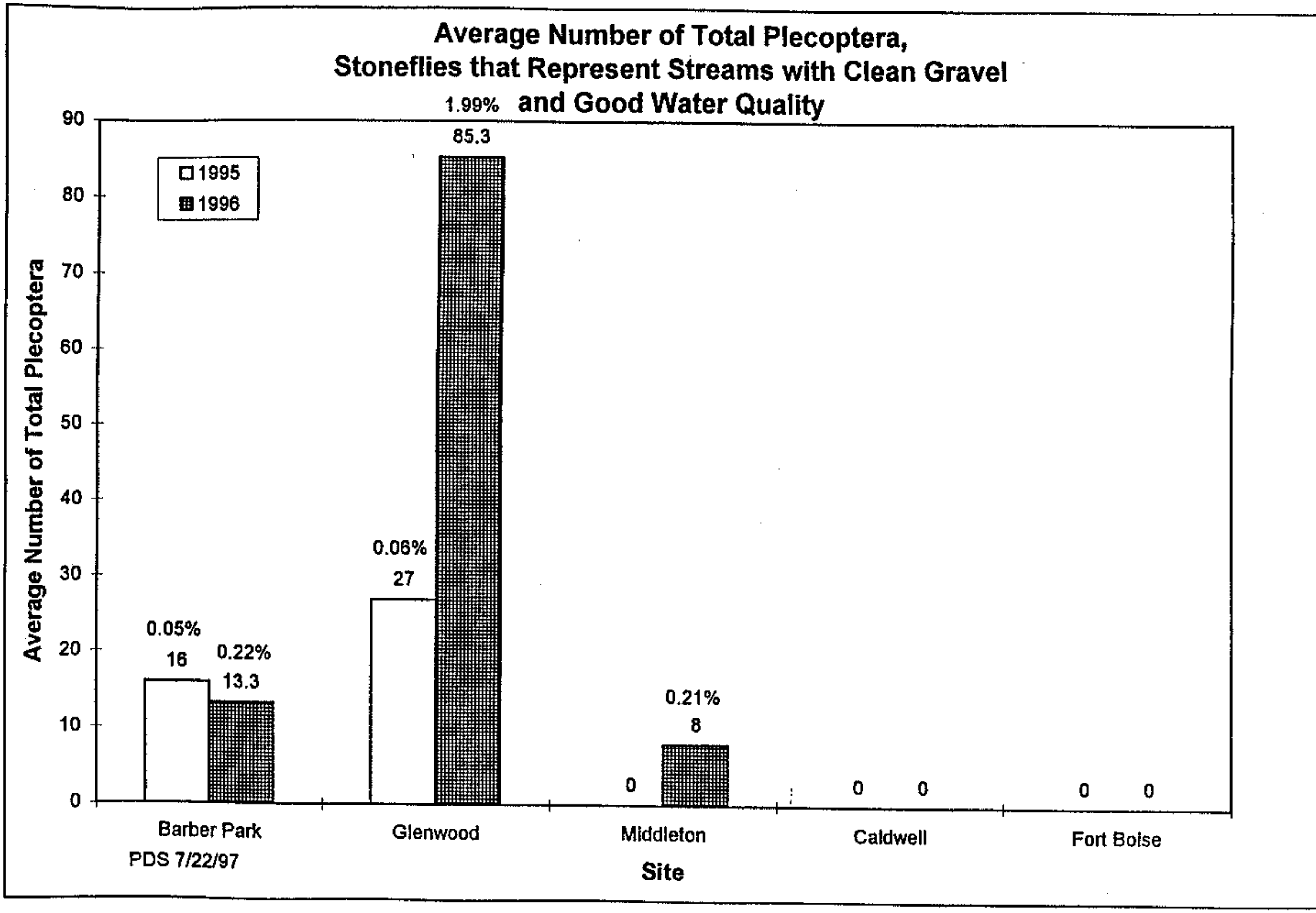

Average Number of Total Plecoptera,
Stoneflies that Represent Streams with Clean Gravel
and Good Water Quality
Average Number of Total Plecoptera
90
80
70
60
50
40
30
20
10
0
1995
1996
0.05%
16
0.22%
13.3
0.06%
27
1.99%
85.3
0
0.21%
8
0
0
0
0
Barber Park
PDS 7/22/97
Glenwood
Middleton
Caldwell
Fort Boise
Site

Table Two

Comparison of Indicator Parameters, Change from 1995 to 1996, by Site

All data collected by the USGS in the first week of October of 1995 and the fourth week of October of 1996

PDS 6/6/98

Eckert Road / Barber Park

Parameter	1995	1996	Change
Taxa	30	22	-8
EPT Taxa	12	12	0
HBI	4.67	4.71	0.04
Predator	1.26	0.22	-1.04
Parasite	2.37	0.35	-2.02
Collector-Gath	25.3	23.98	-1.32
Collector-Filt	63.21	69.02	5.81
Macrophyte-Herb	0	0	0
Piercer-Herb	0	0.57	0.57
Scraper	5.27	4.39	-0.88
Shredder	0	0	0
Xylophage	0	0	0
Omnivore	1.31	0.53	-0.78
Tolerant Taxa	3	3	0
Tolerant%	3.33	2.1	-1.23
Total Abundance	10641.7	6085.5	-4556.2

Glenwood Bridge

Parameter	1995	1996	Change
Taxa	33	23	-10
EPT Taxa	12	10	-2
HBI	5.02	4.28	-0.74
Predator	1.92	4.04	2.12
Parasite	2.35	1.24	-1.11
Collector-Gath	37.94	11.29	-26.65
Collector-Filt	48.7	73.97	25.27
Macrophyte-Herb	0	0	0
Piercer-Herb	0	0	0
Scraper	6.8	6.9	0.1
Shredder	0	0	0
Xylophage	0	0	0
Omnivore	0.65	0.19	-0.46
Tolerant Taxa	5	2	-3
Tolerant%	5.08	3.72	-1.36
Total Abundance	14663	4293.4	-10369.6

Middleton

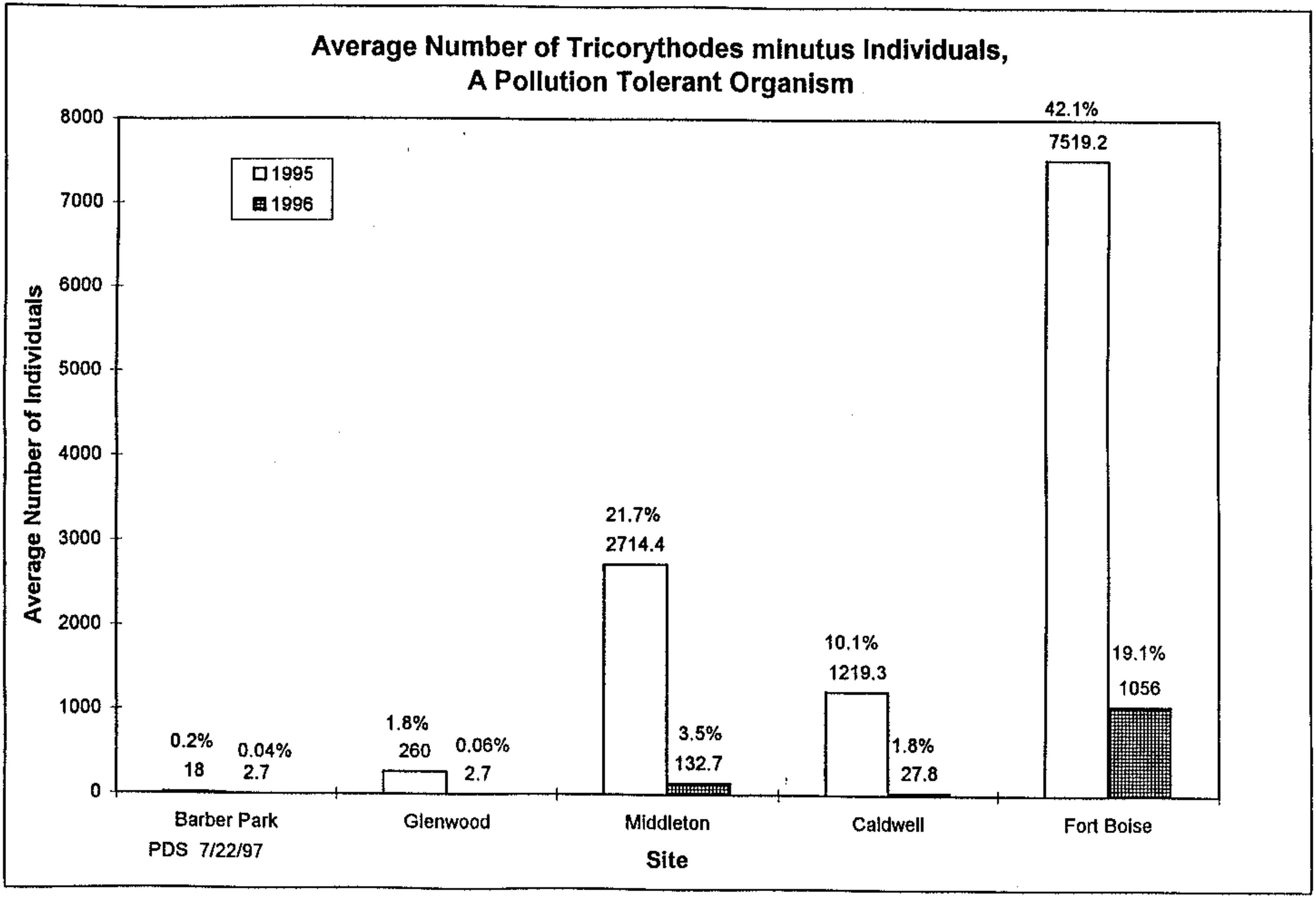
Parameter	1995	1996	Change
Taxa	38	39	1
EPT Taxa	13	14	1
HBI	4.5	4.58	0.08
Predator	2.46	1.81	-0.65
Parasite	5.02	1.36	-3.66
Collector-Gath	50.88	21.5	-29.38
Collector-Filt	36.48	68.03	31.55
Macrophyte-Herb	0	0	0
Piercer-Herb	0.11	0.03	-0.08
Scraper	1.84	0.86	-0.98
Shredder	0	0	0
Xylophage	0	0	0
Omnivore	1.03	3.46	2.43
Tolerant Taxa	10	12	2
Tolerant%	29.63	7.68	-21.95
Total Abundance	12528.8	3827	-8701.8

Caldwell

Parameter	1995	1996	Change
Taxa	30	43	13
EPT Taxa	6	6	0
HBI	5.01	5.91	0.9
Predator	4.52	1.06	-3.46
Parasite	4.32	0.91	-3.41
Collector-Gath	37.69	56.83	19.14
Collector-Filt	49.38	28.65	-20.73
Macrophyte-Herb	0	0	0
Piercer-Herb	0	0	0
Scraper	0.6	5.15	4.55
Shredder	0	0	0
Xylophage	0	0	0
Omnivore	0.71	2.5	1.79
Tolerant Taxa	7	9	2
Tolerant%	11.38	7.53	-3.85
Total Abundance	12037.1	1513.2	-10523.9

Table Two

Mouth			
Parameter	1995	1996	Change
Taxa	28	35	7
EPT Taxa	7	9	2
HBI	4.58	4.82	0.24
Predator	0.5	0.24	-0.26
Parasite	1.36	0.62	-0.74
Collector-Gath	69.87	48.87	-21
Collector-Filt	19.17	41.63	22.46
Macrophyte-Herb	0	0	0
Piercer-Herb	0	0	0
Scraper	7.55	2.22	-5.33
Shredder	0	0	0
Xylophage	0	0	0
Omnivore	0.38	2.8	2.42
Tolerant Taxa	7	6	-1
Tolerant%	48.94	21.37	-27.57
Total Abundance	17864.8	5528.3	-12336.5


Average Number of Tricorythodes minutus Individuals,
A Pollution Tolerant Organism
Average Number of Individuals
8000
7000
6000
5000
4000
3000
2000
1000
0
1995
1996
0.2%
18
0.04%
2.7
1.8%
260
0.06%
2.7
21.7%
2714.4
3.5%
132.7
10.1%
1219.3
1.8%
27.8
42.1%
7519.2
19.1%
1056
Barber Park
Glenwood
Middleton
Caldwell
Fort Boise
PDS 7/22/97
Site

APPENDIX F

Temperature Conditions in the Lower Boise River

DRAFT

Water Temperatures in the Lower Boise River: Conditions and Sources

6/6/98

Prepared for
The State of Idaho

by
The Idaho Division of Environmental Quality, Boise Regional Office

Table of Contents

List of Figures

List of Tables

Summary of Conclusions

- Two segments of the Boise River, Star to Notus and Notus to the Snake River, have temperature as a pollutant on the 1996 303(d) list. The segment of the River from Star to Notus is designated for cold water biota along its entire length, and for salmonid spawning (mountain whitefish) from Star to Caldwell. The segment from Notus to the Snake River is designated for cold water biota along its entire length.

- Along the segment that extends from Star to Notus, water temperatures meet the daily maximum criterion for salmonid spawning (13 deg C). The daily average criterion for salmonid spawning cannot be evaluated, since all available data are either single measurements, or are outside of the October 15 to March 15 time period.

- From Star to the Snake River, the available data indicate that water temperatures are occasionally in excess of state maximum (22 deg C) and average (19 deg C) criteria for cold water biota at Middleton. The frequency of water temperatures in excess of the cold water biota criteria increases at Caldwell, and increases further at Parma. The last few miles of the river exceed both the maximum and the average criteria for cold water biota every July and August from 1987 to 1997 (except 1995, for which no data are available).

- Site specific, seasonal water temperature criteria may be required for the lower Boise River downstream of Middleton.

Sources

- Tributary inputs contribute only minor temperature increases during the months when state criteria are not met.

- Atmospheric sources of temperature contribute the majority of the thermal inputs that raise water temperatures above state criteria.

- The tributaries and point source inputs to the river between Middleton and Parma would have to be cooled by 5 to 6.5 degrees Celsius to prevent daily maximum temperature criteria exceedences at Parma.

- The tributaries and point source inputs to the river between Middleton and Parma would have to be cooled by 7.0 to 11.0 degrees Celsisus to prevent daily average temperature criteria exceedences at Parma.

Introduction

The temperature of the water in the lower Boise River is only one element of the overall water quality, and may have an influence over the use of the river by swimmers, fish, and aquatic macroinvertebrates. The Boise River contains a wide varitey of fish, including rainbow and brown trout upstream of Star and mountain whitefish from Lucky Peak Dam to the confluence with the Snake River. Other species that are present include dace, redside shiners, suckers, and smallmouth bass. The Division of Environmental Quality (DEQ) applies daily maximum and daily average criteria to water temperatures. In the Boise River, two sets of criteria apply, one for cold water biota, the other for salmonid spawning and rearing. This document provides a review of Boise River water temperatures on 303(d) listed stream segments with respect to applicable criteria, and analyzes the sources of thermal inputs to the river.

Segments of the River Listed for Temperature

Two segments of the Boise River have temperature listed as a pollutant on the 1996 303(d) list for Idaho. The first segment extends from Star to Notus, while the second extends from Notus to the Snake. Figure 1 shows a map of the lower Boise River watershed, and indicates which segments of the Boise River are listed for temperature on the 1996 303(d) list. The Boise River has water temperature criteria applicable to segments designated for salmonid spawning, as well as for cold water biota. The water temperature criteria for cold water biota and salmonid spawning are shown in Table 1, below.

Table 1. Water Temperature Criteria

Criteria	Cold Water Biota	Salmonid Spawning
Daily Maximum	22 deg C.	13 deg C.
Maximum Daily Average	19 deg C.	9 deg C.

The cold water biota criteria apply from Lucky Peak Dam to the Snake River, including the two river segments listed for temperature downstream of Star. Salmonid spawning criteria apply from Diversion Dam to Caldwell, and include part of the segment from Star to Notus that is listed for temperature. Since mountain whitefish are the only salmonids known to inhabit the Boise River downstream of Star, the water temperature criteria for spawning apply from October 15 to March 15.

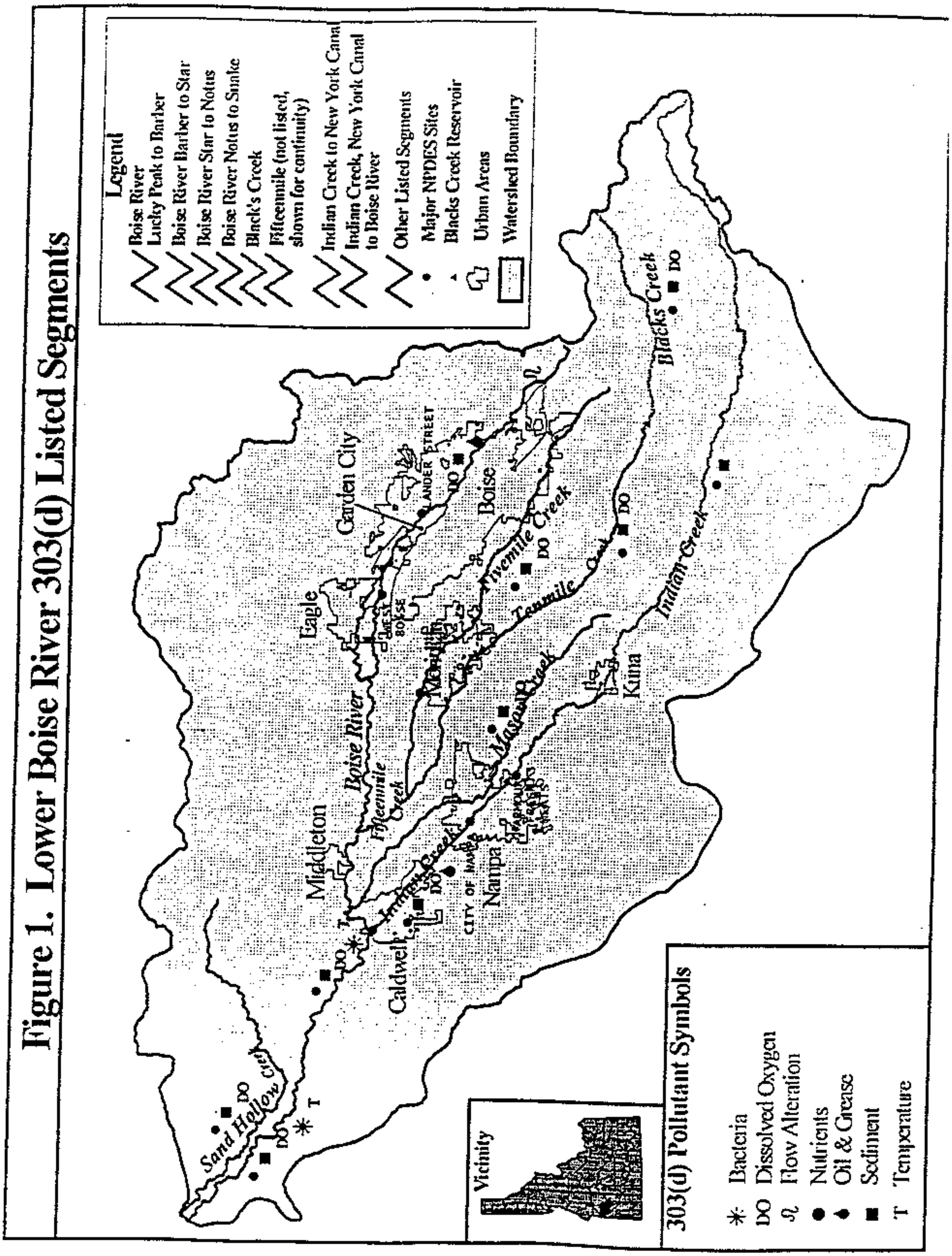


Figure 1. Lower Boise River 303(d) Listed Segments

Scope and Purposes of the Analysis

The analysis of water temperatures in the lower Boise River is designed to assess recent temperature conditions and compare those conditions to State criteria. For segments of the river in which temperature criteria are not met, DEQ identifies the sources affecting water temperature in the river, both natural and human. The primary focus of the analysis is on the two segments listed for temperature, but includes the two segments upstream of Star as sources of temperature. The document does not review temperatures with respect to state criteria on the two river segments upstream of Star.

Water Temperature Conditions and State Criteria

Available Data

The sources of water temperature data available for analysis in the lower Boise River include synoptic monitoring by the USGS at Diversion Dam, Glenwood Bridge, Middleton, at the mouths of major tributaries, and at Parma. The USGS also has long term monitoring data at Parma from 1986 through 1995. During the July and August of 1996, the USGS collected hourly temperature data in the Boise River at Barber Park, Glenwood Bridge, Middleton, Caldwell, Parma, Dixie Drain, and Conway Gulch. Hourly temperature data are now available during 1997 at sites including Diversion Dam, Glenwood, Middleton, Willow Creek, Caldwell, Conway Gulch, Dixie Drain, and Parma.

The data available at Parma are extensive and describe temperature conditions in both low flow, dry years, and high flow, cooler years. The data available at Diversion Dam, Glenwood Bridge, Middleton, Caldwell, and in the tributaries are more sparse, but are still useful for the analysis. Unfortunately, the hourly data collected at Diversion Dam and Glenwood Bridge do not include a very hot, low flow year, making it difficult to assess the impacts of Boise waste water on the river at worst case conditions. Hourly temperature monitoring at Middleton, Caldwell, and in selected tributaries during 1996 and 1997 is especially helpful, as shown later in the source analysis. The available data are summarized in a table attached as Appendix A.

USGS gage stations at Glenwood Bridge, Middleton, and Parma provide daily flow data for the Boise River. In addition, the Idaho Department of Water Resources (IDWR) has estimates of the daily flows from all major lower Boise River tributaries. Daily irrigation diversion flows are from IDWR publications.

Data Gaps

The two significant data gaps are evident with respect to water temperatures downstream of Middleton. First, data are need to characterize the daily average and daily maximum water temperatures in the Boise River between Middleton and Caldwell during the October 15 to March 15 spawning time period. Second, daily average maximum effluent temperature data for the Caldwell waste water treatment plant are needed to improve the accuracy of the analysis described below.

Salmonid Spawning Criteria from Star to Caldwell

The only data available to evaluate against the salmonid spawning water temperature criteria are the USGS synoptic monitoring data for Middleton that fall within the range of dates from October 15 to March 15. The hourly data collected at Middleton and Caldwell in 1996 and 1997 are all outside of the spawning time period, and thus are not pertinent to this analysis. None of the measured temperatures are greater than 13 degrees Celsius. Since the synoptic data include only one measurement per day, the daily average criterion, 9 degrees C, cannot be evaluated. In addition, since the synoptic sampling events do not necessarily coincide with the highest water temperature of the day, the data cannot be used to evaluate compliance with the daily maximum criterion.

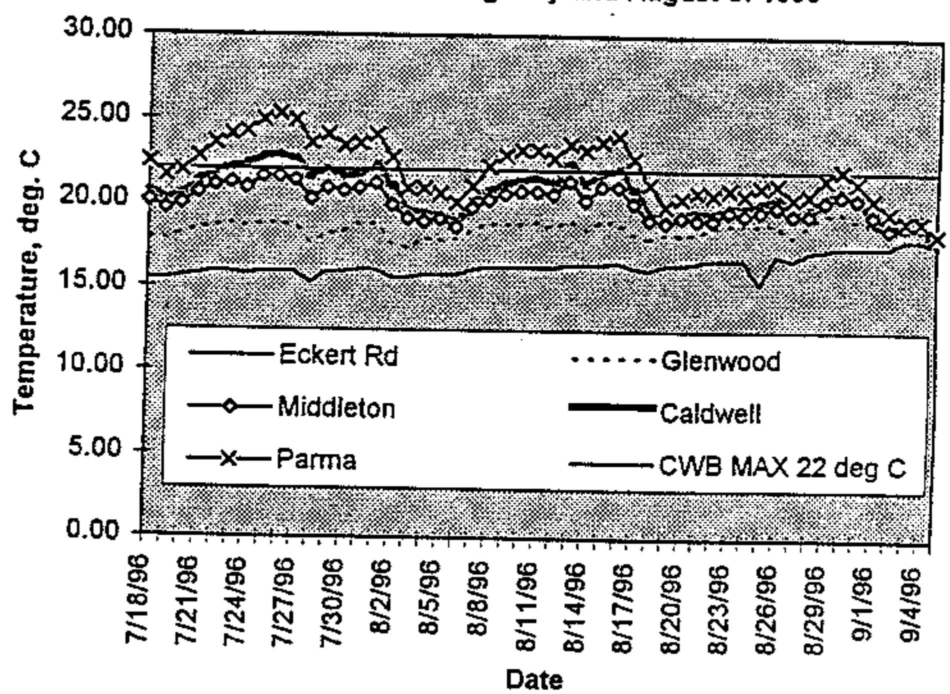
Salmonid Spawning Criteria from Caldwell to Parma

Salmonid spawning for mountain whitefish is an existing, though undesignated use in the the Boise River downstream of Caldwell. As noted above, the time period designated to protect whitefish spans October 15 to March 15. In daily data from the river near Parma from 1987 through 1995, the water temperatures exceed the daily maximum limit from one to twelve times per month during October, depending on the year. The water temperatures at Parma also exceed the daily maximum limit in the first two weeks of March during hot, dry years (1992 and 1994). The total number of days on record with water temperatures greater than 13 degrees at Parma is 50, out of 1389 spawning days monitored from 1986 to 1997. The daily maximum water temperature exceedences represent 3.5 percent of the total days, and are clustered at the beginning and the end of the October 15 to March 15 time period. The daily average water temperatures in the Boise River near Parma are warmer than 9 degrees Celsius (the salmonid spawning daily average criterion) on 258 of 1389 spawning days monitored, or 18.5 percent of the total days. The daily average criteria exceedences are clustered in October, November, February, and March. Only two salmonid spawning daily average criteria exceedences occurred during December and January.

Water Temperatures Greater than Cold Water Biota Criteria

The water released from Lucky Peak dam has a fairly stable temperature during the summer time, because the water leaves the reservoir through deep penstocks. As the water moves downstream, it gradually becomes warmer, and its temperature fluctuates more widely over time. Figure 2 shows the daily maximum water temperatures at different locations in the river. The peaks and valleys are specific to 1996, but the relative positions of each site are the same from year to year. When water arrives at Parma, it is significantly warmer than the other four upstream stations, and is often warmer than the cold water biota maximum criterion during July and August. The daily average values shown in Figure 3, on the following page, show a similar pattern.

Figure 2. Daily Maximum Temperatures in the Lower Boise River during July and August of 1996



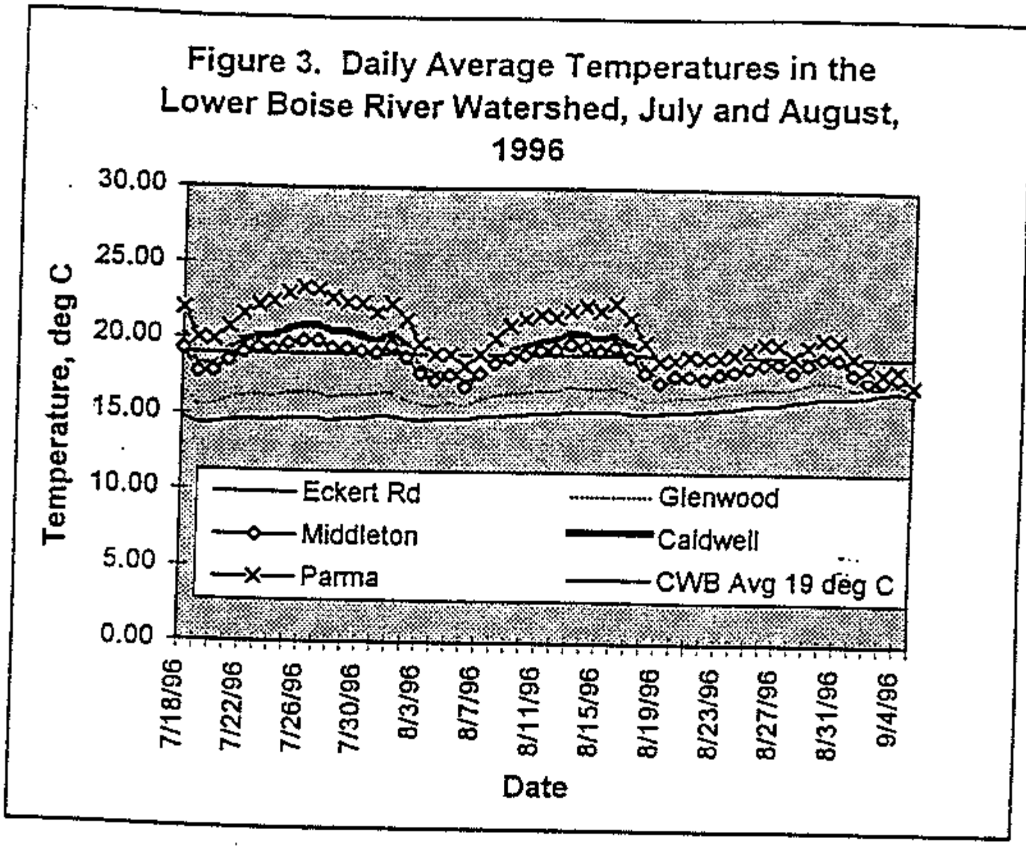
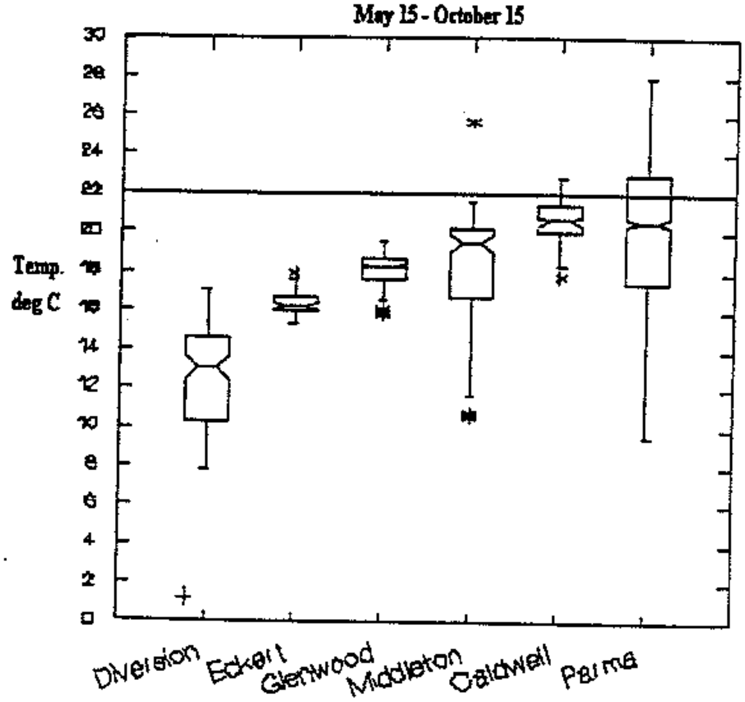


Figure 3. Daily Average Temperatures in the Lower Boise River Watershed, July and August, 1996
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Temperature, deg C
Eckert Rd
Glenwood
Middleton
Caldwell
Parma
CWB Avg 19 deg C
7/18/96
7/22/96
7/26/96
7/30/96
8/3/96
8/7/96
8/11/96
8/15/96
8/19/96
8/23/96
8/27/96
8/31/96
9/4/96
Date

From the upstream end of the watershed, at Lucky Peak Dam, to the lower end of the Boise River near Parma, water temperatures increase quite significantly. Figure 4 shows box plots of daily maximum water temperatures from May through October at various stations in the Boise River. The notches on the boxes represent the 95% confidence around the median values (the center line of the box). Since, the confidence intervals for Diversion Dam, Eckert Road, Glenwood Bridge, Middleton, and Parma do not overlap, the differences between their medians are statistically

Figure 4. Daily Maximum Water Temperatures in the Lower Boise River
May 15 - October 15



significant. The median temperatures at Caldwell and Parma may not be significantly different at the 95% confidence level. A guide to interpreting boxplots is located at the back of the document in Appendix D.

Middleton

The water temperature data available at Middleton are very good for 1996 and 1997, but are sparse prior to 1996. The data are not sufficient to fully evaluate water quality criteria at Middleton during hot, low flow years such as 1992. Water temperatures at Middleton do not always meet the daily average criterion of 19 degrees C. Only one exceedence of the daily maximum criterion occurred at Middleton from 1994 to 1997. Figures One and Two in Appendix B display water temperatures at Middleton. The exceedences by month are summarized in Table 2, below.

Table 2. Review of Temperature Criteria at Middleton, 1996 - 1997

Total by Month 1996 and 1997	Exceed Daily Maximum 22 deg C.	Exceed Daily Average 19 deg C.
May	0	0
June	0	0
July	0	13
August	0	10
September	0	0
Grand Total, 1996 - 1997 n = 189	0	23

Caldwell

During July and August of both 1996 and 1997, water temperatures at Caldwell exceed the daily maximum and average criteria more frequently than at Middleton. The water temperatures observed at Caldwell are displayed in Figures Three and Four of Appendix B. Table 3 contains a summary of criteria exceedences at Caldwell.

Table 3. Review of Temperature Criteria at Caldwell, 1996 - 1997

Total by Month, 96-97	Exceed Daily Maximum 22 deg C.	Exceed Daily Average 19 deg C.
May	0	0
June	0	0
July	11	32
August	1	30
September	0	0
Grand Total, 1996 - 1997 n = 116	12	62

Parma

The water temperature at Parma is often significantly warmer than both of the state criteria for cold water biota during July and August of the past eleven years. June also has numerous water temperatures greater than the criteria. Occasional exceedences occur in May and September, but they are limited to the hottest year such as 1992 and 1994. The large grand totals listed in Table 4 are due in part to the fact that temperature has been measured longer at Parma than at Caldwell or Middleton. Figures Five and Six of Appendix B display the temperature data measured at Parma. Tables 5 and Table 6 show how the temperatures in excess of state criteria at Parma are distributed among the years of record.

Table 4. Review of Temperature Criteria at Parma, 1987 - 1997

Total by Month, 87 - 97	Exceed Daily Maximum 22 deg C.	Exceed Daily Average19 deg C.
May	15	5
June	93	72
July	223	218
August	147	183
September	6	15
Grand Total, 1987 - 1997 n = 3124	484	495

Table 5. Daily Maximum Water Temperatures at Parma that Exceed 22 deg C, by Month and Year

Year	May	June	July	August	September	Totals
1997	0	0	17	9	0*	26
1996	ND	ND	12*	13	0*	25
1995	0	0	3*	0 m	ND	3
1994	2	15	29	23	0	69
1993	0	4	2	6	0*	12
1992	3	20	26	21	2	72
1991	0	2	31	29	2	64

1990	0	14	27	2*	ND	43
1989	0	21	26	7*	0	54
1988	3	17	30	22	0	72
1987	7*	ND	20	14	2	43

*Missing Data, refer to data availability Table in Appendix A.
ND - No data

Table 6. Daily Average Water Temperatures at Parma that Exceed 19 deg C, by Month and Year

Year	April	May	June	July	August	September	Totals
1997	0	0	2	25	28	2	57
1996	ND	ND	ND	14*	26	1*	41
1995	0	0	0	4	ND	ND	4
1994	0	0	9	24	21	0	54
1993	0	0	4	1	10	0*	15
1992	0	2	16	22	21	2	63
1991	0	0	1	30	30	2	63
1990	0	0	11	25	2*	ND	38
1989	0	0	13	28	10*	0*	51
1988	0*	0	16	29	25	0	70
1987	2	3*	ND	16	10	2	33

*Missing Data, refer to data availability Table in Appendix A.
ND - No data

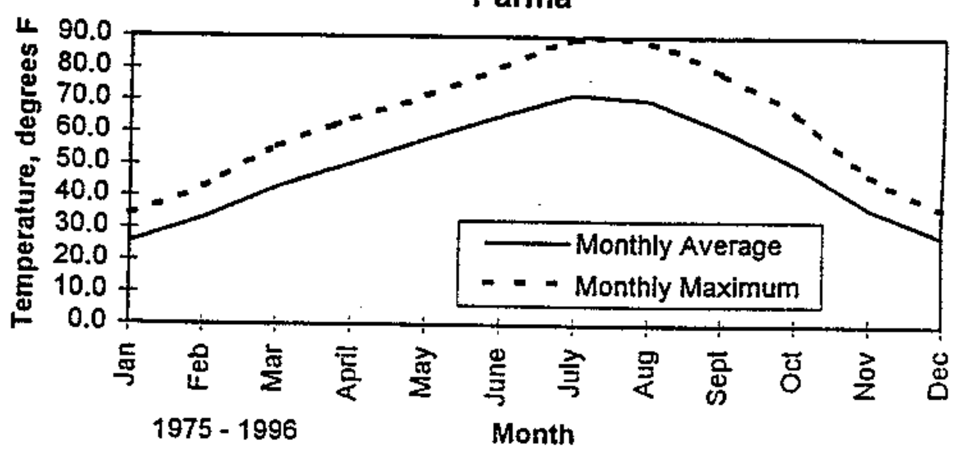
Magnitude of Temperature Exceedences

Exceedences of the both the cold water biota daily maximum and daily average criteria occur at Parma regardless of flow conditions relative to the long term average for the site. In low flow, high temperature years such as 1991 the number of exceedences that occur in a month, as well as the magnitudes of those exceedences, increase. The exceedences in July of 1991 ranged from 22 to 26 degrees C., with the majority between 24 and 26 degrees C. Cooler, higher flow summers do not eliminate exceedences of cold water biota criteria, but they do reduce the frequency and magnitude of exceedences. For example, the water in the Boise River at Parma was warmer than 22 degrees Celsius on 17 days in July of 1997, but was warmer than 22 degrees during all 31 days of July in 1991. During July of 1997 at Parma, all 17 exceedences were between 22 and 24 degrees C. A complete set of frequency tables of water temperatures at Parma is located in Appendix C.

Air Temperatures

Air temperatures collected at Parma and Caldwell by the University of Idaho Climate Data Center are very useful for describing the daily minimum, average, and maximum air conditions over the river. Figure 5 shows the distinct pattern of both average and maximum air temperutures in the Boise River valley, a pattern that is mimicked in water temperature data.

Figure 5. Long Term Monthly Air Temperatures at Parma



The air temperatures associated with maximum water temperatures greater than 22 degrees C at Parma are on average about 12.7 warmer than the air temperatures associated with days on which the maximum water temperatures are less than 22 degrees C. Table 7 shows the typical daily maximum air temperatures associated with exceedence and non-exceedence water temperatures at Parma. Figure 6 shows the positions of monthly average air temperature during the 1990s relative to the long term average monthly air temperatures at Parma (1961-1990).

Figure 6. Monthly Average Air Temperatures at the Parma Climate Station Relative to the Long Term Monthly Averages

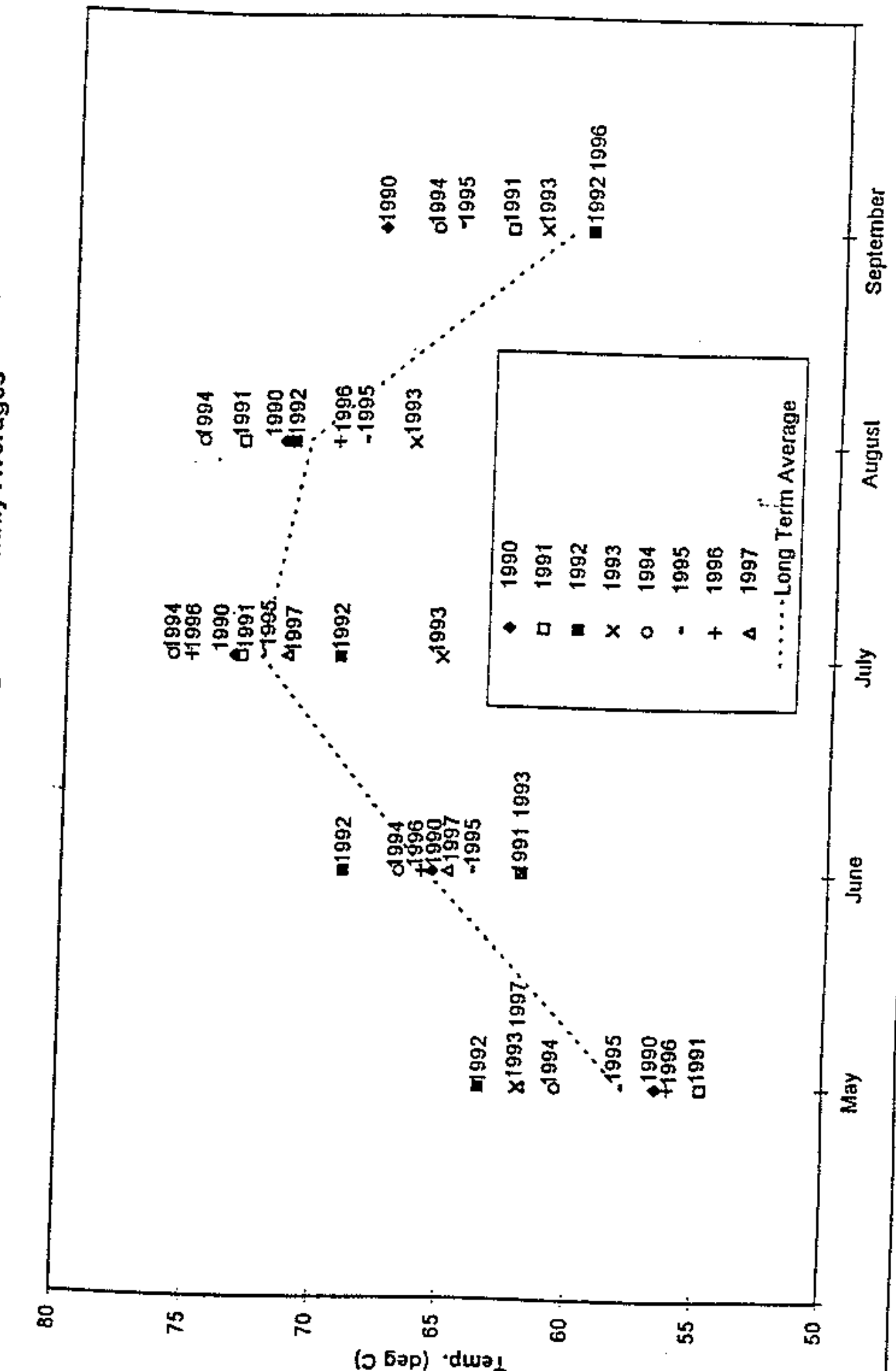


Table 7. Averages of Daily Maximum Air Temperatures at Parma, 1987-1997

Month	Air Temperatures (deg F) When Max. Water Temperatures are <= 22 deg. C	Air Temperatures (deg F) When Max. Water Temperatures Exceed 22 deg. C
May	74	88
June	77	90
July	80	93
August	84	94
September	81	95

Flow Conditions

The flows in the Boise River at Parma were below average during most of the years between 1987 and 1997. The late 1980s and early 1990s were years of well below average flows. Flows were mixed above and below monthly averages in 1995, while 1996 was the first year since 1987 that was above the period of record annual average, based on water years. During years such as 1992 and 1994 when flows were well below average, water temperatures were in excess of state criteria more often, and by wider margins than in wet years like 1996. However, it is important to note that water temperatures at Parma exceeded state maximum and average criteria even when flows were well above average. The average number of daily maximum criteria exceedences in July of below average flow years is 27, while the average for above average flow years is only 9 exceedences. Table 8 displays monthly average flows, and indicates the position of the flows relative to long term averages for the Parma gage.

Table 8. Average Discharge at Parma Gage 13213000, cubic feet per second (cfs) Period of record: 1971 to 1996

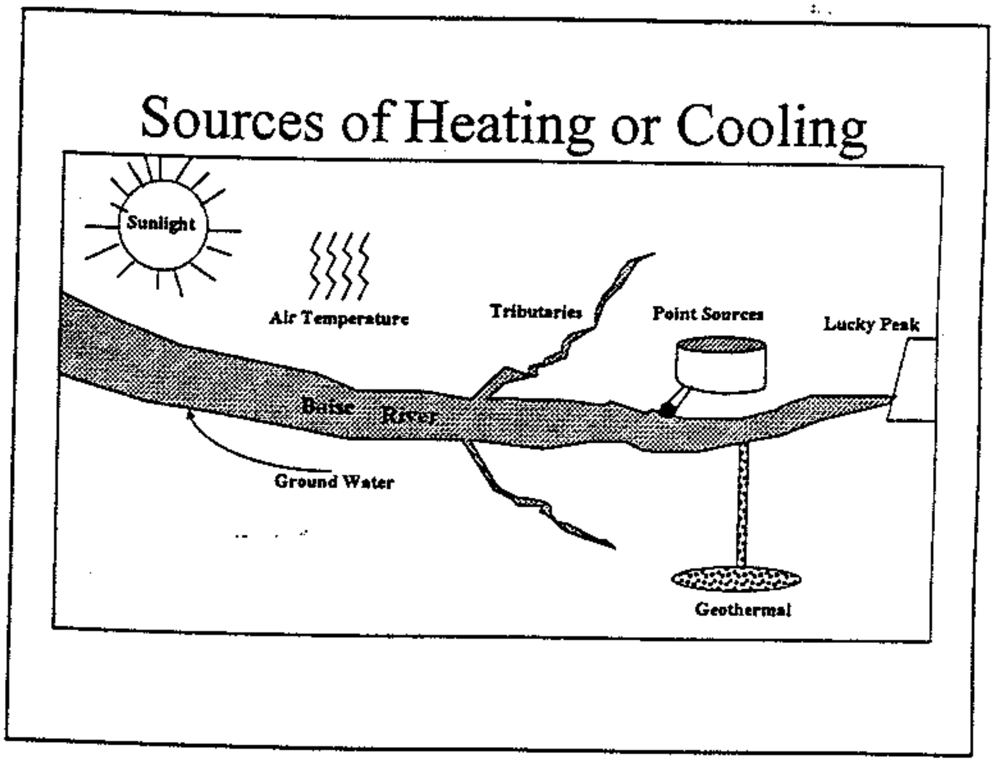
BOLD = Flow larger than average *Italics* = Flow less than average

Water Year	April 2920 cfs	May 3011 cfs	June 2072 cfs	July 983 cfs	Aug 757 cfs	Sept 982 cfs	Annual Avg. 1628 cfs
1997	**6835**	**5255**	**3938**	**1358**	**1542**	**1474**	N/A
1996	**5625**	**5010**	**4217**	**1064**	**1132**	**1117**	**2949**
1995	*1606*	**4551**	**2591**	**2369**	**1028**	**1070**	*1473*
1994	*483*	*806*	*521*	700	*596*	*400*	723
1993	*1705*	**3791**	*1440*	**1010**	**922**	*878*	*1145*
1992	*243*	*276*	*316*	282	*187*	*184*	*459*
1991	*538*	*781*	*671*	534	*424*	*550*	*684*
1990	*357*	*714*	*554*	406	*519*	*633*	*662*
1989	**3392**	*1178*	*564*	578	*739*	**989**	*1013*
1988	*432*	*506*	*481*	301	*306*	*416*	*594*
1987	*283*	*658*	*559*	503	*523*	*685*	*880*

Source Analysis

Potential Sources

The water temperature in the Boise River is controlled by both natural and human factors. The sources affecting temperature are displayed in Figure 7, below. Activities that affect water temperature include the cold water released from Lucky Peak Reservoir, point source discharges of water, and geothermal flows. Tributaries that flow into the Boise River during the summer time are in many cases influenced by irrigation activity, and carry significant quantities of return flow and intercepted shallow groundwater. The tributaries may provide either heating or cooling effects on the river, depending on their temperatures relative to the mainstem. Sunlight that strikes the water is a source of heating, as is the air temperature during the summertime. Ground water is generally neutral or a source of cooling during the summer.



Lucky Peak Dam Release

The water that is released from the reservoir is drawn from deep within the reservoir, and thus is a relatively constant, cold temperature. During the summertime irrigation season, water leaving the reservoir ranges from about 12 to 14 degrees Celsius all day, every day. The release temperature is a function of the pool depth maintained to support irrigation supplies and location of the penstocks deep in the pool.

Waste Water Treatment Plant Temperatures

The municipal waste water treatment plants that discharge to a segment of the Boise River that is listed for temperature are the City of Middleton and the City of Caldwell. The City of Nampa treatment plant discharges to Indian Creek well upstream of the confluence with the Boise River, and thus is incorporated into the temperature of Indian Creek at its mouth. The current design capacity of the Caldwell plant is 12.04 cubic feet per second, and planned expansions will increase the monthly average flow to 13.12 cfs in the future. Holladay Engineering supplied monthly data to characterize the flow and temperature of the Middleton effluent. The City of Caldwell provided daily flow and temperature data. The temperature characteristics of the effluents are described below in

Geothermal Discharge in Boise

Geothermally heated water enters the Boise River from a discharge point just upstream of the diversion dam for the Settlers Canal, near the Americana Boulevard Bridge. The discharge is typically quite small, flowing less than one half of one cubic foot per second. The temperature of the geothermal water is typically between about 90 and 120 degrees F (32.2 and 48.9 deg. C respectively). The geothermal water now released into the Boise River will be re-injected into the ground water system by the end of 1998, eliminating the flow of heated water.

Tributaries to the Boise River

For this analysis, tributaries are considered to be distinct sources of heat load to the river, because many of the tributaries flow during the summer months due to irrigation activities. Though sunlight and air temperature affect the tributaries, their flows are examined as inputs that are separate from the net effect of the atmosphere on the Boise River itself. Many of the tributaries carry a blend of surface runoff from fields, water distributed from canals, and shallow groundwater. Tributaries vary in their typical temperatures. As described in the Available Data section, the USGS monitored water temperatures hourly in Dixie Drain, Conway Gulch, and East Hartley Gulch from 7/18/96 to 9/5/96. Conway Gulch is generally about the same temperature as, or slightly cooler than the Boise River near Notus. Dixie Drain and Hartley Gulch may often be warmer than the river water during the summertime. Graphs of the 1996 summer temperatures in the tributaries are shown in Figures 8, 9, and 10 below.

Figure 8. East Hartley Gulch Water Temperatures, Summer 1996

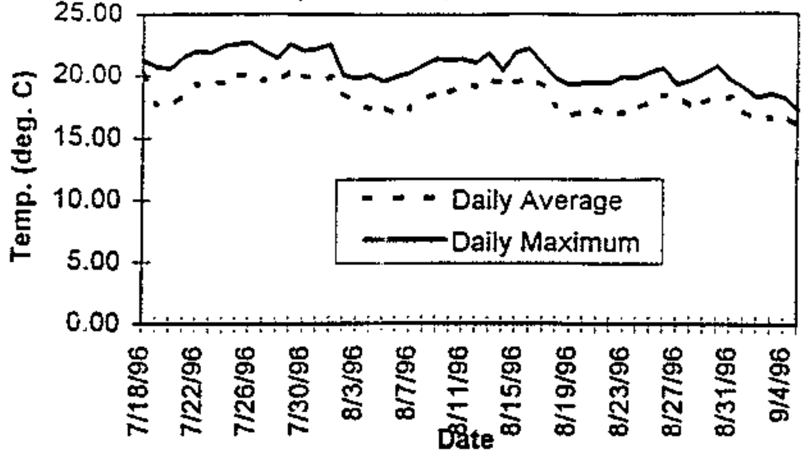


Figure 9. Conway Gulch Water Temperatures, Summer 1996

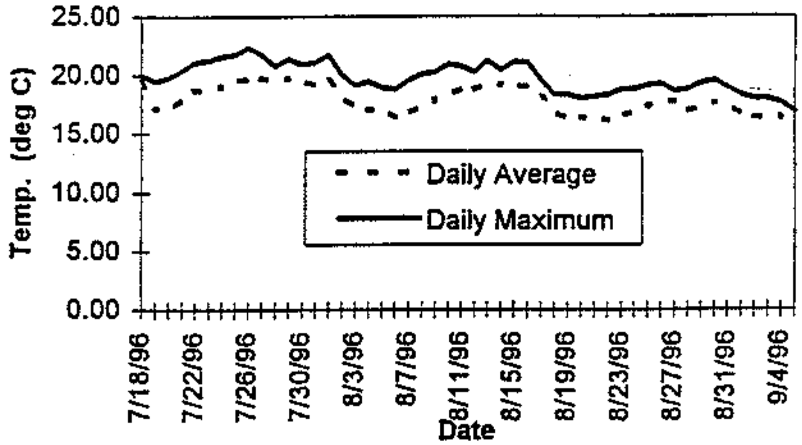
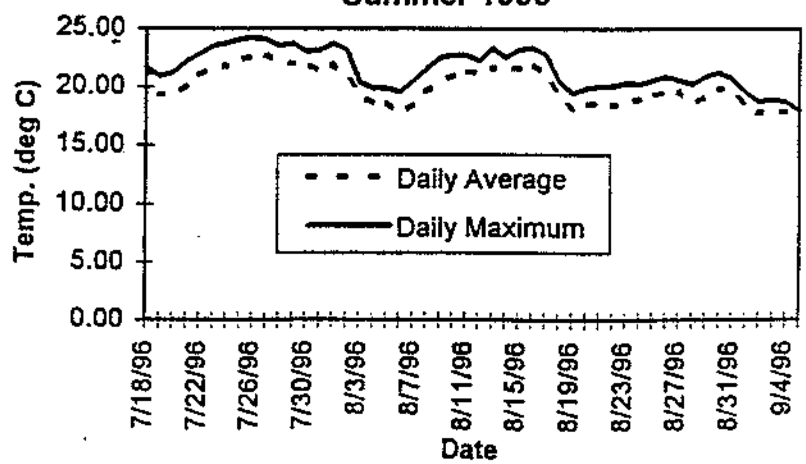


Figure 10. Dixie Drain Water Temperatures, Summer 1996



Net Atmospheric Effect

The atmosphere affects the temperature of the Boise River in two ways. Sunlight striking the water transfers energy from light waves to heat in the water. The air itself, when it is warmer than the water, transfers heat energy to the water. The analysis lumps the two effects, sunlight and air temperature, into one "net" atmospheric input. During the summer months, daily high air temperatures over the lower Boise River valley may regularly be in the high 90s to over 100 degrees Fahrenheit. On many days during the summer, the average air temperature for a day may be warmer than the average daily water temperature in the river, creating a flux of energy into the river water throughout the entire day.

Methodology

The analysis of temperature conditions and contributing sources of heat is an empirical review describing the river in recent years and a characterization of the relative contributions of different heat sources. The analysis is empirical because sufficient data are available to characterize water temperatures in the Boise River across a wide range of flow and air temperature conditions from 1987 to the present. The cold water biota criteria during the summer months are the foci of all calculations, since the majority of criteria exceedences occur in July and August. Winter months are not included, since no salmonid spawning criteria exceedences are evident in the data for the reach from Star to Caldwell.

Two general conditions, average and low flow, are included in the analysis. The average year is 1996, since flows are modestly above the long term averages for the summer months of most interest (July and August). The average year, 1996, is also a data rich year, with hourly temperature available in the river and selected tributaries. A year with lower flows, higher air temperatures, and more water temperature criteria exceedences is 1994, the year which serves as a case example of a problematic year. The climate records for the summer of 1994 reveal prolonged periods with no precipitation and daily high air temperatures over 95 degrees F.

In each example year, temperature and flow data in the Boise River, and its tributaries are mixed longitudinally and compared with measured temperatures in the river. Two reaches of the river are analyzed, as follows: Middleton to Caldwell, and Caldwell to Parma. The reach breaks are based on the availability of gage flow and temperature data. The net flow at the end of a given river reach is the result of river flow, point source inputs, tributary inputs, and diversions. Any residual difference between the calculated flow and a gaged flow is entered into the calculations as groundwater.

Over the length of a reach, a spreadsheet model calculates the water temperature after tributaries and point sources are mixed with the river. The difference between the measured temperature at the end of a reach and the calculated temperature is the empirical derivation of the net atmospheric heat input. For each river reach, sources are analyzed based on both daily maximum and daily average temperatures. The discussion below provides a detailed description of the equations, data, and assumptions used in the analysis.

Mixing Equation

The temperature analysis uses available flow, water temperature, and tributary temperature data to identify the impact of surface water inflows on the Boise River. Point source discharges of water are also included as inputs. The goal of the analysis is to assess the relative impact of temperature inputs on the river water temperature. The temperature of the Boise River itself as it passes Middleton is the first "source" of temperature to the river downstream of Middleton. Thereafter, the accumulated temperature in the Boise River is calculated by mixing in point sources, groundwater, and tributaries. The calculated river temperatures are compared to measured values. Any temperature increase that cannot be attributed to point sources, groundwater, or tributaries is an atmospheric effect. The equation used to model surface water inputs of temperature is a standard temperature mixing equation, shown below:

$$Tm = [(Q*T) + (Qi*Ti)] / (Q + Qi)$$

Where
- Q = mainstem river flow, cfs
- T = mainstem river temperature, deg. C
- Qi = tributary flow, cfs
- Ti = tributary temperature, deg. C
- Tm = average mainstem temperature after mixing, deg. C

Source:

Lee, Richard, Forest Hydrology, New York: Columbia University Press, 1980, p 238.

Example Calculation

Example day: 7/18/96, From Caldwell to Conway Gulch, 7.9 river miles, based on daily maximum temperatures

A	Per mile ground water flow	= 20cfs
B	Ground water temperature	= 16 deg C
C	River flow at Caldwell	= 803cfs
D	River temperature at Caldwell	= 20.0 deg C

E	Eureka #2 Diversion flow	= -118 cfs
F	Upper Center Point Diversion flow	= -22 cfs
G	McManus diversion flow	= -3 cfs
H	Bowman diversion flow	= -8 cfs
I	Lower Center Point diversion flow	= -16 cfs
J	Conway Gulch flow	= 72 cfs
K	Conway Gulch Temperature	= 19.52 deg C

Temperature After Conway Gulch is Mixed Into the River:

(((C+(E+F+G+H+I))*D)+((A*7.9)*B) + (J*K)) / (C+(E+F+G+H+I) + J +(a*7.9))

Mixed temperature = 19.23 deg. C

Since Conway Gulch is slightly cooler than the river water, but its flow is modest, only a very slight change in temperature occurs. In this example, Conway Gulch has a slight cooling influence on the river. Note that the per mile ground water flow, 20 cfs, is multiplied by 7.9 miles, and is then multiplied by 16 deg. Celsius. In this example, both Conway Gulch and the ground water exert cooling influences on the surface water, and the river temperature after the inflows of groundwater and Conway Gulch is slightly less than at Caldwell.

Statement of Assumptions

Several important assumptions are included in the analysis. The assumptions are listed and explained below.

- Ground Water Flow
  The ground water flow is assumed to be the remaining flow after all published inputs and diversions are counted along the length of each of the four reaches analyzed. Groundwater inputs are assumed to enter the river evenly per mile of length in a reach. Thus the total groundwater flow needed to balance a reach between USGS gages is divided by the length of the reach in miles.

- Ground Water Temperature
  The ground water temperature used in the analysis is 16 degrees Celsius. The derivation of the ground water temperature is found below.

- Water Temperatures in Tributaries without Monitoring
  For tributaries that do not have daily water temperature records, the water temperatures measured in a similar tributary are applied. This assumption is most critical in the Middleton to Caldwell reach, where ONLY East Hartley Gulch has daily temperature records. Because East Hartley Gulch has little shade for much of its length, and was warmer than the Boise River during 1996,

the application of its temperatures to all of the other tributaries between Middleton and Caldwell is a reasonable and conservative assumption. The tributaries covered by the East Hartley Gulch data are Mason Creek, Mason Slough, West Hartley Gulch, Mill Slough, and Willow Creek.

- Indian Creek Temperautres
  Indian Creek temperatures are assumed to be the same as those measured downstream of the Nampa wastewater treatment plant. Weekly temperatures are measured by the treatment plant are extended for six days, up to the next weekly measurement.

- Point Source Temperatures
  Two point source discharges enter the Boise River directly, the City of Middleton and the City of Caldwell. The Nampa effluent enters Indian Creek well upstream of its confluence with the Boise River, and is thus lumped into the Indian Creek water temperature. Based on 1996 monthly monitoring data, the Middleton treatment plant water temperatures range from 19.4 degrees C to 20.9 degrees C during July, August, and September. The data from those months are applied to the analysis. Flows from the treatment plant range from 0.52 cfs to 1.31 cfs, again based upon July, August, and September data from 1996. Data to characterize the Middleton WWTP plant during 1994 are not available. Though the data available for the Middleton treatment plant are sparse, the small size of its discharge means that the data are sufficient for this analysis. The Caldwell treatment plant monitors effluent flow and temperature daily. The analysis makes use of the daily data from both 1994 and 1996. Thus the representation of the Caldwell discharge in the analysis is very accurate.

- Mixing
  The analysis assumes uniform mixing of inputs to the river, and does not attempt to quantify variability of water temperatures laterally or through the depth of the river.

Ground Water Characterization

Flows in the spreadsheet are balanced between the Middleton and Caldwell USGS gage data, using known tributary inputs and water diversions. After all inputs and diversions are entered between the gages, the residual flow difference between Middleton and Parma is the ground water input, and is assumed to enter the river evenly on a per mile basis between the two gages.

The temperature of the ground water in the model is 16 degrees C, or 60.8 degrees Fahrenheit. An analysis of monitoring from wells of less than 100 feet in depth shows a range of temperatures. To apply a conservative assumption to the model, the 95th percentile ground water temperature from wells less than 100 feet, 16 degrees C, is used in all calculations. The well data are summarized in Appendix B of

> Boyle, Linda, Sabrina Nicholls, and Deb Parliman, Ground Water Study of the Lower Boise River Valley, Ada and Canyon Counties, Idaho, Water Quality Status Report No. 118, Idaho Department of Health and Welfare, DEQ, May 1996.

Average Year Analysis, 1996

For the analysis, 1996 is an amenable year because hourly temperatures are on record for Eckert Road, Glenwood Bridge, Middleton, Caldwell, Parma, East Hartley Gulch, Conway Gulch, and Dixie Drain. The data, matched with daily flow information, provide an excellent way in which to analyze thermal inputs on many days during July, all of August, and the first five days of September. The averages of the daily analyses represent the typical impacts of various sources. The assumptions listed above apply to this simulation.

Hot, Low Flow Year Simulation (1994)

The year 1994 is an example of time in which summer air temperatures on record are very hot for prolonged periods, and river flows on record are less than the long term monthly averages. Like the 1996 analysis, the hot year analysis centers on July and August. To generate a suitable set of temperature data for 1994, daily values measured in 1996 are scaled upwards to reflect warmer conditions experienced in 1994. The 1994 simulation uses the same structure as the 1996 simulation, but adjusts all flows according to published records for 1994, and inserts warmer water temperatures as described below.

Scaling Technique

Unlike 1996, daily water temperature data from 1994 are available only at the Parma gage site. To analyze temperature conditions in 1994, the daily temperature measurements from 1996, both in the river and in tributaries, are scaled upward to generate a data set for 1994. The percentage of the increase varies by day, and is based on the difference between the water temperatures measured at Parma in 1994, and in 1996.

To scale 1996 measured temperatures upward for the 1994 simulation, the measured daily maximum temperatures at Parma during 1996 are compared to the 1994 daily maximum temperatures measured at the same location to create a multiplier for the temperatures at other sites. The relationship between the 1994 and 1996 temperatures at Parma, on a daily basis, is assumed to be applicable to tributaries and other mainstem Boise River locations. The multiplier, expressed as a percent, is defined by the following equation:

multiplier = (1994 temp, deg. C - 1996 temp, deg. C) / 1996 temp, deg. C * 100

Analysis Results: Source Contributions

The analysis of sources shows that during both average flow years and during low flow, hot years, the atmosphere contributes the majority of the temperature increase that occurs in the Boise River. Point source discharges contribute very little heat load to the river in their present configurations. During the summer months, groundwater is either neutral or a cooling influence on the river. Tables 9. And 10 below show splits of temperature inputs between contributing sources (tributaries and point sources) and the net atmospheric input of heat. Each table shows the number of degrees of increase due to a given source along the length of a river reach. Atmospheric inputs are clearly the dominant influence on the water temperature of the river.

Table 9. Sources of Heat Input - 1996 Daily Conditions

Average Change in Temperature, deg. Celsius	1996 Maximums	1996 Maximums	1996 Average	1996 Average
Location	**Surface Input**	**Ground Water**	**Surface Input**	**Ground Water**
Mill Slough	0.12	-0.41	-0.05	-0.26
Middleton WWTP	0.00	-0.09	0.00	-0.05
Willow Creek	0.02	-0.08	0.00	-0.05
Mason Slough & Mason Creek	0.13	-0.14	0.02	-0.08
East & West Hartley Gulch	0.07	-0.08	0.02	-0.05
Caldwell WWTP	0.02	-0.32	0.04	-0.18
Indian Creek	-0.04	-0.01	0.06	-0.01
NET ATMOS 1	1.25	N/A	0.92	N/A
Conway Gulch	-0.08	-0.28	-0.11	-0.70
Dixie Drain	0.41	-1.09	0.38	-0.18
NET ATMOS 2	2.34	N/A	2.05	N/A

Table 10. Sources of Heat Input - 1994 Daily Conditions

Average Change in Temperature, deg. Celsius	Distance to Location	1994 MAX	1994 MAX	1994 Average	1994 Average
Location	**Miles**	**Surface Input**	**Ground Water**	**Surface Input**	**Ground Water**
Mill Slough		0.10	-0.49	-0.07	-0.31
Middleton WWTP		0.00	-0.10	0.00	-0.06
Willow Creek		0.04	-0.07	0.03	-0.03
Mason Slough & Mason Creek		0.17	-0.17	0.03	-0.10
East & West Hartley Gulch		0.11	-0.10	0.03	-0.06
Caldwell WWTP		0.00	-0.49	0.06	-0.29
Indian Creek		-0.01	-0.02	0.13	-0.01
NET ATMOS 1		1.46	N/A	1.02	N/A
Conway Gulch		-0.16	-1.78	-0.09	-0.95
Dixie Drain		0.87	-0.40	0.60	-0.31
NET ATMOS 2		2.68	N/A	1.74	N/A

Evaluation of Tributary Cooling

After analyzing 1994 and 1996 conditions, the effects of cooling the tributaries to the lower Boise River downstream of Middleton are examined using techniques similar to those described above. For 1994 and 1996, all of the water temperatures for tributaries to the Boise River, excluding the Caldwell waste water treatment plant, are gradually reduced to simulate cooling of the inputs to the river. The reduction analysis considers daily average temperatures, since tributary cooling would occur throughout the day.

For Tables 11 and 12:

Top row = degree reduction in average tributary temperature
Bottom row = percent reduction of daily average exceedences at Parma

Table 11. Daily Average Temperature Reductions
All Tributaries Downstream of Middleton

1996	5.0 deg C	6.0 deg C	7.0 deg C	8.0 deg C
Reduction	49%	66%	78%	93%

Table 12. Daily Average Temperature Reductions
All Tributaries Downstream of Middleton

1994	5.0 deg C	6.0 deg C	7.0 deg C	8.0 deg C	9.0 deg C
Reduction	38%	49%	64%	71%	80%

To eliminate daily average exccedences at Parma would require reductions, for all tributaries downstream of Middleton, of about 8.0 degrees Celsius in 1996 and greater than 9.0 degrees Celsius in 1994. The results show that the reductions needed in tributary water temperatures are very large, and unlikely to be achievable. The result is not unexpected given that the atmosphere drives temperature conditions in the river more strongly than do the tributaries.

Conclusions

Cold Water Biota Criteria

Water temperature criteria for cold water biota are not fully supported during the summer months from Middleton to the mouth of the Boise River. Water temperatures in excess of the state criteria occur occasionally at Middleton and Caldwell, and very frequently in the vicinity of Parma. The majority of criteria exceeding water temperatures occur in June, July, and August. A few exceedences may occur during May and September of especially hot years. Both the daily maximum criterion and the maximum daily average criterion for water temperature with respect to cold water biota are not met downstream of Middleton.

Sources of Heat Load to the River

The climate of the lower Boise river valley has a strong controlling influence on the temperature of the water in the Boise River during the summer months. Other inputs of heat load to the river, such as tributaries and waste water treatment plants, contribute only modest percentages of the total temperature increases that occur in the river.

Recommendations

To be completed pending loading analysis.

Appendix A

Available Water Temperature Data for the Mainstem of the Boise River

Agency	Station Name	Years	Frequency	Reported Data	Comments
USGS	Middleton	7/18/96 to 9/5/96 and 4/15/97 to 9/4/97	Hourly	Water Temp, deg C	Diurnal, HOBO temp. logger
USGS	Middleton	11/91 to the present	Bi - monthly	Water Temp, deg C	Synoptic monitoring
USGS	Caldwell	7/18/96 to 9/5/96 and 6/28/97 to 9/1/97	Hourly	Water Temp, deg C	Diurnal, HOBO temp. logger
USGS	Parma	7/18/96 to 9/5/96 and 4/15/97 to11/11/97	Hourly	Water Temp, deg C	Diurnal, HOBO temp. logger
USGS	Parma	Water Year 95	Daily	Min and Max Temp, deg C	July missing 11 days, August blank, September blank
USGS	Parma	Water Year 94	Daily	Min and Max Temp, deg C	Complete data
USGS	Parma	Water Year 93	Daily	Min and Max Temp, deg C	September missing 2 days
USGS	Parma	Water Year 92	Daily	Min and Max Temp, deg C	Complete data
USGS	Parma	Water Year 91	Daily	Min and Max Temp, deg C	October blank, November blank, December blank, January missing 29 days
USGS	Parma	Water Year 90	Daily	Min and Max Temp, deg C	October missing 11 days, November missing 16 days, August missing 29 days, September blank

USGS	Parma	Water Year 89	Daily	Min and Max Temp, deg C	February missing 10 days, March missing 10 days, July missing 4 days, August missing 11 days, September missing 7 days
USGS	Parma	Water Year 88	Daily	Min and Max Temp, deg C	March missing 18 days, April missing 20 days
USGS	Parma	Water Year 87	Daily	Min and Max Temp, deg C	June blank, April missing 10 days, May missing 3 days

Appendix B

Water Temperatures at Selected Lower Boise River Sites

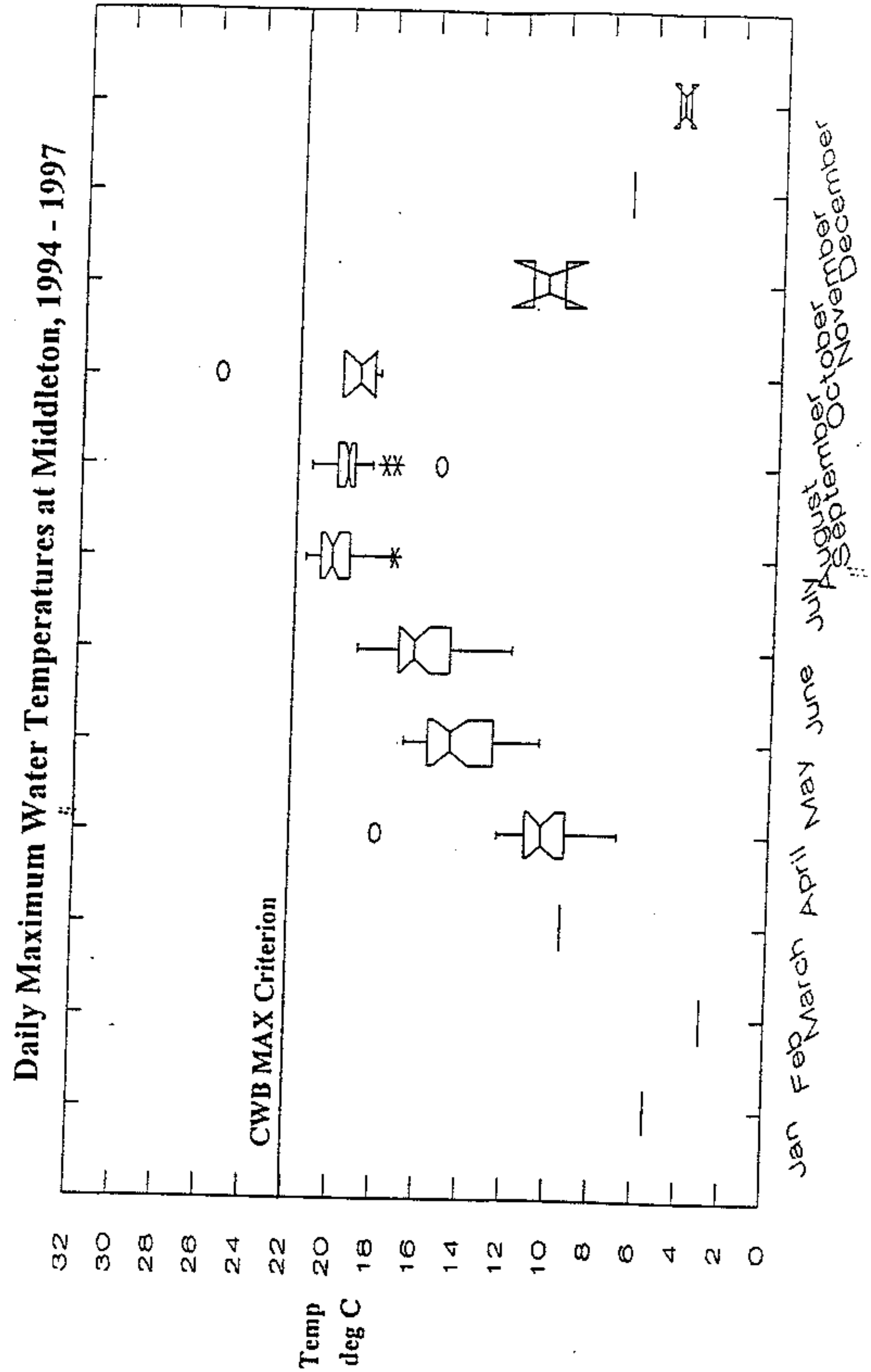

Daily Maximum Water Temperatures at Middleton, 1994 - 1997
CWB MAX Criterion
Temp deg C
32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
Jan Feb March April May June July August September October November December

Figure 1.

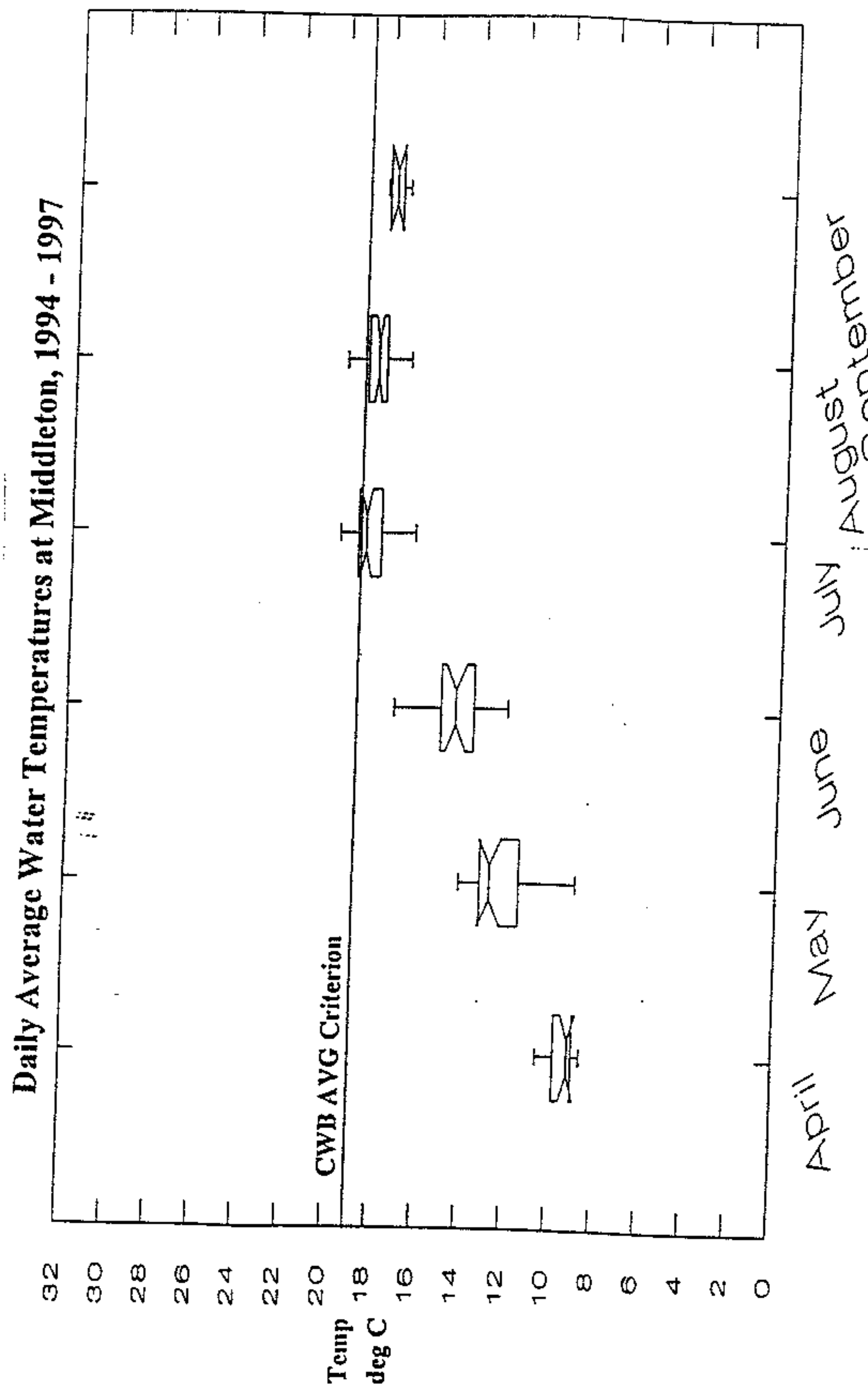

Daily Average Water Temperatures at Middleton, 1994 - 1997
CWB AVG Criterion
Temp
deg C
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Figure 2.

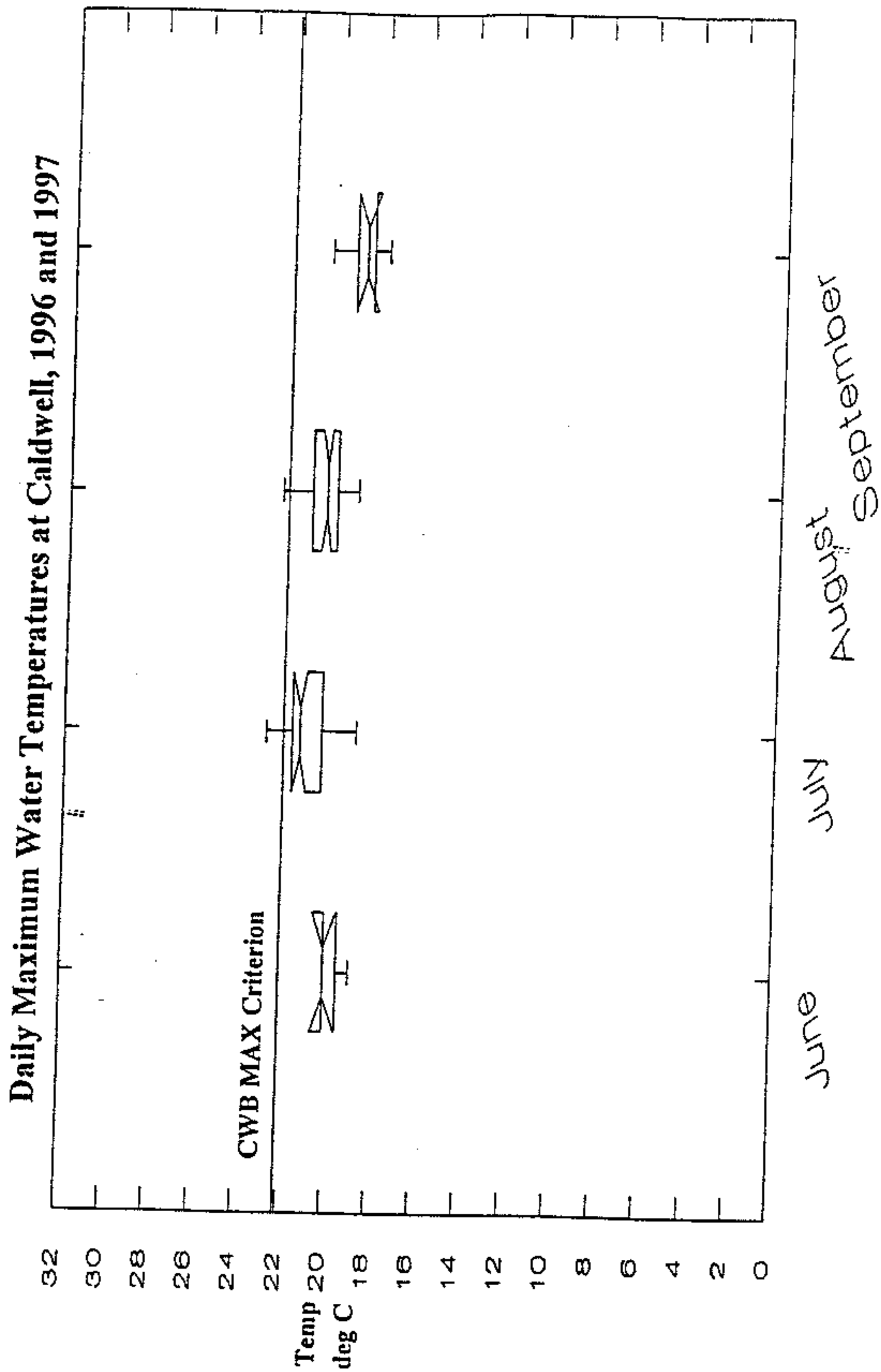
Daily Maximum Water Temperatures at Caldwell, 1996 and 1997
CWB MAX Criterion
Temp deg C
32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
June
July
August
September

Figure 3.

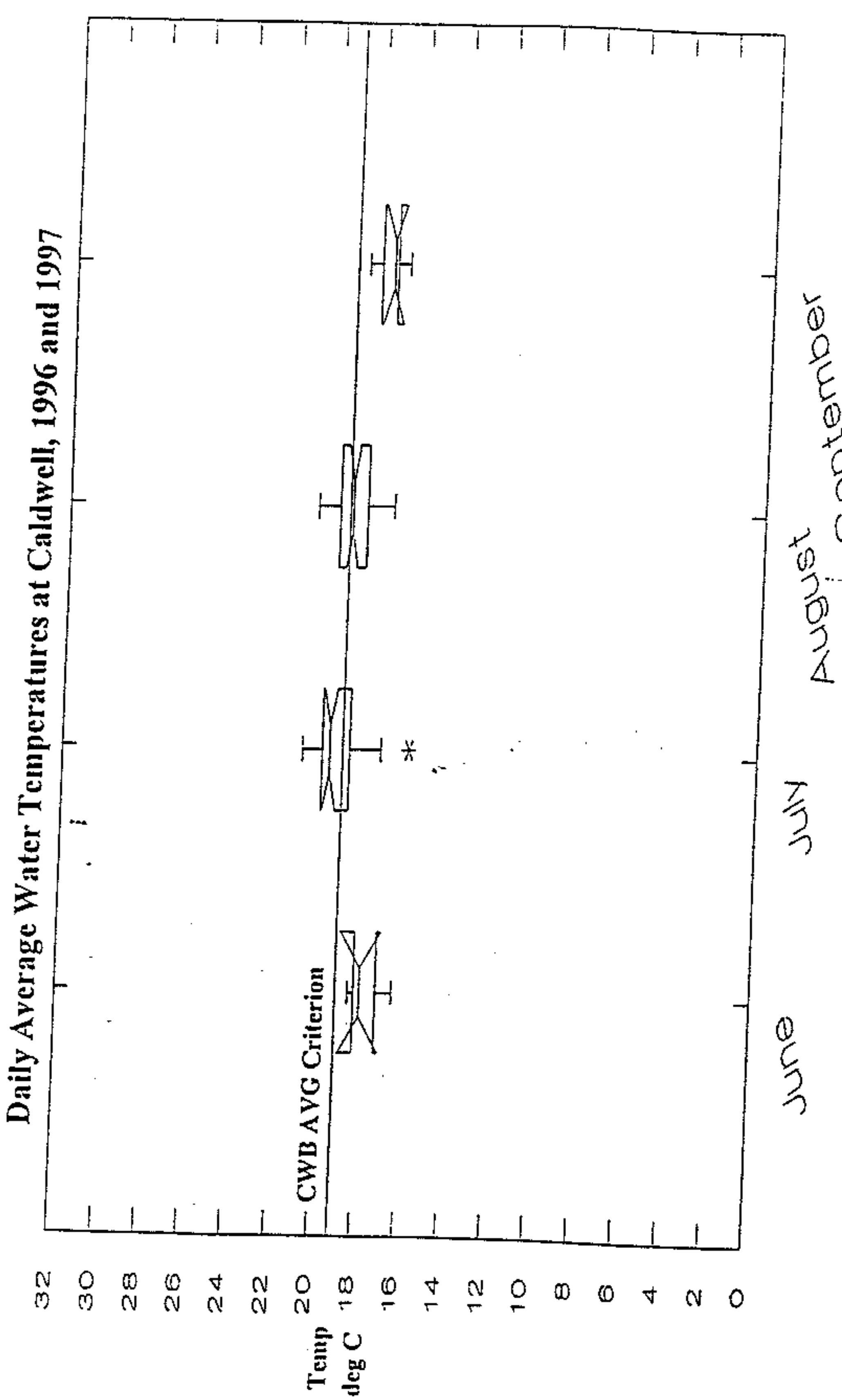
Daily Average Water Temperatures at Caldwell, 1996 and 1997
CWB AVG Criterion
Temp deg C
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Figure 4.

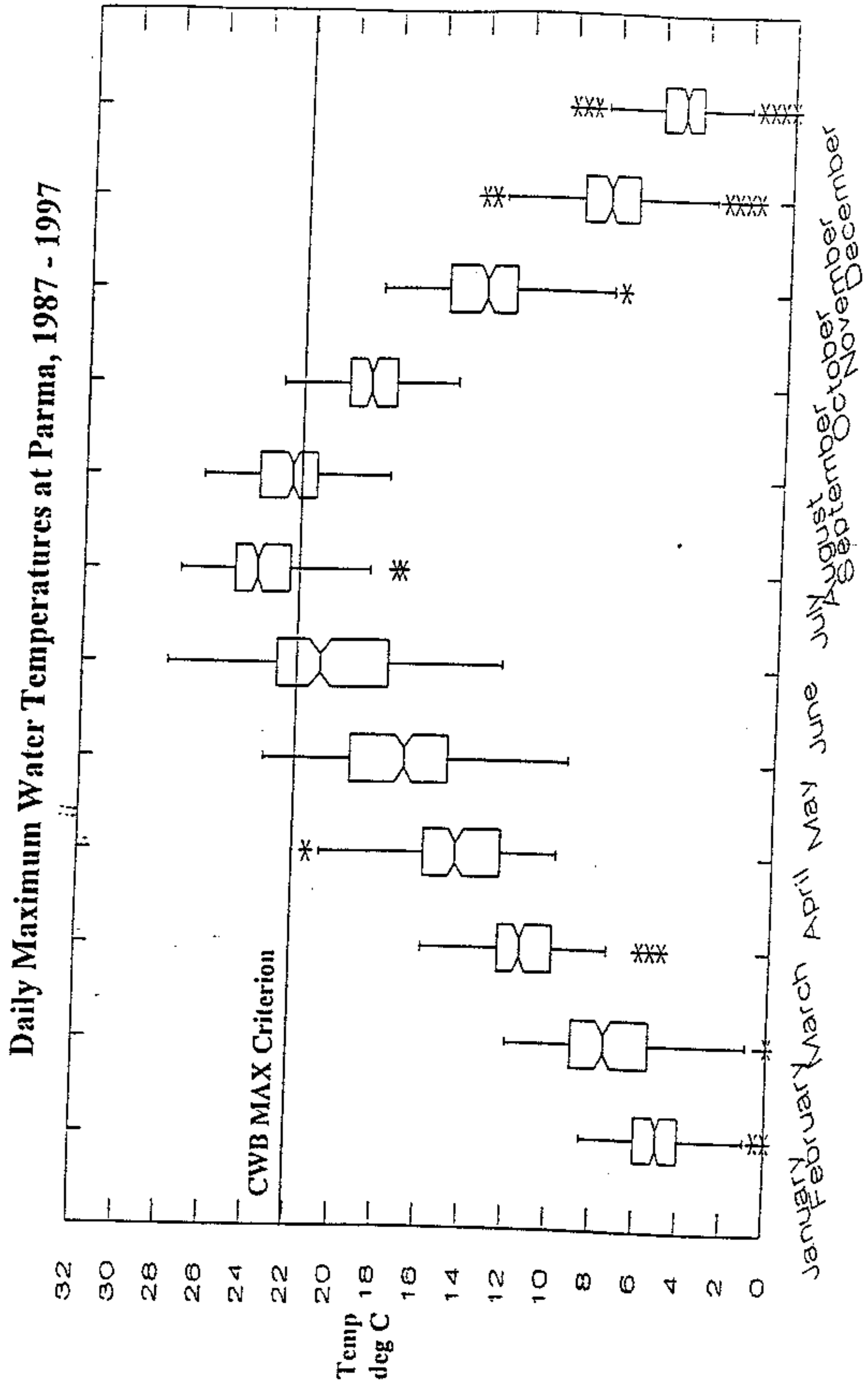
Daily Maximum Water Temperatures at Parma, 1987 - 1997
CWB MAX Criterion
Temp deg C
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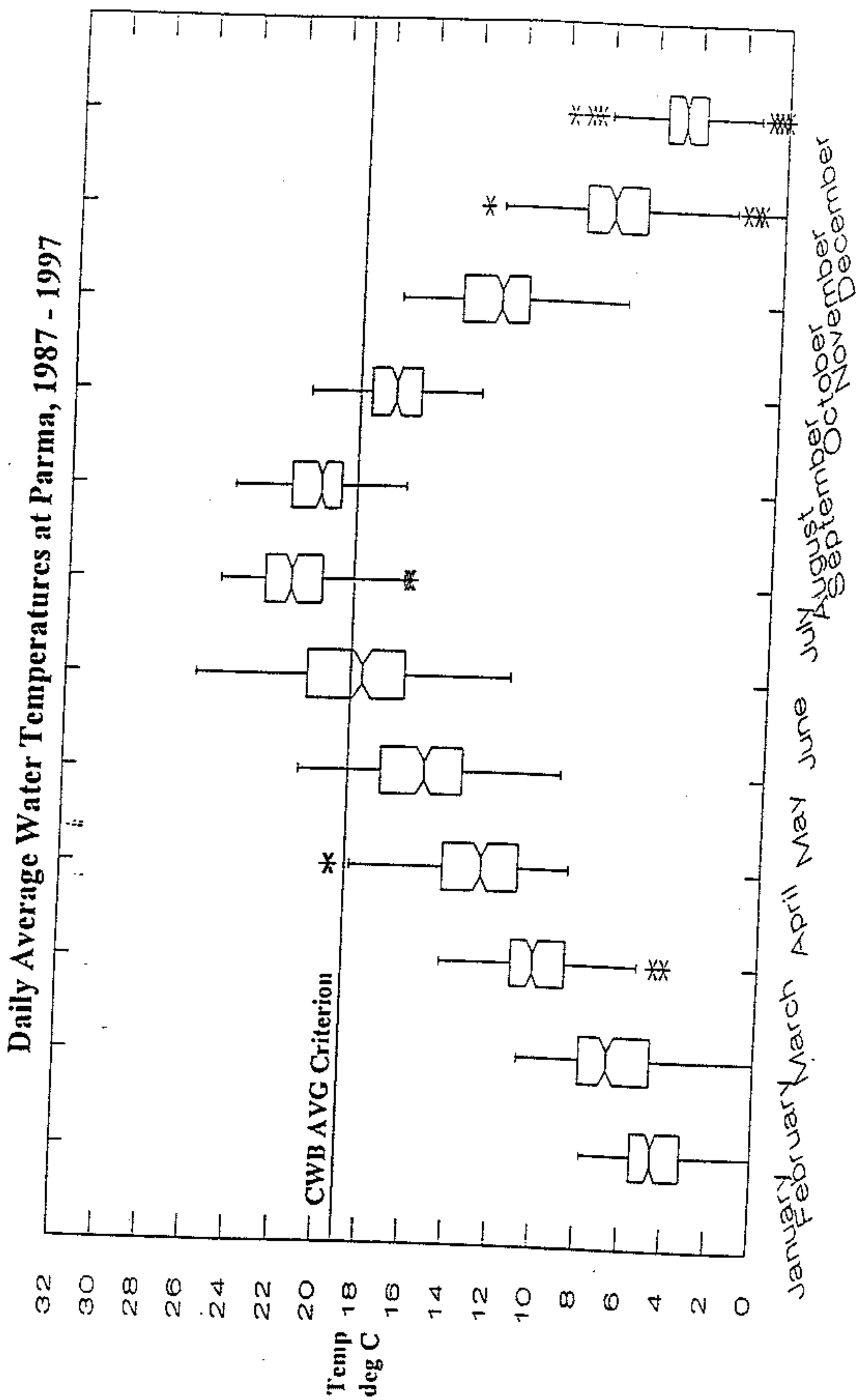
Figure 5.


Daily Average Water Temperatures at Parma, 1987 - 1997
CWB AVG Criterion
Temp
deg C
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September
October
November
December

Figure 6.

Appendix C

Frequency Tables of Water Temperatures at Parma

1987 Daily Maximum Water Temperatures

Temp Category deg C	May *	June	July *	August	September
0 - 22	21	ND	10	16	28
22 - 23	5	ND	3	7	2
23 - 24	2	ND	5	5	
24 - 25		ND	6	3	
25 - 26		ND	6		
26 - 27		ND			
27 - 28		ND			
28 - 29		ND			
29 - 30		ND			

*Incomplete Record ND = No Data Blank Square = no occurrences

1988 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July *	August	September
0 - 22	28	13	1	9	30
22 - 23	3	2	2	11	
23 - 24		2	5	9	
24 - 25		3	7	2	
25 - 26		5	14		
26 - 27		2	2		
27 - 28		3			
28 - 29					
29 - 30					

1989 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July *	August *	September *
0 - 22	31	9	1	13	22
22 - 23		11	1	4	
23 - 24		9	8	2	
24 - 25		1	10	1	
25 - 26			6		
26 - 27			1		
27 - 28					
28 - 29					
29 - 30					

*Incomplete Record ND = No Data Blank Square = no occurrences

1990 Daily Maximum Water Temperatures

Temp Category deg C	May	June *	July	August *	September
0 - 22	31	15	4		ND
22 - 23		3	2		ND
23 - 24		1	3		ND
24 - 25		1	10	2	ND
25 - 26		6	5		ND
26 - 27		3	6		ND
27 - 28			1		ND
28 - 29					ND
29 - 30					ND

*Incomplete Record ND = No Data Blank Square = no occurrences

1991 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July	August	September
0 - 22	31	28		2	28
22 - 23		2	1	8	2
23 - 24			6	9	
24 - 25			13	10	
25 - 26			11	2	
26 - 27					
27 - 28					
28 - 29					
29 - 30					

*Incomplete Record ND = No Data Blank Square = no occurrences

1992 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July	August	September
0 - 22	27	10	2	10	28
22 - 23	3	4	8		2
23 - 24	1	8	8	3	
24 - 25		3	7	10	
25 - 26		3	6	6	
26 - 27		1		2	
27 - 28		1			
28 - 29					
29 - 30					

*Incomplete Record ND = No Data Blank Square = no occurrences

1993 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July	August	September *
0 - 22	31	26	29	25	28
22 - 23		2	2	4	
23 - 24		2		2	
24 - 25					
25 - 26					
26 - 27					
27 - 28					
28 - 29					
29 - 30					

*Incomplete Record ND = No Data Blank Square = no occurrences

1994 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July	August	September
0 - 22	29	15	2	8	30
22 - 23	2	6	7	6	
23 - 24		2	9	8	
24 - 25		3	8	6	
25 - 26		4	5	3	
26 - 27					
27 - 28					
28 - 29					
29 - 30					

*Incomplete Record ND = No Data Blank Square = no occurrences

1995 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July *	August	September
0 - 22	31	30	2	ND	ND
22 - 23				ND	ND
23 - 24				ND	ND
24 - 25				ND	ND
25 - 26				ND	ND
26 - 27				ND	ND
27 - 28				ND	ND
28 - 29				ND	ND
29 - 30				ND	ND

*Incomplete Record ND = No Data Blank Square = no occurrences

1996 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July	August	September *
0 - 22	ND	ND	2	18	5
22 - 23	ND	ND	2	6	
23 - 24	ND	ND	4	5	
24 - 25	ND	ND	5	2	
25 - 26	ND	ND	1		
26 - 27	ND	ND			
27 - 28	ND	ND			
28 - 29	ND	ND			
29 - 30	ND	ND			

*Incomplete Record ND = No Data Blank Square = no occurrences

1997 Daily Maximum Water Temperatures

Temp Category deg C	May	June	July	August	September *
0 - 22	31	30	14	22	3
22 - 23			13	7	
23 - 24			4	2	
24 - 25					
25 - 26					
26 - 27					
27 - 28					
28 - 29					
29 - 30					

*Incomplete Record ND = No Data Blank Square = no occurrences

Appendix D

Guide To Interpreting Notched Box and Whisker Plots

Notched Box and Whisker Plot Elements

Medians

The median of the data (50% of the values below, 50% of the values above) is represented by the horizontal line inside the box.

The Notch

The box has pinched sides, or a "notch" around the median. The notch represents the 95% confidence interval for the median value. When the notch of one box does not overlap with the notch of another box, one can conclude with 95% confidence that a statistically significant difference exists between the medians of the two boxes being compared.

Hinges

The lines that form the top and the bottom of the box define the upper and lower quartiles of the data. Twenty-five percent of the values are less than the bottom of the box, and seventy five percent of the values are less than the top line of the box.

Hspread

The absolute value of the difference between the upper and lower hinges.

Whiskers

The whiskers are the vertical lines above and below the box that represent the values within plus or minus 1.5*Hspread of the upper and lower hinges.

Fences

The short horizontal lines at the ends of the whiskers shows the locations of the distances that are 1.5*Hspread greater than the upper and 1.5*Hspread less than the lower hinge.

Asterisks

Asterisks represent data that are more than 1.5*Hspread from a hinge, but are within 3*Hspread of a hinge.

Open Circles

Open circles represent data that are more than 3*Hspread above or below a hinge.

APPENDIX G

Sediment Conditions in the Lower Boise River

Sediment Problem Assessment for the Lower Boise River TMDL

PREPARED FOR: Lower Boise River Water Quality Plan
PREPARED BY: Stephen D. Miller
DATE: March 26, 1998

Regulatory Background

From the Diversion Dam to the Snake River, the lower Boise River is listed as water quality limited because of sediment. Cold water biota is a designated use for the entire lower Boise River from Lucky Peak Dam to the Snake River. Salmonid spawning is a designated use from Lucky Peak Dam to Caldwell, and it is an existing use from Caldwell to the Snake River.

Sediment-Related, General, and Aquatic Life Surface Water Quality Criteria

The following surface water quality criteria are from the Idaho Department of Health and Welfare Rules, Title 1, Chapter 2, "Water Quality Standards and Wastewater Treatment Requirements," Section 16.01.02-250.02(c) and (d), and Section 16.01.02-200.08.

Cold Water Biota

Turbidity, below any applicable mixing zone set by the Department of Health and Welfare, shall not exceed background turbidity by more than 50 nephelometric turbidity units (NTU) instantaneously or more than 25 NTU for more than 10 consecutive days.

Salmonid Spawning

During the spawning period and incubation for the particular species inhabiting the water, the intergravel dissolved oxygen concentration shall exhibit the following characteristics:

- One-day minimum of not less than 5.0 mg/L
- Seven-day average mean of not less than 6.0 mg/L

The time periods for salmonid spawning and incubation, as listed in the Idaho Water Quality Standards, are shown in Figure 1.

General (or Narrative)

Sediment shall not exceed quantities that impair designated beneficial uses.

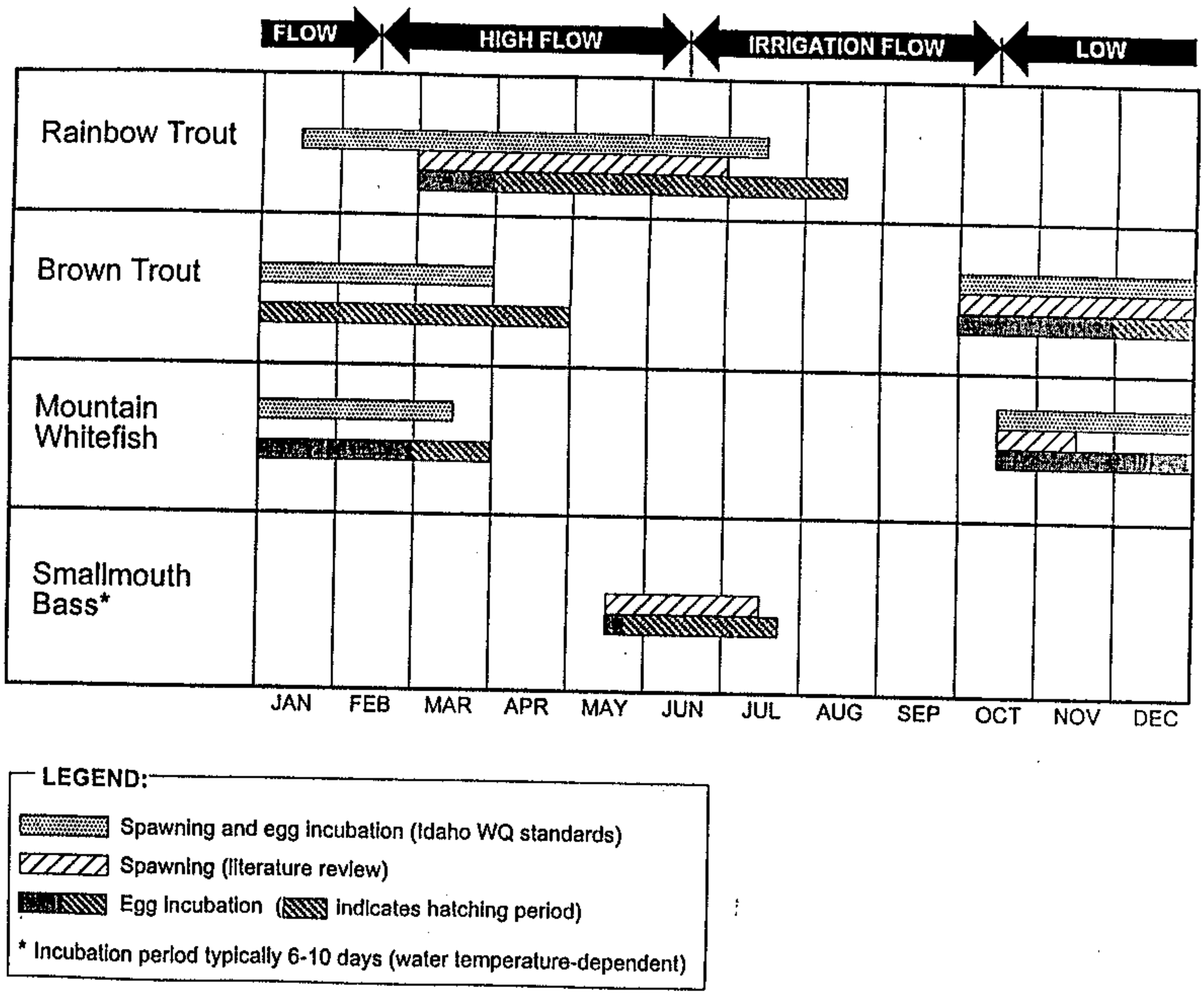


FIGURE 1
Spawning, Incubation, and Hatching Calendar

(Note: As part of the Lower Boise River Water Quality Plan, a literature review was conducted to determine the total suspended sediment (TSS) concentration limits for protection of the aquatic community in the lower Boise River. The recommended limits are a 50 mg/L geometric mean over 60 days (chronic), and an 80 mg/L geometric mean over 14 days (acute). See Appendix A for the basis of this recommendation.)

Summary of Existing Conditions

Background Information

An investigation of sediment in the river environment may involve characterizing either the water column or substrate conditions or both. Common measurements or indices used to quantify the sediment condition of either media follows:

Indices	Media
TSS concentration	Water column
Bed load sediment concentration	Water column/Substrate interface
Sediment particle size distribution	Water column or substrate
Embeddedness	Substrate
Intergravel dissolved oxygen concentration (on direct measurement of substrate quality for spawning)	Substrate

Water Column Sediment

Mass-Based. Sediment in the water column is typically classified by mode of transport—either suspended load or bed load. Suspended load refers to the material moving in suspension and sustained in the water column by turbulence or in colloidal suspension. Bed load is the coarse material moving in continuous or intermittent contact with the bed. Sediment load (either suspended or bed) is derived from sediment concentration and river discharge.

Turbidity. Turbidity is an optical property of water containing suspended material of unknown absolute concentration. Following are two citations presented by MacFarland and Peddicord (1980) that describe properties of turbidity:

- There is no predictable relationship between turbidities produced by equal mass concentrations of different materials (Pickering 1976).
- ...turbidity could be related to the mass concentration of particles only when the particles are of a uniform physical and chemical nature and instruments are calibrated against weighed samples (Kunkle and Comer 1971).

Substrate

Sieve analyses are used to develop particle (grain)-size distributions (PSDs) that describe the physical composition of a sediment sample. PSDs generated from sieve analyses represent the cumulative dry weight of the sample in various size fractions—boulder, cobble, gravel, sand, silt, and clay. Pebble count procedures are used in the field to develop PSDs based on a cumulative frequency distribution rather than a cumulative weight distribution.

Various indices can be computed from PSDs that reflect the quality of the substrate for a variety of aquatic uses such as spawning and rearing habitat, invertebrate production, and cover. Examples of such indices include the following:

- Median (D_{50}) particle size (Garde and Ranga Raju 1977)
- Geometric mean particle size (Platts and Shirazi 1979; Sowden and Powder 1985)
- Fine to coarse ratio (Dysart et al. 1973)
- Percent fines (Young et al. 1991; Adams and Beschta 1980; Sowden and Powder 1985)
- Fredle index (Lotspeich and Everest 1981; Sowden and Powder 1985)
- Gravel size (Witzel and MacCrimmon 1980)
- Percent composition of a given particle size class (Miller 1992)

Permeability is another measure of substrate quality (Chapman 1988); however, it can be obtained without a PSD.

Embeddedness, an optical measure that does not require a PSD, is the amount of fine sediment that is deposited in the interstitial space between larger substrate particles. For example, 30 percent cobble embeddedness means 30 percent of the cobble surface is fixed into surrounding sediment.

Significance of Flow as it Relates to Sediment

Flow, or discharge, is an important variable for studying sediment conditions in a river. The study of sediment transport is complex; however, two basic concepts should be understood:

- Sediment loads are a function of flow and sediment concentration (load = flow x concentration).

- Many variables other than flow influence sediment transport.

Velocity, for instance, is an important sediment transport parameter that is related to both flow and river-channel geometry. At any given flow, the sediment transport capacity can be different, depending on a number of variables such as channel geometry, channel slope, mean flow velocity, local velocity, particle size, and fluid density. Thus, variables other than flow are necessary for studying sediment transport problems such as incipient sediment motion, scour, armoring, and sediment deposition—all of which affect substrate quality for aquatic life purposes; however, only flow and sediment concentration are required to measure sediment loads in the water column.

Since flow and available TSS concentration data for the lower Boise River have been field-sampled (as opposed to modeled), no other information is required for computing water column sediment loads associated with the data. However, solutions to sediment transport problems, such as scour and deposition, cannot be determined from only flow and sediment concentration.

Lower Boise River Flow Regime

The flow regime in the lower Boise River changes on a seasonal basis in response to discharge requirements of the upstream reservoirs and the instream demands for irrigation. The flow regime can be partitioned into three predominant hydrologic seasons: high flow, irrigation flow, and low flow. The dates that define each period are somewhat arbitrary and, in general, are intended to encompass the flow characteristics of that period. But because the system is dynamic, some overlap was expected. Low flow corresponds to flows occurring from October 15 through February 14, the period of lowest flow for the lower Boise River. February 15 through June 14 marks the high-flow season as the reservoir pool levels peak and operators initiate discharge to adjust for snowmelt runoff, and to provide water for the beginning of irrigation season (around April 15). Flows occurring from June 15 through October 14 represent the irrigation-flow season, a period of more stable flows, involving diversions and returns to the river.

Lower Boise River Data

Monitoring Locations and Dates

Water Column Sediment. TSS concentrations, turbidities, and sediment loads were measured at four (water quality) locations along the main stem lower Boise River: 1) below Diversion Dam; 2) Glenwood Bridge; 3) Middleton; and 4) Parma. TSS concentrations and sediment loads (no turbidities) were measured at the mouth of 12 tributaries, upstream of any main stem backwater influence. The 12 tributaries are listed here in order of upstream to downstream location:

Tributary Name	Location Relative to Main Stem Monitoring Locations
Eagle Drain	Between Glenwood Bridge and Middleton
Thurmon Drain	Between Glenwood Bridge and Middleton
Fifteenmile Creek	Between Middleton and Parma
Mill Slough	Between Middleton and Parma
Willow Creek	Between Middleton and Parma
Mason Slough	Between Middleton and Parma
Mason Creek	Between Middleton and Parma
E. Hartley Drain	Between Middleton and Parma
W. Hartley Drain	Between Middleton and Parma
Indian Creek	Between Middleton and Parma
Conway Gulch	Between Middleton and Parma
Dixie Drain	Between Middleton and Parma

Sampling dates for all locations and parameters are listed in Appendix B.

Substrate. Pebble counts and percent embeddedness were measured at three locations in the main stem lower Boise River during a Level I and II habitat survey (Meador et al. 1993) in November 1997 and January 1998. The three locations (relative to the water quality monitoring locations) were: 1) below Eckert Road (between Diversion Dam and Glenwood Bridge); 2) Middleton; and 3) at the mouth (downstream of Parma).

Flow. Daily average flows were obtained from published U.S. Geological Survey (USGS) records for the gages located at each of the four main stem water quality stations. Daily average flows for the 12 tributaries were obtained from the Idaho Department of Water Resources. Additionally, instantaneous flow measurements were performed at all sampling locations whenever TSS concentrations were measured.

Flow data from water year 1990 through current records were used to generate flow statistics for all the sampling locations. Statistics generated from flow records beginning with water year 1955 and 1990 were found to be comparable at each of the main stem USGS gages. Figure 2 illustrates that annual discharges during the 1990s span the entire range of historical annual discharges measured at the Boise River USGS gage (13202000) located at Lucky Peak Dam. Because of the comparable statistics, and the fact that the majority of water quality data were collected during the 1990s, and because flows from this time period are more reflective of current land use practices and development, only the 1990s flow statistics were used for computing seasonal TSS loads.

TSS Concentrations, Median Flows, and TSS Loads

Appendix B contains the sampling date, instantaneous discharge, turbidity, TSS concentration, and sediment load (computed from instantaneous discharge) for all monitoring locations as reported by the USGS. Appendix C contains the normal and log-transformed TSS concentration data for all monitoring locations and seasons.

The "Parma (Historical)" data set, shown in Appendix C, consists of intermittent data from 1974 through 1997 (see the dates in Appendix B). The "Parma 1990s" data set consists of data from the 1990s only. Because the summary statistics generated from the historical data are very similar to the 1990s data, and because the 1990s data are more representative of current land use practices, and the time period is consistent with that used for the flow analysis, statistics from the "Parma 1990s" data are presented and analyzed hereafter.

Applying the statistical methodology described in Appendix E of the *Technical Support Document For Water Quality-based Toxics* (USEPA 1991) to the main stem data (minimum sample size, n = 30), the TSS concentrations were found to be lognormally distributed. The TSS concentration data for the tributaries (smaller n values) were assumed to be lognormally distributed. Therefore, the statistics (geometric mean and 90th percentile) used to describe the TSS concentration data will be based on the log-transformed data shown in Appendix C.

When the data were split into three seasons, the resulting sample size at seven tributaries was <4 during the irrigation season. Four of the same tributaries have a sample size <4 during the low-flow season. However, because the TSS concentration data exhibited a

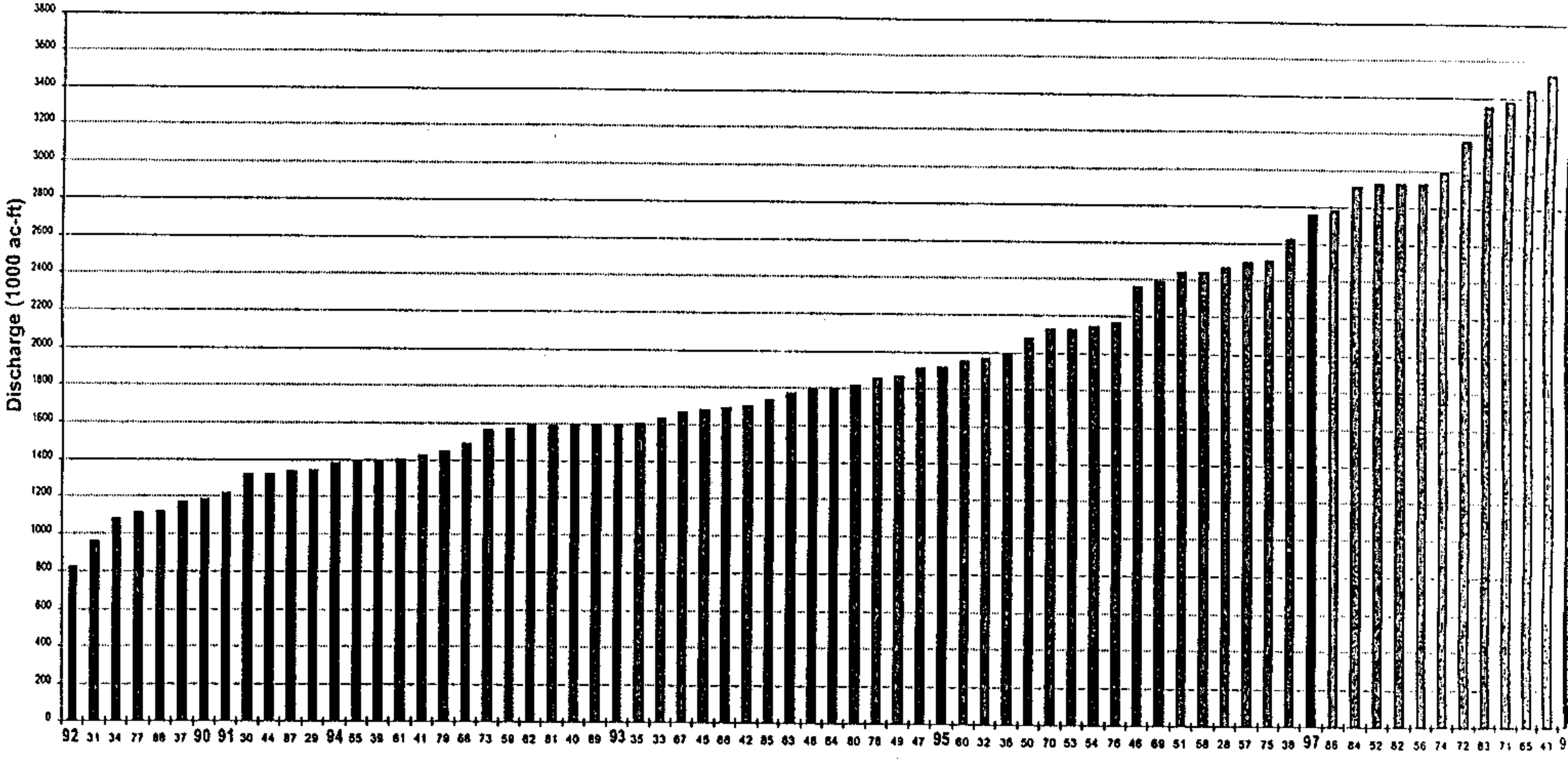


FIGURE 2
Ranking of Total Annual Discharge at USGS Station Boise River NR Boise (1928-1997) Located at Lucky Peak

seasonal trend at the other nine locations (where n≥4), a relationship was developed from these tributaries and used to estimate the irrigation- and/or low-flow season geometric mean and 90th percentile concentrations where needed (Appendix D). The complete list of sample sizes, geometric means, and 90th percentile TSS concentrations for all monitoring locations is presented in Appendix D.

Note that a location named "Hartley (combined)" is included in Appendix D. This location represents the water quality just downstream of the confluence of East Hartley Drain and West Hartley Gulch. TSS concentration data for this location were generated using a mass balance of the daily average flows and TSS concentrations measured on the same day in East Hartley Drain and West Hartley Gulch (mass balance based on n = 15).

Geometric Mean and 90th Percentile TSS Concentrations. Figures 3 and 4 illustrate the seasonal geometric mean and 90th percentile TSS concentrations, respectively, in the main stem lower Boise River. Statistics for the data, undivided by season, are presented for comparison. Both figures illustrate the recommended TSS concentration limits (Appendix A) for supporting the narrative sediment criteria listed above.

The following conclusions can be drawn from these two figures:

- Low-flow season geometric mean and 90th percentile TSS concentrations do not exceed 42 mg/L in the main stem.
- Geometric mean and 90th percentile TSS concentrations from Below Diversion Dam and Glenwood Bridge do not exceed 45 mg/L during any season.
- 50 mg/L TSS is exceeded at Parma during the high- and irrigation-flow seasons based on the geometric mean and 90th percentile concentrations and at Middleton during the high-flow season based on the 90th percentile concentration.

Figures 5 and 6 show the same parameters for the tributaries. Some conclusions that can be drawn from these figures are the following:

- TSS concentrations are lowest during the low-flow season (the only exceptions occur at Indian Creek and Willow Creek).
- In general, the TSS concentrations are higher in the tributaries than in the main stem.
- Mason Creek, Conway Gulch, and Fifteenmile Creek have the highest TSS concentrations during the high-and irrigation-flow seasons.

Median Flows. Figures 7 and 8 illustrate the seasonal median flows (computed from daily average flows) at the main stem and tributary sampling locations, respectively. A number of significant observations pertaining to Figure 7 follow:

- During the high- and irrigation-flow seasons, the median flows decrease from a maximum at Below Diversion Dam to a minimum at Middleton, and then increase again between Middleton and Parma.
- Only during the low-flow season does the magnitude of the median flow increase in a downstream direction.

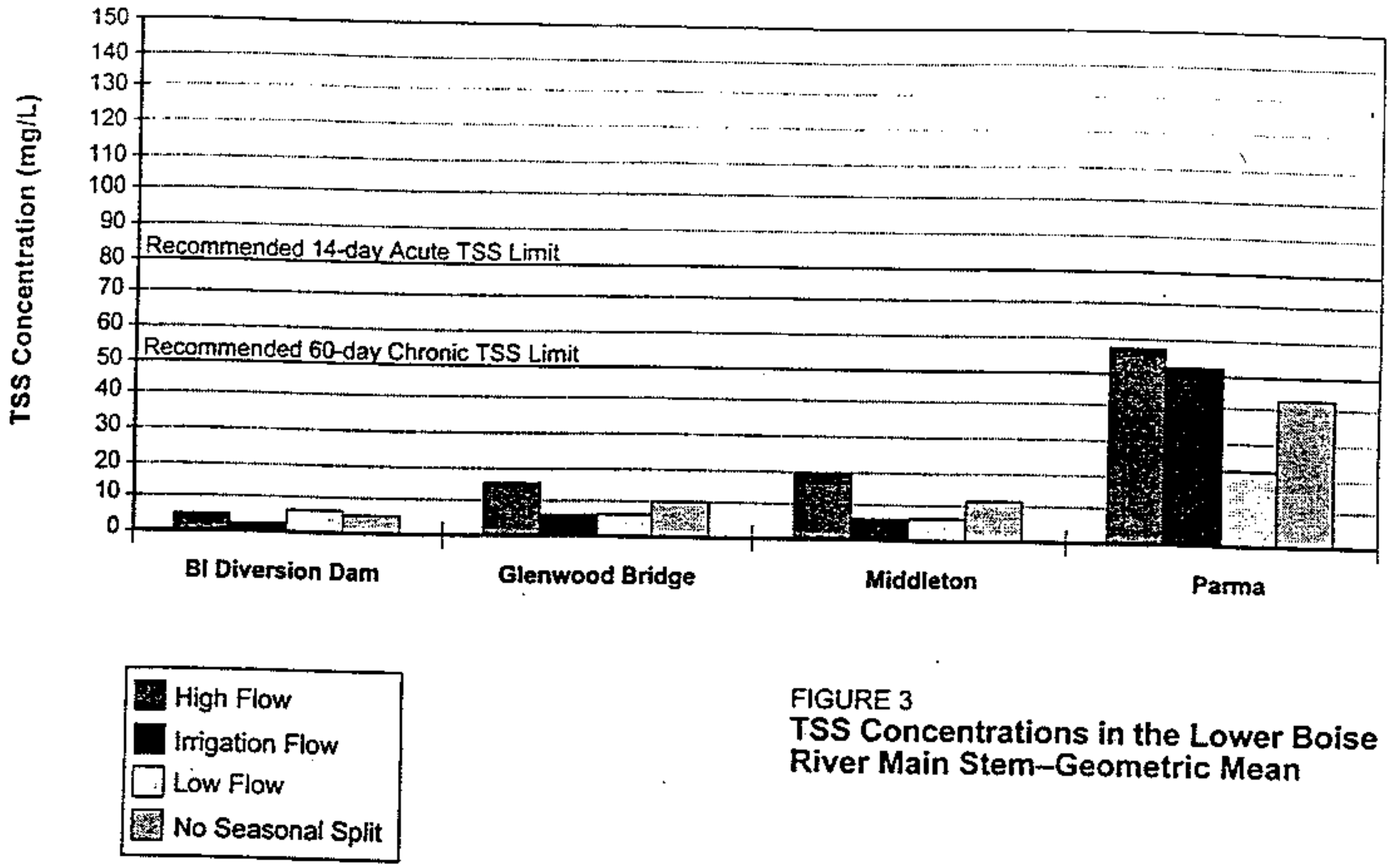


FIGURE 3
TSS Concentrations in the Lower Boise River Main Stem–Geometric Mean

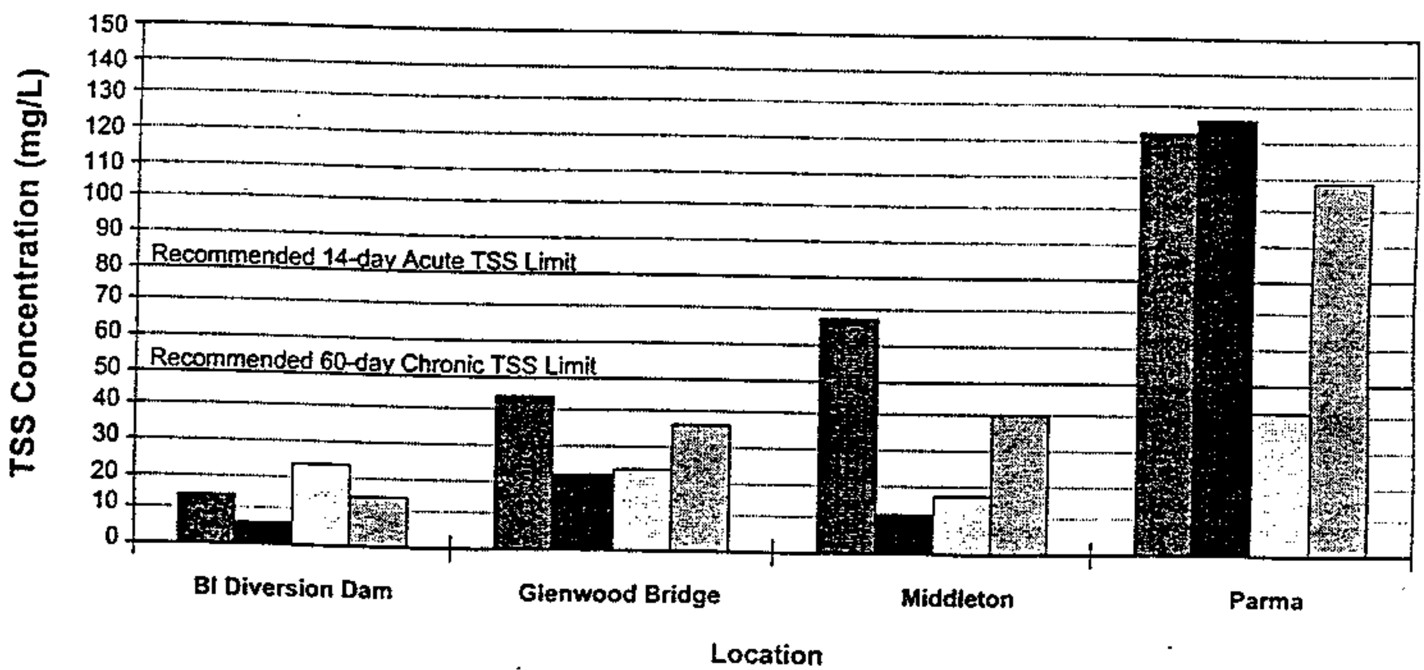


FIGURE 4
TSS Concentrations in the Lower Boise River Main Stem–90th Percentile

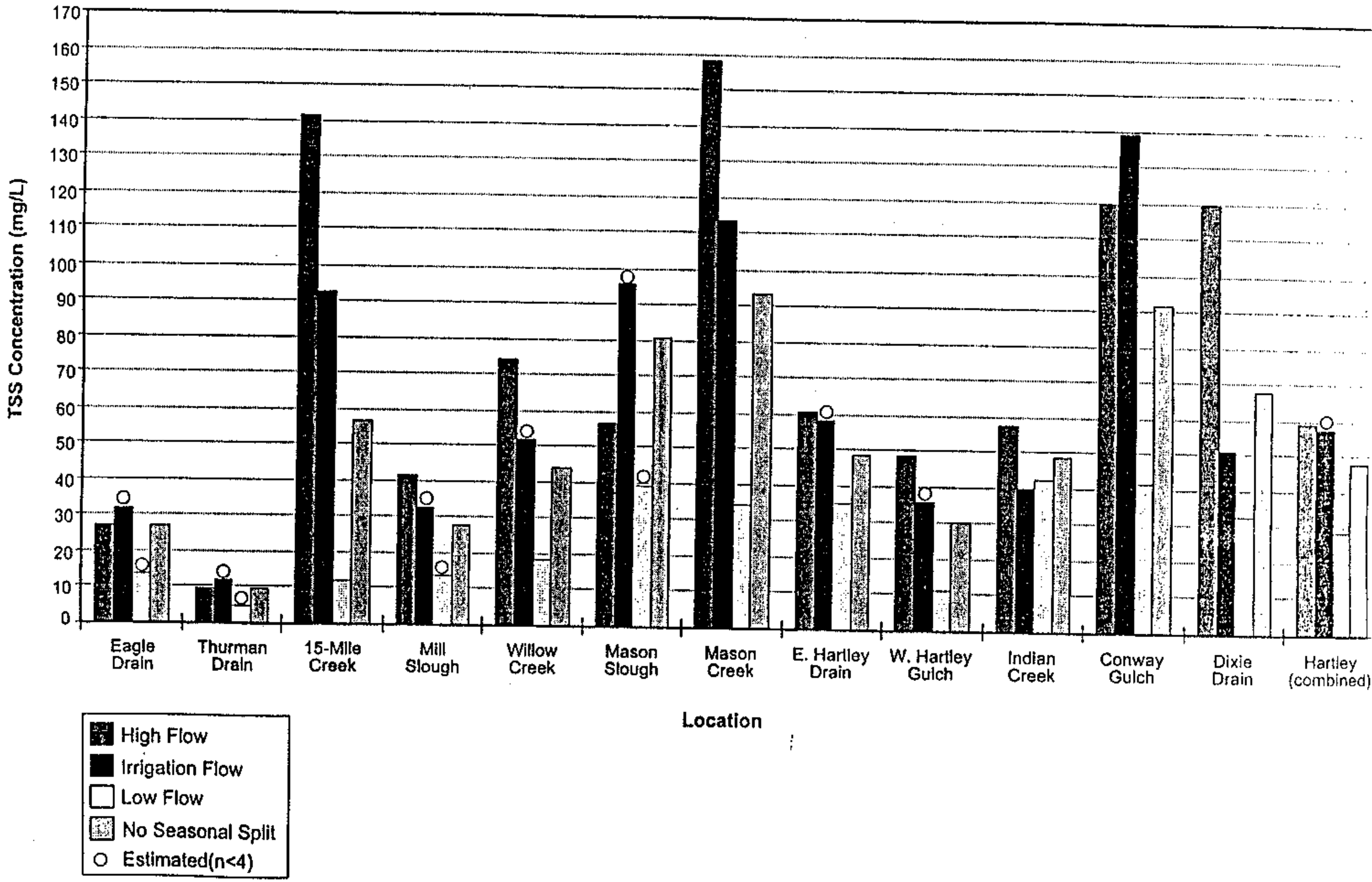


FIGURE 5
TSS Concentrations in the Lower Boise River Tributaries–Geome ic Mean

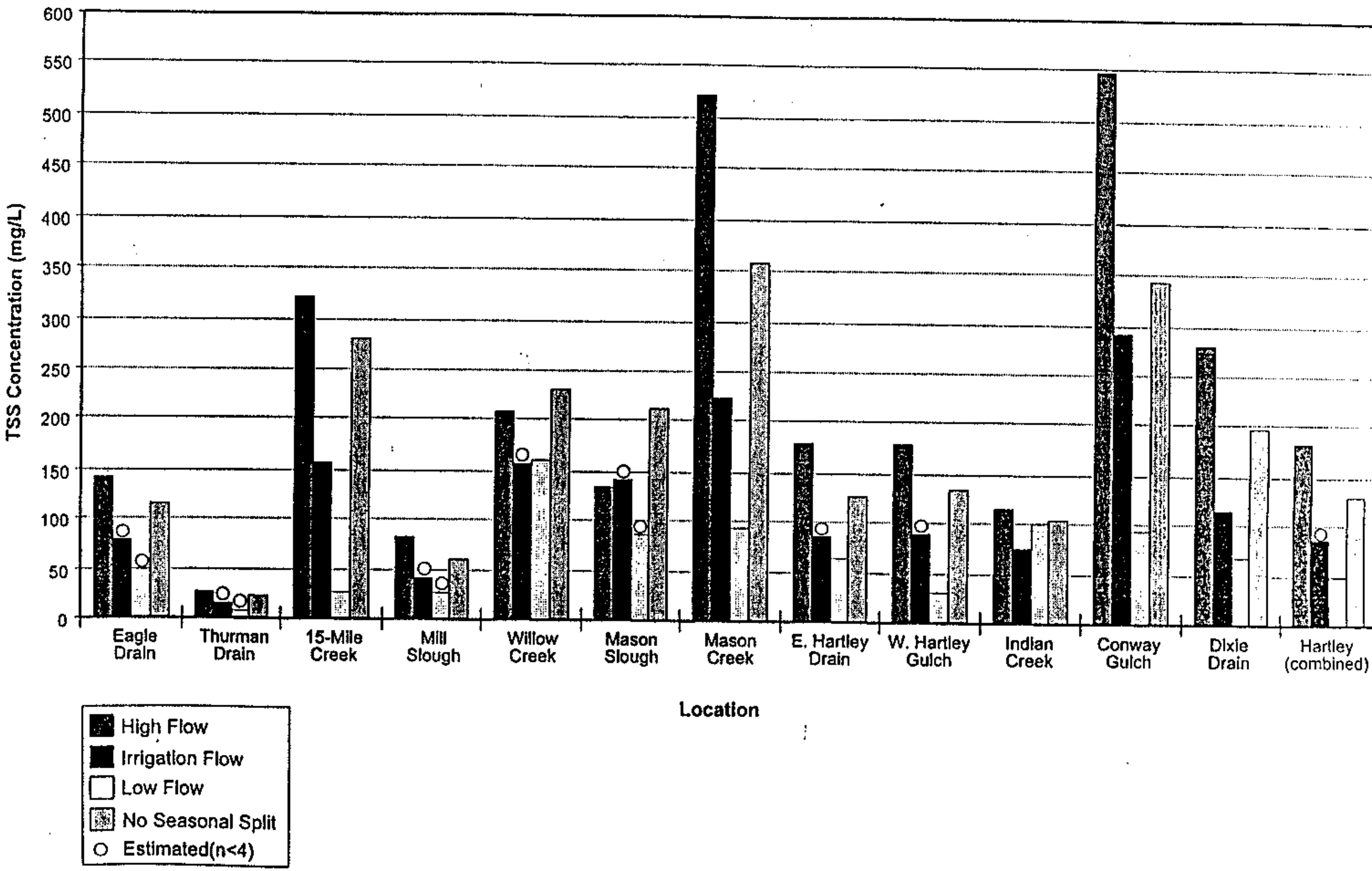


FIGURE 6
TSS Concentrations In the Lower Boise River Tributaries–90th Percentile

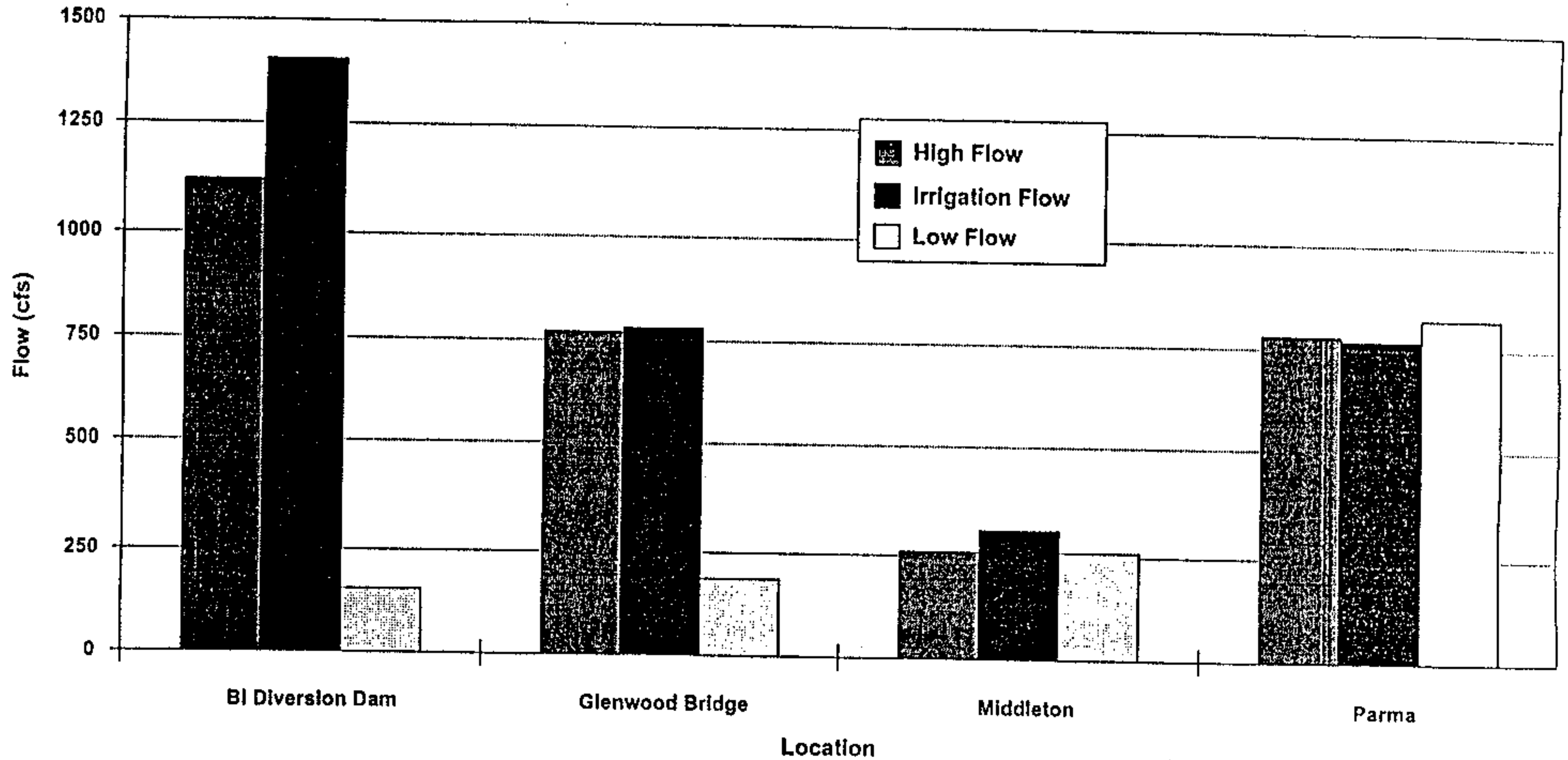


FIGURE 7
Lower Boise River Main Stem Median Flows

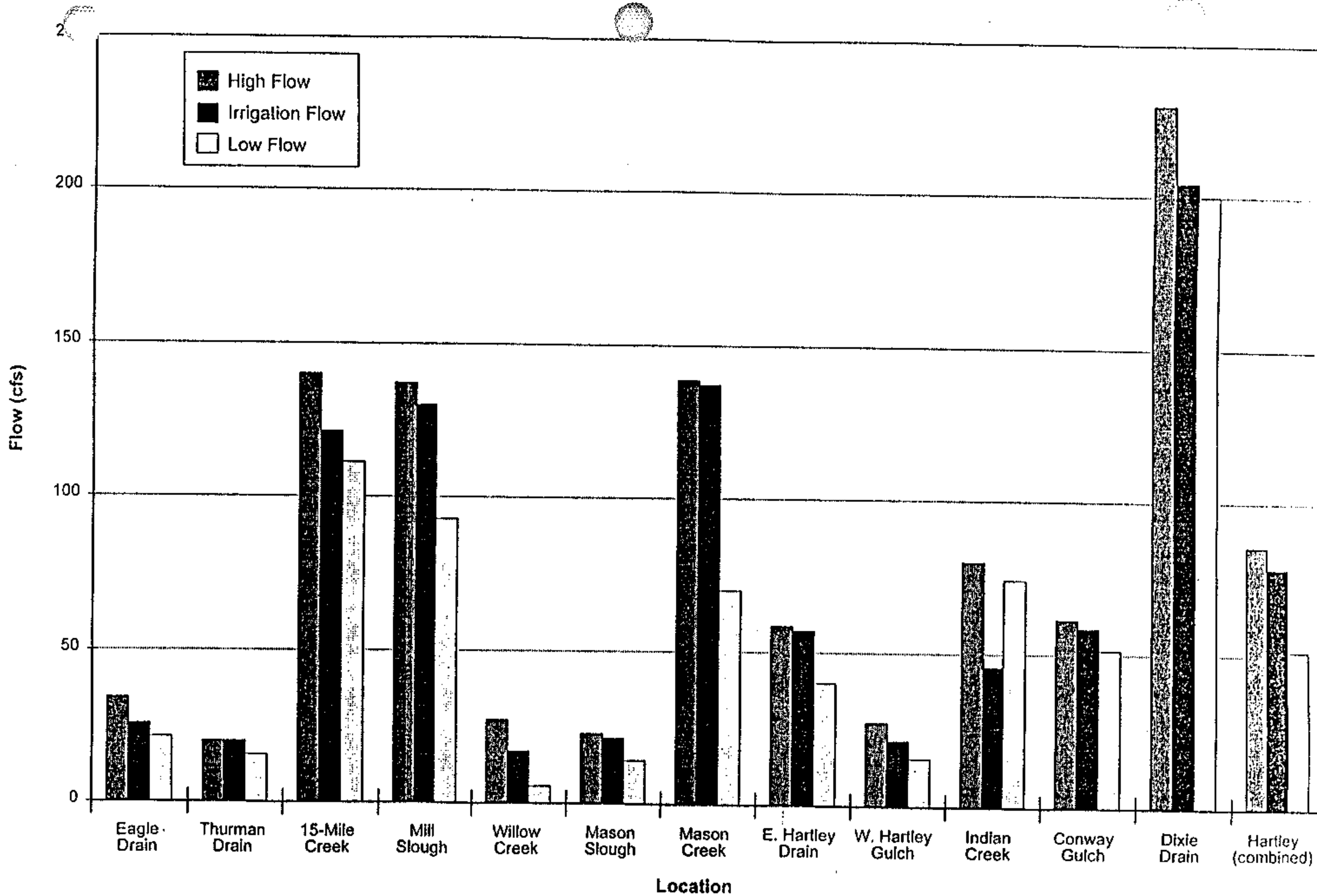


FIGURE 8
Lower Boise River Tributaries–Median Flows

- At the upper two stations, the median flows are significantly greater during the high- and irrigation-flow seasons compared to the low-flow season; however, there is essentially no seasonal difference in median flows at each of the lower two stations.

All three of these observations can be attributed, at least in part, to: 1) significant diversions during the high- and irrigation-flow seasons upstream of Middleton; and 2) significant return flows (via surface or groundwater) during all seasons downstream of Middleton.

Figure 8 shows that the tributaries with the highest median flows (in descending order) are as follows:

- Dixie Drain
- Fifteenmile Creek, Mill Slough, and Mason Creek (all similar in magnitude)
- Indian Creek and Hartley (combined)
- Conway Gulch

TSS Loads Based on Median Flows and Geometric Mean and 90th Percentile Concentrations. Main stem seasonal TSS loads are shown in Figures 9 and 10. TSS loads based on geometric means range from 4 (high-flow season) to 19 (irrigation-flow season) times higher at Parma than the upstream stations. During the high- and irrigation-flow seasons, when median flows are comparable at Parma and Glenwood, TSS loads based on geometric means range from 4 to 7 times higher at Parma. Based on the significant difference in flows at Middleton and Parma, and the relatively high TSS concentrations at Parma, the largest increase in TSS load—between any to main stem monitoring locations—occurs between Middleton and Parma during the high- and irrigation-flow seasons. The trends are similar based on TSS loads computed from the 90th percentile concentration.

Figures 11 and 12 illustrate TSS loads in the 12 tributaries computed from median flows and geometric mean and 90th percentile concentrations, respectively. In terms of highest TSS loads, the three most significant tributaries are the following:

- Dixie Drain
- Mason Creek
- Fifteenmile Creek

These three are followed by Conway Gulch, Mill Slough, and Hartley (combined). Based on the TSS loads computed from the geometric mean concentration, the load at Conway Gulch is approximately four times lower than the high-flow season load at Dixie Slough and the irrigation-flow season load at Mason Creek. The low-flow season TSS loads are lower than both the high- and irrigation-flow season loads at all locations except Indian Creek.

For each of the three seasons, Figures 13, 14, and 15 show the main stem, measured TSS loads compared to those computed from the recommended TSS concentration limits (Appendix A), and median flows. The only location and seasons for which the 50 mg/L target load is exceeded by the measured load—based on the geometric mean concentration—is at Parma during the high- and irrigation-flow seasons. Similarly, only during the high-flow season at Middleton and the high- and irrigation-flow seasons at Parma does the measured load—based on the 90th percentile concentration—exceed either the 50 mg/L or 80 mg/L target loads.

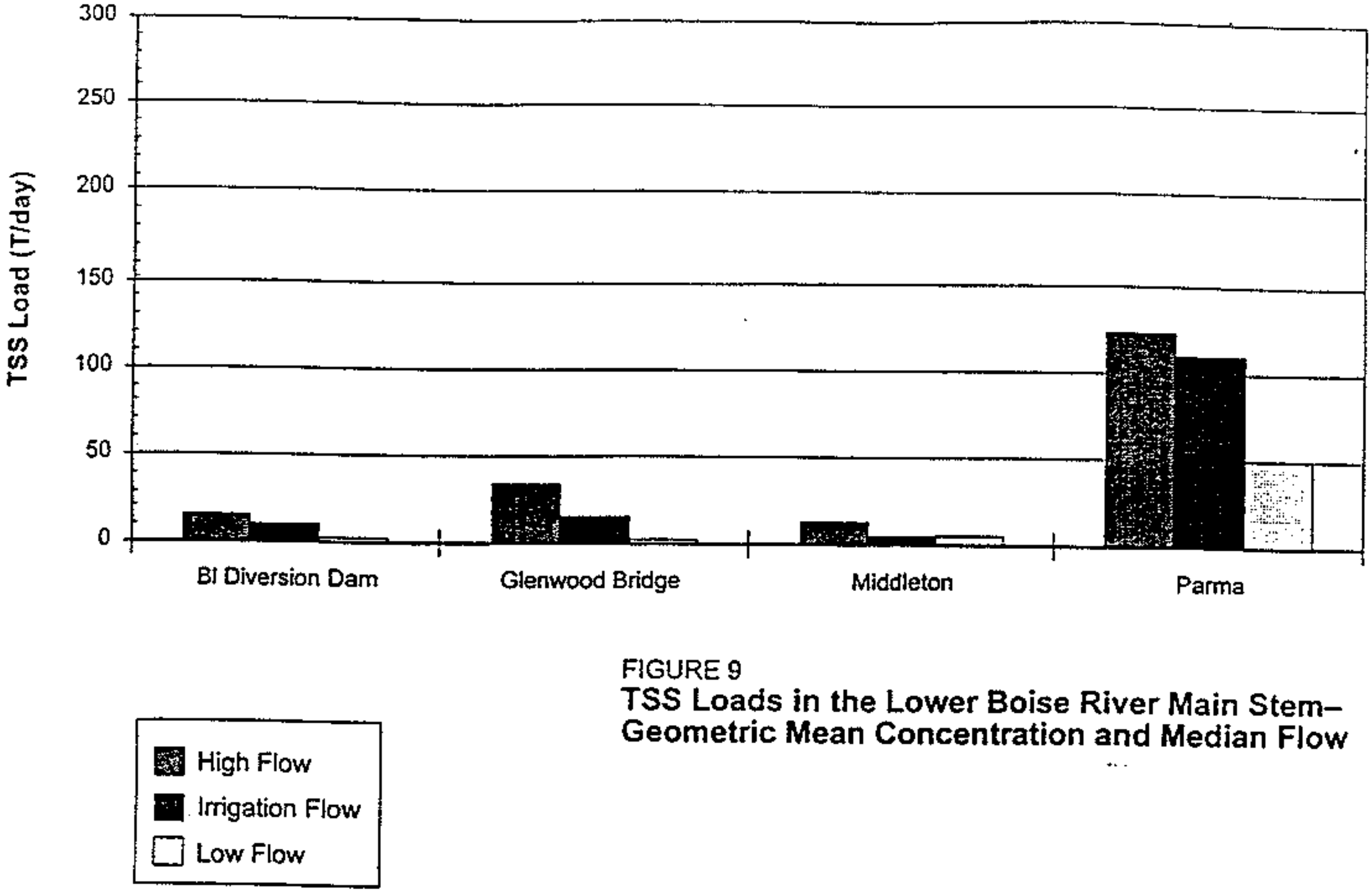


FIGURE 9
TSS Loads in the Lower Boise River Main Stem–Geometric Mean Concentration and Median Flow

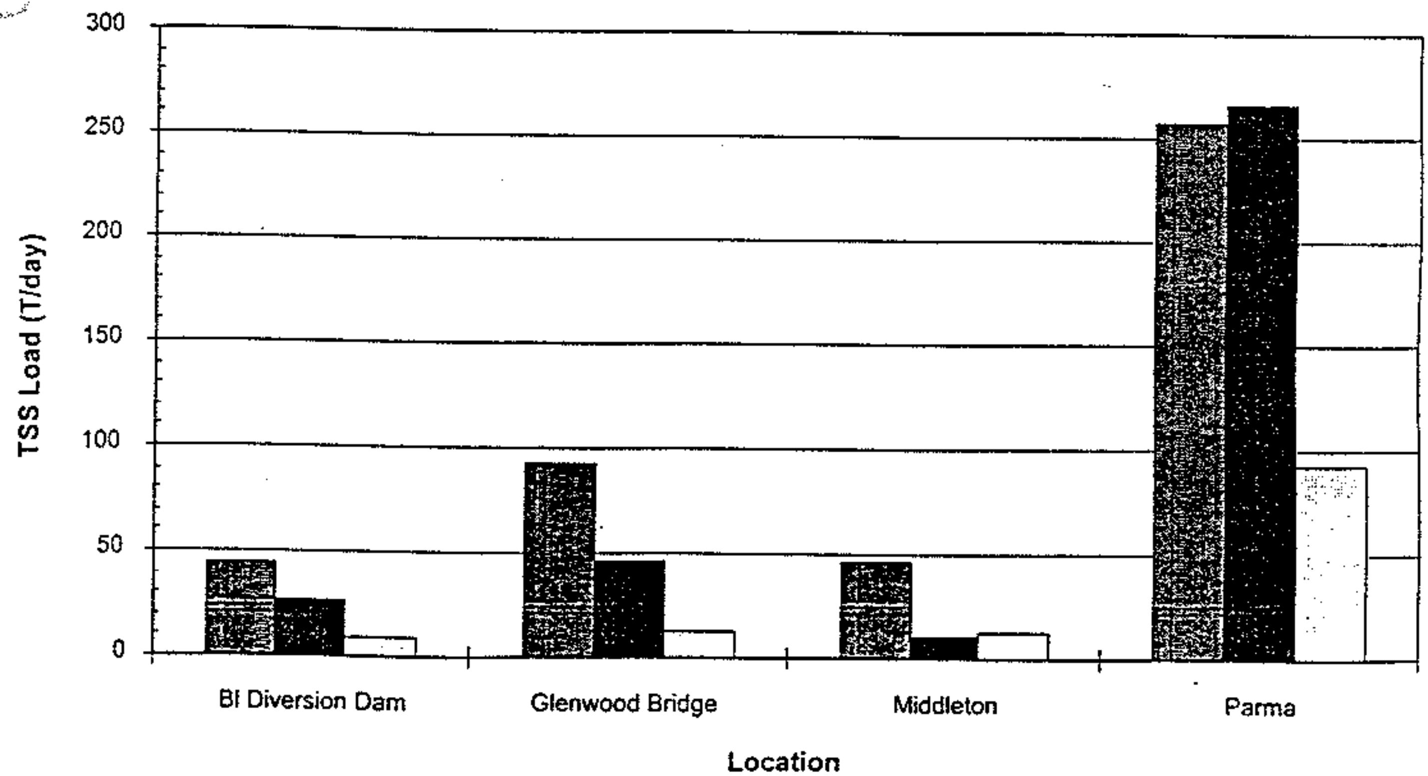


FIGURE 10
TSS Loads in the Lower Boise River Main Stem–90th Percentile Concentration and Median Flow

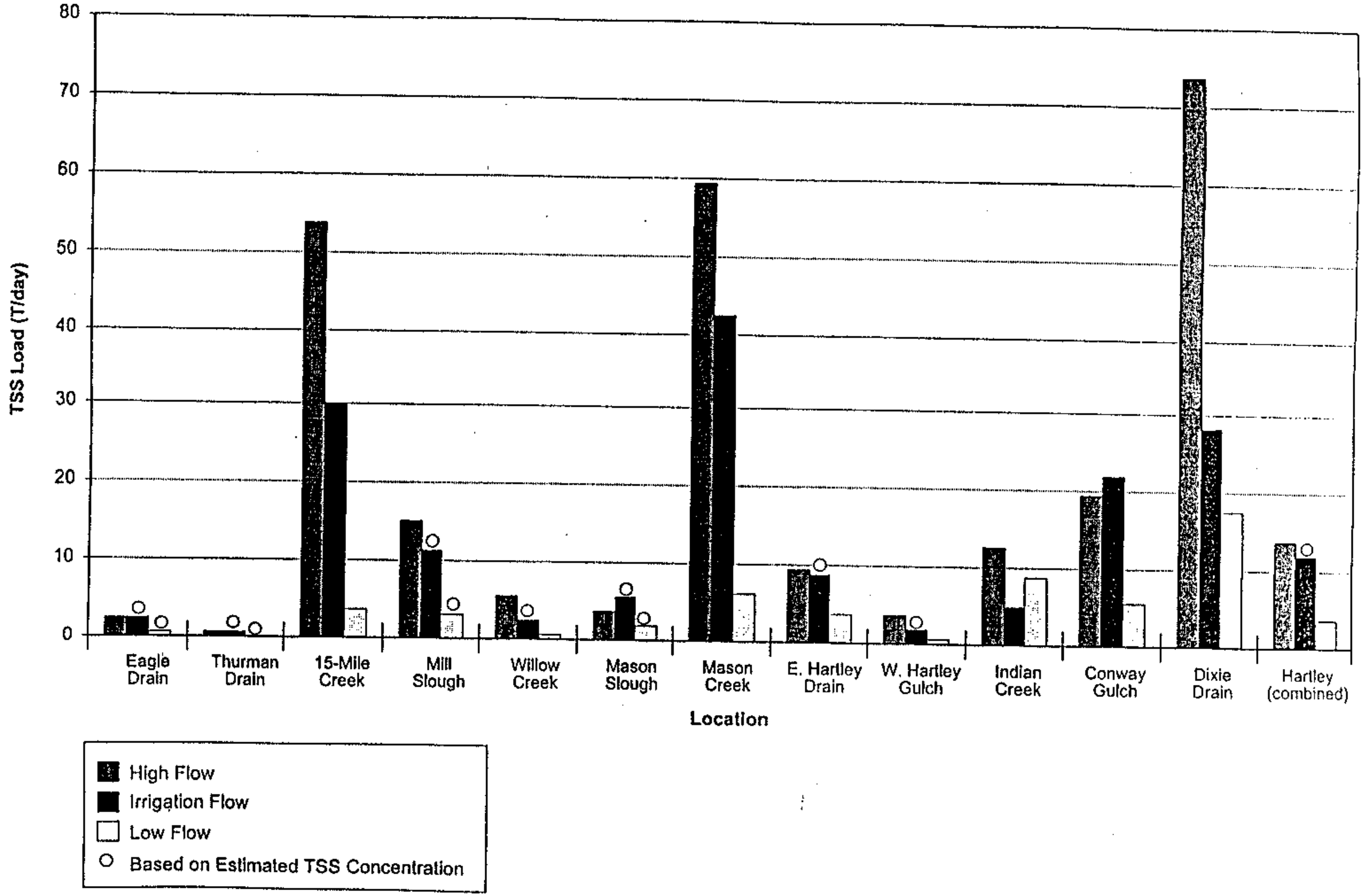


FIGURE 11
TSS Loads in the Lower Boise River Tributaries–Geometric Mean Concentration and Median Flow

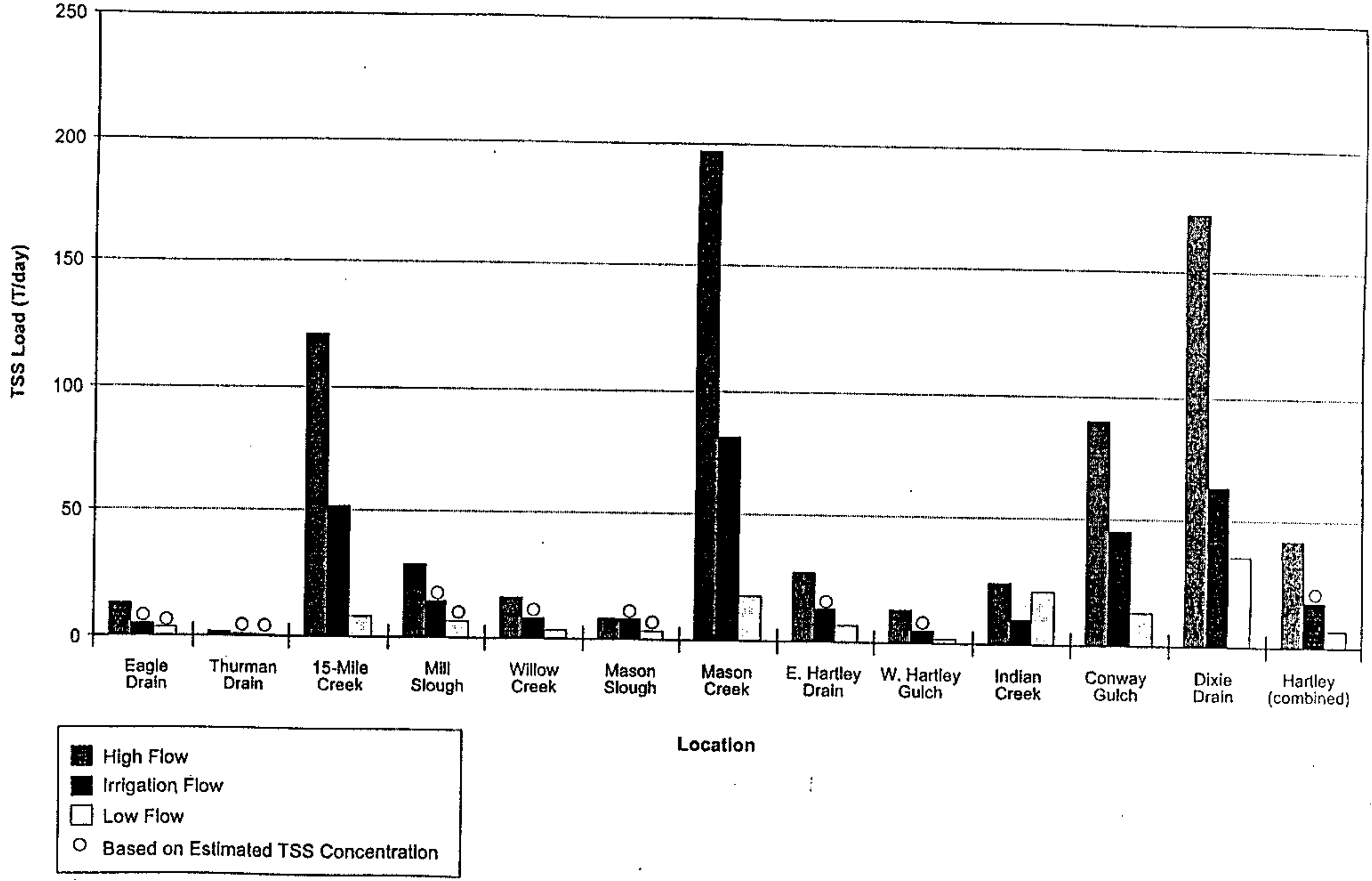


FIGURE 12
TSS Loads in the Lower Boise River Tributaries–90th Percentile Concentration and Median Flow

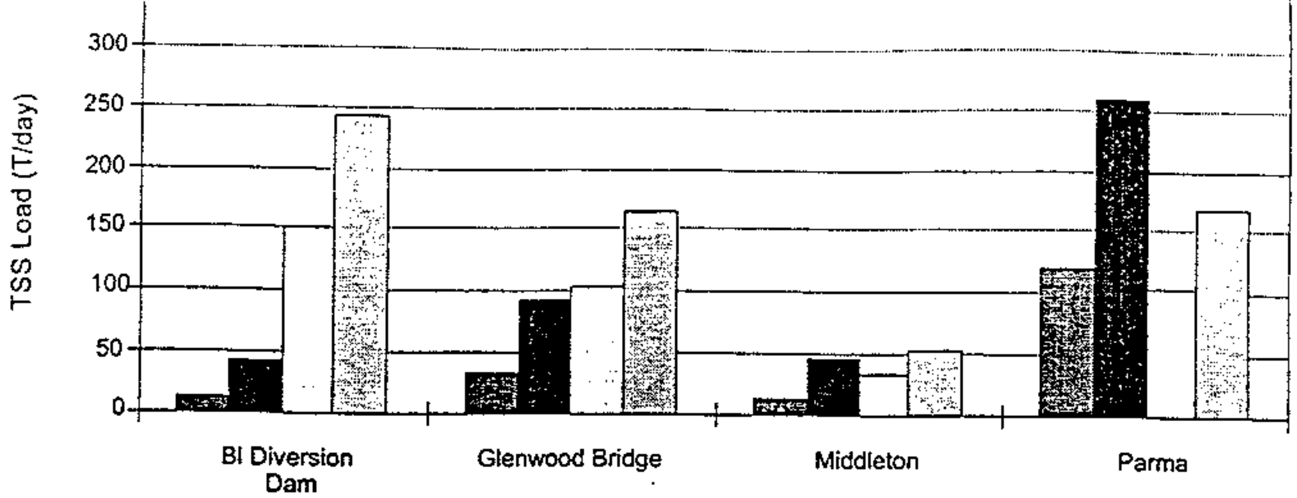


FIGURE 13
Lower Boise River Main Stem TSS Loads High-Flow Season–Median Flow and Existing and Target Concentrations

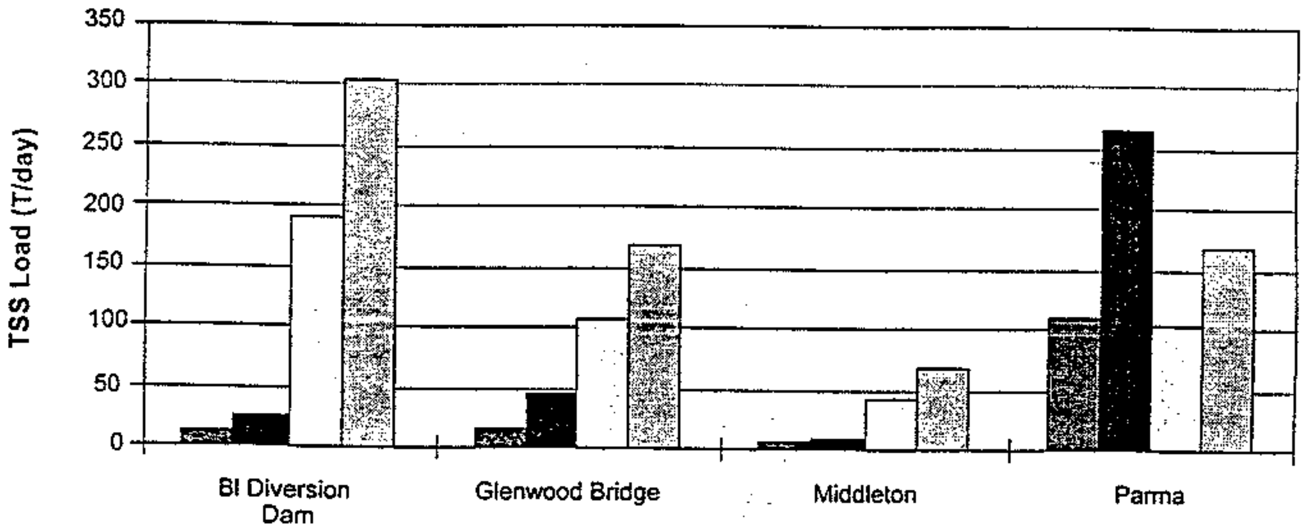


FIGURE 14
Lower Boise River Main Stem TSS Loads Irrigation-Flow Season–Median Flow and Existing and Target Concentrations

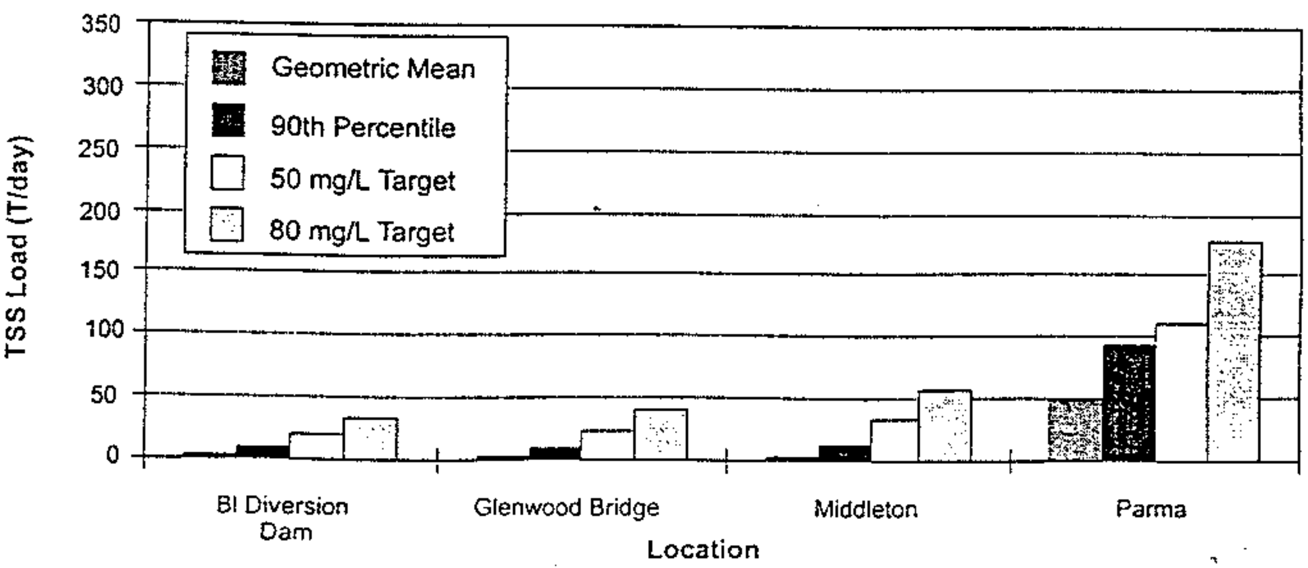


FIGURE 15
Lower Boise River Main Stem TSS Loads Low-Flow Season–Median Flow and Existing and Target Concentrations

Turbidity

Main stem seasonal averages and ranges of turbidity are shown in Figures 16, 17 and 18. Turbidities average less than 5 NTU at the three upstream monitoring locations during all seasons. Parma averages less than 15 NTU during all three seasons. The maximum turbidity of 37 NTU was measured at Parma during the irrigation-flow season.

Figure 19 presents main stem turbidity and TSS concentration data pairs that were sampled on the same day. A linear regression line through the Parma data ($r^2 = 0.66$) indicates that at this location, relatively low turbidities are associated with relatively high TSS concentrations. The State water quality criteria for cold water biota states that turbidity shall not exceed background by more than 50 NTU instantaneous or more than 25 NTU for more than 10 consecutive days. As mentioned above, the maximum turbidity measured in the lower Boise River is 37 NTU. At Parma, based on the regression shown in Figure 19, turbidities >25 NTU would be associated with TSS concentrations >100 mg/L. Because TSS concentrations >100 mg/L are not supportive of the narrative criteria (Appendix A), the existing turbidity standard is not protective of the aquatic life at Parma.

Substrate

Chapman and McLeod (1987) provide a detailed review of the relationship between percent embeddedness and fish densities in the Northwest. Although a variety of relationships (with varying degrees of significance) were found, in general, it could be said that salmonid densities tend to be lower in areas with 50 percent embeddedness or higher.

Figure 20 presents percent embeddedness estimates for the main stem lower Boise River. The mean percent embeddedness for the sampling locations near Middleton and the mouth of the Boise River is ≥ 50 percent. At the location below Eckert Road (between the Diversion Dam and Glenwood Bridge), the mean percent embeddedness ranged from 25 to 50 percent. Data in Figure 20 are based on one sampling event.

Lisle and Eads (1991) reported that thresholds of concern for fine sediment content vary between experiment, species, and grain size of fine sediment, but most commonly fall around 20 percent (see also: Witzel and MacCrimmon 1980; Maret et al. 1993; and Waters 1995). Based on the pebble count data presented in Figure 21, the 20 percent-fines threshold was exceeded in the Boise River near Middleton and the mouth during one event in December 1997 and January 1998, respectively. No silt-sized particles were found at the Eckert Road site; however, sand particles comprised 17 percent of the substrate. The remainder of the substrate at all three sites was comprised mainly of medium gravel to large cobble.

Although the only sediment-related measure pertaining to the salmonid spawning criteria is intergravel dissolved oxygen concentration, the two data sets presented here suggest that the substrate is not conducive to salmonid spawning, at least near Middleton and at the mouth of the river—although whitefish *may* be the exception since they are broadcast spawners. In addition, based on field studies at Rock Creek in south-central Idaho, Maret et al. (1993) determined that mean intergravel dissolved oxygen concentrations should exceed 8.0 mg/L in redds to ensure at least 50 percent survival during the pre-emergence stage. They determined for their study site that sediment with more than 15 percent fines may reduce intergravel dissolved oxygen concentrations to unacceptable levels for survival during incubation.

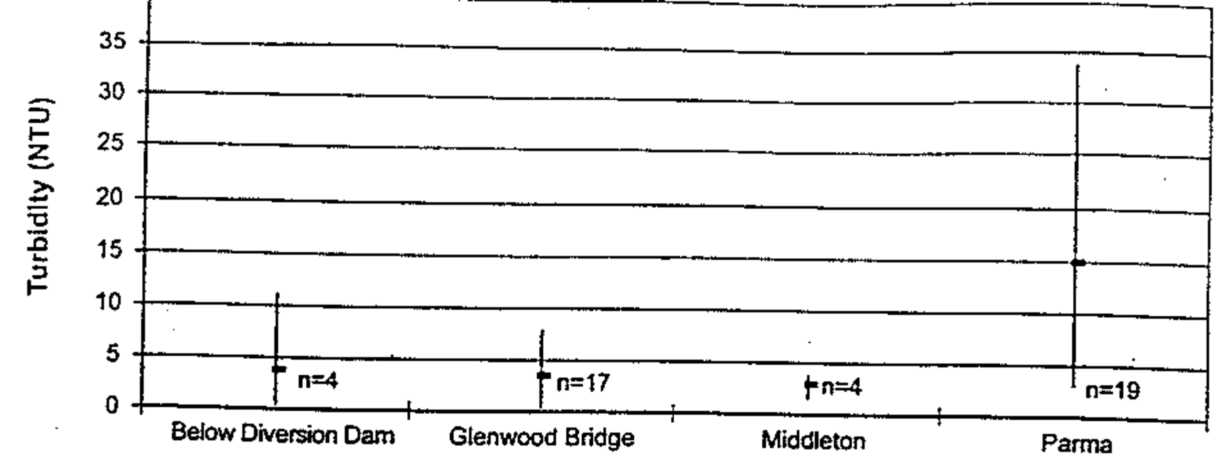


FIGURE 16
Lower Boise River Turbidity–Averages and Ranges During High-Flow Season

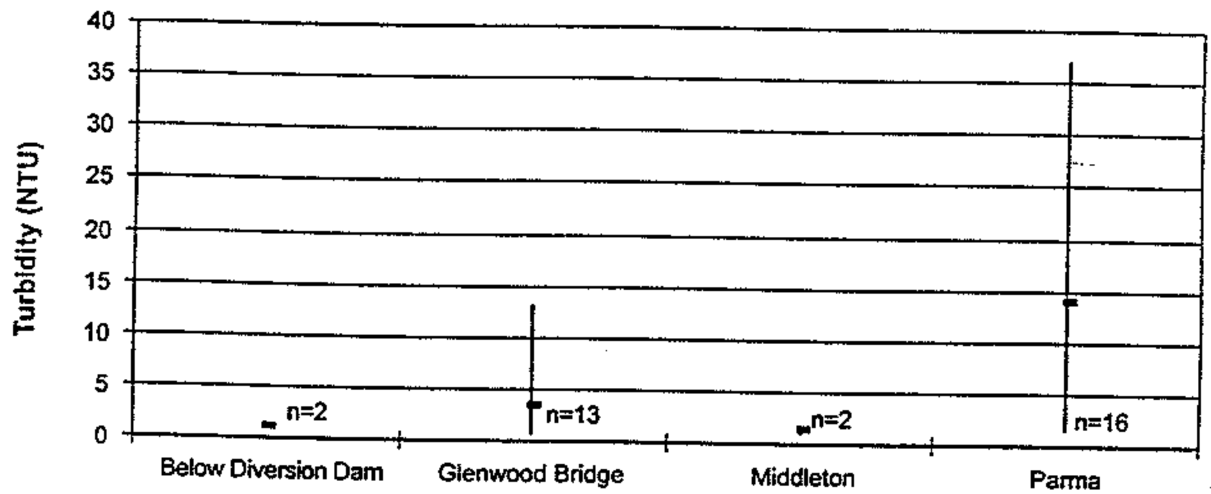


FIGURE 17
Lower Boise River Turbidity–Averages and Ranges During Irrigation-Flow Season

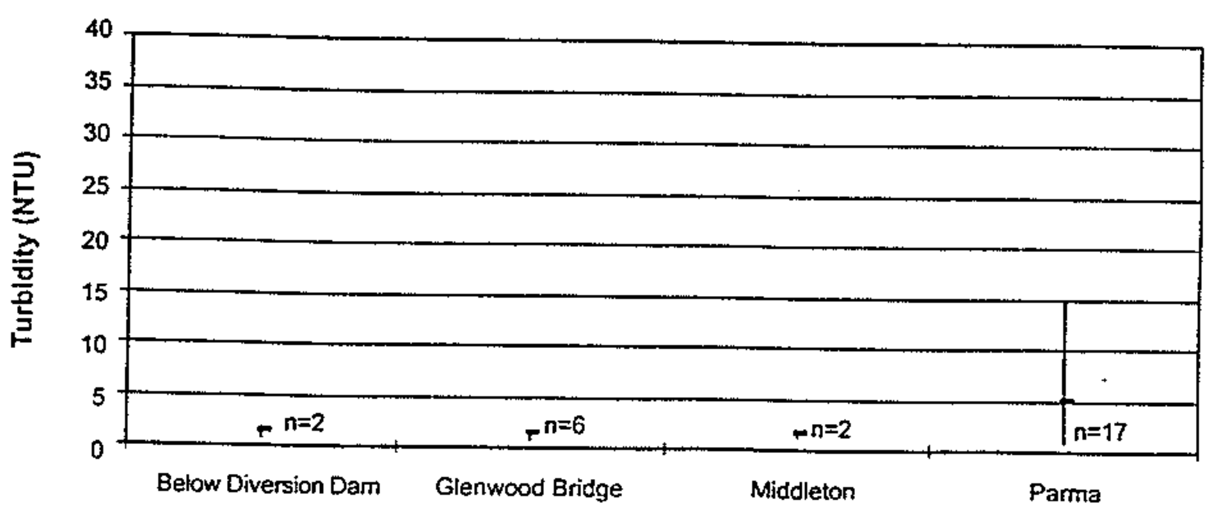


FIGURE 18
Lower Boise River Turbidity–Averages and Ranges During Low-Flow Season

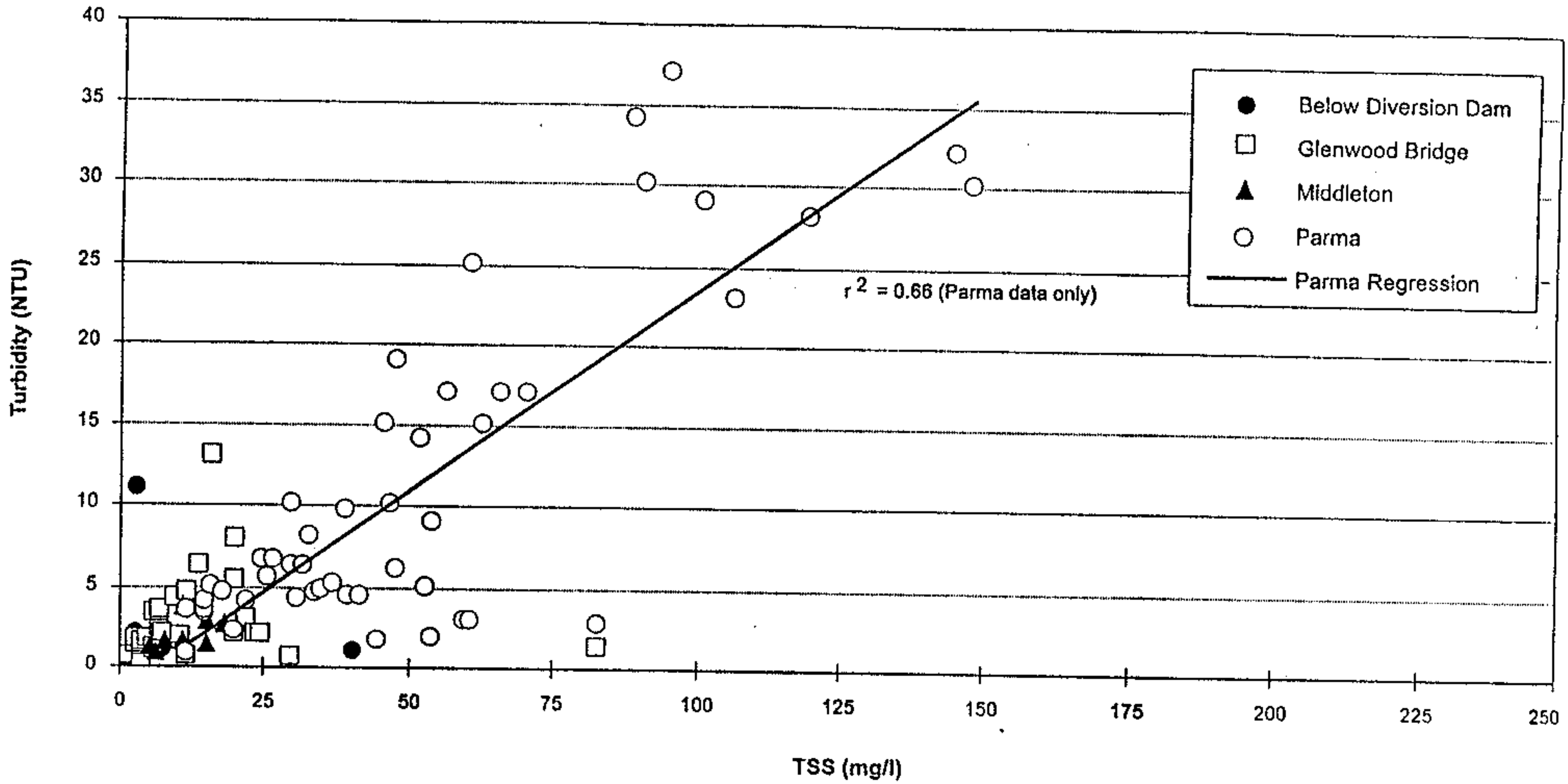


FIGURE 19
Lower Boise River Main Stem–
Turbidity Versus TSS Concentration

Boise River Below Eckert Road:

Station	Deepest Point	1/3	2/3	Mean	% Embeddedness (approx.)
Tran 1 (Deep Run)	2	2	2	2.0	
Tran 2 (Riffle)	3	4	3	3.3	
Tran 3 (Run/Pool)	4	2	2	2.7	
Tran 4 (Run/Pool)	2	3	2	2.3	
Transect 5 (Riffle)	3	4	4	3.7	
Transect 6 (Riffle)	4	4	2	3.3	
			Mean for Reach =	2.9	25 - 50

Boise River Near Middleton:

Station	Deepest Point	1/3	2/3	Mean	% Embeddedness (approx.)
Tran 1 (Riffle)	1	1	1	1.0	
Tran 2 (Run)	1	1	1	1.0	
Tran 3 (Riffle/Run)	2	2	2	2.0	
Tran 4 (Run)	1	1	2	1.3	
Transect 5 (Deep Run)	1	1	1	1.0	
Transect 6 (Run)	1	1	1	1.0	
			Mean for Reach =	1.2	>=75

Boise River Mouth:

Station	Deepest Point	1/3	2/3	Mean	% Embeddedness (approx.)
Tran 1 (Deep Run)	1	1	too deep	1.0	
Tran 2 (Run; 1/2 sampled)	too deep	1	0	0.5	
Tran 3 (Run; 1/2 sampled)	too deep	1	1	1.0	
Tran 4 (Riffle/Run; 3/4 sampled)	4	2	3	3.0	
Transect 5 (Riffle/Run)	2	3	3	2.7	
Transect 6 (Riffle/Run; 3/4 sampled)	4	4	4	4.0	
			Mean for Reach =	2.0	50 - 75

Embeddedness Rating:

0 <= GR; 1>= 75%; 2 = 50-75%; 3 = 25-50%; 4 = 5-25%; 5 <= 5%)

From: Lower Boise River Level I and II Habitat Survey Summary Statistics - USGS 1997.
Eckert Road and Middleton were sampled November 1997; Mouth was sampled January 1998.

FIGURE 20
Lower Boise River Substrate Embeddedness Data

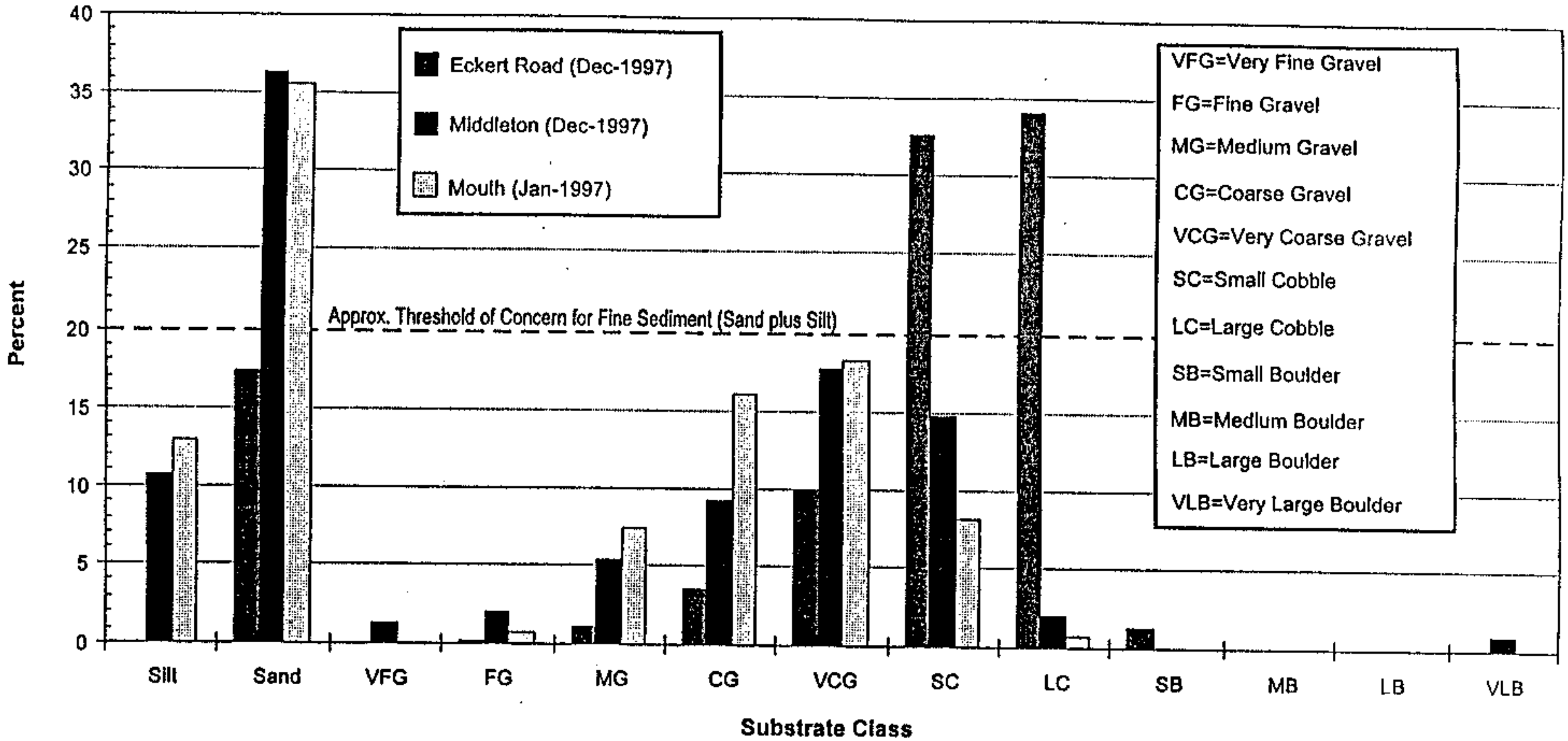


FIGURE 21
Lower Boise River Pebble Count Data

Data Gaps

Following are a list of data gaps:

- TSS duration data (i.e., the range of durations associated with various TSS concentrations)
- Bed load data
- Stream bank erosion rates
- Substrate and water column particle-size data
- Long-term channel geometry data
- Intergravel dissolved oxygen data
- Results from fish sampling efforts designed to collect larval and juvenile fish at specific locations throughout the main stem river and during the high- and irrigation-flow seasons

TSS duration data are important because duration of exposure influences the severity of ill effects of sediment on fish and their habitat (Appendix A). Although there seems to be somewhat of a "first flush" effect of TSS concentration in the lower Boise River (Figures 22 through 25), there is a poor relationship between concentration and discharge (Figure 26). Therefore, predicting the duration of elevated TSS concentrations at various discharges would be extremely difficult in the absence of TSS duration data.

Bed load is a means of sediment transport. If any bed load transport is occurring in the lower Boise River, sediment loads based only on TSS would underestimate the total sediment load. Morris and Fan (1997) reported that in many streams the bed material load constitutes less than 15 percent of the total load. From a biological standpoint, however, even small amounts of moving-sand bed load sediments have been shown to have a major impact on trout populations (Alexander and Hansen 1983).

Stream bank erosion is a potential source of sediment to the river. However, without measurements of stream bank erosion rates, it is difficult to estimate the significance of the source and its location.

Particle-size data are necessary to quantify the substrate quality for spawning and rearing habitat, as well as invertebrate production. Particle-size data are also integral to many sediment transport models and equations for predicting or quantifying armoring, scouring, and sediment deposition—all of which affect substrate quality for spawning.

Long-term channel geometry data can be useful for quantifying fish habitat (such as pool volume) or for quantifying spatial and temporal variations in scour and deposition rates. Measurement of intergravel dissolved oxygen concentration is another means of quantifying substrate spawning and rearing habitat quality.

Fish sampling methods geared toward the collection of larval and juvenile fish would help to better define the success of spawning for different species throughout the length of the river at different times of the year. Results from this type of sampling would provide a direct measure of salmonid (and other species) spawning success.

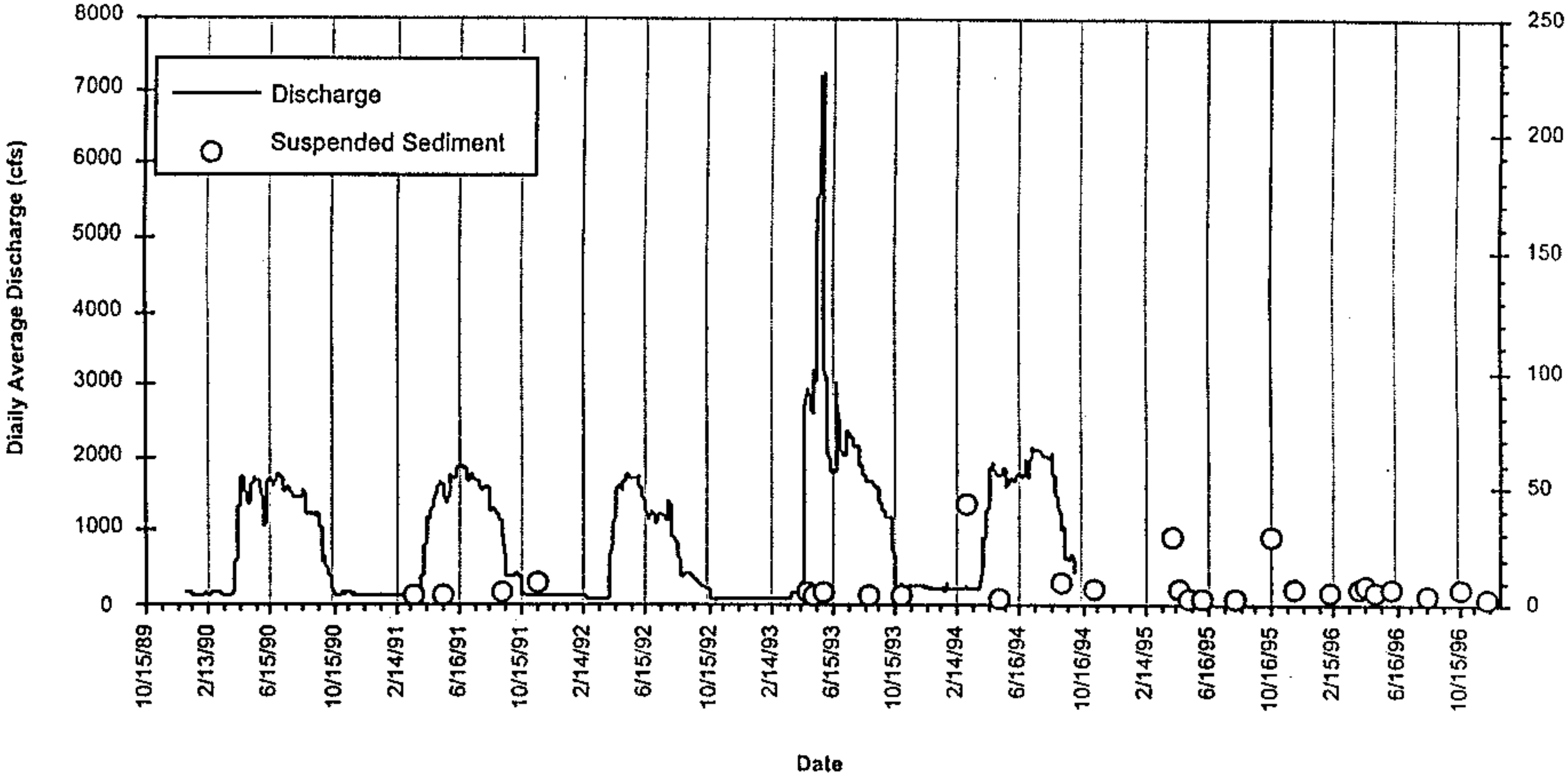


FIGURE 22
Boise River Below Diversion Dam–Daily Average Discharge Hydrograph and Instantaneous TSS Concentrations

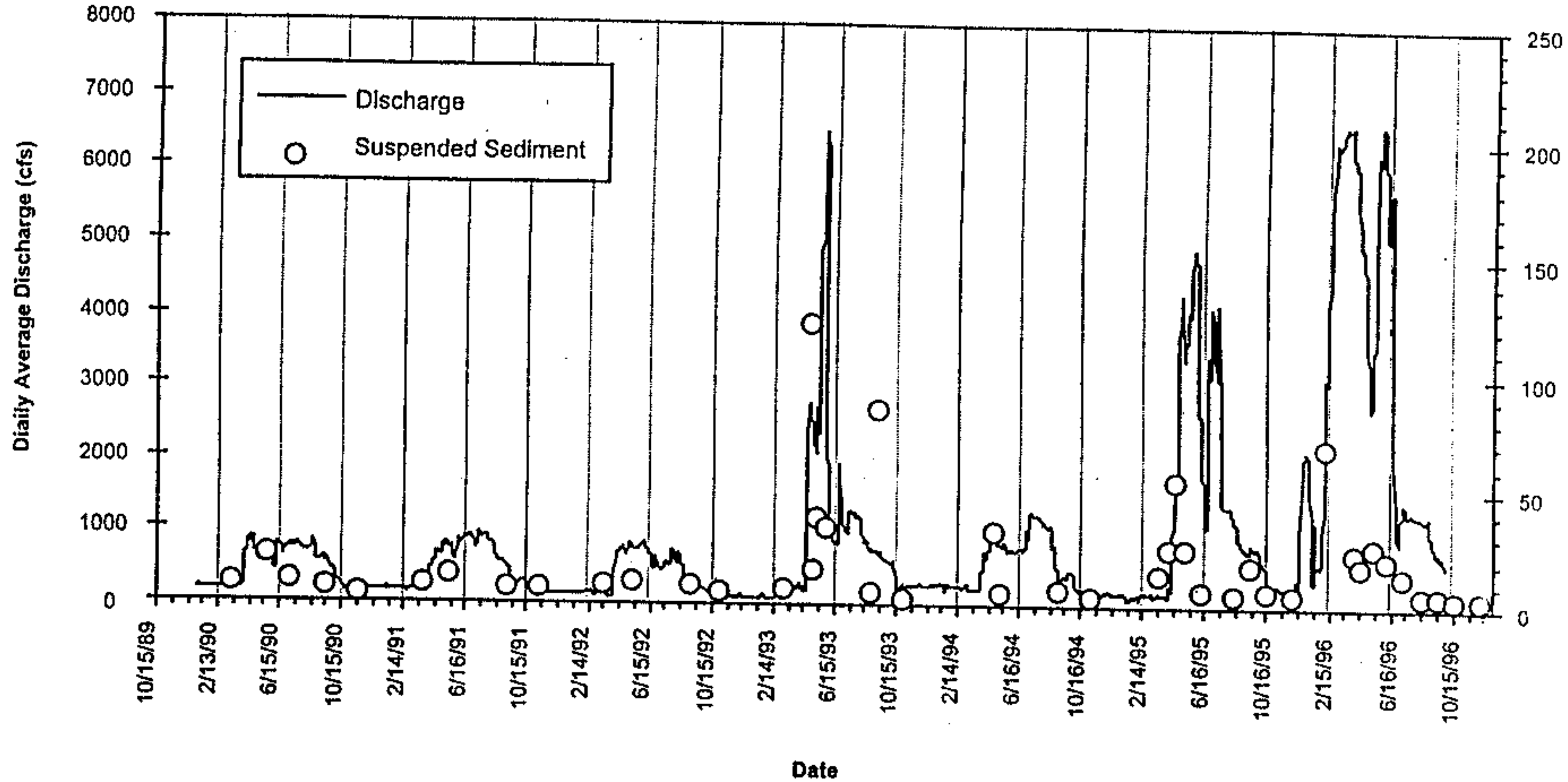


FIGURE 23
Boise River at Glenwood Bridge–Daily Average Discharge Hydrograph and Instantaneous TSS Concentrations

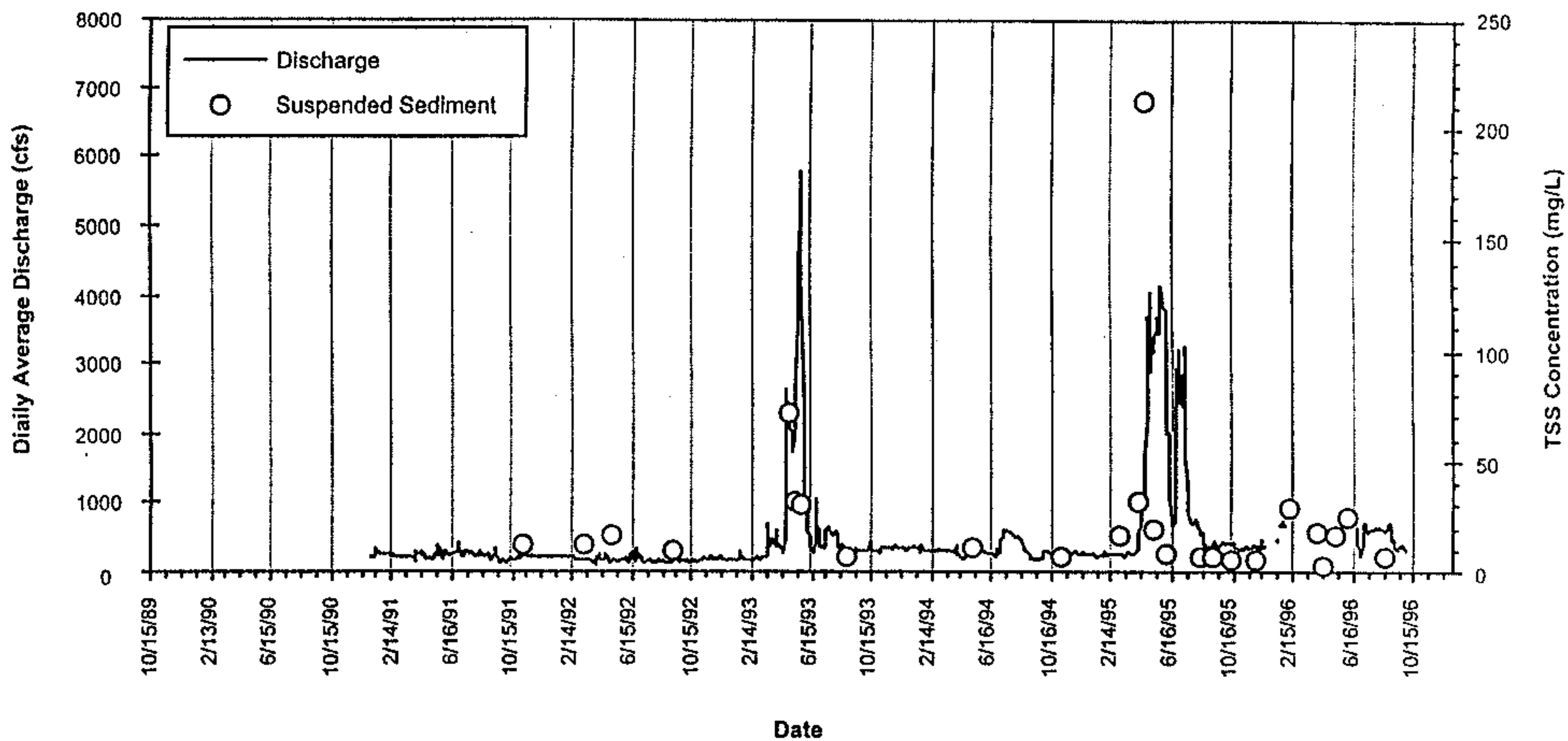


FIGURE 24
Boise River at Middleton–Daily Average Discharge Hydrograph and Instantaneous TSS Concentrations

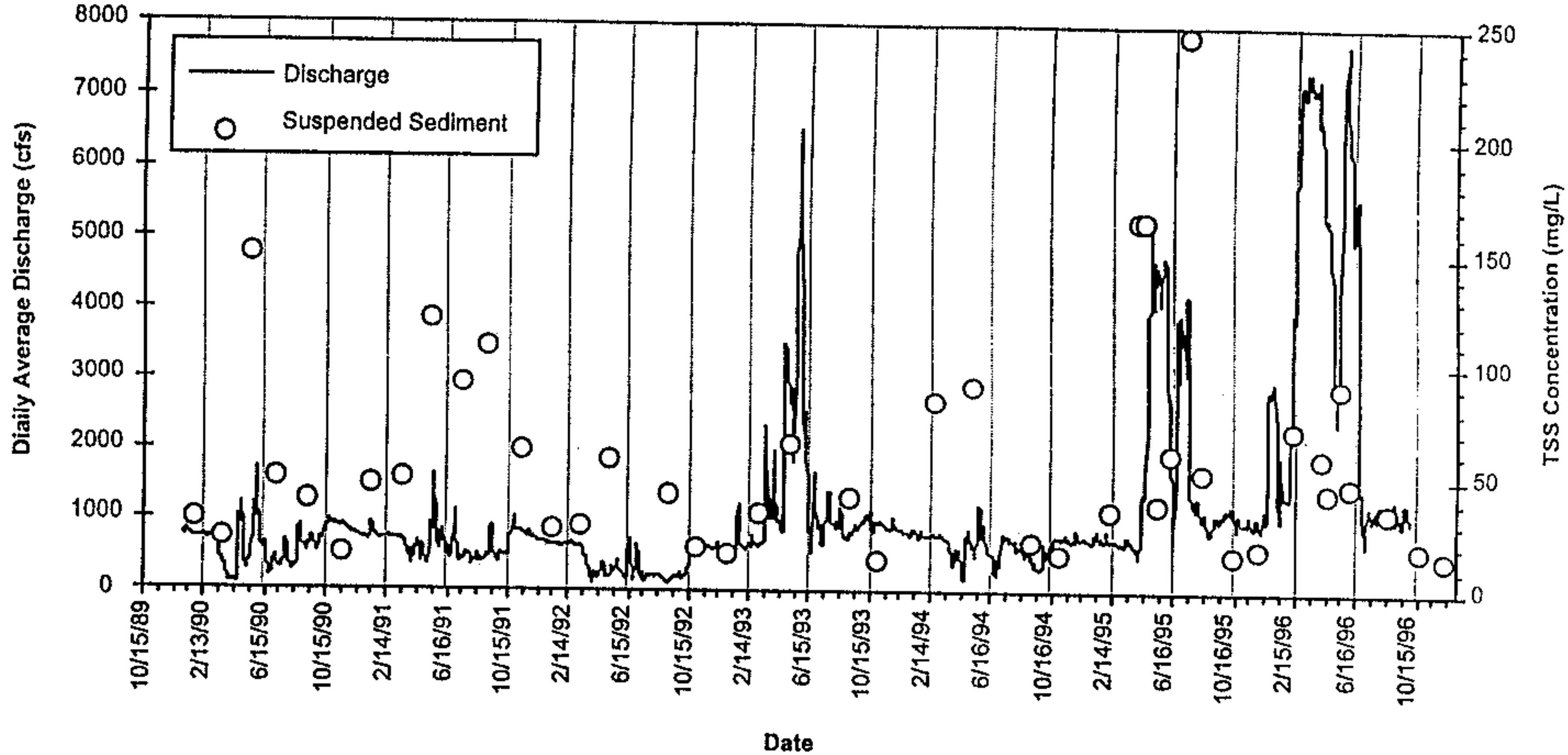
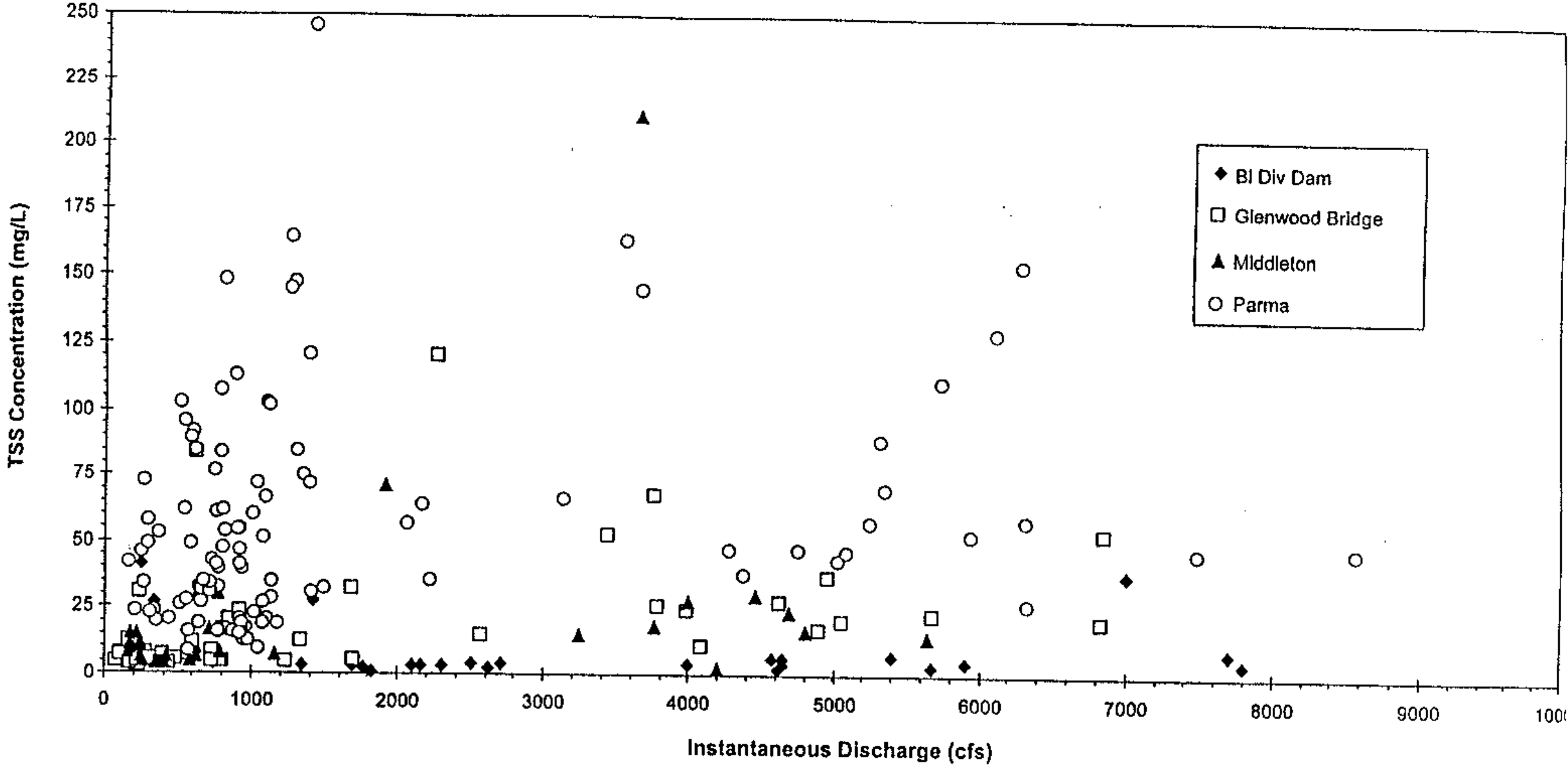


FIGURE 25
Boise River at Parma--Daily Average Discharge Hydrograph and Instantaneous TSS Concentrations



NOTE:
3 data points for Parma are offscale:

Q (cfs)	TSS (mg/L)	Date
1,830	664	12/74
1,670	483	8/75
3,490	467	1/76

FIGURE 26
Lower Boise River TSS Concentration
Versus Instantaneous Discharge

Summary of Extent to Which Beneficial Uses are Impaired

Cold Water Biota

Based on the recommended acute and chronic TSS concentration limits for the protection of fish and their habitat, and based on the seasonal (121 day) TSS geometric mean concentrations in the main stem river and tributaries, the cold water biota use is likely being impaired from downstream of Middleton to the mouth of the river during the high- and irrigation-flow seasons. The word "likely" is used only because continuous (or more frequent) TSS data are unavailable to confirm the durations for which TSS concentrations exceed the 50 mg/L and 80 mg/L recommended TSS limits.

As seen in Figures 3 and 4, the TSS concentration limits are exceeded at Parma based on the geometric mean and 90th percentile concentrations during the high- and irrigation-flow seasons. Figure 25 provides a strong indication that the 50- and 80-mg/L recommended limits are exceeded for more than 60 and 14 days, respectively—thus impairing the cold water designated use.

Although the 90th percentile TSS concentration during the high-flow season at Middleton exceeds 50 mg/L (Figure 4), it seems unlikely that concentrations exceed 50 mg/L for more than 60 days or 80 mg/L for more than 14 days, based on Figure 24.

Salmonid Spawning

Salmonid spawning would be impaired under the same conditions described above. Therefore, salmonid spawning is being impaired from at least Middleton and downstream.

The limited available substrate data would also indicate that salmonid spawning is being impaired at locations near Middleton and the mouth of the Boise River. Although pebble count and percent embeddedness data are specific to a relatively small area at each sampling location, data from these locations are most likely indicative of the overall channel substrate condition between the two sites.

Major Sources

Waters (1995) reported that "among all sources of pollution afflicting streams and rivers, agriculture in its several forms is by far the most important—over three times the amount of pollution contributed by the next leading source (USEPA 1990)." In the lower Boise River watershed, probably the most significant source of sediment is agricultural lands. Among the various agricultural land use practices, the most significant source of sediment likely results from surface irrigated land. Unrestricted use of streamside areas by livestock, and the resulting trampling of streambanks, is another likely major source of sediment. The three tributaries with the highest seasonal loads of sediment in the lower Boise River watershed have drainage areas composed predominantly of agricultural lands.

Morris and Fan (1998) describe a cycle of sediment yield from urbanizing areas as the land use progresses from (1) low-yield predevelopment land uses, to (2) high-yield construction sites characterized by disturbed soil and a high-efficiency storm drainage network, to (3) protected soil cover. Urban areas in the lower Boise River watershed are a source of sediment; however, they are not likely a major source. This results from promotion of onsite stormwater retention and detention, and the relatively low annual rainfall in the valley, which provides little energy for sediment transport.

The watershed above Diversion Dam may represent a significant source of bed load sediment. However, because of a lack of bed load data from the vicinity of the Diversion Dam, the significance of this source remains unknown. The same is true for main stem streambank erosion; however, both of these sources are likely insignificant compared to the agricultural land areas.

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Appendix A

Selection of a Total Suspended Sediment (TSS) Target Concentration for the Lower Boise River TMDL

Selection of a Total Suspended Sediment (TSS) Target Concentration for the Lower Boise River TMDL

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DATE: March 13, 1998

Purpose

The purpose of this technical memorandum is to summarize the results, conclusions, and findings of published and unpublished studies pertaining to the effects of suspended sediment (SS) on selected species of fish and to select one or more appropriate target TSS concentration(s) to protect the existing and/or potential designated uses in the lower Boise River.

Literature Review

Background on Effects of Suspended Sediment

The effects of SS on fish vary with life stage (adult, juvenile, larvae, and eggs) and species (Sorensen et al. 1977; Waters 1995; Newcombe and Jensen 1996; Anderson et al. 1996; Sweeten 1998), as well as concentration of SS, duration of exposure, and particle size and angularity (Waters 1995; Anderson et al. 1996; Newcombe and Jensen 1996). Waters (1995) reported that salmonids have received the greatest attention regarding the effects of sediment on fish. This may be due to a number of reasons, including the great economic interest in the salmonids (Waters 1995) as well as their role as an indicator organism for cold water biota (e.g., Harvey 1989).

In a 1991 report, Newcombe and McDonald indicated that although the effects of SS on fish and aquatic life have been studied intensively, general principles characterizing environmental effects of suspended sediments had not been established. They noted that most published studies had only reported concentration; however, they stressed that the severity of effects is also related to duration of exposure. In exploring the relationship between SS concentration and duration in influencing changes in fish habitat in Canada, Anderson et al. (1996) found duration of exposure played a more dominant role than concentration.

In addition to habitat effects, a variety of effects associated with SS and fish are published in the literature. In general, these include lethal and sublethal effects. Waters (1995) provided discussions involving direct mortality and sublethal effects that included avoidance and distribution, reduced feeding and growth, respiratory impairment, reduced tolerance to disease and toxicants, and physiological stress. Anderson et al. (1996) summarized behavioral, physiological, and population effects, including avoidance of sediment plumes; reduction in feeding; loss of territoriality and interruption of migrational movements of salmonids; impaired growth rate; alteration in blood chemistry; gill trauma; resistance to disease and chemical toxins; phagocytosis (impairment of fish health because of envelopment of fine particles by cells within fish gill and gut tissue, which are then transported to internal repository tissues); egg mortality; and juvenile and adult fish mortality.

Newcombe and Jensen (1996) scored qualitative response data along a semiquantitative ranking (Table 1) to study the effect of sediment doses (concentration times exposure duration) on a variety of fish communities. The severity-of-ill-effect scale was ranked from 0 to 14 and included a variety of responses associated with excess SS. Superimposed on the 15-point scale were four major classes of effect: nil effect, behavioral effects, sublethal effects, and lethal effects. It was found that pollution episodes associated with sublethal or lethal effects also degraded habitat and reduced population size; therefore, these ill effects were grouped together in the hierarchy.

TABLE 1
Scale of the Severity (SEV) of Ill Effects Associated with Excess Suspended Sediment

SEV	Description of Effect
Nil Effect	
0	No behavioral effects
Behavioral Effects	
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
Sublethal Effects	
4	Short-term reduction in feeding rates Short-term reduction in feeding success
5	Minor physiological stress Increase in rate of coughing Increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation Impaired homing
8	Indications of major physiological stress Long-term reduction in feeding rate Long-term reduction in feeding success Poor condition
Lethal and Paralethal Effects	
9	Reduced growth rate Delayed hatching Reduced fish density
10	0-20% mortality; Increased predation Moderate to severe habitat degradation
11	>20-40% mortality
12	>40-60% mortality
13	>60-80% mortality
14	>80-100% mortality

Source: Newcombe and Jensen (1996).

Because the issue of sediment effects on fish versus effects on habitat is an important issue, excerpts from Newcombe and Jensen's (1996) discussion of habitat damage associated with SS dose follows:

> Along the SEV scale, habitat damage ranges from moderate to severe. Habitat damage can be characterized in biological or physical terms or both of these in conjunction. Biological manifestations of habitat damage include underutilization of stream habitat (Birtwell et al. 1984), abandonment of traditional spawning habitat (Hamilton 1961), displacement of fish from their habitat (McLeay et al. 1987), and avoidance of habitat (Swenson 1978). Physical manifestations include degradation of spawning habitat (Slaney et al. 1977; Cederholm et al. 1981), damage to habitat structure (Newcomb and Flagg 1983; Menzel et al. 1984), and loss of habitat (Menzel et al. 1984; Coats et al. 1985). Biophysical manifestations of excess suspended sediment are reported (in one typical example) as habitat degradation that reduces the relative success of one or more fish species that depend on low siltation rates and silt-free (< 3% silt) riffles (Berkmann and Rabeni 1987) (p. 695).
>
> Habitat damage is a valid description of the harm caused by suspended sediment pollution, but it is probably an abstraction insofar as ill effects operate on one or more life stages of a fish's life cycle.... Habitat damage, therefore, should be seen as an accumulative measure of numerous (potentially undocumented) ill effects at various life stages in a fish's life cycle. It is a unique phenomenon in that it can only be studied in the field (in contrast to direct effects—age-specific morbidity and mortality, for example—that can be studied in the laboratory as well as in the field) (p. 695).

Existing or Suggested Mass-Based Suspended Sediment Criteria

The European Inland Fisheries Advisory Commission (EIFAC 1965) suggested the following standards for protection of salmonids and other fish:

<25 mg/L	No effect
25 - 80 mg/L	Slight effect on production
80 - 400 mg/L	Significant reduction in fisheries
>400 mg/L	Poor fisheries

Sorensen et al. (1977) reported that the Committee on Water Quality Criteria from the Environmental Studies Board of the National Academy of Sciences (CWQC 1973) relied heavily on the EIFAC study to recommend water quality criteria for the protection of aquatic communities. They reported the CWQC recommendation as follows:

Maximum Concentration of Suspended Solids	
25 mg/L	High level of protection
80 mg/L	Moderate protection
400 mg/L	Low level of protection
over 400 mg/L	Very low level of protection

In summarizing research needs related to standards on suspended and dissolved solids for protection of freshwater biota, Sorensen et al. (1977) wrote, "Standards which are similar to the recommended criteria of the CWQC (1973) are adequate for protecting fish against suspended solids" (p. 47).

The Water Quality Protection Section of the Alaska Department of Environmental Conservation (ADEC 1996) stated in a review, "It appears that only four states: Nevada, New Jersey, South Dakota, and West Virginia have numeric criteria for suspended solids in the water column" (p. 3-1). As reported in the review, they are as follows:

- Nevada employs specific limits for some stream reaches. The existing or higher quality is to be maintained whether the natural suspended solids concentration is equal to or less than 15 mg/L. The limit for the protection of all beneficial uses in the upper reaches of a watershed is 25 mg/L and 80 mg/L in the lower reaches.
- New Jersey limits suspended solids concentrations to 25 to 40 mg/L on specific streams.
- South Dakota has a 30 mg/L maximum limit for coldwater fisheries.
- West Virginia employs a 30 mg/L maximum suspended solids concentration in receiving waters.

They reported that 17 other states have general narrative statements addressing suspended and settleable solids.

The ADEC (1996) reported that there are no Canadian provinces or territories with water column standards for suspended and settleable solids. However, they list the following guideline established by Canada:

> Suspended solids should not exceed 10 $mg\text{-}L^{-1}$ when background suspended solids concentrations are equal to or less than 100 $mg\text{-}L^{-1}$. Suspended solids should not exceed 10% of background concentrations when background concentrations are greater than 100 $mg\text{-}L^{-1}$ (CCREM 1987).

Results from Suspended Sediment-Related Studies

Newcombe and Jensen (1996) conducted a meta-analysis of 80 published reports to develop matrices of SS concentration and duration of exposure (Figures 1 through 5) for quantifying the severity of ill effects (Table 1) on fish. Their analysis was based on 264 data triplets consisting of SS concentration, duration of exposure, and severity-of-ill effect for fishes. The data included taxonomic group, species of fish, natural history, life history phase, and sediment particle size range. Results of individual studies used in the meta-analysis pertaining to rainbow trout, brown trout, mountain whitefish, and a few from the adult nonsalmonids group are presented in Appendix A for review. Appendix B includes results of studies reviewed by Newcombe and MacDonald (1991) pertaining to aquatic invertebrates.

The matrices show empirical and modeled results for five groups of fish—juvenile and adult salmonids; adult salmonids; juvenile salmonids; eggs and larvae of salmonids and nonsalmonids; and adult freshwater nonsalmonids. The assumption for modeling purposes

Figure 1. Matrices Applicable to Juvenile and Adult Salmonids (from Newcombe and Jensen, [1996])

Duration of exposure to SS ($\log_e$ hours)

(A) Average severity-of-ill-effect scores (empirical)

Concentration (mg SS/L)	0 (1 hour)	1 (3 hours)	2 (7 hours)	3 (1 day)	4 (2 days)	5 (6 days)	6 (2 weeks)	7 (7 weeks)	8 (4 months)	9 (11 months)	10 (30 months)	($\log_e$ mg SS/L)
162755	14	-	-	14	-	-	-	-	-	-	-	12
59874	-	-	12	10	14	12	-	-	-	-	-	11
22026	-	-	-	-	-	11	-	-	-	-	-	10
8103	3	-	-	10	12	10	-	11	-	14	-	9
2981	6	-	-	9	11	8	9	13	-	-	-	8
1097	4	-	-	-	10	9	11	8	-	14	8	7
403	4	5	8	-	-	8	10	9	10	-	-	6
148	4	-	6	9	-	8	9	9	-	-	-	5
55	2	4	5	-	-	7	10	9	10	-	-	4
20	3	4	-	4	-	-	-	10	-	9	-	3
7	-	-	-	-	-	3	-	9	-	9	-	2
3	-	-	-	-	-	5	-	-	-	-	-	1
1	3	-	-	-	-	-	-	-	-	-	-	0

Duration of exposure to SS ($\log_e$ hours)

(B) Average severity-of-ill-effect scores (calculated)

Concentration (mg SS/L)	0 (1 hour)	1 (3 hours)	2 (7 hours)	3 (1 day)	4 (2 days)	5 (6 days)	6 (2 weeks)	7 (7 weeks)	8 (4 months)	9 (11 months)	10 (30 months)	($\log_e$ mg SS/L)
162755	10	11	11	12	12	13	14	14	-	-	-	12
59874	9	10	10	11	12	12	13	13	14	-	-	11
22026	8	9	10	10	11	11	12	13	13	14	-	10
8103	8	8	9	10	10	11	11	12	13	13	14	9
2981	7	8	8	9	9	10	11	11	12	12	13	8
1097	6	7	7	8	9	9	10	10	11	12	12	7
403	5	6	7	7	8	9	9	10	10	11	12	6
148	5	5	6	7	7	8	8	9	10	10	11	5
55	4	5	5	6	6	7	8	8	9	9	10	4
20	3	4	4	5	6	6	7	8	8	9	9	3
7	3	3	4	4	5	6	6	7	7	8	9	2
3	2	2	3	4	4	5	5	6	7	7	8	1
1	1	2	2	3	3	4	5	5	6	7	7	0

Figures 1 through 5: (A) Average empirical severity-of-ill-effect scores for juvenile and adult salmonids (freshwater, group 1) in the matrix of suspended sediment (SS) concentration and duration of exposure. Both matrix axes are expressed in logarithmic and absolute terms. Dashes mean "no data." Shaded bands denote inferred (by manual interpolation) thresholds of sublethal effects (shading without a border) and lethal effects (shading with a border; see Table 1 for criteria.). Severity-of-ill-effect scores calculated by model (1) (Table 2). Severity-of-ill-effect calculations are based on the logarithmic values shown on the axes of the matrix. Shaded areas represent extrapolations beyond empirical data; extrapolations have been capped at 14 (upper limit of the effects scale: Table 1), although higher values are possible. Diagonal terraced lines denote thresholds of sublethal effects (lower left) and lethal effects (middle diagonal) delineated by the model with reference to Table 1.

Figure 2. Matrices Applicable to Adult Salmonids (from Newcombe and Jensen [1996])

(A) Average severity-of-ill-effect scores (empirical)

Concentration (mg SS/L)	1 Hours	3 Hours	7 Hours	1 Days	2 Days	6 Days	2 Weeks	7 Weeks	4 Months	11 Months	30 Months	($\log_e$ mg SS/L)
Duration of exposure to SS ($\log_e$ hours)	0	1	2	3	4	5	6	7	8	9	10	
162755	14	-	-	14	-	-	-	-	-	-	-	12
59874	-	-	12	10	-	12	-	-	-	-	-	11
22026	-	-	-	-	-	10	-	-	-	-	-	10
8103	-	-	-	10	-	-	-	-	-	14	-	9
2981	-	-	-	10	-	-	12	13	-	-	-	8
1097	-	-	-	-	-	7	9	-	-	14	8	7
403	5	5	8	-	-	7	9	12	10	-	-	6
148	4	-	-	10	-	-	-	9	-	-	-	5
55	3	4	-	-	-	7	-	9	10	-	-	4
20	-	4	-	4	-	-	-	10	-	-	-	3
7	-	-	-	-	-	3	-	-	-	-	-	2
3	-	-	-	-	-	5	-	-	-	-	-	1
1	3	-	-	-	-	-	-	-	-	-	-	0

(B) Average severity-of-ill-effect scores (calculated)

Concentration (mg SS/L)	1 Hours	3 Hours	7 Hours	1 Days	2 Days	6 Days	2 Weeks	7 Weeks	4 Months	11 Months	30 Months	($\log_e$ mg SS/L)
Duration of exposure to SS ($\log_e$ hours)	0	1	2	3	4	5	6	7	8	9	10	
162755	11	11	12	12	13	13	14	14	-	-	-	12
59874	10	10	11	11	12	12	13	13	14	14	-	11
22026	9	10	10	11	11	12	12	13	13	14	14	10
8103	8	9	9	10	10	11	11	12	12	13	13	9
2981	8	8	9	9	10	10	11	11	12	12	13	8
1097	7	7	8	8	9	9	10	10	11	11	12	7
403	6	7	7	8	8	9	9	10	10	11	11	6
148	5	6	6	7	7	8	8	9	9	10	10	5
55	5	5	6	6	7	7	8	8	9	9	9	4
20	4	4	5	5	6	6	7	7	8	8	9	3
7	3	4	4	5	5	6	6	7	7	7	8	2
3	2	3	3	4	4	5	5	6	6	7	7	1
1	2	2	3	3	4	4	5	5	5	6	6	0

Figure 3. Matrices Applicable to Juvenile Salmonids (from Newcombe and Jensen [1996])

(A) Average severity-of-ill-effect scores (empirical)

Duration of exposure to SS ($\log_e$ hours)

Concentration (mg SS/L)	0	1	2	3	4	5	6	7	8	9	10	($\log_e$ mg SS/L)
	1 Hours	3 Hours	7 Hours	1 Days	2 Days	6 Days	2 Weeks	7 Weeks	4 Months	11 Months	30 Months	
162755	-	-	-	-	-	-	-	-	-	-	-	12
59874	-	-	-	-	14	12	-	-	-	-	-	11
22026	-	-	-	-	-	11	-	-	-	-	-	10
8103	3	-	-	-	12	10	-	11	-	-	-	9
2981	6	-	-	8	11	8	8	13	-	-	-	8
1097	4	-	-	-	10	10	12	8	-	-	-	7
403	4	-	-	-	-	10	12	9	-	-	-	6
148	4	-	6	6	-	8	9	9	-	-	-	5
55	2	-	5	-	-	-	10	-	9	-	-	4
20	3	-	-	3	-	-	-	-	-	9	-	3
7	-	-	-	-	-	-	-	9	-	9	-	2
3	-	-	-	-	-	-	-	-	-	-	-	1
1	-	-	-	-	-	-	-	-	-	-	-	0

(B) Average severity-of-ill-effect scores (calculated)

Duration of exposure to SS ($\log_e$ hours)

Concentration (mg SS/L)	0	1	2	3	4	5	6	7	8	9	10	($\log_e$ mg SS/L)
	1 Hours	3 Hours	7 Hours	1 Days	2 Days	6 Days	2 Weeks	7 Weeks	4 Months	11 Months	30 Months	
162755	9	10	11	11	12	13	14	14	-	-	-	12
59874	9	9	10	11	11	12	13	14	14	-	-	11
22026	8	9	9	10	11	11	12	13	13	14	-	10
8103	7	8	9	9	10	11	11	12	13	13	14	9
2981	6	7	8	9	9	10	11	11	12	13	13	8
1097	6	6	7	8	9	9	10	11	11	12	13	7
403	5	6	6	7	8	9	9	10	11	11	12	6
148	4	5	6	6	7	8	9	9	10	11	11	5
55	4	4	5	6	6	7	8	8	9	10	11	4
20	3	4	4	5	6	6	7	8	8	9	10	3
7	2	3	4	4	5	6	6	7	8	8	9	2
3	1	2	3	4	4	5	6	6	7	8	8	1
1	1	1	2	3	4	4	5	6	6	7	8	0

Figure 4. Matrices Applicable to Eggs and Larvae Salmonids and Nonsalmonids (from Newcombe and Jensen [1996])

Duration of exposure to SS ($\log_e$ hours)

(A) Average severity-of-ill-effect scores (empirical)

Concentration (mg SS/L)	1 Hours	3 Hours	7 Hours	1 Days	2 Days	6 Days	2 Weeks	7 Weeks	4 Months	11 Months	30 Months	($\log_e$ mg SS/L)
($\log_e$ hours)	0	1	2	3	4	5	6	7	8	9	10	
162755	-	-	-	-	-	-	-	-	-	-	-	12
59874	-	-	-	-	-	-	-	-	-	-	-	11
22026	-	-	-	-	-	-	-	-	-	-	-	10
8103	-	-	-	-	-	-	-	-	-	-	-	9
2981	-	4	-	8	-	-	-	-	-	-	-	8
1097	-	-	-	9	11	10	-	-	-	-	-	7
403	-	-	-	12	12	11	-	-	-	-	-	6
148	4	-	-	9	12	11	13	12	13	-	-	5
55	-	-	-	10	-	-	-	13	-	-	-	4
20	-	-	-	7	10	10	-	13	-	-	-	3
7	-	3	-	-	-	-	-	11	-	-	-	2
3	-	-	-	-	-	-	-	-	-	-	-	1
1	-	-	-	-	-	-	-	-	-	-	-	0

Duration of exposure to SS ($\log_e$ hours)

(B) Average severity-of-ill-effect scores (calculated)

Concentration (mg SS/L)	1 Hours	3 Hours	7 Hours	1 Days	2 Days	6 Days	2 Weeks	7 Weeks	4 Months	11 Months	30 Months	($\log_e$ mg SS/L)
($\log_e$ hours)	0	1	2	3	4	5	6	7	8	9	10	
162755	7	9	10	11	12	13	14	-	-	-	-	12
59874	7	8	9	10	12	13	14	-	-	-	-	11
22026	7	8	9	10	11	12	13	-	-	-	-	10
8103	7	8	9	10	11	12	13	14	-	-	-	9
2981	6	7	8	10	11	12	13	14	-	-	-	8
1097	6	7	8	9	10	11	12	14	-	-	-	7
403	6	7	8	9	10	11	12	13	14	-	-	6
148	5	6	7	9	10	11	12	13	14	-	-	5
55	5	6	7	8	9	10	12	13	14	-	-	4
20	5	6	7	8	9	10	11	12	13	-	-	3
7	4	5	7	8	9	10	11	12	13	14	-	2
3	4	5	6	7	8	10	11	12	13	14	-	1
1	4	5	6	7	8	9	10	11	13	14	-	0

Figure 5. Matrices Applicable to Adult Freshwater Nonsalmonids (from Newcombe and Jensen [1996])

Duration of exposure to SS ($\log_e$ hours)

(A) Average severity-of-ill-effect scores (empirical)

Concentration (mg SS/L)	1 Hours (0)	3 Hours (1)	7 Hours (2)	1 Days (3)	2 Days (4)	6 Days (5)	2 Weeks (6)	7 Weeks (7)	4 Months (8)	11 Months (9)	30 Months (10)	($\log_e$ mg SS/L)
162755	10	-	-	-	-	-	10	-	-	-	-	12
59874	-	-	-	-	-	-	-	-	-	-	-	11
22026	-	-	-	-	-	-	10	-	-	-	-	10
8103	5	-	-	-	-	-	-	-	-	-	-	9
2981	-	-	-	-	-	-	-	-	-	13	-	8
1097	-	-	-	-	-	-	-	12	-	-	-	7
403	4	-	-	-	10	-	-	-	-	-	-	6
148	-	-	-	-	-	-	10	11	-	-	-	5
55	-	-	-	-	-	-	-	9	-	-	-	4
20	4	-	-	-	-	-	-	-	-	12	-	3
7	-	-	-	-	-	-	-	-	-	-	-	2
3	-	-	-	-	-	-	-	-	-	-	-	1
1	-	-	-	-	-	-	-	-	-	-	-	0

Duration of exposure to SS ($\log_e$ hours)

(B) Average severity-of-ill-effect scores (calculated)

Concentration (mg SS/L)	1 Hours (0)	3 Hours (1)	7 Hours (2)	1 Days (3)	2 Days (4)	6 Days (5)	2 Weeks (6)	7 Weeks (7)	4 Months (8)	11 Months (9)	30 Months (10)	($\log_e$ mg SS/L)
162755	7	8	9	10	10	11	12	12	13	14	-	12
59874	7	8	9	9	10	11	11	12	13	14	14	11
22026	7	8	8	9	10	10	11	12	13	13	14	10
8103	7	7	8	9	9	10	11	12	12	13	14	9
2981	6	7	8	8	9	10	11	11	12	13	13	8
1097	6	7	7	8	9	10	10	11	12	12	13	7
403	6	6	7	8	9	9	10	11	11	12	13	6
148	5	6	7	8	8	9	10	10	11	12	13	5
55	5	6	7	7	8	9	9	10	11	12	12	4
20	5	6	6	7	8	8	9	10	11	11	12	3
7	5	5	6	7	7	8	9	10	10	11	12	2
3	4	5	6	7	7	8	9	9	10	11	11	1
1	4	5	6	6	7	8	8	9	10	10	11	0

was that the severity-of-ill-effects scale (Table 1) represented proportional differences in true effects. The attributes, slopes and coefficients, and statistics of the regression models developed for the five different data groupings are shown in Table 2. As pointed out by Anderson et al. (1996), the multiple regression approach used by Newcombe and Jensen (1996) allowed for different factors (slopes) to be assigned separately to the variables of concentration and duration, which is important to address the potential for non-linearity in the relationship between the two variables.

TABLE 2
Attributes, Slopes, and Coefficients, and Statistics of Six Models that Relate Severity of Ill Effects on Fishes (z, 15-Point Scale) to Duration of Exposure (x, h) and Concentration of Suspended Sediment (y, mg/L) in the Form $z = a + b(\log_e x) + c(\log_e y)$.

Term	Model 1	Model 2	Model 3	Model 4	Model 6
Attributes					
Taxon[a]	S	S	S	S + N	N
Life Stage[b]	J + A	A	J	E + L	A
Life History[c]	FW	FW	FW	FW + ES	FW
Sediment Particle Size[d]	F to C	F to C	F	F	F
Slopes and Coefficients					
Intercept (a)	1.0642	1.6814	0.7262	3.7466	4.0815
Slope of $\log_e x$ (b)	0.6068	0.4769	0.7034	1.0946	0.7126
Slope of $\log_e y$ (c)	0.7384	0.7565	0.7144	0.3117	0.2829
Statistics					
Coefficient of Determination[e] (r^2)	0.6009	0.6173	0.5984	0.5516	0.6998
F-statistic	130.28	52.37	82.00	28.03	27.42
Probability (P)	<0.01	<0.01	<0.01	<0.01	<0.01
Sample Size (N)	171	63	108	43	22

[a]S = Salmonids (predominantly); N = nonsalmonids.
[b]A = Adults; J = juveniles; L = larvae; E = eggs.
[c]FW = Freshwater and anadromous; ES = estuarine.
[d]F = Fine (predominately <75 μm); C = coarse (75-250 μm).
[e]Corrected for degrees of freedom.

Source: Newcombe and Jensen (1996).

Buck (1956) showed that "turbidity," expressed as parts per million, had a marked influence on the production of largemouth bass, bluegills, and redear sunfish (warm water fish). The researcher artificially created turbidities in a total of 12 ponds: In 6 ponds, sodium silicate (a relatively inert substance used to keep the clay in suspension) was mixed with native clay and in the remaining 6 ponds, adult carp were added. The ponds were classified as 1) clear ponds—average turbidities <25 ppm; 2) intermediate ponds—turbidity range of 25 to 100 ppm; and 3) muddy ponds—turbidity >100 ppm. Relative to the clear ponds, the intermediate and muddy ponds exhibited lower total weight of fish, slower growth rates, and reduced reproduction rate and success. Results from this study were included in Newcombe and Jensen's (1996) meta-analysis.

The U.S. Fish and Wildlife Service habitat suitability index model for largemouth bass (Stuber et al. 1982) reports the optimum suspended solids concentration for largemouth bass ranges from 5-25 mg/L.

Sweeten (1998) used bentonite clay suspensions (particle size 0.0010-0.0005 mm) in recirculating tanks to quantify the effects of suspended solids on centrarchids and other sight feeding fishes. He proposes that the methodology, similar to those used to regulate toxic substances, is suitable for developing numerical criteria for suspended solids; however, to date, his results have not been field validated. A summary of the results follow:

- The clay concentration causing a 25 percent reduction in total biomass (IC25) after 7 days for juvenile smallmouth bass was 35 mg/L.
- For juvenile bluegill, the IC25 after 14 days was 76 mg/L.
- Survival rates for larval smallmouth bass and bluegill were less than 50 percent at the concentrations listed above.

Reporting that a number of SS criteria have been based on observations of fish populations under chronic exposure, Anderson et al. (1996) extended the work of Newcombe and others and used a multiple regression analysis to develop an acute sediment dose/habitat effect relationship. The following relationship was significant ($P<0.001$); however, they had not yet field tested it:

$$z = 0.637 + 0.740 \text{ Ln(SS Concentration)} + 0.864 \text{ Ln(Duration)}; r^2(adj)=0.627; n=35; p<0.001.$$

where z = severity-of-ill-effect—either 3, 7, 10, 12, or 14 based on a ranking system that followed the one used by Newcombe and Jensen (1996) shown in Table 1.

Peters (1967) studied the effects of sediment from agricultural practices on Bluewater Creek, a trout stream in Montana. The description of the study stream and watershed shares similarities to the lower Boise River system. Excerpts of the author's description follow:

- The study area is subject to low annual precipitation (about 11 inches per year, over three-fourths of which occurs in the winter).
- Irrigation diversions occur from April to October.
- During the irrigation season, the return surface flow changes the quality, quantity, and temperature of the water in the lower 9 miles of the 15-mile stream.
- Except for infrequent runoff in the watershed, caused by rain showers or rapid melting of snowpack, the creek could be characterized as one with an extremely stable year-round flow (except in the lower 9 miles during irrigation season).
- The most populous salmonid is introduced brown trout.
- Other species of fish (classified as rough fish by the author) include flathead chub, longnose dace, white sucker, longnose sucker, and mountain sucker.

The range of suspended sediment concentrations in Bluewater Creek (see Appendix C) are similar to those measured in the lower Boise River system. Like the lower Boise River, Bluewater Creek exhibited a trend of increasing sedimentation in the downstream direction—a trend the author attributed to the predominant agricultural land use in the lower reach of the creek.

The average monthly suspended sediment data measured approximately twice weekly at five stations during the 2-year study are presented in Appendix C. The median values for these monthly concentrations were: Station I—18 ppm; II—79 ppm; III—167 ppm; IV—186 ppm; and V—319 ppm. The stations were spaced approximately 3 miles apart; Station I denoted the upstream station, V the most downstream.

Results of the study showed that trout of all ages were abundant where sediment concentrations or loads were low (range in daily load 0.2 to 11 tons); few were found where sediment concentrations or loads were high (range in daily load 2 to 1,800 tons). Brown trout were "abundant" in the vicinity of Stations I and II; "marginal" near III; and, "incidental" at IV and V. The total number of trout estimated (using mark-and-recapture electrofishing surveys) at Station I was 1.4 times higher than Station II, 2.6 times higher than III, 33.3 times higher than IV, and 44.3 times higher than V (Table C-4).

Another significant finding of the study was the difference in age composition of trout at the different stations. In the vicinity of Stations I and II, the age composition was as follows: Age group, 0-I—42 percent; I-II—30 percent; II-III—14 percent; III-IV—9 percent; and IV and older—5 percent. Only 6 percent of the total number of trout censused in the area of Station III were in the 0-I age group. Downstream of Station III, there were no trout from age-class I or II. (Age-0 group are fish in their first year of life, before their first January 1 birth date; and a fish in age group I has completed 1 year or less of growth from time of hatching to the January 1 birth date and has entered its second growth season [Nielsen and Johnson 1989].)

See Appendix C for the monthly average SS concentrations, monthly mean maximum and minimum temperature, and electrofishing results. Also included in Appendix C is a table of the mortality rates of eyed-rainbow trout eggs incubated in man-made redds at each station. Results from this study were used in Newcombe and Jensen's (1996) meta-analysis.

Bases for the Determination of a Target TSS Concentration for the Lower Boise River

EIFAC (1965) and CWQC (1973) Studies

Based on the EIFAC (1965) suggested standards, an appropriate target concentration for protecting fish from excessive suspended sediment might be anywhere from 25 to 80 mg/L. The associated effect at this range of concentration is described as a "slight effect on production."

Although the original EIFAC report was not reviewed for the development of this memo, a summary table of the data used in the original EIFAC review was presented by Sorenson et al. (1977) and reviewed for this memo. No durations were listed with the EIFAC's suggested concentration ranges; however, it appears that duration was accounted for in terms of when a given effect occurred (for example, 20 percent mortality in 2 to 6 weeks at

90 ppm). In addition, based on the table presented in Sorenson et al. (1977), studies pertaining to various life stages were reviewed by the EIFAC.

Regarding the EIFAC suggested standards, it is important to note that 80 mg/L was the upper limit associated with a "slight effect on production" and the lower limit associated with a "significant reduction in fisheries." Recall also that the CWQC (1973) recommended 80 mg/L as the *maximum* concentration of suspended solids for *moderate* protection of aquatic communities. Based on these two recommendations, 80 mg/L would be considered the maximum concentration not to be exceeded for protection of the aquatic community.

Existing State TSS Water Quality Standards

In comparison to the two studies discussed above, the existing TSS standards for South Dakota, New Jersey, and West Virginia are at the low, or more protective end of the suggested concentration ranges. Nevada's TSS standard spans the 25 to 80 mg/L range with 25 mg/L being applicable to the upper reaches of the watershed and 80 mg/L to the lower.

Individual Studies Used in Newcombe and Jensen's (1996) Quantitative Assessment

From the 80 studies included in Newcombe and Jensen's (1996) meta-analysis, there were 14 data triplets (concentration, duration, and effect) with TSS concentrations ≤80 mg/L that pertain specifically to some of the fish species present in the lower Boise River (see Appendix A). Of the 14 data triplets, the durations ranged from 1 to 365 days. Thirteen of these resulted in sublethal, or lethal and paralethal effects, as defined by the authors. The minimum duration associated with the 13 data triplets was 30 days. Six of the 13 data sets described effects associated with forest harvesting practices; three involved agricultural practices; one involved artificially induced turbidity and turbidity generated by other fish; one dealt with placer mining; and two dealt with sediment from an industrial origin.

Based on a strict interpretation of the data sets listed in Appendix A, if a target concentration were set at >50 mg/L but ≤80 mg/L, three data sets (shaded in Appendix A) suggest that if concentrations in this range were sustained for 30 or more days, lethal or paralethal effects may occur. Two data sets (shaded) suggest sublethal and behavioral effects might occur at durations ≤7 days. Similarly, three data sets (shaded) in Appendix B suggest the potential for significant reductions in invertebrate populations as well.

Using the same logic, if a target concentration were set at 50 mg/L, eight data sets in Appendix A (shown with bold borders) suggest that lethal or paralethal effects may occur at or below 50 mg/L if sustained for 30 or more days. One data set indicates sublethal effects may occur if 17 mg/L were sustained for only 1 day. Similarly, five (bold-bordered) data sets in Appendix B suggest the potential for a reduction in the invertebrate standing crop if concentrations as low as 8 mg/L or 10 mg/L were sustained for at least 60 or 30 days, respectively.

Matrices and Models Developed by Newcombe and Jensen (1996)

Benefits

The individual data sets in Appendices A and B provide insight as to the sensitivity—and ultrasensitivity in the case of the egg and larval stages—of fish. However, the study conditions associated with these relatively few data sets may not adequately represent the range of conditions that exist in the lower Boise River. Because Newcombe and Jensen (1996) synthesized 264 data sets from 80 studies to develop their matrices and models (Figures 1 through 5 and Table 2), their analysis included a broad range of conditions. Therefore, these matrices and models are very useful for selecting a target concentration that would be protective over a wide range of conditions.

This is important because the impacts on fish populations subjected to an event of high sediment concentrations may very depending on study conditions. For example, the effect of a given sediment dose on a fish population may be different if the population is confined to a laboratory flume with no refuge, compared to a wild population in a natural stream that may have the ability to move about the stream system. Confounding factors such as temperature of the receiving environment and particle size and shape add to the potential variation in effect that may be observed at a given sediment dose.

General Observations

For the matrices shown in Figures 1 through 4, the thresholds of lethal effects are typically more conservative from the empirical matrices than the calculated matrices; however, across the full range of TSS concentrations, the relationship is the reverse for the matrices applicable to the adult freshwater nonsalmonids group. Figure 4 reflects that the most sensitive life stages are the egg and larval stages—a finding consistently supported throughout the literature. A comparison of Figure 5 to Figures 1 and 2 indicates that the adult nonsalmonids seem to be more sensitive to sediment doses than the adult salmonids.

Validation

Before employing the matrices as a tool for selecting an appropriate target TSS limit, it is worth discussing validation of the models. The authors stated that validation would rely on new studies to add to the data available at that time; however, even prior to publishing, they were able to utilize new data that had emerged. They cited recent finding of four studies that tended to support the predictions of the models—one of which (Sweeten 1998) was presented earlier in this paper and involved the most sensitive life stage of fish. It is shown again here in relation to the appropriate model developed by Newcombe and Jensen (1996).

> At a concentration of 35 mg/L and a duration of 7 days, the calculated severity-of-ill-effect score computed from Model 4 (eggs and larvae of salmonids and nonsalmonids) is 10. From Table 1, the description of SEV = 10 is: 0 to 20 percent mortality; increased predation; and moderate to severe habitat degradation. Sweeten (1998) reported survival rates for larval smallmouth bass of less than 50 percent at this sediment dose under laboratory conditions. Thus, although the model actually underestimated the severity of ill effect, it was accurate in predicting exceedance of the lethal threshold ($SEV \geq 9$).

At a concentration of 76 mg/L and a duration of 14 days, Model 4 results in a SEV = 11: >20 to 40 percent mortality (Table 1). Sweeten (1998) reported survival rates for larval bluegill of less than 50 percent at this sediment dose under laboratory conditions. Again, in this case, the model prediction was very close, only slightly underestimating the actual effect.

Selecting an Appropriate Duration for Protection Against Chronic Impacts

Choosing an appropriate duration for the selection of a target TSS concentration is critical because it is an important variable that influences the severity of ill effect on a fishery. This significance is not lost when employing the matrices and models developed by Newcombe and Jensen (1996). An example follows, using Model 2 (presented in matrix form in Figure 2), of a situation that must be avoided when employing the matrices and models. (Note that if Model 4 were used in the example, the threshold of lethal effects (SEV ≥ 9; see Table 1) would be exceeded at a much shorter duration:

> If the target TSS concentration not to be exceeded—based on a 10-day average or geometric mean—were 100 mg/L, then technically, 100 mg/L could be sustained for 365 days, year after year, and the target would never be exceeded. After 129 days, however, the threshold of lethal effects would be exceeded (SEV = 9, computed by Model 2). It could be argued that the selected target is not protective since lethal effects could occur, even within the limits of the target, after only approximately 4 months.

Because of this situation, it is appropriate to select a target TSS concentration that would be protective over a *duration equal to the maximum probable length of time for which an elevated TSS concentration would be sustained*. This approach would rely on the seasonal variation in flow regimes and land use practices to avoid having to select a duration that continues indefinitely, or even annually; yet, it would be protective for a duration equal to the maximum probable length of time for which elevated TSS concentrations would be sustained.

In the lower Boise River, this period of elevated TSS concentrations might be 121 days to equal the duration of the three predominant seasonal flow regimes (hereafter referred to as hydrologic seasons): High flow—February 15 to June 14; irrigation flow—June 15 to October 14; and low flow—October 15 to February 14. However, in the absence of TSS-duration data, and due to the TSS first-flush effect during the high-flow and irrigation-flow hydrologic seasons, *a protective, yet not overly conservative, duration would be 60 days*. This duration is one-half of each of the three hydrologic seasons and one-third of the agricultural diversion period (April 15 to October 15). Sustained elevated concentrations of TSS are not likely to occur during the low-flow season or for the entire duration of the high-flow and irrigation-flow hydrologic seasons.

Sublethal and Paralethal TSS Concentrations Associated with 60-Day Durations

Table 3 presents for a range of TSS concentrations the computed durations of exposure associated with an SEV=9—the minimum severity-of-ill-effect score in the lethal and paralethal category of Newcombe and Jensen's (1996) severity scale (Table 1). Thus, for the life stages and fish species represented by the models, the TSS concentrations associated with the shaded durations in Table 3 would not be protective against lethal and paralethal effects if sustained for up to 60 days. Similarly, based on the Anderson et al. (1996) fish

Table 3

Calculated Durations Associated with a Severity-of-Ill-Effect Score = 9 Based on Six Different Models[a]

TSS Concentration (mg/L)	Calculated Duration (days)					
	Acute Habitat Impact Model[b]	Model Number[c]				
		1[d]	2[e]	3[f]	4[g]	6[h]
1	666	19932	192556	5348	5	41
5	168	2812	14990	1043	3	22
10	93	1210	4992	516	3	17
15	65	739	2624	342	2	14
20	51	520	1662	255	2	13
25	42	397	1167	203	2	12
30	36	318	874	169	2	11
35	32	263	684	145	2	10
40	28	224	554	126	2	10
45	26	194	459	112	2	9
50	23	171	389	101	2	9
55	22	152	334	91	2	8
60	20	137	291	84	2	8
65	19	124	256	77	2	8
70	18	113	228	71	2	8
75	17	104	204	67	1	7
80	16	96	184	62	1	7
85	15	89	167	59	1	7
90	14	83	153	55	1	7
100	13	73	129	50	1	7
110	12	65	111	45	1	6
120	11	59	97	41	1	6
130	10	53	85	38	1	6
140	10	49	76	35	1	6
150	9	45	68	33	1	6
160	9	41	61	31	1	6
170	8	38	56	29	1	5

[a] See Table 1 for a description of the severity-of-ill-effect scores.

[b] From Anderson et al. 1996.

[c] From Newcombe and Jensen (1996); see Table 2 for model attributes.

[d] Juvenile + adult salmonids.

[e] Adult salmonids.

[f] Juvenile salmonids.

[g] Egg + larvae of salmonids and nonsalmonids.

[h] Adult nonsalmonids.

habitat model, moderate to moderately severe habitat degradation would be predicted if the TSS concentrations associated with the shaded durations were sustained for up to 60 days.

The Newcombe and Jensen (1996) models predict that for a duration of exposure equal to 60 days, the maximum TSS concentrations that would *not exceed* the lethal and paralethal threshold are as follows:

80 mg/L for juvenile salmonids

110 mg/L for juvenile and adult salmonids modeled together

160 mg/L for adult salmonids

The equivalent TSS concentration based on the Anderson et al. (1996) acute fish habitat impact model is 15 mg/L. However, it is important to note that although Anderson et al. (1996) assigned SEV scores that "followed" the Newcombe and Jensen (1996) SEV scale (Table 1), they only reported assigning an SEV equal to either 3, 7, 10, 12, or 14 (not 9). The authors suggested that the exposure levels that "approach" causing habitat damage are based on a SEV=7—defined in their report as "moderate habitat degradation—measured by a change in the invertebrate community."

When Table 3 is recomputed for the Anderson et al. (1996) model using a SEV=7, the maximum TSS concentration that would not exceed the lethal and paralethal threshold after a duration of 60 days is 5 mg/L. Under the same criteria, the TSS concentration associated with a SEV=10 is 60 mg/L. Anderson et al. (1996) defined the SEV=10 as "moderately severe habitat degradation—as defined by measurable reductions in the productivity of habitat for extended periods (months) or over a large area (kms)."

For the egg and larval life stages of salmonids and nonsalmonids, Newcombe and Jensen's (1996) model predicts the lethal and paralethal threshold to be exceeded at any TSS concentration ≥1 mg/L after 5 days of exposure. The same would be predicted for adult nonsalmonids after 41 days of exposure.

These models suggest that for a duration no longer than 60 days, an appropriate upper limit for the protection of juvenile salmonids is 80 mg/L of TSS, and up to 160 mg/L for adult salmonids. However, for the early life stages of fish and adult nonsalmonids, they suggest protection from lethal and paralethal effects cannot be afforded at TSS concentrations ≥1 mg/L when sustained for 60 days.

Thus, based on these models, a maximum target TSS limit of 80 mg/L would be required to protect juvenile salmonids; however, special consideration would have to be given to nonsalmonids, the early life stages of fish, and fish habitat—all requiring a lower TSS concentration for protection against lethal and paralethal effects.

Acute Habitat Impact Model Developed by Anderson et al. (1996)

The model developed by Anderson et al. (1996) provides a tool for selecting a TSS concentration that would be protective of fish and their habitat from acute sediment release episodes. Anderson et al. (1996) data included subsets of Newcombe and Jensen's (1996) database (as well as data compiled by Newcombe and others in previous work) and some 53 new documents of TSS effects. The new information was weighted heavily toward field data. The subset of data from Newcombe and others work only included information on events less than one month in duration, since the goal of Anderson et al. (1996) was to quantify acute effects rather than chronic effects.

Reviewing the calculated durations shown in Table 3 for the acute habitat impact model, it can be seen that 80 mg/L could be sustained for up to 2 weeks and still be protective against acute impacts. Or, in other words, the model predicts that after a 2-week period, with TSS concentrations ≥80 mg/L, acute impacts would occur.

Other Studies

Results from Buck's (1956) study of SS and selected species of warm water fish would suggest setting an upper limit for the protection of a fishery no higher than 100 mg/L. Because fish from ponds in the "intermediate" SS concentration range of 25 to 100 mg/L (based on averages) exhibited lower total weights, slower growth rates, and a reduced reproduction rate and success compared to those from ponds with an average SS concentration of <25 mg/L, a concentration below 100 mg/L might be more appropriate for protection of a fishery. Making a "finer" split of the 25 to 100 mg/L range would be purely speculative based on this study; however, the range of SS concentrations and the associated "impacts" are consistent with the SS concentration ranges set forth or measured in many of the other studies presented in this memo.

Results from Peters' (1967) study suggest that a concentration as high as 80 mg/L may be protective of a healthy fishery—including all life stages. However, it could not be determined from the study whether the young-of-year brown trout collected in the vicinity of the stream where the median monthly SS concentration was 79 mg/L migrated downstream from an area where the median monthly SS concentration was only 18 mg/L. Also, because the raw data of twice-weekly measurements were not published with the study, the exact magnitudes and durations of SS concentrations cannot be ascertained; however, based on a description of the study area, the climate, land use, and timing of hydrologic events were similar to those in the lower Boise River watershed today.

Results from Sweeten's (1998) laboratory study dealing with juvenile and larval smallmouth bass and bluegill indicate that a protective SS concentration should be much lower than 80 or 100 mg/L if the larval stage is to be protected. This study suggests that the existing TSS criteria presented from other states and the model developed by Newcombe and Jensen (1996) for the egg and larval stages of fish may not be overly protective or conservative.

Based on a personal communication (1998), Sweeten intends to be working under an EPA grant in the near future to further explore the effects of TSS on fish during the life stage immediately following yolk-sac absorption. It is during this time, when the fish transitions to becoming a sight-feeder, that he believes the fish may be most vulnerable to elevated SS concentrations. To date, however, the results from his first study have not been field verified.

Conclusions and Recommendation

The effects of suspended sediment on fish will vary with life stage, species, concentration of SS, duration of exposure, and SS particle size and shape. The early life stages of fishes clearly seem to be the most sensitive to TSS doses, whereas the larger adult fish seem to be able to withstand higher TSS concentrations and longer durations of exposure.

Suggested or existing TSS standards typically range from 25 to 80 mg/L. The higher end of this range seems to have been derived from the impacts of TSS on adult fish, whereas the low-end concentrations seems to be related to protecting the more sensitive life stages of fish—the egg and larval stages. Models developed to predict the impact of various sediment doses would support either ends of this range, depending on the life stage and species of concern, as well as the duration of exposure.

Duration of TSS exposure is a significant variable in determining the severity of ill effect on fish. Even at 25 mg/L, if sustained for a long enough period of time, this concentration may result in significant negative effects. In a laboratory environment, at least one study indicates that over a period as short as 7 days, TSS concentrations as low as 35 mg/L can result in greater than 50 percent mortality of fish larvae. In a Montana field study, however, young-of-year brown trout were collected in the vicinity of a stream sampling location that had a median monthly TSS concentration of 79 mg/L, measured twice weekly over 2 years. In either case, some uncertainty exists: To date, the laboratory study has not been field tested; and in the field study, the young-of-year trout may have migrated downstream from an area with a median monthly TSS concentration of only 18 mg/L.

Based on the durations of the seasonal hydrologic events in the lower Boise River, the various life stages and species of fish present from Lucky Peak Dam to the Snake River, and because spawning of various species occurs throughout the river, the recommended TSS concentration limit for the protection of the lower Boise River fishery and aquatic community is 50 to 80 mg/L . The 50 mg/L target is intended to be protective against the ill effects attributable to a 60-day chronic TSS exposure, whereas the 80 mg/L target is to be protective against a 14-day acute TSS exposure.

In the absence of TSS duration data, it is recommended that these targets be based on geometric means over the 60- and 14-day durations, respectively. However, it is important to realize that sustaining these recommended TSS limits beyond the 60- and 14-day durations would not afford protection of the aquatic communities. These durations are based on the fact that the river experiences periods of low TSS concentrations—periods that are essential for providing "relief" from the potential of sustained elevated TSS concentrations. If ongoing and future TSS monitoring indicates that the maximum length of time for which elevated TSS concentrations are sustained is actually less than 60 days, then the chronic TSS limit can be adjusted. For example, if this duration is determined to be only 30 days, then the appropriate TSS concentration for protection against chronic effects may only be 100 mg/L based on a 30-day geometric mean.

In light of the existing and pending research involving the effects of TSS on the sensitive, early life stages of fishes, and the importance of a long-term self-sustaining fishery, it is emphasized that the recommended limit of 50 to 80 mg/L should not be reason, or provide incentive to point- and nonpoint-sources that may currently be discharging (continuously or discontinuously) at concentrations <50 mg/L, to increase their sediment mass loading to a level that results in a *sustained* TSS concentration equal to the recommended limit.

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Appendix A

Selected Data Sets from Newcombe and Jensen's (1996) Meta-Analysis Database

inbow Trout									
	Behavioral			Sublethal			Lethal and Paralethal		
	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect
Eggs/embryo							7	48	11: [E] Mortality rate 40%
							21	48	13: [E] Mortality rate 72%
							47	48	14: [E] Mortality rate 100%
							57	62	12: [E] Mortality rate 47% (controls, 32%)
							101	60	14: [E] Mortality rate 98% (controls, 15%)
							120	16	13: [E] Mortality rates 60-70% (controls, 39%)
							157	72	14: 100% mortality of eggs
							1,750	6	10: [EE] Mortality rate greater than controls (controls, 6%)
Juvenile				171	4	8: [J] Particles penetrated cells of branchial epithelium	90	19	10: [Y] Mortality rates 0-20% (DE)
				4,887	16	8: [J] Hyperplasia of gill tissue	90	19	10: [Y] Mortality rates 0-15% (KC)
				4,887	16	8: [J] Parasitic infection of gill tissue	270	19	11: [Y] Mortality rates 10-35% (KC)
							270	19	12: [Y] Mortality rates 25-80% (DE)
							810	19	12: [Y] Mortality rates 35-85% (DE)
							810	19	12: [Y] Mortality rates 5-80% (KC)
							1,750	20	12: [FF] Mortality rate 57% (control 5%)
							2,120	28	14: [Y] Mortality rate 100%
							4,250	28	12: [Y] Mortality rate 50%
							4,315	2.4	10: [Y] Mortality rates ~100% (CSS)
							7,433	28	11: [Y] Mortality rate 40% (CS)
Adult	66	0.04	3: Avoidance behavior manifested part of the time	100	0.01	5: Rate of coughing increased (FSS)	18	30	10: Abundance reduced
	100	>0.01	3: Fish avoided turbid water (avoidance behavior)	250	0.01	5: Rate of coughing increased (FSS)	50	40	9: Rate of weight gain reduced (CWS)
	665	0.04	3: Fish attracted to turbidity	810	21	8: Gills of fish that survived had thickened epithelium	50	40	9: Rate of weight gain reduced (WF)
				17,500	7	8: Fish survived; gill epithelium proliferated and thickened	59	93	10: Habitat damage; reduced porosity of gravel
							200	1	10: Test fish began to die on the first day (WF)
							270	135	10: Survival rate reduced
							810	21	10: Some fish died
							3,500	62	13: Catastrophic reduction in population size
							4,250	25	12: Mortality rate 50% (CS)
							49,838	4	12: Mortality rate 50% (DM)
							80,000	1	10: No mortality
							160,000	1	14: Mortality rate 100%

[J] juvenile
[EE] eyed egg
[FF] young fry
[DE] diatomaceous earth

[CS] calcium sulfate
[WF] wood fibers
[FSS] fine
[E] egg

[Y] approx. yearling
[KC] kaolin clay
[CWS] coal washery solids
[DM] drilling mud (non toxic)

	Behavioral			Sublethal			Lethal and Paralethal		
	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect
Brown Trout									
Eggs/embryo							110	60	14: 98% mortality of eggs
Adult				1,040	730	8: Gill lamellae thickened (VFSS)	18	30	10: Abundance reduced
				1,210	730	8: Some gill lamellea became fused (VFSS)	100	30	11: Population reduced
							1,040	365	14: Population one-seventh of expected size
							5,838	365	14: Fish numbers one-seventh of expected
Trout									
Eggs/embryo							117	40	10: [E] Mortality; deterioration of spawning gravel
Adult				16.5	1	4: Feeding behavior apparently reduced	300	30	12: Decrease in population size
				[illegible]75	[illegible]7	[illegible] 7: Reduced quality of rearing habitat	525	25	10: No mortality (other end points not investigated)
				270	13	8: Gill tissue damage			
Mountain Whitefish									
Adult							10,000	1	10: Fish died; silt-clogged gills

	Behavioral			Sublethal			Lethal and Paralethal		
	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect	Conc. (mg/l)	Duration (days)	Scale of Severity: Description of Effect
Largemouth Bass (warmwater species)									
Adult							63	30	9: Weight gain reduced ~50%
							145	30	9: Growth retarded
							145	30	12: Fish unable to reproduce
Adult Nonsalmonids (species not specified)									
Adult							22	365	12: Fish populations destroyed
							120	16	10: Density of fish reduced
							620	2	10: Fish kills downstream from sediment source

Appendix B

Selected Data Sets from Newcombe and MacDonald's (1991) TSS Review

vertebrates									
	Behavioral			Sublethal			Lethal		
	Conc. (mg/l)	Duration (days)	Effect	Conc. (mg/l)	Duration (days)	Effect	Conc. (mg/l)	Duration (days)	Effect
Benthic invert.							8	0.10	increased rate of drift
							8	60	up to 50% reduction in standing crop
							16	60	Reduction in standing crop
							32	60	Reduction in standing crop
							62	100	77% reduction in population
							77	100	53% reduction in population
							278	100	80% reduction in population size
							390	30[a]	Reduction in population size
							743	100	85% reduction in population size
							1,700	0.08	alter. comm. structure and drift patterns
							5,108	100	94% reduction in population size
							29	30[a]	Populations of Trichoptera, Ephemeroptera, Crustacea, and Mollusca, disappear
Bottom fauna							261-390	30[a]	Reduction in population size
Zoobenthos							10-15	30[a]	Reduction in standing crop
							>100	28[a]	Reduction in standing crop
Cladocera							82-392	3[a]	Survival and reproduction harmed
Cladocera and Copepoda							300-500	3	Lethal: Gills and gut clogged
Stream invert.							130[b]	365	Lethal: 40% reduction in species diversity
							25,000[b]	365	Reduction or elimination of populations
	24[a]	<0.01	Reduced capacity to assimilate food						
							53-92	1[a]	Reduction in population size

[a] Estimated
[b] China clay

Appendix C

Data Tables from Peters (1967) on the Effects of Sediment from Agricultural Practices on a Montana Trout Stream

Table C-1

Monthly Average Suspended-Sediment Concentration in Parts per Million Based on Approximately Twice Weekly Samples from April 1960 to March 1962 at Five Stations on Bluewater Creek

Month	1960-61 Station					1961-62 Station				
	I	II	III	IV	V	I	II	III	IV	V
April	37	118	192	123	323	16	113	178	118	185
May	27	122	147	139	310	35	86	241	280	2280
June	33	92	119	85	395	17	58	120	197	319
July	16	72	104	115	188	11	42	201	210	428
August	12	49	188	229	577	13	35	204	199	355
September	16	20	85	73	242	39	79	357	754	2030
October	19	39	104	211	314	23	75	189	284	353
November	14	36	64	188	252	20	97	174	328	254
December	10	45	126	179	221	13	118	142	282	246
January	22	69	194	291	267	16	147	276	343	398
February	14	55	167	137	159	28	160	378	574	556
March	16	96	119	105	114	25	131	156	323	368

From: Peters, J.C. 1967. Effects on a Trout Stream of Sediment from Agricultural Practices. *Journal of Wildlife Management* 31(4):805-812.

Table C-2

Monthly Mean Maximum and Minimum Temperature (C) at
Two Stations in Bluewater Creek from January 1961 Through December 1961

Month	Station II Mean Monthly		Station IV Mean Monthly	
	Max.	Min.	Max.	Min.
January	9.4	4.4	6.7	2.8
February	10.6	4.4	7.8	3.3
March	12.2	4.4	10.0	3.9
April	13.9	5.6	12.8	5.6
May	17.2	7.2	17.8	8.9
June*	18.3	6.7	22.8	15.6
July	19.4	8.3	23.9	17.2
August	18.3	6.7	21.7	15.6
September	13.3	6.1	13.3	9.4
October	11.7	5.6	11.1	5.6
November	10.0	4.4	7.8	4.4
December	10.0	6.7	5.6	2.8

*Values for Station II based on 27 days in June.

From: Peters, J.C. 1967. Effects on a Trout Stream of Sediment from Agricultural Practices
Journal of Wildlife Management 31(4):805-812.

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Table C-3

Number of Trout and Rough Fish Captured by Electrofishing in 4,000-Square-Foot Areas During August and September 1961 in Bluewater Creek

	Station									
	I		II		III		IV		V	
Section	Trout	Rough Fish	Trout	Rough Fish	Trout	Rough Fish	Trout	Rough Fish	Trout	Rough Fish
1	177	9	209	0	87	238	10	1446	4	425
2	230	6	218	19	36	141	7	1515	9*	471*
3	241	4	164	30	40	296	7	641	4*	236*
Average	216	7	197	17	55	225	8	1201	6	378

*Sampled in May 1962.

From: Peters, J.C. 1967. Effects on a Trout Stream of Sediment from Agricultural Practices. *Journal of Wildlife Management* 31(4):805-812.

BOI980750020.XLS/lh

Table C-4
Population Estimate of Trout by Mark and Recapture in Bluewater Creek (One section sampled near each station)

Station No.	Number of Trout Captured by Electrofishing	Estimate Total Number of Trout Without Separation by Size Classes		Estimate Total Number of Trout With Separation by Size Classes	
I	230	266	(86)*	269	(86)*
II	164	197	(83)*	198	(83)*
III	87	102	(85)*	102	(85)*
IV	7	8	(88)*	8	(88)*
V	4	6	(67)*	6	(67)*

*Ratio of the number of trout captured by electrofishing to the estimate of the total number of trout.

From: Peters, J.C. 1967. Effects on a Trout Stream of Sediment from Agricultural Practices. *Journal of Wildlife Management* 31(4):805-812.

Table C-5
Mortality of Eyed Rainbow Eggs Incubated in Five Areas of Bluewater Creek

Station	Percent Mortality			Average Mortality (Percent)
	Box 1	Box 2	Box 3	
I	2	4	4	3
II	35	22	8	22
III	81	38	42	54
IV	51	83	75	70
V	19	37	83	47

Notes:
1. An estimated 476 eggs were placed in the streambed in each Vibert box on May 24, 1961; pulled out on June 2, 1961.
2. The relatively low mortality of eggs at Station V was attributed to high flows that carried out the sediment rather than depositing it in the streambed gravels.

From: Peters, J.C. 1967. Effects on a Trout Stream of Sediment from Agricultural Practices. *Journal of Wildlife Management* 31(4):805-812.

Appendix B

USGS Lower Boise River Sediment Water Quality Data

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13203510
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Ft/Sec (00061)	Turbidity (NTU) (00076)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
11/20/90	175	2.1	8	3.8
3/28/91	177	2	3	1.4
5/22/91	1350	11	3	11
9/11/91	737	1	4	8
5/4/93	2700		4	29
5/18/93	5680		3	46
6/3/93	2510		4	27
9/1/93	1690		3	14
11/3/93	258	0.7	3	2.1
3/10/94	245	1.0	41	27
5/11/94	1770	0.4	2	9.6
9/13/94	620	1.0	8	13
11/14/94	161		6	2.6
4/13/95	1420		28	107
4/26/95	4640		6	75
5/16/95	4610		2	25
6/12/95	2620		2	14
8/14/95	1830		1	4.9
9/19/95	337		27	25
12/7/95	200		5	2.7
2/13/96	4000		4	43
4/11/96	5900		5	80
4/22/96	5400		7	102
5/15/96	4650		4	50
6/12/96	7800		5	105
8/21/96	2100		3	17
10/21/96	321		6	5.2
12/16/96	240		2	1.3
2/10/97	7010		38	720
4/14/97	7700		9	187
6/9/97	4570		6	74
7/14/97	2300		3	19
8/11/97	2160		3	17
Min	161	0.4	1	1.3
Max	7800	11	41	720
Average	2663	2	8	57
Count	33	8	33	33

GLENWOOD BRIDGE
DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13206000
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Ft/Sec (00061)	Turbidity (NTU) (00076)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
11/22/89	185	1.5	4	1.9
3/16/90	147	3.5	7	2.8
5/29/90	850	7.8	20	46
7/9/90	736		8	16
9/21/90	491	1.6	5	6.6
11/19/90	169	1.6	3	1.4
3/28/91	157	2.4	7	3
5/22/91	602	1.9	11	18
9/11/91	574	1.1	6	9.3
11/12/91	153	1.6	5	2.1
3/18/92	114	3.2	7	2.2
5/14/92	732	2	8	16
9/11/92	287	3	7	5.4
11/2/92	83	1.2	4	0.90
1/7/93	71			
3/10/93	120	3.3	6	1.9
5/4/93	2270		120	735
5/12/93	2,570	6.2	14	97
5/18/93	4970		36	483
6/2/93	1690		32	146
8/6/93	1130	9.7		
9/1/93	748		4	8.1
9/14/93	626	1.2	83	140
11/1/93	240	0.6	2	1.3
5/4/94	248	0.6	30	20
5/13/94	806	0.4	4	8.7
9/9/94	398	0.9	6	6.4
11/10/94	188	1.2	3	1.5
3/20/95	167	4.6	12	5.4
4/13/95	923		23	57
4/26/95	3,450		52	484
5/16/95	3,990	2.0	24	259
6/12/95	1,710		5	23
8/14/95	790		4	8.5
9/19/95	811	13.0	16	35
10/19/95	321		5	4.3
12/7/95	235		4	2.5
2/13/96	3,760		67	680
4/11/96	5,690	2.9	22	338
4/22/96	4,910		17	225
5/16/96	3,790	2.0	25	256
6/11/96	5,060	2.0	20	273

GLENWOOD BRIDGE
DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13206000
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Ft/Sec (00061)	Turbidity (NTU) (00076)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
7/12/96	1,340	0.6	12	43
8/21/96	1,250	1.1	4	13
9/24/96	743	1.5	4	8.0
10/21/96	386		3	3.1
12/16/96	446		3	3.6
2/10/97	6,860		53	982
4/15/97	6,850	5.2	20	370
5/23/97	4,630		27	338
6/9/97	4,100	4.2	10	111
7/16/97	1,400	5.2		
8/11/97	1,420	1.4	4	15
9/8/97	1,420	1.9		
Min	71	0	2	1
Max	6,860	13	120	982
Average	1,626	3	18	126
Count	54	36	50	50

DISTRICT CODE 16

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97

Station Number 13210050

WATER - QUALITY DATA

Date	Discharge Inst. Cubic Ft/Sec (00061)	Turbidity (NTU) (00076)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
11/13/91	241	1.7	11	7.2
3/18/92	174	3.9	11	5.2
5/11/92	169	3	15	6.8
9/11/92	161	1.6	8	3.5
5/5/93	1910		71	88
5/19/93	4460		30	361
6/3/93	625		29	49
9/1/93	245		6	4
5/12/94	234		10	6.3
11/9/94	258	1.2	5	3.5
3/10/95	224	1.4	15	9.1
4/13/95	765		30	62
4/28/95	3,630		211	2070
5/17/95	3,760	2.7	18	183
6/13/95	1,160		7	22
8/15/95	573		5	7.7
9/11/95	417	1.0	6	6.8
10/19/95	356		4	3.8
12/5/95	382		4	4.1
2/14/96	4,000		28	302
4/11/96	4,800		17	220
4/23/96	4,200		2	23
5/15/96	3,240		15	131
6/13/96	4,690		24	304
8/22/96	620		6	10
10/24/96	412		4	4.4
12/16/96	342		4	3.7
4/16/97	5,640		14	213
7/15/97	704		17	32
8/11/97	783		8	17
Min	161	1	2	4
Max	5,640	4	211	2,070
Average	1,639	2	21	139
Count	30	8	30	30

PARMA
DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13213000
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Ft/Sec (00061)	Turbidity (NTU) (00076)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
1/23/74	1040		71	199
3/20/74	5260		57	814
6/25/74	6300		154	2620
7/23/74	758		76	156
9/4/74	810		47	103
10/16/74	1140		28	86
11/18/74	1090		18	53
12/12/74	1020		664	1830
1/21/75	920		20	50
2/24/75	944		39	99
3/21/75	2070		56	313
4/23/75	7500		46	931
5/28/75	5950		52	835
6/24/75	1310		84	297
7/17/75	1120		102	308
8/25/75	1280		483	1670
9/17/75	933		40	101
[illegible]/17/75	1300		147	516
11/18/75	1050		9	26
12/22/75	1030		22	61
1/21/76	2770		467	3490
2/19/76	1080		26	76
3/17/76	3140		66	560
4/21/76	5740		111	1720
5/20/76	3680		145	1440
6/30/76	624		84	142
7/21/76	902		112	273
8/17/76	1360		74	272
9/22/76	13900		43	1610
10/14/76	1110		20	60
11/16/76	1090		18	53
12/15/76	965		17	44
1/12/77	784		32	68
2/9/77	669		28	51
3/8/77	650		32	56
4/12/77	344		23	21
5/10/77	523		102	144
6/7/77	219		23	14
7/21/77	275		72	53
[illegible]/10/77	273		33	24
9/8/77	364		19	19
10/12/77	575		8	12

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13213000
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Ft/Sec (00061)	Turbidity (NTU) (00076)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
6/10/81	6120		129	2130
11/12/86	2230	4.8	35	211
1/22/87	827	4.9	53	118
3/19/87	933	9	54	136
5/28/87	1270	32	145	497
7/27/87	549	25	61	90
9/9/87	732	4.3	42	83
11/23/87	906	1.8	54	132
1/13/88	761	2.9	60	123
3/14/88	667	4.2	31	56
5/23/88	380	14	52	53
7/20/88	258	1.6	45	31
9/21/88	514	6.5	25	35
11/10/88	842	4.9	16	36
1/19/89	723	6.2	30	59
3/13/89	1130	29	101	308
5/8/89	1400	17	71	268
7/5/89	543	37	95	139
8/29/89	1100	17	66	196
11/16/89	950	3.5	12	31
1/30/90	1420	10	30	115
3/26/90	323	4	22	19
5/21/90	830	30	148	332
7/12/90	309	19	48	40
9/17/90	784	9.6	39	83
11/21/90	888	4	15	36
1/16/91	932	15	46	116
3/25/91	587	6	48	76
5/20/91	1400	28	120	454
7/22/91	608	30	91	149
9/10/91	796	23	107	230
11/14/91	808	3	61	133
1/22/92	660	5.4	26	46
3/17/92	564	6.5	27	41
5/12/92	308	17	57	47
9/8/92	170		41	19
11/3/92	648	4.5	18	31
1/5/93	576	3.5	15	23
3/11/93	723	8.0	33	64
5/13/93	2,170	15.0	63	369
9/8/93	772	4.4	40	83
11/2/93	981	0.8	12	32

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13213000
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Ft/Sec (00061)	Turbidity (NTU) (00076)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
1/19/94	870	3.7		
3/1/94	800	2.8	83	179
5/10/94	587	34.0	89	141
9/7/94	444	2.2	20	24
11/8/94	779	3.2	15	32
2/15/95	686	4.5	34	63
4/14/95	1,270		164	562
4/27/95	3,560		163	1570
5/18/95	4,380	5.1	37	438
6/14/95	1,010		59	161
7/19/95	1,420	12.0	245	939
8/16/95	1,080		51	149
10/18/95	942		15	38
12/5/95	935		18	45
2/15/96	5,360		70	1010
4/10/96	6,320		58	990
4/24/96	5,040		43	585
5/17/96	5,320		89	1280
6/10/96	5,100		46	633
8/21/96	1,140		34	105
10/23/96	1,190		18	58
12/17/96	929		14	35
2/11/97	8,580		47	1090
4/17/97	6,340		26	445
5/22/97	4,760		47	604
6/10/97	4,280	10.0	47	543
7/18/97	1,350	20.0		
8/12/97	1,500	6.2	32	130
9/9/97	1,510	3.7		
Min	170	1	8	12
Max	13,900	37	664	3,490
Average	1,783	11	69	367
Count	113	52	110	110

DISTRICT CODE 16

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97

Station Number 13206400

WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/3/94	39	74	7.8
11/15/94	13	12	0.42
5/17/95	29	7	0.55
12/5/95	11	64	1.9
5/14/96	29	90	7.1
6/9/97	33	11	0.98
Min	11	7	0.42
Max	39	90	7.8
Average	26	43	3.1
Count	6	6	6

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY   PROCESS DATE 10/16/97
Station Number 13209450
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/3/94	29	20	1.6
11/15/94	10	11	0.30
5/18/95	14	12	0.46
12/7/95	14	11	0.42
5/14/96	14	11	0.42
6/9/97	16	3	0.13
Min	10	3	0.13
Max	29	20	1.6
Average	16	11	0.56
Count	6	6	6

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13210810
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/4/94	116	192	60
11/16/94	23	9	0.57
4/11/95	83	196	44
4/24/95	110	152	45
5/17/95	119	67	22
6/15/95	89	133	32
8/17/95	99	100	27
10/17/95	62	8	1.3
12/5/95	36	13	1.3
2/14/96	37	23	2.3
4/11/96	118	518	165
4/23/96	170	111	51
5/16/96	199	167	90
6/13/96	104	65	18
8/20/96	147	56	22
10/21/96	60	5	0.81
12/19/96	33	20	1.8
2/13/97	51	20	2.7
6/12/97	182	95	47
7/16/97	167	139	63
8/13/97	156	65	27
Min	23	5	0.57
Max	199	518	165
Average	103	103	34
Count	21	21	21

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 132108247
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/3/94	139	48	18
11/15/94	66	23	4.1
5/12/95	157	62	26
12/5/95	65	29	5.1
5/13/96	116	51	16
6/10/96	149	19	7.6
7/15/96	166	17	7.6
8/12/96	146	11	4.3
Min	65	11	4.1
Max	166	62	26
Average	126	33	11
Count	8	8	8

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13210835
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/2/94	75	102	21
11/17/94	1.5	3	0.01
4/18/95	82	124	27
4/26/95	56	71	11
5/12/95	118	162	52
6/7/95	46	42	5.2
8/14/95	18	50	2.5
10/16/95	33	13	1.2
12/4/95	1.7	11	0.05
2/12/96	41	190	21
4/8/96	20	36	2
4/25/96	121	357	117
5/13/96	27	25	1.8
6/11/96	42	68	7.7
8/19/96	28	68	5.2
10/22/96	32	10	0.87
12/18/96	939	5	13
2/12/97	299	196	158
6/10/97	59	38	6
Min	1.5	3	0.01
Max	939	357	158
Average	107	83	24
Count	19	19	19

MASON SLOUGH AT MOUTH NR CALDWELL
DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13210850
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/4/94	21	112	6.4
11/16/94	12	202	6.7
5/15/95	15	55	2.2
12/7/95	9.0	128	3.1
5/14/96	42	73	8.3
5/18/97	17	23	1.1
Min	9.0	23	1.1
Max	42	202	8.3
Average	19	99	4.6
Count	6	6	6

MASON CREEK AT MOUTH NR CALDWELL
DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY   PROCESS DATE 10/16/97
Station Number 13210985
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/4/94	126	335	114
11/16/94	47	17	2.1
4/12/95	28	21	1.6
4/24/95	75	122	25
5/15/95	116	116	36
6/15/95	134	191	69
8/17/95	168	116	53
10/17/95	84	28	6.4
12/7/95	61	81	13
2/16/96	62	131	22
4/9/96	59	84	13
4/26/96	92	263	65
5/14/96	121	525	172
6/12/96	124	407	136
10/24/96	93	12	3.0
12/18/96	58	47	7.4
2/12/97	77	73	15
6/11/97	170	159	73
7/16/97	155	135	56
8/13/97	142	55	21
Min	28	12	1.6
Max	170	525	172
Average	100	146	45
Count	20	20	20

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13210987
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/5/94	64	157	27
11/18/94	23	55	3.4
4/11/95	16	14	0.61
4/25/95	25	56	3.8
5/11/95	50	60	8.1
6/7/95	66	91	16
8/15/95	96	75	19
10/16/95	63	41	6.9
12/4/95	25	46	3.1
2/12/96	21	21	1.2
4/8/96	17	14	0.64
4/25/96	34	91	8.4
5/13/96	63	133	23
6/11/96	71	70	13
8/19/96	85		
10/22/96	40	35	3.7
12/18/96	22	52	3.0
2/12/97	13	15	0.51
6/10/97	72	87	17
Min	13	14	0.51
Max	96	157	27
Average	46	62	8.8
Count	19	18	18

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13210986
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/5/94	30	84	6.7
11/17/94	8.1	3	0.07
4/11/95	5.1	8	0.11
4/25/95	11	17	0.49
5/11/95	23	49	3.0
6/7/95	40	248	27
8/15/95	44	66	7.8
10/16/95	14	10	0.38
12/4/95	7.0	15	0.28
2/12/96	7.5	11	0.22
4/8/96	5.1	16	0.22
4/25/96	22	67	4.1
5/13/96	28	93	7.0
6/11/96	31	77	6.5
8/19/96	44	114	14
10/22/96	15	6	0.25
12/18/96	7.5	18	0.36
2/12/97	7.6	33	0.67
6/10/97	36	68	6.5
Min	5.1	3	0.07
Max	44	248	27
Average	20	53	4.5
Count	19	19	19

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13211445
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/5/94	75	101	20
11/17/94	162	17	7.4
4/12/95	92	101	25
4/24/95	100	45	12
5/16/95	167	41	18
6/12/95	83	42	9.4
8/17/95	33	75	6.6
10/17/95	150	36	15
12/6/95	201	47	26
2/13/96	205	58	32
4/9/96	102	36	9.9
4/26/96	101	57	16
5/16/96	151	176	72
6/11/96	55	42	6.2
8/20/96	76	26	5.3
10/22/96	256	30	21
2/17/96	204	33	18
2/11/97	214	150	87
6/11/97	63	34	5.7
7/16/97	50	47	6.3
8/13/97	63	28	4.8
Min	33	17	4.8
Max	256	176	87
Average	124	58	20
Count	21	21	21

DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13212550
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/6/94	40	295	31
11/18/94	23	31	1.9
4/12/95	17	39	1.7
4/25/95	31	140	12
5/18/95	42	219	25
6/14/95	45	248	30
8/16/95	47	144	18
10/18/95	27	23	1.7
12/6/95	19	22	1.1
2/15/96	15	9	0.36
4/9/96	14	49	1.9
4/24/96	40	174	19
5/16/96	52	217	30
6/10/96	52	425	60
8/20/96	50	68	9.2
10/23/96	33	111	9.8
12/17/96	20	58	3.2
2/10/97	19	48	2.5
6/18/97	55	160	24
7/15/97	58	321	50
8/12/97	52	104	15
Min	14	9	0.36
Max	58	425	60
Average	36	138	17
Count	21	21	21

DIXIE DRAIN NR WILDER
DISTRICT CODE 16
UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 10/16/97
Station Number 13212890
WATER - QUALITY DATA

Date	Discharge Inst. Cubic Feet Per Second (00061)	Sediment, Suspended (MG/L) (80154)	Sediment, Discharge, Suspended (T/Day) (80155)
5/6/94	219	111	66
11/18/94	81	50	11
4/18/95	162	140	61
4/27/95	183	102	50
5/19/95	182	60	29
6/14/95	156	126	53
8/16/95	222	39	23
10/18/95	196	20	11
12/6/95	81	30	6.6
2/15/96	85	41	9.4
4/10/96	166	134	60
4/24/96	240	223	145
5/17/96	370	460	460
6/10/96	219	88	52
8/21/96	154	21	8.7
10/23/96	166	25	11
12/17/96	76	22	4.5
2/11/97	92	79	20
6/18/97	228	91	56
7/16/97	258	97	68
8/12/97	249	48	32
Min	76	20	4.5
Max	370	460	460
Average	180	96	59
Count	21	21	21

APPENDIX H

Sediment Loading Analysis

Task Order No. 8—Sediment Loading Analysis and Allocation for the Lower Boise River TMDL

PREPARED FOR: Lower Boise River Water Quality Plan

PREPARED BY: Stephen D. Miller/CH2M HILL

DATE: July 27, 1998

Objectives

This technical memorandum (TM) was prepared to partially fulfill the requirements of Task Order 8 under CH2M HILL's contract with the Lower Boise River Water Quality Plan (LBRWQP). The objective of this task was to develop load allocations and wasteload allocations for sediment for the lower Boise River watershed. A companion TM has been prepared for bacteria allocation.

Background

This memorandum describes the loading analysis and allocation of sediment for the lower Boise River from Lucky Peak Dam to the mouth. For this analysis, "sediment" is expressed as total suspended sediment (TSS) in terms of mass per unit volume (mg/L). A quantitative assessment of sediment-related water column (TSS and turbidity) and substrate (percent embeddedness and pebble count) data for the lower Boise River is described in the "Sediment Problem Assessment for the Lower Boise River TMDL" (Miller 1998a).

Parameter Selection

TSS was selected as the basis for the lower Boise River sediment load analysis for the following reasons:

- Based on the relationship between turbidity and TSS data collected in the Boise River at Parma, the existing numeric water quality standard for turbidity was found to be unprotective of aquatic biota, at least in the vicinity of Parma (see Miller 1998a).
- Setting a load capacity for TSS will reduce the sediment influx to the river, which contributes to substrate embeddedness from Middleton downstream.
- The largest sample size, longest period of record, and most frequently sampled sediment-related parameter for the TMDL study area is TSS.

Instream TSS Targets

Because Idaho does not have a numeric water quality standard for TSS, the narrative water quality standard was translated into measurable water quality targets shown in Table 1. A complete description of the literature review and analyses used to establish these targets is presented in "Selection of a Total Suspended Sediment (TSS) Target Concentration for the Lower Boise River TMDL" (Miller 1998b).

TABLE 1
Instream TSS Targets

Concentration (mg/L)	Averaging Statistic	Averaging Period (days)
50	Geometric Mean	60
80	Geometric Mean	14

Hydrologic Seasons

A description of the regulated flow regime of the lower Boise River is included in the "DRAFT Subbasin Assessment for the Lower Boise River" (IDEQ 1998). In general, there are three predominant hydrologic flow seasons based on main stem river conditions. These seasons are listed in Table 2.

TABLE 2
Hydrologic Seasons

Season Name	Time Period
High-Flow	February 15 – June 14
Irrigation Flow	June 15 – October 14
Low-Flow	October 15 – February 14

It is important to realize that the seasonal names and time periods listed in Table 2 are meant to describe the dominant flow regime in the main stem Boise River during a typical year. It should be recognized, however, that the flow characteristics of the system will change somewhat from year-to-year in response to varying snowmelt or drought conditions, for example.

With this in mind, from approximately February 15 through June 14, main stem flow releases from Lucky Peak Dam are governed predominately by flood control—although demands for irrigation begin as early as April 1. Thus, irrigation diversions occur during approximately the last 63 percent of the high-flow season. During the drought of 1992 there were no flood control releases.

During a typical irrigation flow season defined in Table 2, main stem flows are governed predominately by irrigation demands. However, there have been wet years such as 1996 when flood flow releases occur beyond June 15 and diversions occur prior to April 1 to provide additional capacity in the main stem river for flood control.

Description of Available Data

Flow and TSS data sources and sampling locations are described in Miller (1998a) and Idaho Division of Environmental Quality (IDEQ 1998). Additional information is provided below for further detail.

Flow

Main Stem Boise River. Daily average flows were obtained from published U.S. Geological Survey (USGS) records for the gages located at each of the four main stem water quality sampling stations (Miller 1998a). A description of the available data is presented in Table 3.

TABLE 3
USGS Flow Data Available for the Lower Boise River at the Four Main Stem Water Quality Sampling Stations

Gaging Station Name	Station Number	Period of Record	Missing Days
Boise River below Diversion Dam	13203510	October 29, 1986, through September 30, 1994	0
Boise River at Glenwood Bridge near Boise	13206000	March 2, 1982, through November 2, 1997	0
Boise River near Middleton	13210050	December 10, 1974, through September 31, 1990 (low-flow periods only)	1598
		October 1, 1990, through October 13, 1997	351
Boise River near Parma	13213000	August 26, 1971, through October 8, 1997	0

Daily average flows from the USGS gage near Middleton were correlated with concurrent data recorded near Parma for the period of August 26, 1971, through October 8, 1997. The correlation is shown in Appendix A. The modeled daily average flows were used for the 351 missing days of record at Middleton, which occurred primarily from January through June of 1996 and 1997, respectively.

Drains and Diversions. Historical daily average flows for the tributaries, drains, and diversions were obtained from the Idaho Department of Water Resources (IDWR). Period of records typically go back as far as 1977; however, the most complete data are from 1990 through 1997. With the exception of water year 1997, the coverage of data within each year is from April 1 through October 31—consistent with the irrigation diversion period. For water year 1997, daily average flows are available for some of the major tributaries and drains during the low-flow months. A list of the names, IDWR station numbers, and approximate river mile for all the tributaries, drains, and diversions is included with the mass balance described below (see Appendices B through E). A schematic showing the relative locations of the drains and diversions is included in IDEQ (1998).

Point Sources. The three major wastewater treatment facilities (WWTFs) that discharge directly to the Boise River are Boise's Lander Street and West Boise WWTFs and Caldwell's

WWTF. Daily average effluent flows from the time periods listed in Table 4 were used to compute the existing, seasonal average WWTF effluent flows.

TABLE 4
Period of Analyses for WWTF Effluent Flow

WWTF	Period of Record Analyzed
Lander Street WWTF	February 1, 1993 – November 20, 1996
West Boise WWTF	January 1, 1993 – November 20, 1996
Caldwell WWTF	January 1, 1993 – December 31, 1996

TSS

Monitoring locations, sampling dates, measured TSS values, and sample sizes for all main stem locations and major tributaries and drains are described in Miller (1998a). For the point sources, daily average TSS effluent concentrations from the time periods listed in Table 5 were used to compute seasonal average TSS concentrations.

TABLE 5
Period of Analyses for WWTF Effluent TSS

WWTF	Period of Record Analyzed
Lander Street WWTF	February 1, 1993 – November 25, 1996
West Boise WWTF	January 1, 1993 – November 23, 1996
Caldwell WWTF	January 1, 1993 – December 31, 1996

TSS Load Capacities for Middleton and Parma Control Points

Analysis of Low, Median, and High-Flow Years

USGS flow records for the Boise River near Boise gage (USGS station number 13202000), which represents flow from Lucky Peak Dam, were analyzed to select a low, median, and high-flow water year (WY). Based on the total annual discharge, the low-flow WY is 1992. The high-flow WY is 1996. WY 1995 was selected as the typical year for the following reasons: 1) based on total annual discharge for WY 1928 through WY 1996, WY 1995 is within 5 (out of 69 total) years of the actual median WY; 2) based on post-Lucky Peak Dam flows (WY 1955-1996), WY 1995 is within 3 years of the actual median WY; 3) WY 1995 is more current and therefore more representative of the current watershed conditions than the actual median years of 1948 and 1964 for cases 1 and 2 above, respectively; and 4) water quality monitoring for the lower Boise River TMDL was ongoing during WY 1995.

Figures 1 and 2 illustrate the median and average flows, respectively, at the mouths of the major tributaries and drains during the high-flow season of 1992, 1995, and 1996. Figures 3 and 4 illustrate similar data for the main stem Boise River. Based on average and median flows during the high-flow season, these figures illustrate that, for the selected years, the flows at a given location can vary substantially. Although the main stem river experiences a proportionately larger range in flow variation than do the tributaries and drains, the range of flow in the tributaries and drains is substantial. For example, for the 11 tributaries and drains shown in Figure 1, the difference between the 1996 and 1992 median flows, expressed as a percent of the 1995 median flow, averages 56 percent. Because flow conditions in the main stem, tributaries and drains can vary substantially between two different years, load capacities were calculated for the low-, median-, and high-flow years.

Seasonal Critical Flows and Load Capacities

As described in Miller (1998a), there is a poor relationship between TSS concentration and discharge in the lower Boise River. The only fairly consistent relationship between TSS and discharge is the occurrence of a "first flush" effect (i.e., a TSS spike concurrent with a significant rising limb of the hydrograph). Because TSS data were collected roughly once every 2 months, or monthly at best, it is difficult to determine the duration of the elevated TSS concentrations.

Because of the high degree of scatter in the TSS versus discharge rating curve, determination of the seasonal critical flow conditions included consideration of the different land uses, land management practices, and timing of these practices such as irrigation. All of these factors were related to the seasonal TSS data and hydrologic regime of the watershed. Only the high and irrigation flow seasons were analyzed because the TSS concentrations in the Boise River did not indicate a need for a low-flow season TSS allocation (see Miller 1998a). The critical flow condition for any given year during either the high or irrigation flow season was determined to be a low-flow condition in the main stem river with contributing flows from the irrigation return drains. This scenario results in a full contribution of TSS from the major source—irrigation return drains—and the least available water for transport and dilution in the main stem river.

For the lower Boise River, the critical flows are defined as the minimum 30-day and 7-day average flows within each season. This definition is based on the fact that the primary impact of TSS in the lower Boise River is on the aquatic biota; thus, the seasonal critical flows are based on one-half of the averaging periods associated with each of the TSS target concentrations (Table 1). Recall that the TSS target concentration averaging periods are based on analyses of duration-of-exposure of aquatic organisms and habitat to TSS (Miller 1998b).

One-half of the averaging periods are used because the minimum 30- or 7-day average flow period during the irrigation flow season could follow immediately after the respective 30- or 7-day average flow period of the high-flow season. If this should ever occur, the combined duration of the two seasonal critical flow periods would not exceed the duration of the TSS target averaging period.

The seasonal load capacities are computed by multiplying the minimum 30- and 7-day average flows by the 50 and 80 mg/L TSS target concentrations, respectively. Table 6 lists

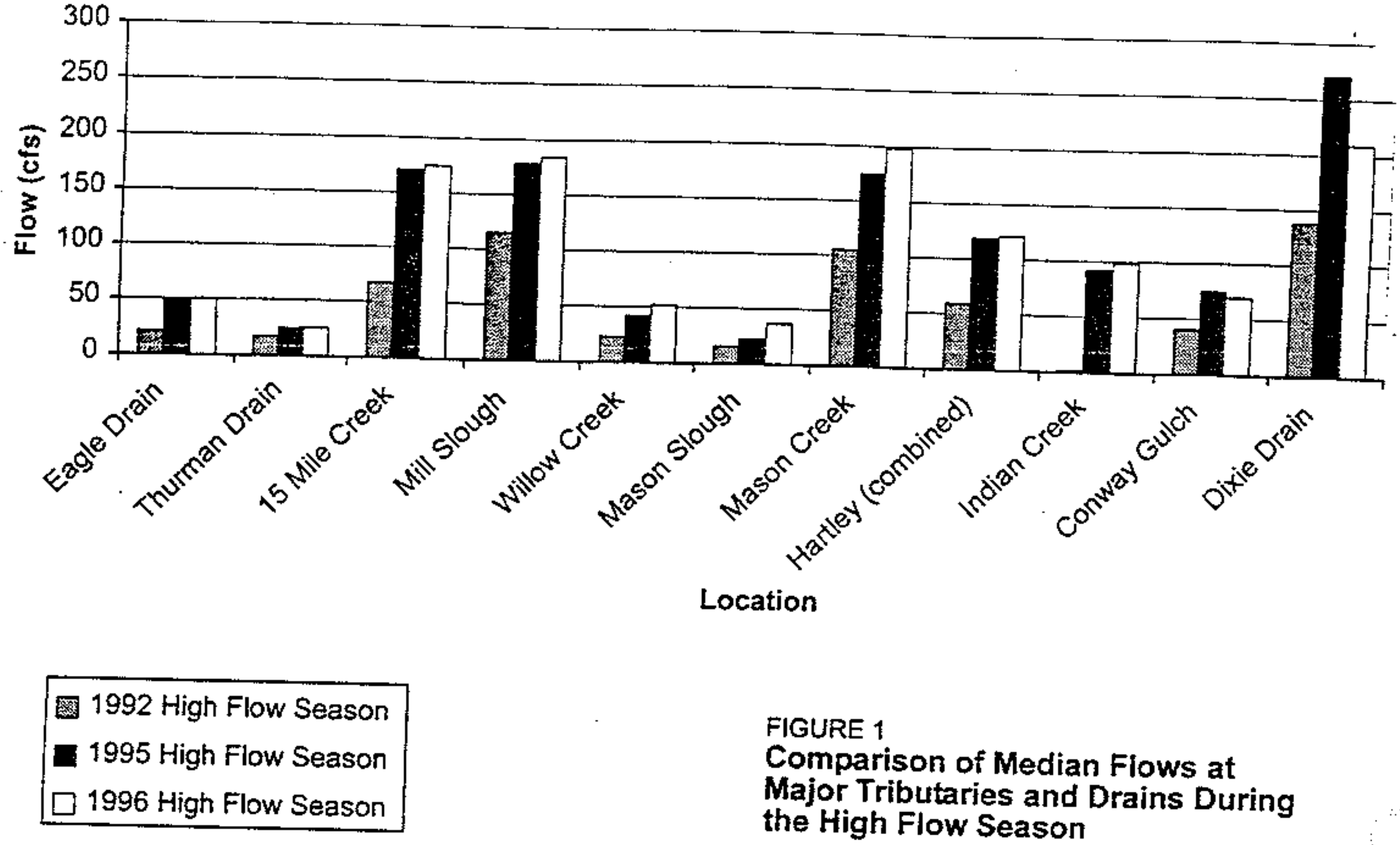

FIGURE 1
Comparison of Median Flows at Major Tributaries and Drains During the High Flow Season

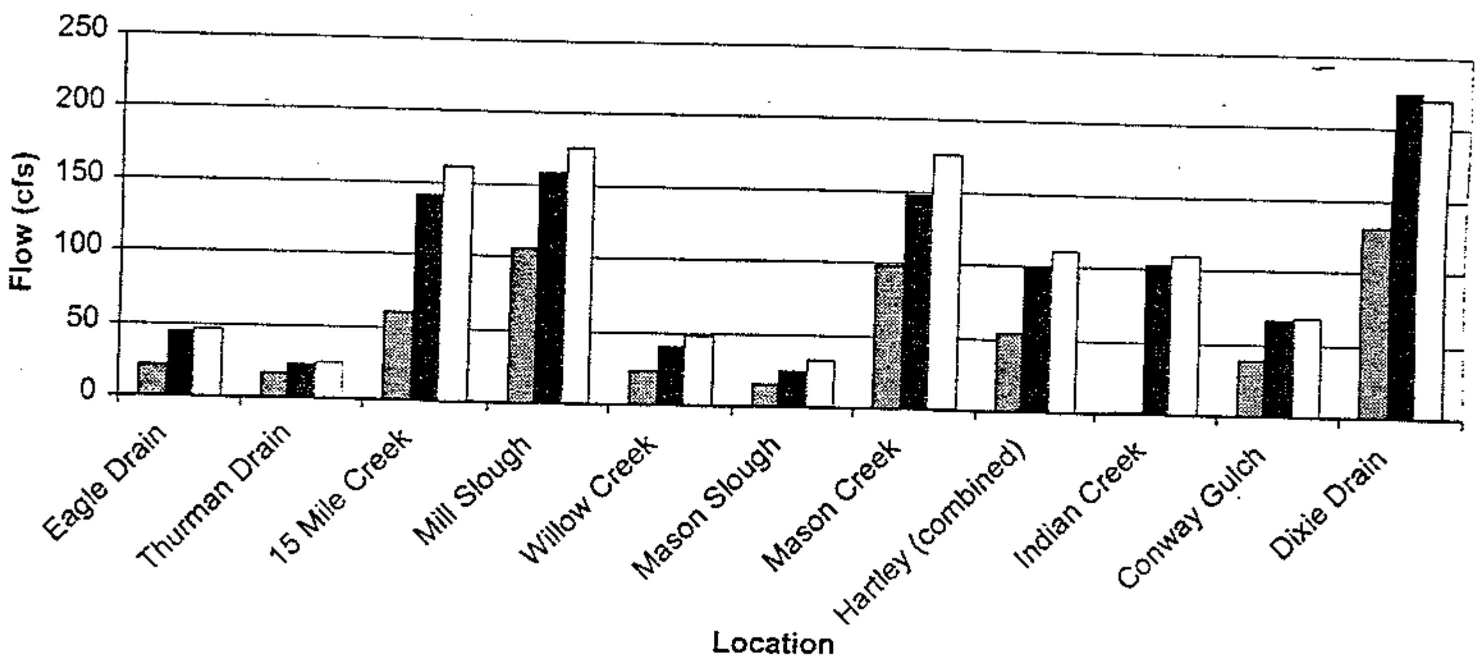

FIGURE 2
Comparison of Average Flows at Major Tributaries and Drains During the High Flow Season

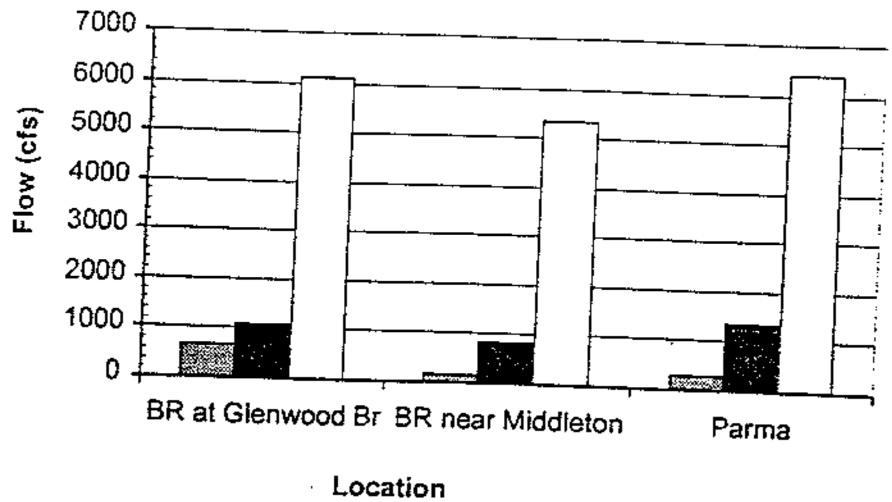

FIGURE 3
Comparison of Median Flows at Boise River Main Stem Stations During the High Flow Season

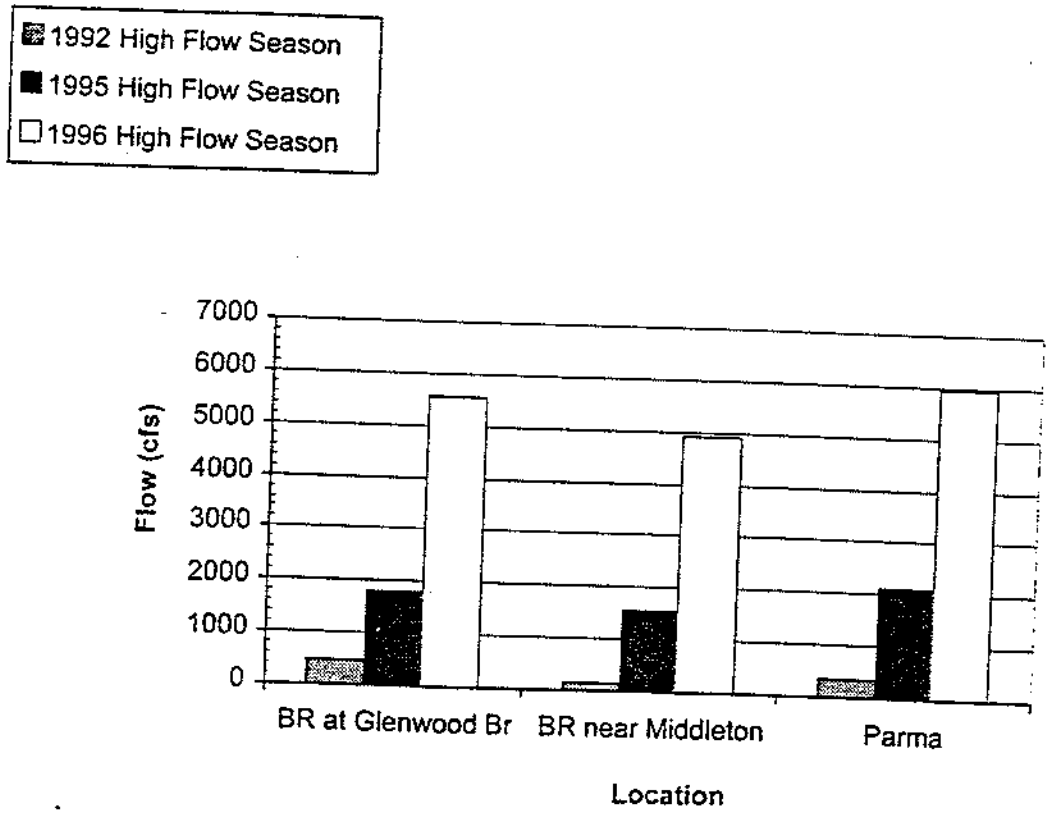

FIGURE 4
Comparison of Average Flows at Boise River Main Stem Stations During High Flow Season

the critical flows and load capacities computed for the high and irrigation flow seasons for each of the low, median, and high-flow years at Middleton and Parma.

TABLE 6
Seasonal Critical Flows and Chronic and Acute TSS Load Capacities for Middleton and Parma

	Middleton						Parma					
	High-flow Season			Irrigation Flow Season			High-flow Season			Irrigation Flow Season		
	1992	1995	1996	1992	1995	1996	1992	1995	1996	1992	1995	1996
Chronic Target												
Critical Flow (cfs)	152	257	2498	151	380	299	233	667	3990	160	968	1038
Load Capacity (T/day)	20	35	337	20	51	40	31	90	538	22	131	140
Acute Target												
Critical Flow (cfs)	121	237	1298	133	348	207	167	577	2710	113	852	789
Load Capacity (T/day)	26	51	280	29	75	45	36	124	585	24	184	170

By analyzing the system on a seasonal basis, the critical flow and load capacity calculations are more sensitive to the seasonal characteristics of the watershed. In addition, since the critical flows represent low-flow scenarios, this ensures the resulting allocations consider aquatic life and beneficial uses under a low-flow river condition.

Existing and Critical Conditions Analyses

Mass Balance Development

A main stem TSS mass balance was developed to evaluate TSS sources; TSS fate in the river system; instream, longitudinal TSS concentrations and loads; quantification of TSS load reduction scenarios; and sensitivity analysis. Twelve different mass balances were developed—one for each TSS target condition (i.e., 50 mg/L and 80 mg/L chronic and acute targets, respectively) for both the high and irrigation flow seasons for 1992, 1995, and 1996.

Flow Period. In order to achieve, or approach a good flow balance, and thus mass balance, it was necessary to analyze the system synoptically. It was found that the critical flows at the main stem stations did not occur over the same 30-or 7-day period; it was necessary to define a specific period of interest to be analyzed so that a synoptic flow balance could be achieved. Because the Parma location exhibits the highest (i.e, most critical) river TSS concentrations, the occurrence of the Parma critical flow period was used to define the periods to be analyzed in the mass balances. Table 7 lists the start dates of the critical flow periods at Parma. The seasonal flow values for all locations in the mass balance except the three WWTFs are the 30-day (chronic conditions) or 7-day (acute conditions) average flows concurrent with the critical, or minimum 30- or 7-day average flow at Parma, respectively.

TABLE 7
Start Dates of the Critical Flow Periods at Parma

Year	Season	Start Date of Occurrence	
		Min. 30-day Average	Min. 7-day Average
1992	High-Flow	March 24	March 30
	Irrigation Flow	August 21	August 29
1995	High-Flow	March 12	April 2
	Irrigation Flow	August 19	August 22
1996	High-Flow	April 18	May 4
	Irrigation Flow	June 28	June 29

Point Sources. For the point sources, flows were based on the arithmetic mean of the daily average effluent flows computed by season during the time periods listed in Table 4. The TSS concentrations for the point sources were based the arithmetic mean of the daily TSS effluent concentrations computed by season during the time periods listed in Table 5.

Tributaries, Drains, Main Stem Stations, and Diversions. For all tributaries, drains, and main stem stations (which are essentially calibration points), the 1990s geometric mean TSS concentrations were used in the mass balances. Because of the sample sizes, it was not feasible to use data from only one individual year and season. For a detailed description of the tributary, drain, and main stem TSS data, refer to Miller (1998a).

Field-measured TSS data were available for 14 of the 18 tributaries, drains, and point sources. TSS data were not available for: Drainage District No. 3, Star Feeder, Long Feeder, and Watts Creek. Because all of these drains are located within the Boise River subbasin (see Figure 8 in IDEQ [1998]), surrogate TSS concentrations were computed based on the average TSS concentration of the three other monitored drains from the same subbasin: Eagle Drain, Thurman Drain, and Mason Slough. Other means of establishing surrogate TSS concentrations for these four drains were explored, such as relationships between TSS concentration and land use or subbasin area, but none resulted in a consistent and meaningful relationship that was applicable. The TSS concentrations for the diversions were based on the mass balance-computed river concentration at the point of diversion.

Groundwater. With the exceptions described below, median seasonal groundwater inflows as determined by Smith (1998) were used in the mass balances. Smith (1998) computed main stem seasonal groundwater inflows per reach using data from October 1989 through September 1997. For the mass balance analyses, the seasonal median values were distributed proportionally by river mile along each reach defined by Smith (1998).

The groundwater inflows used for the 1992 high-flow season, chronic and acute mass balances, and the 1995 high-flow season chronic mass balance were based on a refinement of

Smith's (1998) results to improve the accuracy of the mass balances. These balances were refined because the associated critical flow periods at Parma occurred prior to April 1 when no diversions were occurring. Because the magnitude of groundwater inflows during these critical periods would be expected to be different from seasonal groundwater contributions computed over a number of years—the same methodology that Smith (1998) used to compute the seasonal groundwater inflows was used to compute the groundwater contribution on a reach-by-reach basis specific to the critical 30- or 7-day period. This was especially important for 1992 since it was a severe drought year.

Mass Balance Setup and Structure. Appendices B and C contain the existing conditions mass balances for 1992, 1995, and 1996 high-flow season using the chronic (50 mg/L) and acute (80 mg/L) TSS targets, respectively. Appendices D and E contain the existing conditions mass balances for 1992, 1995, and 1996 irrigation flow seasons using the chronic and acute TSS targets, respectively.

For the Parma station, the mass balance column titled "Measured Flow (cfs)" is the seasonal critical flow (defined above) for each target condition (chronic or acute). For all other locations, it is the average flow computed for either the 30- or 7-day period during which the respective critical flow period occurred at Parma. The bold-bordered cells in the "Concentration (mg/L)" column are based on the measured TSS data described above. The TSS concentrations for the diversions are based on the mass balance-computed river concentration (see "River Concentration (mg/L)" column) at the point of diversion. The "Incremental Daily Mass Load (T/day)" column is the TSS load computed for each main stem gaging location, tributary, drain, or diversion. The "Incremental Groundwater Flow (cfs)" is the local groundwater inflow (computed as described above) that enters the main stem river between the location for which it is listed and the previous upstream location. The "Groundwater Concentration (mg/L)" refers to the groundwater TSS concentration that was assumed to be zero. The next three columns in the mass balance spreadsheet are the computed river flow, TSS concentration, and TSS load in the main stem river at each location. The final column is percent reductions applied to the tributaries, drains, and point sources. The percent reductions are zero for the existing conditions.

The main stem gaging locations are shaded on the mass balance spreadsheet because these are the calibration points along the river. The unbordered values in the shaded row immediately below each main stem gaging location represent the difference in the mass balance-computed flows and loads compared to the measured values at that location. The associated, unbordered TSS concentration (in the "Concentration (mg/L)" column) is back-calculated from the differential flow and load. The bordered river flow, concentration, and load on the right side of the shaded row immediately below each main stem gaging location allows values to be reset so that the error at the calibration point is not carried downstream in the calculations.

Mass Balance Analyses and Results

Seasonal Mass Balance Analyses for 1992, 1995, and 1996. To use the mass balance as a tool for analyzing TSS loads in the river, the flows must be reasonably balanced. Figures 5 and 6 show a comparison of the mass balance-computed flows and the measured flows at the USGS gage near Middleton for the high and irrigation flow seasons, respectively. Figures 7 and 8 illustrate the same data for the flows at the USGS gage near Parma. The difference

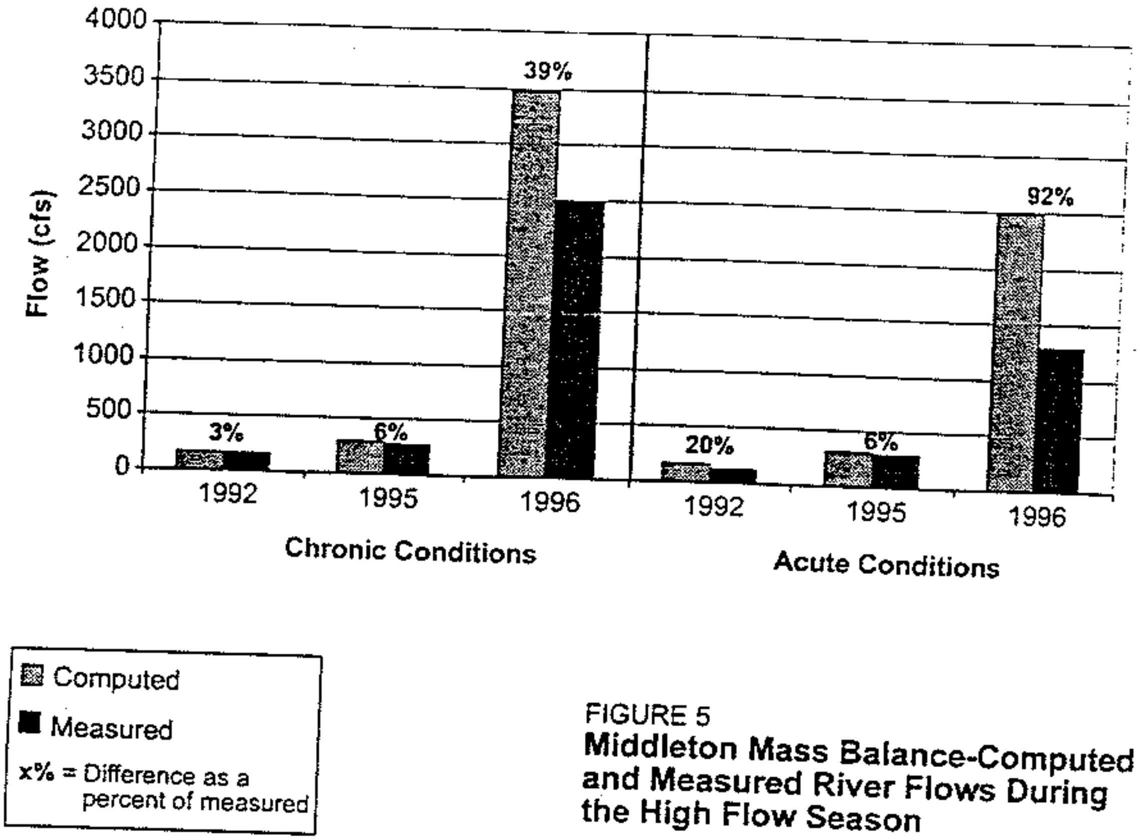

FIGURE 5
Middleton Mass Balance-Computed and Measured River Flows During the High Flow Season

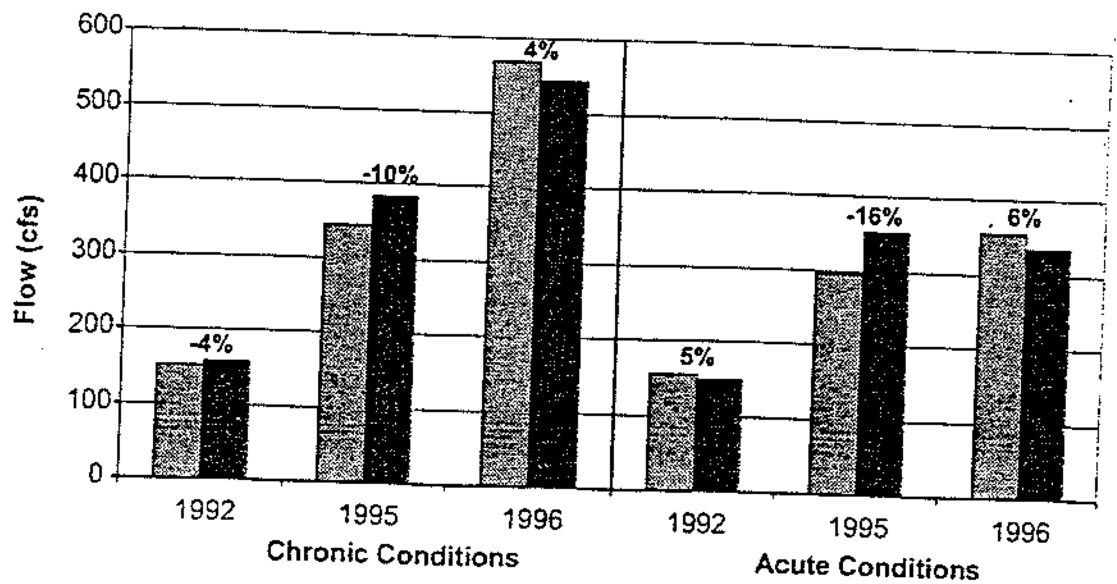

FIGURE 6
Middleton Mass Balance–Computed and Measured River Flows During the Irrigation Flow Season

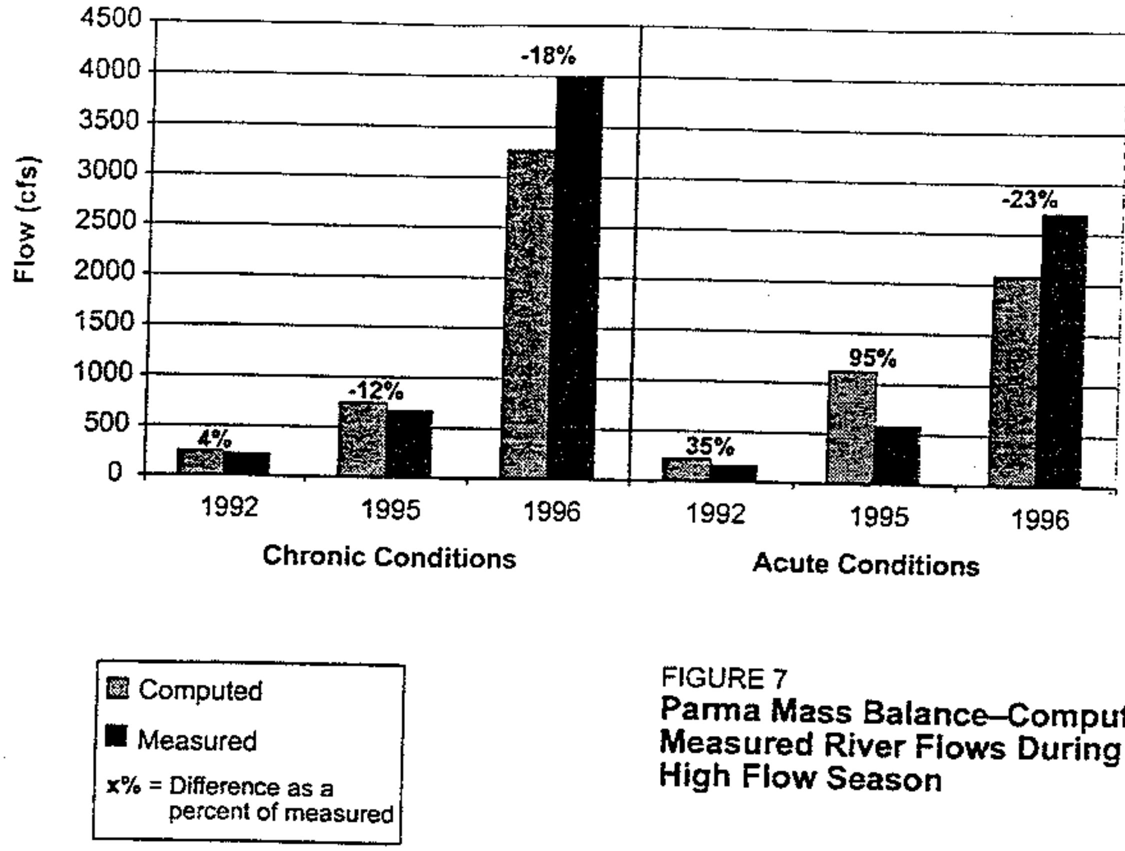

FIGURE 7
Parma Mass Balance–Computed and Measured River Flows During the High Flow Season

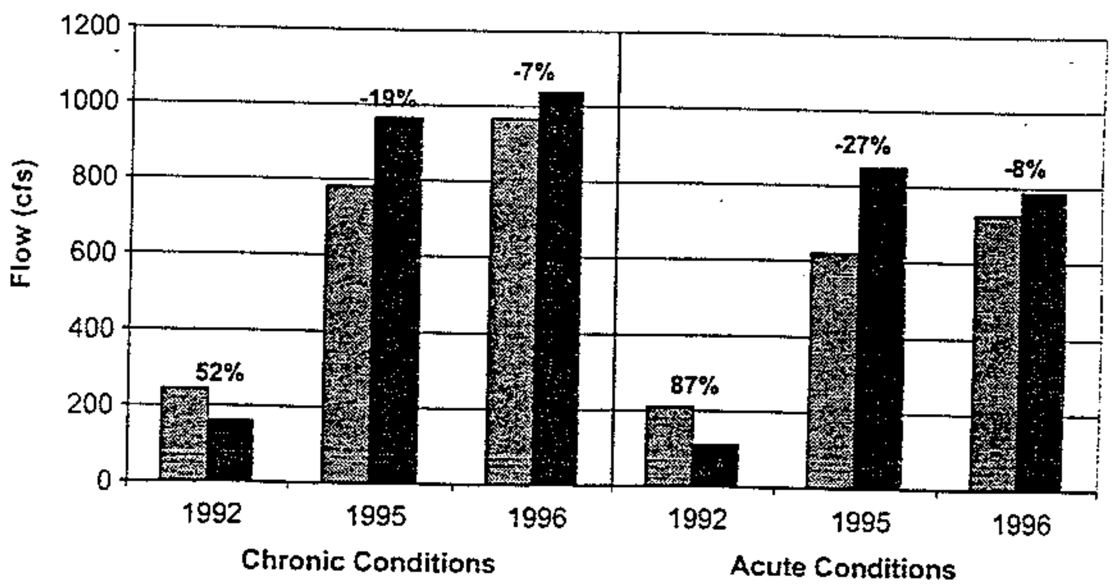

FIGURE 8
Parma Mass Balance–Computed and Measured River Flows During the Irrigation Flow Season

between the computed and measured flows is shown on the figures as a percentage of the measured flow.

Figures 9 through 12 show the seasonal mass balance-computed TSS loads, measured TSS loads, and TSS load capacities from Table 6. As Figures 9 and 10 illustrate, neither the mass balance-computed loads nor the measured loads at Middleton exceed their respective load capacities for any year, season, or target condition. There are, however, load capacity exceedances during the high and irrigation flow seasons at Parma. Differences between the mass balance-computed loads and measured loads are discussed below.

Measured versus Mass Balance-Computed Flows and Loads. To use the mass balance analysis as an effective tool for investigating the TSS loads in the river, the computed flows should balance at least reasonably well to the measured flows. This will ensure that the difference between the computed and measured loads is not attributable to a flow imbalance. Having the flows balanced also helps to define the seasonal scour and depositional cycles in the river.

As mentioned above, only during the 1992 and 1995 high-flow season did the computed loads at Parma exceed the load capacities (Figure 11). However, when considering the magnitude of the flow imbalance for the 1995 high-flow season acute target conditions, the computed loads for this scenario should not be relied upon (see Figure 7). Similarly, for the 1992 high-flow season acute target conditions, there is a 35 percent error in the flow balance at Parma. This, coupled with a computed river TSS concentration 60 percent greater than the measured, resulted in a computed load 115 percent larger than the measured load. Because of these discrepancies, the mass balance for that scenario was considered unreliable for decision-making.

The mass balance-computed river flows for the 1995 high-flow season chronic target conditions at Parma were 77 cfs greater than the measured flows (12 percent error). The measured TSS concentration at Parma was 26 mg/L less than computed. The resulting computed load at Parma was 62 percent greater than the measured load (Figure 11).

The mass balance scenario that resulted in the smallest flow imbalance during the high-flow season at Parma was the 1992 chronic target conditions (Figure 7). For this scenario there was a 9 cfs difference between the computed and measured flows at Parma (4 percent error). There was a 14 mg/L difference between the computed and measured TSS concentrations, and a 25 percent difference between the computed and measured loads. This scenario represents the lowest, or most stringent load capacity, and a low-flow main stem river condition during which significant irrigation return flows were occurring.

The measured load based on the chronic target conditions during the 1996 high-flow season exceeded the load capacity by 16 percent (Figure 11). However, the respective computed load was well below the load capacity. These results suggest a scour condition since the measured load exceeded the computed load. Thus, this exceedance was due to resuspension of in-channel sediment in addition to the tributary and drain contributions during the season. These conditions are indicative of what might be expected in the main stem river during an early season high-flow event. Indications of scour and depositional cycles are explored below.

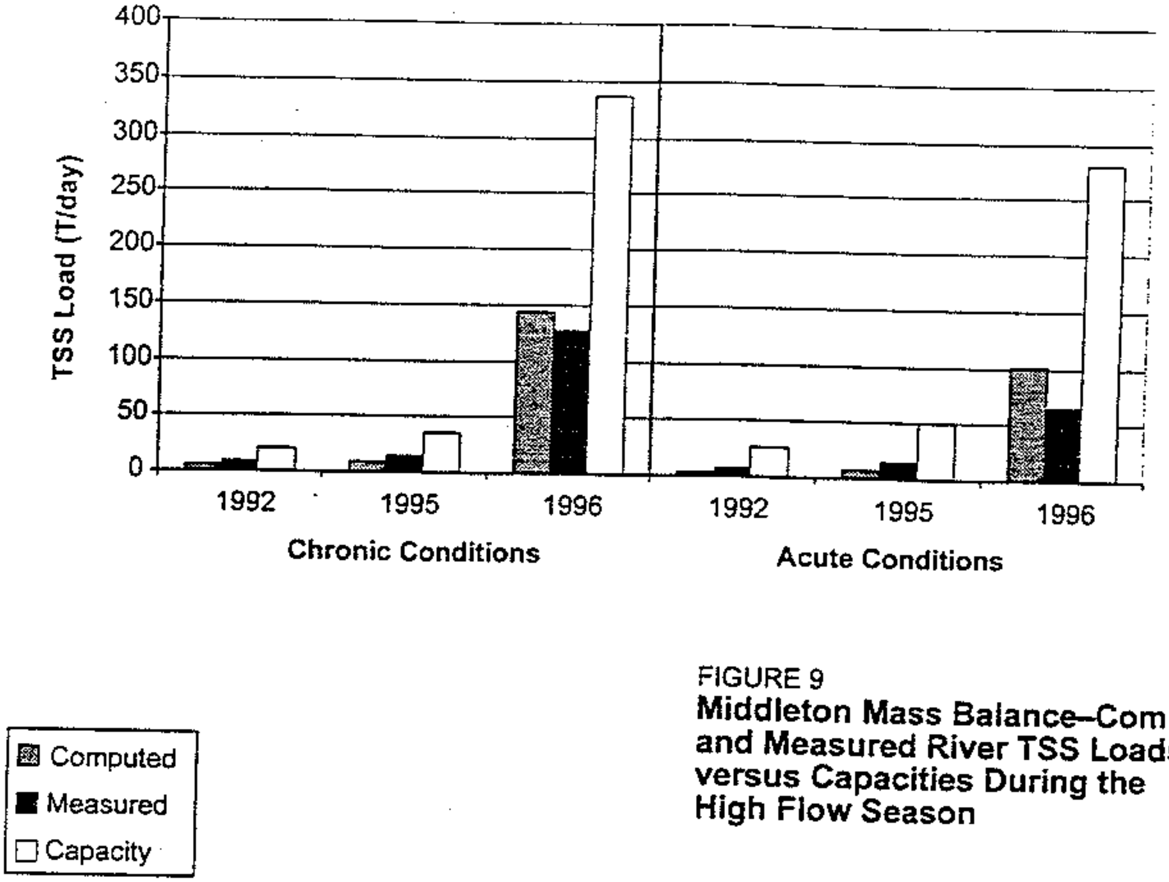

FIGURE 9
Middleton Mass Balance–Computed and Measured River TSS Loads versus Capacities During the High Flow Season

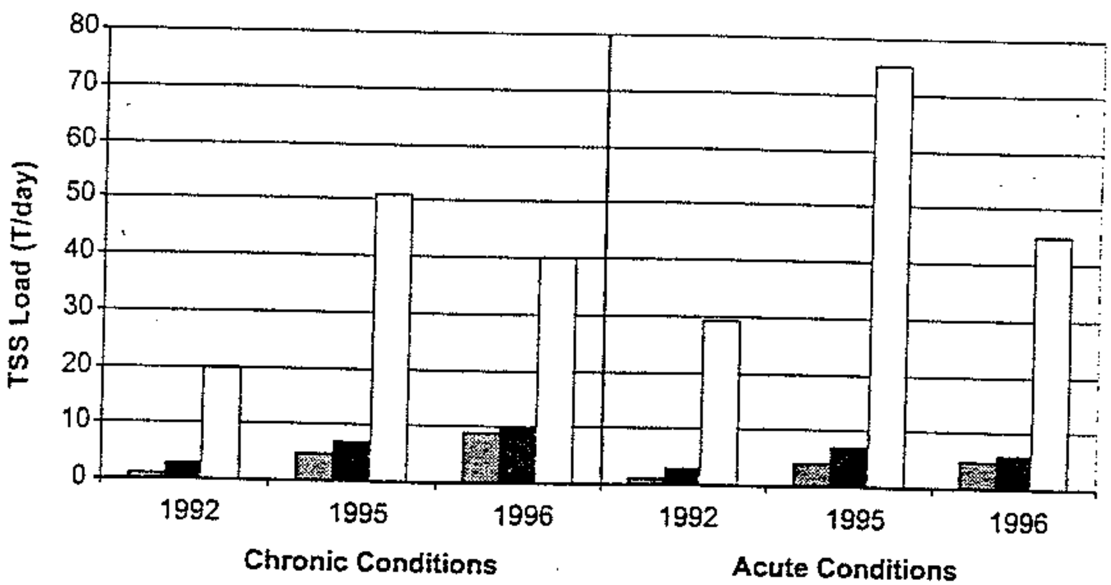

FIGURE 10
Middleton Mass Balance–Computed and Measured River TSS Loads versus Capacities During the Irrigation Flow Season

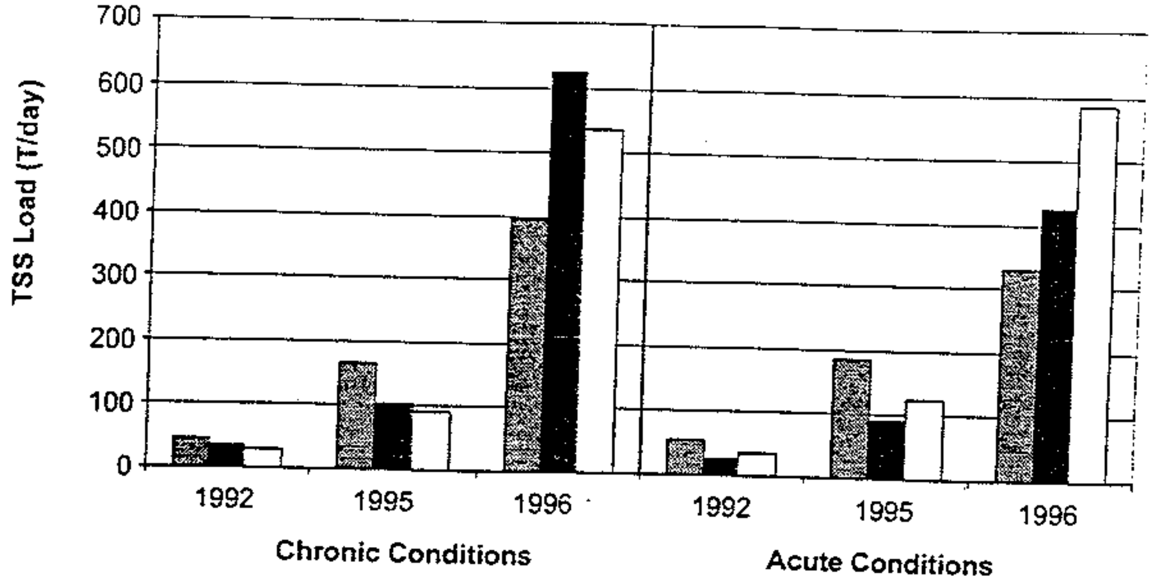

FIGURE 11
Parma Mass Balance–Computed and Measured River TSS Loads versus Capacities During the High Flow Season

Computed
Measured
Capacity

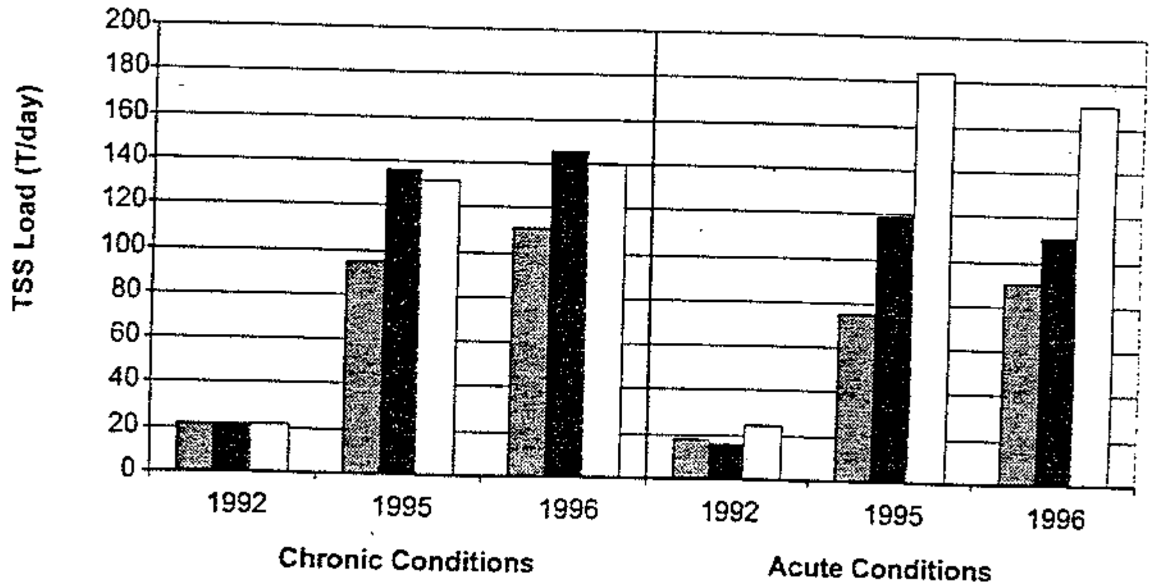

FIGURE 12
Parma Mass Balance–Computed and Measured River TSS Loads versus Capacities During the Irrigation Flow Season

Scour and Depositional Cycles. The difference between the mass balance-computed TSS loads and the measured loads is likely due to the natural scour and depositional cycles of the river, so long as the analysis is based on balanced flows. Higher computed than measured TSS loads for the 1992 high-flow season chronic target condition (when flows were balanced well) indicates sediment deposition. Because 1992 was a drought year, deposition would be expected under the conditions that existed in the lower Boise River watershed during 1992. For example, May 1992 was the driest month on record for rainfall at Boise (IDWR undated). Also during 1992, warm temperatures early in the growing season resulted in very high irrigation demands (IDWR undated). Heavy irrigation over dry soils during a low-flow condition in the main stem river comprises a condition conducive to deposition.

Because scour and depositional trends would be expected to vary over the short term, the mass balance was applied to each of the three seasons over the most recent 8-year (longer term) period (water years 1990 through 1997). The purpose of the analysis was to see if the scour and depositional trends would indicate channel equilibrium, deposition, or aggradation. This somewhat "gross" analysis suggested that the low-flow and high-flow seasons were depositional seasons, and the irrigation flow season was a scour season. The net effect of the three seasons averaged over the 8-year period indicated a slight depositional trend at Parma. This result is consistent with the findings of Thomas and Dion (1974) who stated that the channel in the Boise River Valley has aggraded.

Determination of the Critical Condition Based on Required Reductions. The percent reductions from the measured and mass balance-computed loads at Parma necessary to meet the appropriate load capacities were presented above. Recall from Figures 9 and 10 that for all 3 years, seasons, and target conditions analyzed, the load capacities at Middleton were not exceeded; thus, meeting the load capacity at Parma is the main issue. This section describes the analyses used to determine the reductions in loads from the various tributaries, drains, and point sources required to achieve the load capacity at Parma. Two methods of reductions were investigated using the mass balance analysis: equal percent reduction and equal concentration discharge.

The first method required an equal percent reduction from all tributaries and drains so that the load capacity was not exceeded at Parma. The second method required all tributaries and drains with existing TSS concentrations above a certain level to discharge at an equal, but lower, concentration until the load capacity at Parma was not exceeded. These reductions were investigated for all 12 mass balance scenarios presented earlier. The 1992 high-flow season chronic condition was determined to be the most critical condition based on the results and discussion presented in the previous three sections; the required reductions from the tributaries, drains, and point sources; and because it represents the most stringent load capacity and hydrologic conditions.

Based on the equal percent reduction method, a 34 percent reduction would be required to meet the load capacity at Parma for the 1992 high-flow chronic condition scenario. Based on the equal concentration discharge method, Fifteen Mile Creek, Mason Creek, Conway Gulch, and Dixie Drain would have to discharge at a TSS concentration of no more than 77 mg/L. Reducing their existing concentrations to 77 mg/L equates to the following percent reductions for these tributaries and drains: 46 percent (Fifteen Mile Creek);

51 percent (Mason Creek); 36 percent (Conway Gulch); and 36 percent (Dixie Drain). The mass balance reduction analyses for these scenarios are included as Appendix F.

Although the 34 percent equal reduction, or maximum TSS concentration of 77 mg/L, would result in load capacity compliance at Parma, the in-river chronic TSS target concentration would be exceeded by a maximum of 3 mg/L over an approximately 2.5 mile reach downstream of Dixie Drain. This is illustrated in Figure 13, which shows the mass balance-computed in-river TSS concentration from Middleton (river mile 31.2) to Parma (river mile 3.5).

In order to achieve an in-river TSS concentration less than or equal to 50 mg/L everywhere, the equal percent reduction requirement would be 37 percent. Likewise, the equal concentration discharge would require the same tributaries and drains listed above to discharge at no more than 73 mg/L. This would equate to the following percent reductions: 48 percent (Fifteen Mile Creek); 54 percent (Mason Creek); 39 percent (Conway Gulch); and 39 percent (Dixie Drain).

Sensitivity Analyses. The 1992 high-flow season chronic condition mass balance was slightly adjusted, or balanced, so that the computed flows and loads equaled those measured at Glenwood and Middleton. In short, this meant using the measured load at Glenwood and adding a balancing load of 2.6 T/day at Middleton. The measured load at Glenwood was used because the computed load significantly underestimated the measured value—5 T/day computed versus 21 T/day measured (see Appendix B). Reductions from sources upstream of Glenwood (i.e., Drainage District #3 and the Lander Street WWTF) were subtracted from the measured load of 21 T/day. This adjustment, in addition to adding the small balancing load at Middleton resulted in a longitudinal TSS mass balance that was used for analyzing a variety of reduction and loading scenarios. These sensitivity analyses are summarized in Table 8.

For the sensitivity analyses, the equal percent reductions were applied to all the tributaries and drains from the Diversion Dam to Parma. The percent reductions shown in Table 8 result in the load capacity at Parma being met. The various point source load reductions are defined in the table for each case. Appendix G provides a summary of the point source data used in the sensitivity analyses.

A significant finding of the sensitivity analyses is that the relative location of the sources, diversions, and groundwater input to one another and the control points are very important. For example, the influence of Fifteen Mile Creek and Dixie Drain on meeting the load capacity at Parma is different largely because Dixie Drain is only approximately 6 miles upstream of Parma, whereas Fifteen Mile Creek is approximately 24.5 miles upstream. The primary result is the TSS load from Fifteen Mile Creek is diminished more than the load from Dixie Drain because of the greater quantity of diverted TSS loads between the relative sources and Parma.

Another important result of the sensitivity analyses is that TSS sources upstream of Middleton have very little, perhaps negligible, effect on loads and needed reductions in the river downstream of Middleton.

Figure 13. Lower Boise River Mass Balance-Computed TSS Concentration from Middleton to Parma

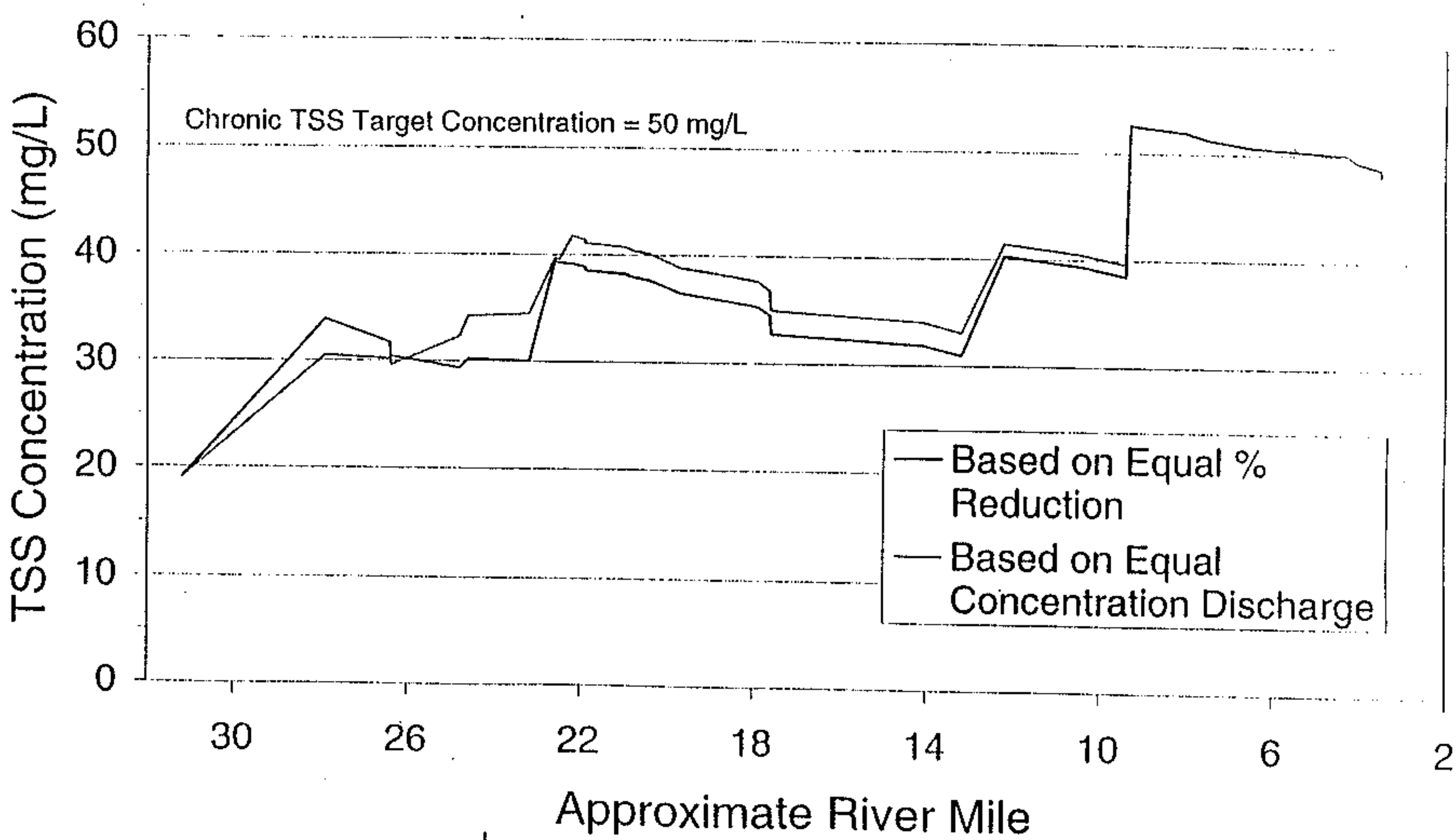

TABLE 8
Sensitivity Analyses Based on the Critical Condition and Equal Percent Reduction Scenarios

Case Number	Scenario	Equal Percent Reduction from All Tribs and Drains Required to Meet the Load Capacity at Parma
1	All point sources at zero load	34%
2	All non-point sources upstream of Middleton at zero load (and point sources at existing loads)	34%
3	Boise City WWTF loads at current permitted loads; other point sources (basinwide) at buildout loads added to tributaries to which they discharge	38%
4	Same as Case 3 except decrease non-point sources upstream of Middleton by only 10%	38%
5	a. Same as Case 3 and reduce 50 mg/L target by 10%	45%
	b. Same as Case 4 and reduce 50 mg/L target by 10%	45%
6	Same as Case 3 except no reduction upstream of Middleton	38%
7	Same as Case 3 except in-river TSS concentration at Middleton set at:	
	a. 28.5 mg/L (50% increase above existing measured concentration)	39%
	b. 38 mg/L (100% increase above existing measured concentration)	41%
	c. 45 mg/L (137% increase above existing measured concentration)	42%
8	Same as existing conditions except Middleton set at:	
	a. 28.5 mg/L	36%
	b. 38 mg/L	37%
	c. 45 mg/L	38%
	d. 50 mg/L	39%

Recommended Lower Boise River TSS Load Allocation

Margin of Safety

An implicit margin of safety is appropriate for the Lower Boise River TMDL TSS allocation for the following reasons:

- Reasonably extensive and reliable flow and sediment data are available.
- The TSS target concentrations are derived from the best available scientific literature.
- The flow and TSS data used for the TMDL analyses encompass the lowest, highest, and typical flow conditions in the historical record for the lower Boise River.
- The seasonal analyses are more representative of the changing climatic and hydrologic conditions compared to characterizations based on annual averages.
- Additional conservatism was gained by computing the Middleton and Parma load capacities using flows computed from averaging periods of only one-half of the recommended TSS target concentration averaging periods (resulting in lower flows and therefore more conservative load capacities).
- The required TSS load reductions are conservative since the point sources, which were included in the analyses, are likely discharging very little total suspended sediment and more total suspended solids in the form of biomass that likely degrade relatively quickly and are not as persistent as inorganic particles.

Background

The high flow season background TSS concentration at Diversion Dam, the upstream monitoring location in the watershed, is 5 mg/L. Similarly, the background TSS concentration for the irrigation flow season is 3 mg/L. These background concentrations and associated loads are inputs to the mass balance analyses used to compute the required TSS load reductions and allocations. Because of the extensive diversions, background TSS loads can only be handled in the mass balance analyses rather than as a subtracted load from the allocations (as implied by the TMDL equation). This is demonstrated by the fact that the TSS load at Diversion Dam, or background load, exceeds the TSS load at Middleton during the 1992 high flow season chronic conditions. Even though the TSS concentration at Middleton exceeds that at Diversion Dam for this particular scenario, the flow below the Diversion Dam is much greater than at Middleton.

Reserve for Growth and TSS Allocations

Three allocation workshops and several technical and watershed advisory group (WAG) meetings were conducted to discuss the TMDL requirements, results of the mass balance and sensitivity analyses, and various load reduction alternatives. During the June 11, 1998 WAG meeting, the WAG reached consensus on the following issues:

- The initial (excluding reserve for growth) wasteload TSS allocations for the point sources should be set equivalent to the existing peak month flow times the permitted TSS concentration.

- A set-aside for growth for all the municipal point sources in the watershed should be computed by multiplying the expected 20-year increase in the peak monthly flows times the existing permitted TSS concentration. This set-aside will be a lumped allocation to be shared among all the point sources in the watershed. Increased growth in agricultural sources of TSS is not anticipated.
- The equal percent reduction method should be applied to the tributaries and drains downstream of Middleton. The resulting loads should be discrete rather than a total load to be shared amongst the numerous tributaries and drains; but trading mechanisms should be allowed to achieve cost-effective overall load reductions.

No consensus was reached at the June 11 WAG meeting regarding whether or not the equal percent reductions should apply to the tributaries and drains upstream of Middleton.

Even though the lower Boise River is regulated, it is subject to relatively significant changes in flow from year to year primarily due to drought and snowmelt conditions. Because load capacities are computed from flows, they are subject to significant yearly variation. Thus, meeting load capacities derived from a drought year like 1992 would be impractical during extreme high flow years such as 1996. Thus, to establish the load allocations, the 34 percent (equal) reduction required to meet the load capacity at Parma based on the 1992 high flow season chronic target conditions (i.e., critical conditions) is applied to the 1995 non-point source loads. The 1995 non-point source loads are those computed for the high flow season chronic conditions analysis (i.e., the seasonal geometric mean TSS concentration times the 30-day average flow concurrent to the minimum 30-day average flow at Parma for the season). Table 9 lists the load allocations for the non-point sources assuming the 34 percent reduction would be applied to all the tributaries and drains including those upstream of Middleton. It is understood that the WAG did not reach consensus on how to address non-point sources upstream of Middleton, and the sensitivity analyses summarized in Table 8 show that these upstream sources do not substantially affect the percent load reductions downstream of Middleton. Thus, the calculations in Table 9 should not be viewed as an endorsement of any particular method of load allocation upstream of Middleton.

Note from Table 9 that although 1992 and 1995 were two considerably different hydrologic years, the tributary and drain loads were comparable. This is because the tributaries and drains are influenced predominantly by irrigation demands during both the typical and low (dry) flow years, as opposed to the larger loads that result during a high flow year like 1996. In fact, some of the tributaries and drains had lower actual loads in 1995 than in 1992. Also, the sum of the allocated loads (derived from 1995 loads) is less than the sum of the 1992 loads—which are loads associated with the extreme low-flow year. Recall also that the actual loads are loads computed from a low flow scenario—the 30 day average flow concurrent with the minimum 30-day average flow at Parma. Thus, although 1995 is a typical year, the equal percent reduction applied to the actual 1995 tributary and drain loads results in a conservative load allocation.

As shown in Table 9, the 1992 actual load computed for Indian Creek was a result of nearly all of the flow being diverted out of the creek. This should be taken into consideration when comparing the magnitude of the 1992, 1995, and allocated loads presented in Table 9. Even with the extremely low load in Indian Creek during 1992, the sum of the allocated loads is still less than that for the 1992 actual loads.

TABLE 9
Lower Boise River TSS Non-point Source
Load Allocation Assuming Equal Percentage Reduction to all Tributaries and Drains

Tributary/Drain	Actual TSS Load (T/day) 1992	Actual TSS Load (T/day) 1995	Load Allocation (T/day)Computed from 34% Reduction of 1995 Load
Drainage District #3	0.41	0.35	0.23
Eagle Drain @ Eagle	1.01	1.61	1.06
Thurman Drain	0.31	0.34	0.22
Fifteen Mile Drain	17.40	28.60	18.88
Star Feeder	2.84	2.75	1.82
Long Feeder	0.75	0.56	0.37
Watts Creek	0.48	0.45	0.29
Mill Slough	10.68	11.24	7.42
Willow Creek @ Middleton	3.78	3.62	2.39
Mason Slough	1.95	1.91	1.26
Mason Creek	26.10	34.10	22.50
Hartley (combined)	6.62	8.43	5.57
Indian Creek	0.16	9.11	6.01
Conway Gulch @ Notus	11.67	11.34	7.48
Dixie Drain Near Wilder	32.20	41.12	27.14
Sum (excluding Indian Cr.)	116.19	146.42	96.64
Sum (including Indian Cr.)	116.35	155.53	102.65

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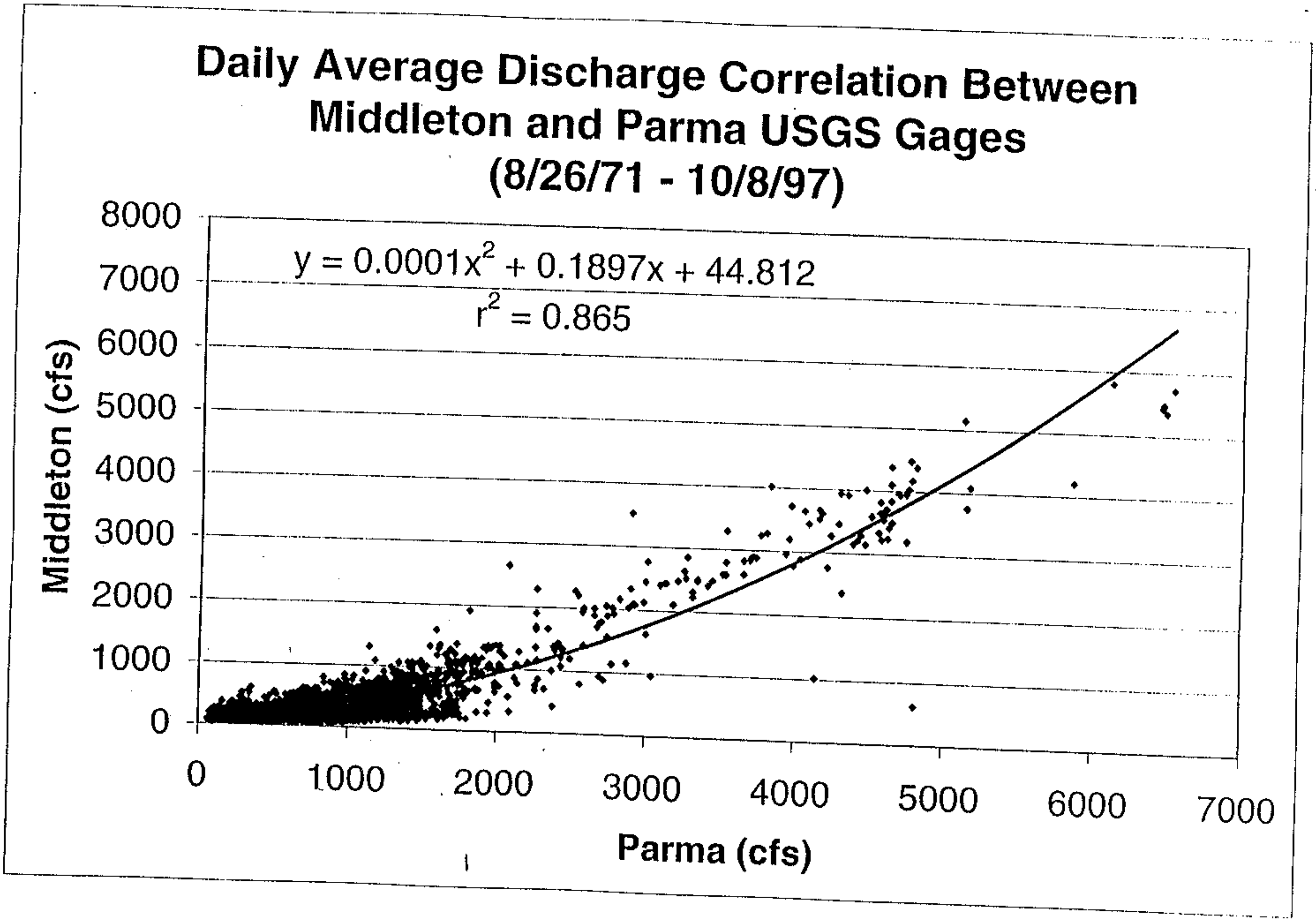
Appendix A

Daily Average Discharge Correlation Between Middleton and Parma USGS Gages (8/26/71 – 10/8/97)



p:\137544\flows\relate middleton to parma.xls

Appendix B

High-Flow Season Mass Balances— Existing Conditions Based on the Critical 30-Day (Chronic) Flow Period at Parma for: 1992, 1995, and 1996

Table D-2

Seasonal Relationships for Estimating Geometric Mean and 90th Percentile Concentrations for Tributaries with Seasonal Sample Sizes < 4

	Geometric Mean Percent of NSS (TSS mg/L)				90th Percentile Percent of NSS (TSS mg/L)			
Location	HF	IF	LF	NSS	HF	IF	LF	NSS
Eagle Drain	0.99			1.00	1.22			1.00
Thurman Dr	0.95			1.00	1.19			1.00
15-Mile Cr	2.50	1.63	0.22	1.00	1.15	0.56	0.09	1.00
Mill Slough	1.48			1.00	1.33			1.00
Willow Cr	1.70		0.43	1.00	0.90		0.69	1.00
Mason Slough	0.71			1.00	0.63			1.00
Mason Cr	1.69	1.21	0.37	1.00	1.47	0.62	0.26	1.00
E. Hartley Dr	1.23		0.70	1.00	1.40		0.51	1.00
W. Hartley Gulch	1.63		0.37	1.00	1.34		0.22	1.00
Indian Cr	1.19	0.82	0.87	1.00	1.14	0.74	0.98	1.00
Conway Gulch	1.31	1.52	0.45	1.00	1.59	0.85	0.27	1.00
Dixie Dr	1.77	0.76	0.49	1.00	1.43	0.59	0.34	1.00
Hartley (combined)	1.23			1.00	1.39		0.36	1.00
AVG	**1.41**	**1.19**	**0.49**		**1.25**	**0.67**	**0.41**	
STD	**0.46**	**0.40**	**0.21**		**0.26**	**0.12**	**0.28**	
CV	**0.33**	**0.33**	**0.43**		**0.21**	**0.18**	**0.67**	

Notes:

NSS = No Seasonal Split

HF = High Flow

IF = Irrigation Flow

LF = Low Flow

Table D-1

TSS Concentration Data: Sample Sizes, Geometric Mean Concentrations, and 90th Percentile Concentrations

Location	Sample Size TSS Concentration				Geometric Mean TSS Concentration (mg/L)				90th Percentile TSS Concentration (mg/L)			
	HF	IF	LF	NSS	HF	IF	LF	NSS	HF	IF	LF	NSS
Below Div. Dam	17	7	9	33	5	3	7	5	15	7	24	15
Glenwood	25	13	12	50	16	7	6	10	45	22	24	37
Middleton	16	7	7	30	19	7	6	12	68	12	17	40
Parma	23	11	14	48	58	52	22	43	122	127	42	108
Eagle Drain	4	0	2	6	27	**32**	**13**	27	142	**78**	**48**	117
Thurman Dr	4	0	2	6	9	**12**	**5**	10	27	**15**	**9**	22
15-Mile Cr	9	5	7	21	141	92	12	57	322	157	26	279
Mill Slough	4	2	2	8	41	**33**	**14**	28	81	**41**	**25**	61
Willow Cr	10	2	7	19	74	**52**	**19**	44	210	**156**	**160**	233
Mason Slough	4	0	2	6	57	**96**	**39**	80	134	**143**	**87**	213
Mason Cr	10	4	6	20	158	113	34	93	523	222	93	356
E. Hartley Dr	10	1	7	18								
W. Hartley Gulch	10	2	7	19								
Indian Cr	10	4	7	21	58	40	42	49	117	75	101	103
Conway Gulch	10	5	6	21	120	139	41	92	546	290	91	344
Dixie Dr	10	5	6	21	120	51	33	68	281	115	66	196
Hartley (combined)	10	1	4	15	59	**57**	29	48	181	**87**	47	130

Notes:

Bold borders indicate estimated TSS concentrations based on the following relationship (see Table D-2):

Geometric Mean:
Sample Size < 4
IF = 1.19 * NSS
LF = 0.49 * NSS

90th Percentile:
Sample Size < 4
IF = 0.67 * NSS
LF = 0.41 * NSS

NSS = No Seasonal Split
HF = High Flow
IF = Irrigation Flow
LF = Low Flow

Appendix D

TSS Concentration Data: Sample Sizes, Geometric Mean Concentrations, and 90th Percentile Concentrations

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Tributaries (Low Flow)

	Mason Creek		E Hartley Drain		W Hartley Gulch		Indian Creek		Conway Gulch		Dixie Drain	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	17	2.83321334	55	4.00733319	3	1.09861229	17	2.83321334	31	3.4339872	50	3.91202301
Value 2	28	3.33220451	41	3.71357207	10	2.30258509	36	3.58351894	23	3.13549422	20	2.99573227
Value 3	81	4.39444915	46	3.8286414	15	2.7080502	47	3.8501476	22	3.09104245	30	3.40119738
Value 4	12	2.48490665	21	3.04452244	11	2.39789527	58	4.06044301	111	4.7095302	25	3.21887582
Value 5	47	3.8501476	35	3.55534806	6	1.79175947	30	3.40119738	58	4.06044301	22	3.09104245
Value 6	73	4.29045944	52	3.95124372	18	2.89037176	33	3.49650756	48	3.87120101	79	4.36944785
Value 7			15	2.7080502	33	3.49650756	150	5.01063529				
Value 8												
Value 9												

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	6	6	7	7	7	7	7	7	6	6	6	6
Mean	43.0000	3.5309	37.8571	3.5441	13.7143	2.3837	53.0000	3.7480	48.8333	3.7169	37.6667	3.4981
Standard Deviation	29.0586	0.7804	15.1924	0.4897	9.8947	0.7756	44.6915	0.6770	33.6298	0.6224	22.9666	0.5359
C.V.	0.6758	0.2210	0.4013	0.1382	0.7215	0.3254	0.8432	0.1806	0.6887	0.1674	0.6097	0.1532
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181

	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	60	93	57	65	26	29	110	101	92	91	67	66
10th Percentile	7	13	19	19	1	4	-2	18	7	19	9	17
Geometric Mean		34		35		11		42		41		33
$\exp^{(\text{Standard Deviation})}$		2		2		2		2		2		2

Note: Data presented here were only used if sample sizes were ≥ 4.

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Log-normal Distributions
Lower Boise River - Tributaries (Low Flow)

	Eagle Drain		Thurman Drain		15-Mile Creek		Mill Slough		Willow Creek		Mason Slough	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	12	2.48490665	11	2.39789527	9	2.19722458	23	3.13549422	3	1.09861229	202	5.3082677
Value 2	64	4.15888308	11	2.39789527	8	2.07944154	29	3.36729583	13	2.56494936	128	4.85203026
Value 3					13	2.56494936			11	2.39789527		
Value 4					23	3.13549422			190	5.24702407		
Value 5					5	1.60943791			10	2.30258509		
Value 6					20	2.99573227			5	1.60943791		
Value 7					20	2.99573227			196	5.27811466		
Value 8												
Value 9												
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	2	2	2	2	7	7	2	2	7	7	2	2
Mean	38.0000	3.3219	11.0000	2.3979	14.0000	2.5111	26.0000	3.2514	61.1429	2.9284	165.0000	5.0801
Standard Deviation	36.7696	1.1837	0.0000	0.0000	7.0238	0.5716	4.2426	0.1639	90.1581	1.6728	52.3259	0.3226
C.V.	0.9676	0.3563	0.0000	0.0000	0.5017	0.2276	0.1632	0.0504	1.4745	0.5712	0.3171	0.0635
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	85	126	11	11	23	26	31	32	177	160	232	243
10th Percentile	-8	6	11	11	5	6	21	21	-51	2	100	106
Geometric Mean		28		11		12		26		19		161
$\exp^{(\text{Standard Deviation})}$		3		1		2		1		5		1

Note: Data presented here were only used if sample sizes were ≥ 4.

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Log-normal Distributions
Lower Boise River - Tributaries (Irrigation Flow)

	Mason Creek		E Hartley Drain		W Hartley Gulch		Indian Creek		Conway Gulch		Dixie Drain	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	191	5.25227343	75	4.31748811	66	4.18965474	75	4.31748811	144	4.9698133	39	3.66356165
Value 2	116	4.75359019			114	4.73619845	26	3.25809654	68	4.21950771	21	3.04452244
Value 3	135	4.90527478					47	3.8501476	160	5.07517382	91	4.51085951
Value 4	55	4.00733319					28	3.33220451	321	5.77144112	97	4.57471098
Value 5									104	4.6443909	48	3.87120101
Value 6												
Value 7												

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	4	4	1	1	2	2	4	4	5	5	5	5
Mean	124.2500	4.7296	75.0000	4.3175	90.0000	4.4629	44.0000	3.6895	159.4000	4.9361	59.2000	3.9330
Standard Deviation	56.0796	0.5248	#DIV/0!	#DIV/0!	33.9411	0.3865	22.7303	0.4946	97.1792	0.5738	33.2896	0.6347
C.V.	0.4513	0.1110	#DIV/0!	#DIV/0!	0.3771	0.0866	0.5166	0.1341	0.6097	0.1162	0.5623	0.1614
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181

	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	196	222	#DIV/0!	#DIV/0!	134	142	73	75	284	290	102	115
10th Percentile	55	59	#DIV/0!	#DIV/0!	48	54	16	22	39	68	18	23
Geometric Mean		113		75		87		40		139		51
exp^(Standard Deviation)		2		#DIV/0!		1		2		2		2

Note: Data presented here were only used if sample sizes were ≥ 4.

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Tributaries (Irrigation Flow)

	Eagle Drain		Thurman Drain		15-Mile Creek		Milt Slough		Willow Creek		Mason Slough	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1					133	4.89034913	17	2.83321334	50	3.91202301		
Value 2					100	4.60517019	11	2.39789527	68	4.21950771		
Value 3					56	4.02535169						
Value 4					139	4.93447393						
Value 5					65	4.17438727						
Value 6												
Value 7												
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	0	0	0	0	5	5	2	2	2	2	0	0
Mean	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	98.6000	4.5259	14.0000	2.6156	59.0000	4.0658	#DIV/0!	#DIV/0!
Standard Deviation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	37.9513	0.4124	4.2426	0.3078	12.7279	0.2174	#DIV/0!	#DIV/0!
C.V.	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.3849	0.0911	0.3030	0.1177	0.2157	0.0535	#DIV/0!	#DIV/0!
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	147	157	19	20	75	77	#DIV/0!	#DIV/0!
10th Percentile	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	52	55	9	9	43	45	#DIV/0!	#DIV/0!
Geometric Mean		#DIV/0!		#DIV/0!		92		14		58		#DIV/0!
exp$^{(\text{Standard Deviation})}$		#DIV/0!		#DIV/0!		2		1		1		#DIV/0!

Note: Data presented here were only used if sample sizes were ≥ 4.

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Log-normal Distributions
Lower Boise River - Tributaries (High Flow)

	Mason Creek		E Hartley Drain		W Hartley Gutch		Indian Creek		Conway Gulch		Dixie Drain	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	335	5.81413053	157	5.05624581	84	4.4308168	101	4.61512052	295	5.68697536	111	4.7095302
Value 2	21	3.04452244	14	2.63905733	8	2.07944154	101	4.61512052	39	3.66356165	140	4.94164242
Value 3	122	4.80402104	56	4.02535169	17	2.83321334	45	3.80666249	140	4.94164242	102	4.62497281
Value 4	116	4.75359019	60	4.09434456	49	3.8918203	41	3.71357207	219	5.38907173	60	4.09434456
Value 5	131	4.87519732	91	4.51085951	248	5.51342875	42	3.73766962	248	5.51342875	126	4.83628191
Value 6	84	4.4308168	14	2.63905733	16	2.77258872	36	3.58351894	9	2.19722458	41	3.71357207
Value 7	263	5.57215403	91	4.51085951	67	4.20469262	57	4.04305127	49	3.8918203	134	4.8978398
Value 8	525	6.26339826	133	4.89034913	93	4.53259949	176	5.170484	174	5.1590553	223	5.40717177
Value 9	407	6.00881319	70	4.24849524			42	3.73766962	217	5.37989735	460	6.13122649
Value 10	159	5.0689042	87	4.46590812	77	4.34380542	34	3.52636052	425	6.05208917	88	4.47733681
Value 11					68	4.21950771						
Value 12												
Value 13												
Value 14												
Value 15												

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	10	10	10	10	10	10	10	10	10	10	10	10
Mean	216.3000	5.0636	77.3000	4.1061	72.7000	3.8822	67.5000	4.0549	181.5000	4.7875	148.5000	4.7834
Standard Deviation	160.9314	0.9328	45.6364	0.8371	68.6441	1.0218	45.6442	0.5531	128.5217	1.1825	120.1797	0.6659
C.V.	0.7440	0.1842	0.5904	0.2038	0.9442	0.2632	0.6762	0.1364	0.7081	0.2470	0.8093	0.1392
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181

	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	423	523	136	178	161	180	126	117	346	546	303	281
10th Percentile	17	50	21	22	-12	14	11	29	22	28	-1	52
Geometric Mean		158		61		49		58		120		120
exp[Standard Deviation]		3		2		3		2		3		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Tributaries (High Flow)

	Eagle Drain		Thurman Drain		15-Mile Creek		Mill Slough		Willow Creek		Mason Slough	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	74	4.30406509	20	2.99573227	192	5.25749537	48	3.87120101	102	4.62497281	112	4.71849887
Value 2	7	1.94591015	12	2.48490665	196	5.27811466	62	4.12713439	124	4.82028157	55	4.00733319
Value 3	90	4.49980967	11	2.39789527	152	5.02388052	51	3.93182563	71	4.26267988	73	4.29045944
Value 4	11	2.39789527	3	1.09861229	67	4.20469262	19	2.94443898	162	5.08759634	23	3.13549422
Value 5					518	6.24997524			42	3.73766962		
Value 6					111	4.7095302			36	3.58351894		
Value 7					167	5.11799381			357	5.87773578		
Value 8					65	4.17438727			25	3.21887582		
Value 9					95	4.55387689			68	4.21950771		
Value 10									38	3.63758616		
Value 11												
Value 12												
Value 13												
Value 14												
Value 15												

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	4	4	4	4	9	9	4	4	10	10	4	4
Mean	45.5000	3.2869	11.5000	2.2443	173.6667	4.9522	45.0000	3.7187	102.5000	4.3070	65.7500	4.0379
Standard Deviation	42.6810	1.3031	6.9522	0.8080	138.3908	0.6420	18.3485	0.5276	99.5571	0.8117	37.1248	0.6689
C.V.	0.9380	0.3965	0.6045	0.3600	0.7969	0.1296	0.4077	0.1419	0.9713	0.1885	0.5646	0.1657
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	100	142	20	27	351	322	69	81	230	210	113	134
10th Percentile	-7	5	3	3	2	64	22	21	-21	27	20	25
Geometric Mean		27		9		141		41		74		57
$\exp^{(\text{Standard Deviation})}$		4		2		2		2		2		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Log-normal Distributions
Lower Boise River - Tributaries (No Seasonal Split)

	Mason Creek		E Hartley Drain		W Hartley Gulch		Indian Creek		Conway Gulch		Dixie Drain	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	335	5.81413053	157	5.05624581	84	4.4308168	101	4.61512052	295	5.68697536	111	4.7095302
Value 2	17	2.83321334	55	4.00733319	3	1.09861229	17	2.83321334	31	3.4339872	50	3.91202301
Value 3	21	3.04452244	14	2.63905733	8	2.07944154	101	4.61512052	39	3.66356165	140	4.94164242
Value 4	122	4.80402104	56	4.02535169	17	2.83321334	45	3.80666249	140	4.94164242	102	4.62497281
Value 5	116	4.75359019	60	4.09434456	49	3.8918203	41	3.71357207	219	5.38907173	60	4.09434456
Value 6	191	5.25227343	91	4.51085951	248	5.51342875	42	3.73766962	248	5.51342875	126	4.83628191
Value 7	116	4.75359019	75	4.31748811	66	4.18965474	75	4.31748811	144	4.9698133	39	3.66356165
Value 8	28	3.33220451	41	3.71357207	10	2.30258509	36	3.58351894	23	3.13549422	20	2.99573227
Value 9	81	4.39444915	46	3.8286414	15	2.7080502	47	3.8501476	22	3.09104245	30	3.40119738
Value 10	131	4.87519732	21	3.04452244	11	2.39789527	58	4.06044301	9	2.19722458	41	3.71357207
Value 11	84	4.4308168	14	2.63905733	16	2.77258872	36	3.58351894	49	3.8918203	134	4.8978398
Value 12	263	5.57215403	91	4.51085951	67	4.20469262	57	4.04305127	174	5.1590553	223	5.40717177
Value 13	525	6.26339826	133	4.89034913	93	4.53259949	176	5.170484	217	5.37989735	460	6.13122649
Value 14	407	6.00881319	70	4.24849524	77	4.34380542	42	3.73766962	425	6.05208917	88	4.47733681
Value 15	12	2.48490665			114	4.73619845	26	3.25809654	68	4.21950771	21	3.04452244
Value 16	47	3.8501476	35	3.55534806	6	1.79175947	30	3.40119738	111	4.7095302	25	3.21887582
Value 17	73	4.29045944	52	3.95124372	18	2.89037176	33	3.49650756	58	4.06044301	22	3.09104245
Value 18	159	5.0689042	15	2.7080502	33	3.49650756	150	5.01063529	48	3.87120101	79	4.36944785
Value 19	135	4.90527478	87	4.46590812	68	4.21950771	34	3.52636052	160	5.07517382	91	4.51085951
Value 20	55	4.00733319					47	3.8501476	321	5.77144112	97	4.57471098
Value 21							28	3.33220451	104	4.6443909	48	3.87120101
Value 22												
Value 23												

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	20	20	18	18	19	19	21	21	21	21	21	21
Mean	145.9000	4.5370	61.8333	3.9004	52.7895	3.3912	58.1905	3.8830	138.3333	4.5170	95.5714	4.2137
Standard Deviation	137.9767	1.0437	39.6444	0.7372	58.4851	1.1778	41.3190	0.5835	114.2376	1.0317	97.9299	0.8292
C.V.	0.9457	0.2300	0.6411	0.1890	1.1079	0.3473	0.7101	0.1503	0.8258	0.2284	1.0247	0.1968
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	323	356	113	127	128	134	111	103	285	344	221	196
10th Percentile	-25	26	13	20	-20	7	7	24	-3	25	-26	24
Geometric Mean		93		49		30		49		92		68
exp(Standard Deviation)		3		2		3		2		3		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Tributaries (No Seasonal Split)

	Eagle Drain		Thurman Drain		15-Mile Creek		Mill Slough		Willow Creek		Mason Slough	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	74	4.30406509	20	2.99573227	192	5.25749537	48	3.87120101	102	4.62497281	112	4.71849887
Value 2	12	2.48490665	11	2.39789527	9	2.19722458	23	3.13549422	3	1.09861229	202	5.3082677
Value 3	7	1.94591015	12	2.48490665	196	5.27811466	62	4.12713439	124	4.82028157	55	4.00733319
Value 4	64	4.15888308	11	2.39789527	152	5.02388052	29	3.36729583	71	4.26267988	128	4.85203026
Value 5	90	4.49980967	11	2.39789527	67	4.20469262	51	3.93182563	162	5.08759634	73	4.29045944
Value 6	11	2.39789527	3	1.09861229	133	4.89034913	19	2.94443898	42	3.73766962	23	3.13549422
Value 7					100	4.60517019	17	2.83321334	50	3.91202301		
Value 8					8	2.07944154	11	2.39789527	13	2.56494936		
Value 9					13	2.56494936			11	2.39789527		
Value 10					23	3.13549422			190	5.24702407		
Value 11					518	6.24997524			36	3.58351894		
Value 12					111	4.7095302			357	5.87773578		
Value 13					167	5.11799381			25	3.21887582		
Value 14					65	4.17438727			68	4.21950771		
Value 15					56	4.02535169			68	4.21950771		
Value 16					5	1.60943791			10	2.30258509		
Value 17					20	2.99573227			5	1.60943791		
Value 18					20	2.99573227			196	5.27811466		
Value 19					95	4.55387689			38	3.63758616		
Value 20					139	4.93447393						
Value 21					65	4.17438727						
Value 22												
Value 23												

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	5	6	6	6	21	21	8	8	19	19	6	6
Mean	43.0000	3.2986	11.3333	2.2955	102.5714	4.0370	32.5000	3.3261	82.6842	3.7737	98.8333	4.3853
Standard Deviation	37.1268	1.1399	5.3914	0.6309	113.9643	1.2444	18.6701	0.6087	90.1955	1.3078	63.2564	0.7609
C.V.	0.8634	0.3456	0.4757	0.2748	1.1111	0.3082	0.5745	0.1830	1.0908	0.3465	0.6400	0.1735
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	91	117	18	22	249	279	56	61	198	233	180	213
10th Percentile	-3	7	5	5	-39	12	9	13	-29	9	20	31
Geometric Mean		27		10		57		28		44		80
$exp^{(Standard Deviation)}$		3		2		3		2		4		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Main Stem (Low Flow)

	Diversion Dam		Glenwood		Middleton	
	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	8	2.07944154	4	1.38629436	11	2.39789527
Value 2	3	1.09861229	3	1.09861229	5	1.60943791
Value 3	6	1.79175947	5	1.60943791	4	1.38629436
Value 4	27	3.29583687	4	1.38629436	4	1.38629436
Value 5	5	1.60943791			28	3.33220451
Value 6	4	1.38629436	2	0.69314718	4	1.38629436
Value 7	6	1.79175947	3	1.09861229	4	1.38629436
Value 8	2	0.69314718	5	1.60943791		
Value 9	38	3.63758616	4	1.38629436		
Value 10			67	4.20469262		
Value 11			3	1.09861229		
Value 12			3	1.09861229		
Value 13			53	3.97029191		

	Parma (Historical)		Parma (1990s)	
	Value	ln(value)	Value	ln(value)
Value 1	71	4.26267988	30	3.40119738
Value 2	28	3.33220451	15	2.7080502
Value 3	18	2.89037176	46	3.8286414
Value 4	664	6.49828215	61	4.11087386
Value 5	20	2.99573227	26	3.25809654
Value 6	147	4.99043259	18	2.89037176
Value 7	9	2.19722458	15	2.7080502
Value 8	22	3.09104245	12	2.48490665
Value 9	467	6.14632926		
Value 10	18	2.89037176	15	2.7080502
Value 11	17	2.83321334	15	2.7080502
Value 12	32	3.4657359	18	2.89037176
Value 13	28	3.33220451	18	2.89037176
Value 14	35	3.55534806	14	2.63905733
Value 15	53	3.97029191	47	3.8501476
Value 16	54	3.98898405		
Value 17	60	4.09434456		
Value 18	16	2.77258872		
Value 19	30	3.40119738		
Value 20	12	2.48490665		
Value 21	30	3.40119738		
Value 22	15	2.7080502		
Value 23	46	3.8286414		
Value 24	61	4.11087386		
Value 25	26	3.25809654		
Value 26	18	2.89037176		
Value 27	15	2.7080502		
Value 28	12	2.48490665		
Value 29				
Value 30	15	2.7080502		
Value 31	15	2.7080502		
Value 32	18	2.89037176		
Value 33	18	2.89037176		
Value 34	14	2.63905733		
Value 35	47	3.8501476		

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	9	9	12	12	7	7	34	34	14	14
Mean	11.0000	1.9315	13.0000	1.7200	8.5714	1.8407	63.2647	3.4197	25.0000	3.0769
Standard Deviation	12.6194	0.9657	22.1729	1.1360	8.9416	0.7544	132.3140	0.9597	15.4023	0.5234
C.V.	1.1472	0.5000	1.7056	0.6604	1.0432	0.4098	2.0914	0.2806	0.6161	0.1701
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	27	24	41	24	20	17	233	105	45	42
10th Percentile	-5	2	-15	1	-3	2	-101	9	6	11
Geometric Mean		7		6		6		31		22
$\exp^{(\text{Standard Deviation})}$		3		3		2		3		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Main Stem (Irrigation Flow)

	Diversion Dam		Glenwood		Middleton		Parma (Historical)		Parma (1990s)	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	4	1.38629436	8	2.07944154	8	2.07944154	154	5.0369526	48	3.87120101
Value 2	3	1.09861229	5	1.60943791	6	1.79175947	76	4.33073334	39	3.66356165
Value 3	8	2.07944154	6	1.79175947	5	1.60943791	47	3.8501476	91	4.51085951
Value 4	1	0	7	1.94591015	6	1.79175947	84	4.4308168	107	4.67282883
Value 5	3	1.09861229			6	1.79175947	102	4.62497281	41	3.71357207
Value 6	3	1.09861229	4	1.38629436	17	2.83321334	483	6.18001665	40	3.68887945
Value 7	3	1.09861229	83	4.41884061	8	2.07944154	40	3.68887945	20	2.99573227
Value 8			6	1.79175947			84	4.4308168	245	5.50125821
Value 9			4	1.38629436			112	4.71849887	51	3.93182563
Value 10			16	2.77258872			74	4.30406509	34	3.52636052
Value 11			12	2.48490665			43	3.76120012		
Value 12			4	1.38629436			20	2.99573227	32	3.4657359
Value 13			4	1.38629436			72	4.27666612		
Value 14							33	3.49650756		
Value 15			4	1.38629436			19	2.94443898		
Value 16							8	2.07944154		
Value 17							61	4.11087386		
Value 18							42	3.73766962		
Value 19							45	3.80666249		
Value 20							25	3.21887582		
Value 21							95	4.55387689		
Value 22							66	4.18965474		
Value 23							48	3.87120101		
Value 24							39	3.66356165		
Value 25							91	4.51085951		
Value 26							107	4.67282883		
Value 27							41	3.71357207		
Value 28							40	3.68887945		
Value 29							20	2.99573227		
Value 30							245	5.50125821		
Value 31							51	3.93182563		
Value 32							34	3.52636052		
Value 33										
Value 34							32	3.4657359		

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	7	7	13	13	7	7	33	33	11	11
Mean	3.5714	1.1229	12.5385	1.9866	8.0000	1.9967	76.7576	4.0094	68.0000	3.9583
Standard Deviation	2.1492	0.6120	21.4772	0.8569	4.1231	0.4061	86.0966	0.7805	64.1701	0.6914
C.V.	0.6018	0.5451	1.7129	0.4314	0.5154	0.2034	1.1217	0.1947	0.9437	0.1747
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218	-1.2410218
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	6	7	40	22	13	12	187	150	150	127
10th Percentile	1	1	-14	3	3	4	-30	21	-12	22
Geometric Mean		3		7		7		55		52
exp$^{(Standard Deviation)}$		2		2		2		2		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Main Stem (High Flow)

	Diversion Dam		Glenwood		Middleton		Parma (Historical)		Parma (1990s)	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	3	1.09861229	7	1.94591015	11	2.39789527	57	4.04305127	22	3.09104245
Value 2	3	1.09861229	20	2.99573227	15	2.7080502	39	3.66356165	148	4.99721227
Value 3	4	1.38629436	7	1.94591015	71	4.26267988	56	4.02535169	48	3.87120101
Value 4	3	1.09861229	11	2.39789527	30	3.40119738	46	3.8286414	120	4.78749174
Value 5	4	1.38629436	7	1.94591015	29	3.36729583	52	3.95124372	27	3.29583687
Value 6	41	3.71357207	8	2.07944154	10	2.30258509	26	3.25809654	57	4.04305127
Value 7	2	0.69314718	6	1.79175947	15	2.7080502	66	4.18965474	33	3.49650756
Value 8	28	3.33220451	120	4.78749174	30	3.40119738	111	4.7095302	63	4.14313473
Value 9	6	1.79175947	14	2.63905733	211	5.35185813	145	4.97673374	83	4.41884061
Value 10	2	0.69314718	36	3.58351894	18	2.89037176	32	3.4657359	89	4.48863637
Value 11	2	0.69314718	32	3.4657359	7	1.94591015	23	3.13549422	34	3.52636052
Value 12	5	1.60943791	30	3.40119738	17	2.83321334	102	4.62497281	164	5.09986643
Value 13	7	1.94591015	4	1.38629436	2	0.69314718	23	3.13549422	163	5.0937502
Value 14	4	1.38629436	12	2.48490665	15	2.7080502	129	4.8598124	37	3.61091791
Value 15	5	1.60943791	23	3.13549422	24	3.17805383	54	3.98898405	59	4.07753744
Value 16	9	2.19722458	52	3.95124372	14	2.63905733	145	4.97673374	70	4.24849524
Value 17	6	1.79175947	24	3.17805383			31	3.4339872	58	4.06044301
Value 18			5	1.60943791			52	3.95124372	43	3.76120012
Value 19			22	3.09104245			101	4.61512052	89	4.48863637
Value 20			17	2.83321334			71	4.26267988	46	3.8286414
Value 21			25	3.21887582			22	3.09104245	26	3.25809654
Value 22			20	2.99573227			148	4.99721227	47	3.8501476
Value 23			20	2.99573227			48	3.87120101	47	3.8501476
Value 24			27	3.29583687			120	4.78749174		
Value 25			10	2.30258509			27	3.29583687		
Value 26							57	4.04305127		
Value 27							33	3.49650756		
Value 28							63	4.14313473		
Value 29							83	4.41884061		
Value 30							89	4.48863637		
Value 31							34	3.52636052		
Value 32							164	5.09986643		
Value 33							163	5.0937502		
Value 34							37	3.61091791		
Value 35							59	4.07753744		
Value 36							70	4.24849524		
Value 37							58	4.06044301		
Value 38							43	3.76120012		
Value 39							89	4.48863637		
Value 40							46	3.8286414		
Value 41							26	3.25809654		
Value 42							47	3.8501476		
Value 43							47	3.8501476		

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	17	17	25	25	16	16	43	43	23	23
Mean	7.8824	1.6191	22.3600	2.7783	32.4375	2.9243	68.2326	4.0578	68.3913	4.0603
Standard Deviation	10.4516	0.8430	23.3682	0.7967	50.1344	1.0076	40.9813	0.5794	42.6793	0.5773
C.V.	1.3259	0.5206	1.0451	0.2868	1.5456	0.3446	0.6006	0.1428	0.6240	0.1422
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181

	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	21	15	52	45	97	88	121	122	123	122
10th Percentile	-5	2	-7	6	-30	5	17	28	15	28
Geometric Mean		5		16		19		58		58
exp[illegible]		2		2		3		2		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Main Stem (No Seasonal Split)

	Diversion Dam		Glenwood		Middleton		Parma (Historical)		Parma (1990s)	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 69							46	3.8286414		
Value 70							48	3.87120101		
Value 71							120	4.78749174		
Value 72							91	4.51085951		
Value 73							107	4.67282883		
Value 74							61	4.11087386		
Value 75							26	3.25809654		
Value 76							27	3.29583687		
Value 77							57	4.04305127		
Value 78							41	3.71357207		
Value 79							18	2.89037176		
Value 80							15	2.7080502		
Value 81							33	3.49650756		
Value 82							63	4.14313473		
Value 83							40	3.68887945		
Value 84							12	2.48490665		
Value 85										
Value 86							83	4.41884061		
Value 87							89	4.48863637		
Value 88							20	2.99573227		
Value 89							15	2.7080502		
Value 90							34	3.52636052		
Value 91							164	5.09986643		
Value 92							163	5.0937502		
Value 93							37	3.61091791		
Value 94							59	4.07753744		
Value 95							245	5.50125821		
Value 96							51	3.93182563		
Value 97							15	2.7080502		
Value 98							18	2.89037176		
Value 99							70	4.24849524		
Value 100							58	4.06044301		
Value 101							43	3.76120012		
Value 102							89	4.48863637		
Value 103							46	3.8286414		
Value 104							34	3.52636052		
Value 105							18	2.89037176		
Value 106							14	2.63905733		
Value 107							47	3.8501476		
Value 108							26	3.25809654		
Value 109							47	3.8501476		
Value 110							47	3.8501476		
Value 100							32	3.4657359		

	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Number of Values	33	33	50	50	30	30	110	110	48	48
Mean	7.8182	1.5991	17.5600	2.3185	21.1667	2.4550	69.2545	3.8460	55.6458	3.7501
Standard Deviation	10.1040	0.8600	22.6789	1.0026	38.3452	0.9697	90.2898	0.8182	46.7904	0.7251
C.V.	1.2924	0.5378	1.2915	0.4324	1.8116	0.3950	1.3037	0.2127	0.8409	0.1933
Z90	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876	1.28172876
Z10	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181	-1.24102181
	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution	Normal Distribution	Log-Normal Distribution
90th Percentile	21	15	47	37	70	40	185	134	116	106
10th Percentile	-5	2	-11	3	-26	3	-43	17	-2	17
Geometric Mean		5		10		12		47		43
$\exp^{(\text{Standard Deviation})}$		2		3		3		2		2

Calculation of Geometric Means, 90th and 10th Percentiles of TSS Conc. Data Set for Normal and Lognormal Distributions
Lower Boise River - Main Stem (No Seasonal Split)

	Diversion Dam		Glenwood		Middleton		Parma (Historical)		Parma (1990s)	
	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)	Value	ln(value)
Value 1	8	2.07944154	4	1.38629436	11	2.39789527	71	4.26267988	30	3.40119738
Value 2	3	1.09861229	7	1.94591015	11	2.39789527	57	4.04305127	22	3.09104245
Value 3	3	1.09861229	20	2.99573227	15	2.7080502	154	5.0369526	148	4.99721227
Value 4	4	1.38629436	8	2.07944154	8	2.07944154	76	4.33073334	48	3.87120101
Value 5	4	1.38629436	5	1.60943791	71	4.26267988	47	3.8501476	39	3.66356165
Value 6	3	1.09861229	3	1.09861229	30	3.40119738	28	3.33220451	15	2.7080502
Value 7	4	1.38629436	7	1.94591015	29	3.36729583	18	2.89037176	46	3.8286414
Value 8	3	1.09861229	11	2.39789527	6	1.79175947	664	6.49828215	48	3.87120101
Value 9	3	1.09861229	6	1.79175947	10	2.30258509	20	2.99573227	120	4.78749174
Value 10	41	3.71357207	5	1.60943791	5	1.60943791	39	3.66356165	91	4.51085951
Value 11	2	0.69314718	7	1.94591015	15	2.7080502	56	4.02535169	107	4.67282883
Value 12	8	2.07944154	8	2.07944154	30	3.40119738	46	3.8286414	61	4.11087386
Value 13	6	1.79175947	7	1.94591015	211	5.35185813	52	3.95124372	26	3.25809654
Value 14	28	3.33220451	4	1.38629436	18	2.89037176	84	4.4308168	27	3.29583687
Value 15	6	1.79175947			7	1.94591015	102	4.62497281	57	4.04305127
Value 16	2	0.69314718	6	1.79175947	5	1.60943791	483	6.18001665	41	3.71357207
Value 17	2	0.69314718	120	4.78749174	6	1.79175947	40	3.68887945	18	2.89037176
Value 18	1	0	14	2.63905733	4	1.38629436	147	4.99043259	15	2.7080502
Value 19	27	3.29583687	36	3.58351894	4	1.38629436	9	2.19722458	33	3.49650756
Value 20	5	1.60943791	32	3.4657359	28	3.33220451	22	3.09104245	63	4.14313473
Value 21	4	1.38629436			17	2.83321334	467	6.14632926	40	3.68887945
Value 22	5	1.60943791	4	1.38629436	2	0.69314718	26	3.25809654	12	2.48490665
Value 23	7	1.94591015	83	4.41884061	15	2.7080502	66	4.18965474		
Value 24	4	1.38629436	2	0.69314718	24	3.17805383	111	4.7095302	83	4.41884061
Value 25	5	1.60943791	30	3.40119738	6	1.79175947	145	4.97673374	89	4.48863637
Value 26	3	1.09861229	4	1.38629436	4	1.38629436	84	4.4308168	20	2.99573227
Value 27	6	1.79175947	6	1.79175947	4	1.38629436	112	4.71849887	15	2.7080502
Value 28	2	0.69314718	3	1.09861229	14	2.63905733	74	4.30406509	34	3.52636052
Value 29	38	3.63758616	12	2.48490665	17	2.83321334	43	3.76120012	164	5.09986643
Value 30	9	2.19722458	23	3.13549422	8	2.07944154	20	2.99573227	163	5.0937502
Value 31	6	1.79175947	52	3.95124372			18	2.89037176	37	3.61091791
Value 32	3	1.09861229	24	3.17805383			17	2.83321334	59	4.07753744
Value 33	3	1.09861229	5	1.60943791			32	3.4657359	245	5.50125821
Value 34			4	1.38629436			28	3.33220451	51	3.93182563
Value 35			16	2.77258872			32	3.4657359	15	2.7080502
Value 36			5	1.60943791			23	3.13549422	18	2.89037176
Value 37			4	1.38629436			102	4.62497281	70	4.24849524
Value 38			67	4.20469262			23	3.13549422	58	4.06044301
Value 39			22	3.09104245			72	4.27666612	43	3.76120012
Value 40			17	2.83321334			33	3.49650756	89	4.48863637
Value 41			25	3.21887582			19	2.94443898	46	3.8286414
Value 42			20	2.99573227			8	2.07944154	34	3.52636052
Value 43			12	2.48490665			129	4.8598124	18	2.89037176
Value 44			4	1.38629436			35	3.55534806	14	2.63905733
Value 45			4	1.38629436			53	3.97029191	47	3.8501476
Value 46			3	1.09861229			54	3.98898405	26	3.25809654
Value 47			3	1.09861229			145	4.97673374	47	3.8501476
Value 48			53	3.97029191			61	4.11087386	47	3.8501476
Value 49			20	2.99573227			42	3.73766962		
Value 50			27	3.29583687			54	3.98898405	32	3.4657359
Value 51			10	2.30258509			60	4.09434456		
Value 52							31	3.4339872		
Value 53			4	1.38629436			52	3.95124372		
Value 54							45	3.80666249		
Value 55							25	3.21887582		
Value 56							16	2.77258872		
Value 57							30	3.40119738		
Value 58							101	4.61512052		
Value 59							71	4.26267988		
Value 60							95	4.55387689		
Value 61							66	4.18965474		
Value 62							12	2.48490665		
Value 63							30	3.40119738		
Value 64							22	3.09104245		
Value 65							148	4.99721227		
Value 66							48	3.87120101		
Value 67							39	3.66356165		
Value 68							15	2.7080502		

Appendix C

Normal and Lognormal Statistics for TSS Concentration Data

1992 High Flow Season - Existing Conditions with No Reductions

30 day Avg. Minimum at Parma (start date 3/24/92)

To Input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All)	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 99999999.0 mg/L	Load Ca at 50mg
Glenwood U.S.		7	
Glenwood Control pt.		21	
Middleton U.S.		6	
Middleton Control pt.		9	
Parma U.S.		47	
Parm Control Pt.		36	

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reductic
BR Below Diversion Dam	13203510	n/a	61.2		749.17	5	10.1	0	0	749	5	10	C
Ridenbaugh	13203760	-	58.3		-175.8	5	-2.4	1	0	575	5	8	
Bubb	13204005	-	57.5		0.0	5	0.0	1	0	576	5	8	
Meeves	13204020	-	56.8		-0.2	5	0.0	1	0	577	5	8	
Rossi Mill	13204060	-	56.4		-1.6	5	0.0	1	0	577	5	8	
River Run	13204070	-	56.1		-13.2	5	-0.2	1	0	565	5	8	
Boise City	13204190	-	56.0		-4.2	5	-0.1	1	0	562	5	7	
Boise Water Corp.	200	-	55.9		-1.5	5	0.0	1	0	562	5	7	
Settlers	13205515	-	52.0		-74.7	5	-1.0	1	0	489	5	6	
Davis	13205517	-	52.0		-1.2	5	0.0	1	0	489	5	6	
Boise City Parks	13205613	-	51.5		-0.1	5	0.0	1	0	490	5	6	
Drainage District #3*	13205617	+	51.0		4.9	31	0.4	1	0	497	5	7	C
Thurman Mill	13205622	-	51.0		-5.2	5	-0.1	1	0	493	5	7	
Farmers Union	13205640	-	50.4		-32.1	5	-0.4	1	0	462	5	6	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	1	0	477	5	7	
BR At Glenwood Bridge	13206000	n/a	47.4		475	16	20.5	4	0	481	5	7	C
				Difference:	5	-949	14		Reset:	475	16	21	
Boise Valley	41	-			-23.4	16	-1.0	0.43	0	452	16	19	
Capitol View	43	-			-3.033	16	-0.1	0.43	0	450	16	19	
New Dry Creek	13206090	-	46.0		-19.793	16	-0.9	0.43	0	430	16	19	
New Union	92	-			-3.9	16	-0.2	0.43	0	427	16	18	
Lemp Ditch	13206205	-	45.4		-1.1	16	0.0	0.43	0	426	16	18	
Warm Springs Ditch	13206220	-	44.8		-2.7	16	-0.1	0.43	0	424	16	18	
Graham-Gilbert	13206260	-	44.2		-0.213	16	0.0	0.43	0	424	16	18	
Ballentyne	13206265	-	43.6		-2.77	16	-0.1	0.43	0	422	16	18	
Conway-Hamming	13206270	-	43.0		-0.6	16	0.0	0.43	0	422	16	18	
Eagle Island Park	13206274	-	42.4		-0.07	16	0.0	0.43	0	422	16	18	
Aiken, Thomas	13206290	-	41.8		-1	16	0.0	0.43	0	421	16	18	
Mace-Catlin	13206292	-	41.2		-2.827	16	-0.1	0.43	0	419	16	18	
Mace & Mace	13206295	-	41.1		0	16	0.0	0.43	0	419	16	18	
West Boise WWTF	2	+	40.9		19.998	9	0.5	0.43	0	440	15	18	
Wroten, Jon Pump	13206308	-	40.8		0	15	0.0	3.91	0	444	15	18	
Eagle Drain @ Eagle	13206400	+	40.7		13.998	27	1.0	3.91	0	462	16	19	0.
Hart-Davis	13208450	-	40.5		-5.3	16	-0.2	1.09	0	458	16	19	
Middleton Irrigation	13208710	-	40.4		-66.733	16	-2.8	1.09	0	392	15	16	
Barber Pumps	13208738	-	40.4		-0.023	15	0.0	1.09	0	393	15	16	
Seven Suckers	13208740	-	40.4		-0.44	15	0.0	1.09	0	394	15	16	
Thurman Drain	13209450	+	40.0		12.086	9	0.3	1.09	0	407	15	17	0.
Phyliss	13209480	-	39.2		-153.46	15	-6.3	4.74	0	258	15	10	
Eureka #1	82	-			-22	15	-0.9	4.74	0	241	15	9	
Little Pioneer	13209630	-	38.0		-16.23	15	-0.6	4.74	0	229	14	9	
Canyon County	13209990	-	32.9		-43.44	14	-1.7	4.74	0	191	14	7	
Caldwell High Line	13210005	-	32.4		-22.41	14	-0.8	4.74	0	173	14	6	
BR At Middleton	50	n/a	31.2		172	19	8.8	5	0	178	13	6	0.
				Difference:	6	-166	2		Reset:	172	19	9	
Fifteen Mile Drain	13210810	+	27.9		45.6	141	17.4	4.76	0	222	44	26	0.
Star Feeder*	13210826	+	26.4		33.957	31	2.8	3.07	0	259	42	29	0.
Long Feeder*	13210828	+	26.4		8.967	31	0.7	3.07	0	272	41	30	0.
Watts Creek*	13210829	+	26.4		5.727	31	0.5	3.07	0	280	40	30	0.
Mill Slough	24	+	24.8		96.157	41	10.7	3.07	0	380	40	41	0.
Willow Creek @ Middleton	13210835	+	24.6		18.907	74	3.8	0.79	0	399	42	45	0.
Mason Slough	13210849	+	23.2		12.763	57	2.0	5.55	0	418	41	47	0.
Mason Creek	13210980	+	22.5		61.197	158	26.1	2.77	0	482	56	73	0.
Riverside	13210984	-	22.6		-160.6	56	-24.3	0.59	0	322	56	49	
Hartley (combined)	87	+	22.2		41.587	59	6.6	0.59	0	364	56	55	0.
Sebree	13210992	-	21.9		-145.67	56	-22.1	1.65	0	220	56	33	
Campbell	13210993	-	21.9		-13.713	56	-2.1	1.65	0	208	55	31	
Siebenberg	13210994	-	21.0		-5.4	55	-0.8	1.65	0	204	55	30	
Shipley Pumps	13211001	-	20.8		-0.2	55	0.0	1.65	0	205	54	30	
Wagner Pumps	13211003	-	20.4		-0.2	54	0.0	1.65	0	207	54	30	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	1.65	0	216	52	30	
Indian Creek	13211445	+	18.8		1	58	0.2	3.57	0	220	51	31	0.
Simplot Pumps	13211603	-	17.9		-0.6	51	-0.1	3.74	0	224	50	30	
Eureka No.2	13211725	-	17.6		-71.21	50	-9.7	3.74	0	156	49	21	
Upper Center Point	13211735	-	17.6		-12.713	49	-1.7	3.74	0	147	48	19	
McManus-Teater	13211745	-	17.6		-1.413	48	-0.2	3.74	0	149	47	19	
Lower Center Point	13211825	-	13.2		-13.58	47	-1.7	3.74	0	140	46	17	
Bowman & Swisher	13212548	-	14.1		-8.163	46	-1.0	3.74	0	135	44	16	
Conway Gulch @ Notus	13212550	+	12.2		36.07	120	11.7	3.74	0	175	59	28	0.
Baxter	13212645	-	10.4		-5.677	59	-0.9	3.83	0	173	58	27	
Andrews Ditch	13212832	-	9.4		-5.567	58	-0.9	3.83	0	171	56	26	
Dixie Drain Near Wilder	90	+	9.3		99.937	120	32.2	3.83	0	275	79	58	0.
Mammon Pumps	13212896	-	8.0		-1.95	79	-0.4	3.28	0	276	78	58	
Hass	13212938	-	7.5		-7.323	78	-1.5	3.28	0	272	77	56	
Parma Ditch	13212954	-	6.5		-14.97	77	-3.1	3.28	0	261	76	53	
Island High Line	13212966	-	4.3		-12.723	76	-2.6	3.28	0	251	75	51	
Crawforth Pumps	13212992	-	4.1		0	75	0.0	3.28	0	255	74	51	
McConnel Island	13212994	-	3.5		-19.43	74	-3.9	3.28	0	238	73	47	
BR Near Parma	13213000	n/a	3.5		233	58	36.4	3	0	242	72	47	0.(
				Difference:	-9	427	-10		Measured:	233	58	36	

Notes:

* Surrogate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

1995 High Flow Season - Existing Conditions with No Reductions

30 day Avg. Minimum at Parma - (start date 3/12/95)
To input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All)	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reduction	Tons/day with 9999999.0 mg/L	Load Cap. at 50mg/L
Glenwood U.S.		0	
Glenwood Control pt.		8	22
Middleton U.S.		10	
Middleton Control pt.		15	35
Parma U.S.		168	
Parm Control Pt.		104	90

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	5	0.0	0	0	0	5	0	0.0
Ridenbaugh	13203760	-	58.3		-26.4	5	-0.4	1	0	-25	5	0	
Bubb	13204005	-	57.5		0.0	5	0.0	1	0	-24	6	0	
Meeves	13204020	-	56.8		0.0	6	0.0	1	0	-22	6	0	
Rossi Mill	13204060	-	56.4		0.0	6	0.0	1	0	-21	6	0	
River Run	13204070	-	56.1		-6.0	6	-0.1	1	0	-25	7	0	
Boise City	13204190	-	56.0		0.0	7	0.0	1	0	-24	7	0	
Boise Water Corp.	200	-	55.9		-1.5	7	0.0	1	0	-24	8	0	
Settlers	13205515	-	52.0		0.0	8	0.0	1	0	-23	8	0	
Davis	13205517	-	52.0		0.0	8	0.0	1	0	-21	8	0	
Boise City Parks	13205613	-	51.5		0.0	8	0.0	1	0	-20	9	0	
Drainage District #3*	13205617	+	51.0		4.2	31	0.4	1	0	-14	3	0	0.0
Thurman Mill	13205622	-	51.0		0.0	3	0.0	1	0	-13	4	0	
Farmers Union	13205640	-	50.4		0.0	4	0.0	1	0	-11	4	0	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	1	0	3	27	0	
BR At Glenwood Bridge	13206000	n/a	47.4		183	16	7.9	4	0	8	11	0	0.0
				Difference:	176	16	8		Reset:	183	16	8	
Boise Valley	41	-			0	16	0.0	0.65	0	184	16	8	
Capitol View	43	-			0	16	0.0	0.65	0	185	16	8	
New Dry Creek	13206090	-	46.0		0	16	0.0	0.65	0	185	16	8	
New Union	92	-			0	16	0.0	0.65	0	186	16	8	
Lemp Ditch	13206205	-	45.4		0	16	0.0	0.65	0	186	16	8	
Warm Springs Ditch	13206220	-	44.8		0	16	0.0	0.65	0	187	16	8	
Graham-Gilbert	13206260	-	44.2		0	16	0.0	0.65	0	188	16	8	
Ballentyne	13206265	-	43.6		0	16	0.0	0.65	0	188	16	8	
Conway-Hamming	13206270	-	43.0		0	16	0.0	0.65	0	189	16	8	
Eagle Island Park	13206274	-	42.4		0	16	0.0	0.65	0	190	15	8	
Aiken, Thomas	13206290	-	41.8		0	15	0.0	0.65	0	190	15	8	
Mace-Catlin	13206292	-	41.2		0	15	0.0	0.65	0	191	15	8	
Mace & Mace	13206295	-	41.1		0	15	0.0	0.65	0	192	15	8	
West Boise WWTF	2	+	40.9		19.998	9	0.5	0.65	0	212	15	8	
Wroten, Jon Pump	13206308	-	40.8		0	15	0.0	5.96	0	218	14	8	
Eagle Drain @ Eagle	13206400	+	40.7		22.36	27	1.6	5.96	0	247	15	10	0.0
Hart-Davis	13208450	-	40.5		0	15	0.0	1.67	0	248	15	10	
Middleton Irrigation	13208710	-	40.4		0	15	0.0	1.67	0	250	15	10	
Barber Pumps	13208738	-	40.4		0	15	0.0	1.67	0	252	15	10	
Seven Suckers	13208740	-	40.4		0	15	0.0	1.67	0	253	15	10	
Thurman Drain	13209450	+	40.0		13.38	9	0.3	1.67	0	268	14	10	0.0
Phyliss	13209480	-	39.2		-6.667	14	-0.3	7.22	0	269	14	10	
Eureka #1	82	-			0	14	0.0	7.22	0	276	14	10	
Little Pioneer	13209630	-	38.0		0	14	0.0	7.22	0	283	13	10	
Canyon County	13209990	-	32.9		0	13	0.0	7.22	0	291	13	10	
Caldwell High Line	13210005	-	32.4		-1.033	13	0.0	7.22	0	297	13	10	
BR At Middleton	50	n/a	31.2		286	19	14.7	7	0	304	12	10	0.0
				Difference:	-18	-95	5		Reset:	286	19	15	
Fifteen Mile Drain	13210810	-	27.9		74.968	141	28.6	-7.25	0	354	45	43	0.0
Star Feeder*	13210826	-	26.4		32.933	31	2.8	-4.68	0	382	45	46	0.0
Long Feeder*	13210828	-	26.4		6.725	31	0.6	-4.68	0	384	45	47	0.0
Watts Creek*	13210829	-	26.4		5.348	31	0.4	-4.68	0	385	45	47	0.0
Mill Slough	24	+	24.8		101.115	41	11.2	-4.68	0	481	45	58	0.0
Willow Creek @ Middleton	13210835	-	24.6		18.054	74	3.6	-1.21	0	498	46	62	0.0
Mason Slough	13210849	+	23.2		12.512	57	1.9	-6.45	0	502	47	64	0.0
Mason Creek	13210980	-	22.5		79.955	158	34.1	-4.23	0	578	63	98	0.0
Riverside	13210984	-	22.6		0	63	0.0	-0.91	0	577	63	98	
Hartley (combined)	87	-	22.2		53.017	59	8.4	-0.91	0	629	63	105	0.0
Sebree	13210992	-	21.9		-0.19	63	0.0	-2.52	0	626	63	106	
Campbell	13210993	-	21.9		0	63	0.0	-2.52	0	624	63	106	
Siebenberg	13210994	-	21.0		0	63	0.0	-2.52	0	621	63	106	
Shipley Pumps	13211001	-	20.8		-0.2	63	0.0	-2.52	0	619	64	106	
Wagner Pumps	13211003	-	20.4		0	64	0.0	-2.52	0	616	64	106	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	-2.52	0	621	64	106	
Indian Creek	13211445	-	18.8		58.552	58	9.1	-5.43	0	674	64	116	0.0
Simplot Pumps	13211603	-	17.9		-0.2	64	0.0	-5.69	0	668	64	116	
Eureka No.2	13211725	-	17.6		0	64	0.0	-5.69	0	662	65	116	
Upper Center Point	13211735	-	17.6		0	65	0.0	-5.69	0	657	65	116	
McManus-Teater	13211745	-	17.6		0	65	0.0	-5.69	0	651	66	116	
Lower Center Point	13211825	-	13.2		0	66	0.0	-5.69	0	645	66	116	
Bowman & Swisher	13212548	-	14.1		0	66	0.0	-5.69	0	640	67	116	
Conway Gulch @ Notus	13212550	-	12.2		35.038	120	11.3	-5.69	0	669	70	127	0.0
Baxter	13212645	-	10.4		0	70	0.0	-5.84	0	663	71	127	
Andrews Ditch	13212632	-	9.4		0	71	0.0	-5.84	0	657	72	127	
Dixie Drain Near Wilder	90	+	9.3		127.603	120	41.1	-5.84	0	779	80	168	0.0
Mammon Pumps	13212898	-	8.0		0	80	0.0	-5.00	0	774	80	168	
Hass	13212938	-	7.5		0	80	0.0	-5.00	0	769	81	168	
Parma Ditch	13212954	-	6.5		0	81	0.0	-5.00	0	764	82	168	
Island High Line	13212966	-	4.3		0	82	0.0	-5.00	0	759	82	168	
Crawforth Pumps	13212992	-	4.1		0	82	0.0	-5.00	0	754	83	168	
McConnel Island	13212994	-	3.5		0	83	0.0	-5.00	0	749	83	168	
BR Near Parma	13213000	n/a	3.5		667	58	104.4	-5	0	744	84	168	0.0
				Difference:	-77	308	-64		Measured:	667	58	104	

Notes:

* Surrogate TSS average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data available for USGS station Boise River Below Diversion Dam

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

1996 High Flow Season - Existing Conditions with No Reductions

30 day Avg. Minimum at Parma (start date April 18)
To Input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All)	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 50mg/L
Glenwood U.S.		-8	
Glenwood Control pt.		170	[illegible]530
Middleton U.S.		144	
Middleton Control pt.		128	[illegible]337
Parma U.S.		395	
Parm Control Pt.		624	[illegible]538

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	5	0.0	0	0	0	5	0	0.0
Ridenbaugh	13203760	-	58.3		-376.4	5	-5.1	2	0	-376	5	-5	
Bubb	13204005	-	57.5		-8.2	5	-0.1	2	0	-382	5	-5	
Meeves	13204020	-	56.8		-0.2	5	0.0	2	0	-380	5	-5	
Rossi Mill	13204060	-	56.4		-6.5	5	-0.1	2	0	-384	5	-5	
River Run	13204070	-	56.1		-18.0	5	-0.2	2	0	-400	5	-6	
Boise City	13204190	-	56.0		-26.1	5	-0.4	2	0	-423	5	-6	
Boise Water Corp.	200	-	55.9		-2.4	5	0.0	2	0	-423	5	-6	
Settlers	13205515	-	52.0		-83.3	5	-1.2	2	0	-504	5	-7	
Davis	13205517	-	52.0		-2.7	5	0.0	2	0	-505	5	-7	
Boise City Parks	13205613	-	51.5		-0.2	5	0.0	2	0	-503	5	-7	
Drainage District #3*	13205617	+	51.0		7.6	31	0.6	2	0	-493	5	-7	0.0
Thurman Mill	13205622	-	51.0		-24.2	5	-0.3	2	0	-515	5	-7	
Farmers Union	13205640	-	50.4		-108.3	5	-1.4	2	0	-621	5	-8	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	2	0	-605	5	-8	
BR At Glenwood Bridge	13206000	n/a	47.4		3933	16	169.7	7	0	-598	5	-8	0.0
				Difference:	4530	15	178		Reset:	3933	16	170	
Boise Valley	41	-			-54	16	-2.3	1.49	0	3880	16	167	
Capitol View	43	-			-7	16	-0.3	1.49	0	3875	16	167	
New Dry Creek	13206090	-	46.0		-19.563	16	-0.8	1.49	0	3857	16	166	
New Union	92	-			-9	16	-0.4	1.49	0	3849	16	166	
Lemp Ditch	13206205	-	45.4		-0.917	16	0.0	1.49	0	3850	16	166	
Warm Springs Ditch	13206220	-	44.8		-1.84	16	-0.1	1.49	0	3849	16	166	
Graham-Gilbert	13206260	-	44.2		-0.467	16	0.0	1.49	0	3850	16	166	
Ballentyne	13206265	-	43.6		-10.243	16	-0.4	1.49	0	3842	16	165	
Conway-Hamming	13206270	-	43.0		-1.4	16	-0.1	1.49	0	3842	16	165	
Eagle Island Park	13206274	-	42.4		-0.3	16	0.0	1.49	0	3843	16	165	
Aiken, Thomas	13206290	-	41.8		-2.19	16	-0.1	1.49	0	3842	16	165	
Mace-Catlin	13206292	-	41.2		-5.463	16	-0.2	1.49	0	3838	16	165	
Mace & Mace	13206295	-	41.1		0	16	0.0	1.49	0	3840	16	165	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.49	0	3861	16	165	
Wroten, Jon Pump	13206308	-	40.8		-0.067	16	0.0	13.61	0	3875	16	165	
Eagle Drain @ Eagle	13206400	+	40.7		46.59	27	3.4	13.61	0	3935	16	169	0.0
Hart-Davis	13208450	-	40.5		-5.727	16	-0.2	3.81	0	3933	16	168	
Middleton Irrigation	13208710	-	40.4		-95.343	16	-4.1	3.81	0	3841	16	164	
Barber Pumps	13208738	-	40.4		-0.513	16	0.0	3.81	0	3845	16	164	
Seven Suckers	13208740	-	40.4		-1.143	16	0.0	3.81	0	3847	16	164	
Thurman Drain	13209450	+	40.0		26.77	9	0.7	3.81	0	3878	16	165	0.0
Phyliss	13209480	-	39.2		-355.32	16	-15.1	16.48	0	3539	16	150	
Eureka #1	82	-			-30	16	-1.3	16.48	0	3526	16	149	
Little Pioneer	13209630	-	38.0		-23.097	16	-1.0	16.48	0	3519	16	148	
Canyon County	13209990	-	32.9		-44.31	16	-1.9	16.48	0	3491	15	146	
Caldwell High Line	13210005	-	32.4		-49.173	15	-2.1	16.48	0	3458	15	144	
BR At Middleton	50	n/a	31.2		2498	19	128.0	16	0	3475	15	144	0.0
				Difference:	-977	8	-16		Reset:	2498	19	128	
Fifteen Mile Drain	13210810	+	27.9		176.567	141	67.4	5.44	0	2680	27	195	0.0
Star Feeder*	13210826	+	26.4		68.93	31	5.8	3.51	0	2752	27	201	0.0
Long Feeder*	13210828	+	26.4		14.057	31	1.2	3.51	0	2770	27	202	0.0
Watts Creek*	13210829	+	26.4		20.383	31	1.7	3.51	0	2794	27	204	0.0
Mill Slough	24	+	24.8		166.183	41	18.5	3.51	0	2963	28	222	0.0
Willow Creek @ Middleton	13210835	+	24.6		55.343	74	11.1	0.91	0	3019	29	233	0.0
Mason Slough	13210849	+	23.2		31.357	57	4.8	6.34	0	3057	29	238	0.0
Mason Creek	13210980	+	22.5		188.303	158	80.3	3.17	0	3249	36	319	0.0
Riverside	13210984	-	22.6		-200.073	36	-19.6	0.68	0	3049	36	299	
Hartley (combined)	67	+	22.2		113.36	59	18.0	0.68	0	3163	37	317	0.0
Sebree	13210992	-	21.9		-154.307	37	-15.5	1.89	0	3011	37	302	
Campbell	13210993	-	21.9		-15.04	37	-1.5	1.89	0	2998	37	300	
Siebenberg	13210994	-	21.0		-6.327	37	-0.6	1.89	0	2993	37	299	
Shipley Pumps	13211001	-	20.8		-0.2	37	0.0	1.89	0	2995	37	299	
Wagner Pumps	13211003	-	20.4		-0.4	37	0.0	1.89	0	2996	37	299	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	1.89	0	3006	37	300	
Indian Creek	13211445	+	18.8		121.043	58	18.8	4.08	0	3131	38	318	0.0
Simplot Pumps	13211603	-	17.9		-0.6	38	-0.1	4.27	0	3135	38	318	
Eureka No.2	13211725	-	17.6		-90.07	38	-9.1	4.27	0	3049	38	309	
Upper Center Point	13211735	-	17.6		-15.023	38	-1.5	4.27	0	3038	38	308	
McManus-Teater	13211745	-	17.6		-1.053	38	-0.1	4.27	0	3041	38	308	
Lower Center Point	13211825	-	13.2		-20.037	38	-2.0	4.27	0	3025	37	305	
Bowman & Swisher	13212548	-	14.1		-7.82	37	-0.8	4.27	0	3022	37	305	
Conway Gulch @ Notus	13212550	+	12.2		76.953	120	24.9	4.27	0	3103	39	330	0.0
Baxter	13212645	-	10.4		-9.51	39	-1.0	4.38	0	3098	39	329	
Andrews Ditch	13212832	-	9.4		-14.977	39	-1.6	4.38	0	3057	39	327	
Dixie Drain Near Wilder	90	+	9.3		243.557	120	78.5	4.36	0	3335	45	406	0.0
Mammon Pumps	13212896	-	8.0		-0.933	45	-0.1	3.75	0	3338	45	405	
Hass	13212938	-	7.5		-5.337	45	-0.6	3.75	0	3337	45	405	
Parma Ditch	13212954	-	6.5		-22.533	45	-2.7	3.75	0	3318	45	402	
Island High Line	13212966	-	4.3		-40.523	45	-4.9	3.75	0	3281	45	397	
Crawforth Pumps	13212992	-	4.1		-0.453	45	-0.1	3.75	0	3284	45	397	
McConnel Island	13212994	-	3.5		-15.83	45	-1.9	3.75	0	3272	45	395	
BR Near Parma	13213000	n/a	3.5		3990	58	624.1	4	0	3276	45	395	0.0
				Difference:	714	119	229		Measured:	3990	58	624	

Notes:

* Surrogate TSS average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data available for USGS station Boise River Below Diversion Dam.

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

Appendix C

High-Flow Season Mass Balances—Existing Conditions Based on the Critical 7-Day (Acute) Flow Period of Parma for: 1992, 1995, and 1996

1992 High Flow Season - Existing Conditions with No Reductions

7-day Avg. Minimum at Parma (start date 3/30/92)
Acute TSS Target Concentration of 80 mg/L.

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All)	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day 0.0 Percent Red.	Load Cap. at 80mg/L
Glenwood U.S.		4	
Glenwood Control pt.		9	22
Middleton U.S.		4	
Middleton Control pt.		7	26
Parma U.S.		56	
Parm Control Pt.		26	36

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	
BR Below Diversion Dam	13203510	n/a	61.2		235	5	3.2	0	0	235	5	3	
Ridenbaugh	13203760	-	58.3		0.0	5	0.0	0	0	235	5	3	
Bubb	13204005	-	57.5		0.0	5	0.0	0	0	236	5	3	
Meeves	13204020	-	56.8		0.0	5	0.0	0	0	236	5	3	
Rossi Mill	13204060	-	56.4		0.0	5	0.0	0	0	237	5	3	
River Run	13204070	-	56.1		-12.9	5	-0.2	0	0	225	5	3	
Boise City	13204190	-	56.0		0.0	5	0.0	0	0	225	5	3	
Boise Water Corp.	200	-	55.9		-1.4	5	0.0	0	0	224	5	3	
Settlers	13205515	-	52.0		0.0	5	0.0	0	0	225	5	3	
Davis	13205517	-	52.0		0.0	5	0.0	0	0	225	5	3	
Boise City Parks	13205613	-	51.5		0.0	5	0.0	0	0	226	5	3	
Drainage District #3*	13205617	+	51.0		4.2	31	0.3	0	0	230	5	3	0
Thurman Mill	13205622	-	51.0		0.0	5	0.0	0	0	231	5	3	
Farmers Union	13205640	-	50.4		0.0	5	0.0	0	0	231	5	3	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	0	0	245	6	4	
BR At Glenwood Bridge	13206000	n/a	47.4		217	16.0	9.3	2	0	247	6	4	0
				Difference:	-30	-70	6		Reset:	217	16	9	
Boise Valley	41	-			0	16	0.0	0.83	0	218	16	9	
Capitol View	43	-			0	16	0.0	0.83	0	218	16	9	
New Dry Creek	13206090	-	46.0		0	16	0.0	0.83	0	219	16	9	
New Union	92	-			0	16	0.0	0.83	0	220	16	9	
Lemp Ditch	13206205	-	45.4		0	16	0.0	0.83	0	221	16	9	
Warm Springs Ditch	13206220	-	44.8		0	16	0.0	0.83	0	222	16	9	
Graham-Gilbert	13206260	-	44.2		-0.286	16	0.0	0.83	0	222	16	9	
Ballentyne	13206265	-	43.6		0	16	0.0	0.83	0	223	16	9	
Conway-Hamming	13206270	-	43.0		-0.857	16	0.0	0.83	0	223	15	9	
Eagle Island Park	13206274	-	42.4		0	15	0.0	0.83	0	224	15	9	
Aiken, Thomas	13206290	-	41.8		0	15	0.0	0.83	0	225	15	9	
Mace-Catlin	13206292	-	41.2		-0.857	15	0.0	0.83	0	225	15	9	
Mace & Mace	13206295	-	41.1		0	15	0.0	0.83	0	226	15	9	
West Boise WWTF	2	+	40.9		19.998	9	0.5	0.83	0	246	15	10	
Wroten, Jon Pump	13206308	-	40.8		0	15	0.0	7.62	0	254	14	10	
Eagle Drain @ Eagle	13206400	+	40.7		14.009	27	1.0	7.62	0	276	14	11	0
Hart-Davis	13208450	-	40.5		-2	14	-0.1	2.13	0	276	14	11	
Middleton Irrigation	13208710	-	40.4		-31.429	14	-1.2	2.13	0	246	14	9	
Barber Pumps	13208738	-	40.4		0	14	0.0	2.13	0	249	14	9	
Seven Suckers	13208740	-	40.4		0	14	0.0	2.13	0	251	14	9	
Thurman Drain	13209450	+	40.0		10.746	9	0.3	2.13	0	264	14	10	0
Phyliss	13209480	-	39.2		-66.071	14	-2.4	9.23	0	207	13	7	
Eureka #1	82	-			-21.429	13	-0.8	9.23	0	195	12	7	
Little Pioneer	13209630	-	38.0		-14.529	12	-0.5	9.23	0	189	12	6	
Canyon County	13209990	-	32.9		-36.571	12	-1.2	9.23	0	162	11	5	
Caldwell High Line	13210005	-	32.4		-18.743	11	-0.6	9.23	0	152	11	4	
BR At Middleton	50	n/a	31.2		135	19	6.9	9	0	162	10	4	0
				Difference:	-26	-37	3		Reset:	135	19	7	
Fifteen Mile Drain	13210810	+	27.9		22.098	141	8.4	-3.34	0	154	37	15	0
Star Feeder*	13210826	+	26.4		20.934	31	1.7	-2.16	0	173	37	17	0
Long Feeder*	13210828	+	26.4		5.757	31	0.5	-2.16	0	176	37	18	0
Watts Creek*	13210829	+	26.4		1.106	31	0.1	-2.16	0	175	37	18	0
Mill Slough	24	+	24.8		72.6	41	8.1	-2.16	0	246	39	26	0
Willow Creek @ Middleton	13210835	+	24.6		11.557	74	2.3	-0.56	0	257	41	28	0
Mason Slough	13210849	+	23.2		10.66	57	1.6	-3.90	0	264	42	30	0
Mason Creek	13210980	+	22.5		37.354	158	15.9	-1.95	0	299	57	46	0
Riverside	13210984	-	22.6		-122.7	57	-16.7	-0.42	0	176	57	27	
Hartley (combined)	87	+	22.2		23.27	59	3.7	-0.42	0	199	57	31	0
Sebree	13210992	-	21.9		0	57	0.0	-1.16	0	198	57	31	
Campbell	13210993	-	21.9		0	57	0.0	-1.16	0	196	58	31	
Siebenberg	13210994	-	21.0		0	58	0.0	-1.16	0	195	58	31	
				Difference:	-26	-37	3		Reset:	135	19	7	
Fifteen Mile Drain	13210810	+	27.9		22.098	141	8.4	-3.34	0	154	37	15	0
Star Feeder*	13210826	+	26.4		20.934	31	1.7	-2.16	0	173	37	17	0
Long Feeder*	13210828	+	26.4		5.757	31	0.5	-2.16	0	176	37	18	0
Watts Creek*	13210829	+	26.4		1.106	31	0.1	-2.16	0	175	37	18	0
Mill Slough	24	+	24.8		72.6	41	8.1	-2.16	0	246	39	26	0
Willow Creek @ Middleton	13210835	+	24.6		11.557	74	2.3	-0.56	0	257	41	28	0
Mason Slough	13210849	+	23.2		10.66	57	1.6	-3.90	0	264	42	30	0
Mason Creek	13210980	+	22.5		37.354	158	15.9	-1.95	0	299	57	46	0
Riverside	13210984	-	22.6		-122.7	57	-16.7	-0.42	0	176	57	27	
Hartley (combined)	87	+	22.2		23.27	59	3.7	-0.42	0	199	57	31	0
Sebree	13210992	-	21.9		0	57	0.0	-1.16	0	198	57	31	
Campbell	13210993	-	21.9		0	57	0.0	-1.16	0	196	58	31	
Siebenberg	13210994	-	21.0		0	58	0.0	-1.16	0	195	58	31	
Shipley Pumps	13211001	-	20.8		-0.143	58	0.0	-1.16	0	194	58	31	
Wagner Pumps	13211003	-	20.4		0	58	0.0	-1.16	0	193	59	31	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	-1.16	0	199	57	31	
Indian Creek	13211445	+	18.8		0.837	58	0.1	-2.50	0	197	58	31	0
Simplot Pumps	13211603	-	17.9		-0.429	58	-0.1	-2.62	0	194	59	31	
Eureka No.2	13211725	-	17.6		-14.286	59	-2.3	-2.62	0	177	60	29	
Upper Center Point	13211735	-	17.6		0	60	0.0	-2.62	0	175	61	29	
McManus-Teater	13211745	-	17.6		0	61	0.0	-2.62	0	172	62	29	
Lower Center Point	13211825	-	13.2		0	62	0.0	-2.62	0	170	63	29	
Bowman & Swisher	13212548	-	14.1		-1.429	63	-0.2	-2.62	0	165	64	28	
Conway Gulch @ Notus	13212550	+	12.2		25.751	120	8.3	-2.62	0	189	72	37	0
Baxter	13212645	-	10.4		0	72	0.0	-2.69	0	186	73	37	
Andrews Ditch	13212832	-	9.4		0	73	0.0	-2.69	0	183	74	37	
Dixie Drain Near Wilder	90	+	9.3		60.18	120	19.4	-2.69	0	241	86	56	0
Mammon Pumps	13212896	-	8.0		0	86	0.0	-2.31	0	238	87	56	
Hass	13212938	-	7.5		0	87	0.0	-2.31	0	236	88	56	
Parma Ditch	13212954	-	6.5		0	88	0.0	-2.31	0	234	89	56	
Island High Line	13212966	-	4.3		0	89	0.0	-2.31	0	231	90	56	
Crawforth Pumps	13212992	-	4.1		0	90	0.0	-2.31	0	229	91	56	
McConnel Island	13212994	-	3.5		0	91	0.0	-2.31	0	227	92	56	
BR Near Parma	13213000	n/a	3.5		167	58	26.2	-2	0	225	93	56	0
				Difference:	-57	194	-30		Measured:	167	58	26	

Notes:

* Surrogate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

1995 High Flow Season - Existing Conditions with No Reductions

7-day Avg. Minimum at Parma (start date 4/2/95)
Acute TSS Target Concentration of 80 mg/L

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All).	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 80mg/L
Glenwood U.S.		0	
Glenwood Control pt.		8	[illegible]33
Middleton U.S.		7	
Middleton Control pt.		15	[illegible]51
Parma U.S.		185	
Parm Control Pt.		90	[illegible]124

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	5	0.0	0	0	0	5	0	0.0
Ridenbaugh	13203760	-	58.3		-64.6	5	-0.9	2	0	-62	5	-1	
Bubb	13204005	-	57.5		0.0	5	0.0	2	0	-60	5	-1	
Meeves	13204020	-	56.8		0.0	5	0.0	2	0	-58	6	-1	
Rossi Mill	13204060	-	56.4		0.0	6	0.0	2	0	-55	6	-1	
River Run	13204070	-	56.1		-18.0	6	-0.3	2	0	-71	6	-1	
Boise City	13204190	-	56.0		0.0	6	0.0	2	0	-69	6	-1	
Boise Water Corp.	200	-	55.9		-4.6	6	-0.1	2	0	-71	6	-1	
Settlers	13205515	-	52.0		0.0	6	0.0	2	0	-68	7	-1	
Davis	13205517	-	52.0		0.0	7	0.0	2	0	-66	7	-1	
Boise City Parks	13205613	-	51.5		0.0	7	0.0	2	0	-64	7	-1	
Drainage District #3*	13205617	+	51.0		6.0	31	0.5	2	0	-55	5	-1	0.0
Thurman Mill	13205622	-	51.0		0.0	5	0.0	2	0	-53	5	-1	
Farmers Union	13205640	-	50.4		0.0	5	0.0	2	0	-51	5	-1	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	2	0	-35	4	0	
BR At Glenwood Bridge	13206000	n/a	47.4		193	16	8.3	7	0	-28	5	0	0.0
				Difference:	220	15	9		Reset:	193	16	8	
Boise Valley	41	-			-54	16	-2.3	1.49	0	140	16	6	
Capitol View	43	-			-7	16	-0.3	1.49	0	135	16	6	
New Dry Creek	13206090	-	46.0		0	16	0.0	1.49	0	136	15	6	
New Union	92	-			-9	15	-0.4	1.49	0	129	15	5	
Lemp Ditch	13206205	-	45.4		0	15	0.0	1.49	0	130	15	5	
Warm Springs Ditch	13206220	-	44.8		0	15	0.0	1.49	0	132	15	5	
Graham-Gilbert	13206260	-	44.2		0	15	0.0	1.49	0	133	15	5	
Ballentyne	13206265	-	43.6		0	15	0.0	1.49	0	134	15	5	
Conway-Hamming	13206270	-	43.0		0	15	0.0	1.49	0	136	14	5	
Eagle Island Park	13206274	-	42.4		0	14	0.0	1.49	0	137	14	5	
Aiken, Thomas	13206290	-	41.8		0	14	0.0	1.49	0	139	14	5	
Mace-Catlin	13206292	-	41.2		0	14	0.0	1.49	0	140	14	5	
Mace & Mace	13206295	-	41.1		0	14	0.0	1.49	0	142	14	5	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.49	0	163	13	6	
Wroten, Jon Pump	13206308	-	40.8		0	13	0.0	13.61	0	177	12	6	
Eagle Drain @ Eagle	13206400	+	40.7		23.3	27	1.7	13.61	0	214	13	7	0.0
Hart-Davis	13208450	-	40.5		0	13	0.0	3.81	0	218	13	7	
Middleton Irrigation	13208710	-	40.4		0	13	0.0	3.81	0	222	12	7	
Barber Pumps	13208738	-	40.4		0	12	0.0	3.81	0	225	12	7	
Seven Suckers	13208740	-	40.4		0	12	0.0	3.81	0	229	12	7	
Thurman Drain	13209450	+	40.0		18.529	9	0.5	3.81	0	252	12	8	0.0
Phyliss	13209480	-	39.2		0	12	0.0	16.48	0	268	11	8	
Eureka #1	82	-			-30	11	-0.9	16.48	0	254	10	7	
Little Pioneer	13209630	-	38.0		0	10	0.0	16.48	0	271	10	7	
Canyon County	13209990	-	32.9		0	10	0.0	16.48	0	287	9	7.0	
Caldwell High Line	13210005	-	32.4		0	9	0.0	16.48	0	304	8.6	7.05	
BR At Middleton	50	n/a	31.2		301	19	15.4	16	0	320	8.2	7.05	0.0
				Difference:	19	-164	8		Reset:	301	19	15	
Fifteen Mile Drain	13210810	+	27.9		72.8	141	27.8	5.44	0	380	42	43	0.0
Star Feeder*	13210826	+	26.4		42.857	31	3.6	3.51	0	426	41	47	0.0
Long Feeder*	13210828	+	26.4		10.414	31	0.9	3.51	0	440	40	48	0.0
Watts Creek*	13210829	+	26.4		0	31	0.0	3.51	0	443	40	48	0.0
Mill Slough	24	+	24.8		145.6	41	16.2	3.51	0	593	40	64	0.0
Willow Creek @ Middleton	13210835	+	24.6		14.857	74	3.0	0.91	0	608	41	67	0.0
Mason Slough	13210849	+	23.2		13.429	57	2.1	6.34	0	628	41	69	0.0
Mason Creek	13210980	+	22.5		85.657	158	36.5	3.17	0	717	55	105	0.0
Riverside	13210984	-	22.6		0	55	0.0	0.68	0	718	54	105	
Hartley (combined)	67	+	22.2		53.086	59	8.4	0.68	0	771	55	114	0.0
Sebree	13210992	-	21.9		0	55	0.0	1.89	0	773	55	114	
Campbell	13210993	-	21.9		0	55	0.0	1.89	0	775	54	114	
Siebenberg	13210994	-	21.0		0	54	0.0	1.89	0	777	54	114	
Shipley Pumps	13211001	-	20.8		-0.6	54	-0.1	1.89	0	778	54	114	
Wagner Pumps	13211003	-	20.4		0	54	0.0	1.89	0	780	54	114	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	1.89	0	790	54	114	
Indian Creek	13211445	+	18.8		77.243	58	12.0	4.08	0	871	54	126	0.0
Simplot Pumps	13211603	-	17.9		-0.6	54	-0.1	4.27	0	875	53	126	
Eureka No.2	13211725	-	17.6		0	53	0.0	4.27	0	879	53	126	
Upper Center Point	13211735	-	17.6		0	53	0.0	4.27	0	883	53	126	
McManus-Teater	13211745	-	17.6		0	53	0.0	4.27	0	887	53	126	
Lower Center Point	13211825	-	13.2		0	53	0.0	4.27	0	892	52	126	
Bowman & Swisher	13212548	-	14.1		0	52	0.0	4.27	0	896	52	126	
Conway Gulch @ Notus	13212550	+	12.2		39.114	120	12.7	4.27	0	939	55	139	0.0
Baxter	13212645	-	10.4		0	55	0.0	4.38	0	944	54	139	
Andrews Ditch	13212832	-	9.4		0	54	0.0	4.38	0	948	54	139	
Dixie Drain Near Wilder	90	+	9.3		145.143	120	46.8	4.38	0	1098	63	185	0.0
Mammon Pumps	13212896	-	8.0		0	63	0.0	3.75	0	1101	62	185	
Hass	13212938	-	7.5		0	62	0.0	3.75	0	1105	62	185	
Parma Ditch	13212954	-	6.5		0	62	0.0	3.75	0	1109	62	185	
Island High Line	13212966	-	4.3		0	62	0.0	3.75	0	1113	62	185	
Crawforth Pumps	13212992	-	4.1		0	62	0.0	3.75	0	1116	62	185	
McConnel Island	13212994	-	3.5		0	62	0.0	3.75	0	1120	61	185	
BR Near Parma	13213000	n/a	3.5		577	58	90.2	4	0	1124	61	185	0.0
				Difference:	-547	64	-95		Measured:	577	58	90	

Notes:

* Surrogate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data available for USGS station Boise River Below Diversion Dam.

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

1996 High Flow Season - Existing Conditions with No Reductions

7-day Avg. Minimum at Parma (start date 5/4/96)
Acute TSS Target Concentration of 80 mg/L

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All)	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 80mg/L
Glenwood U.S.		-10	
Glenwood Control pt.		129	639
Middleton U.S.		101	
Middleton Control pt.		66	280
Parma U.S.		331	
Parm Control Pt.		424	585

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	5	0.0	0	0	0	5	0	0.0
Ridenbaugh	13203760	-	58.3		-432.3	5	-5.8	2	0	-430	5	-6	
Bubb	13204005	-	57.5		-7.5	5	-0.1	2	0	-435	5	-6	
Meeves	13204020	-	56.8		-0.7	5	0.0	2	0	-434	5	-6	
Rossi Mill	13204060	-	56.4		-6.1	5	-0.1	2	0	-437	5	-6	
River Run	13204070	-	56.1		-16.0	5	-0.2	2	0	-453	5	-6	
Boise City	13204190	-	56.0		-29.0	5	-0.4	2	0	-480	5	-7	
Boise Water Corp.	200	-	55.9		-2.7	5	0.0	2	0	-480	5	-7	
Settlers	13205515	-	52.0		-114.9	5	-1.6	2	0	-592	5	-8	
Davis	13205517	-	52.0		-6.0	5	-0.1	2	0	-596	5	-8	
Boise City Parks	13205613	-	51.5		-0.2	5	0.0	2	0	-594	5	-8	
Drainage District #3*	13205617	+	51.0		7.2	31	0.6	2	0	-584	5	-8	0.0
Thurman Mill	13205622	-	51.0		-25.5	5	-0.3	2	0	-608	5	-8	
Farmers Union	13205640	-	50.4		-129.7	5	-1.7	2	0	-735	5	-10	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	2	0	-719	5	-10	
BR At Glenwood Bridge	13206000	n/a	47.4		2997	16	129.3	7	0	-712	5	-10	0.0
				Difference:	3709	14	139		Reset:	2997	16	129	
Boise Valley	41	-			-54	16	-2.3	1.49	0	2945	16	127	
Capitol View	43	-			-7	16	-0.3	1.49	0	2939	16	127	
New Dry Creek	13206090	-	46.0		-22.714	16	-1.0	1.49	0	2918	16	126	
New Union	92	-			-9	16	-0.4	1.49	0	2910	16	125	
Lemp Ditch	13206205	-	45.4		-1.529	16	-0.1	1.49	0	2910	16	125	
Warm Springs Ditch	13206220	-	44.8		-3.186	16	-0.1	1.49	0	2909	16	125	
Graham-Gilbert	13206260	-	44.2		-0.8	16	0.0	1.49	0	2909	16	125	
Ballentyne	13206265	-	43.6		-12.971	16	-0.6	1.49	0	2898	16	125	
Conway-Hamming	13206270	-	43.0		-2.386	16	-0.1	1.49	0	2897	16	124	
Eagle Island Park	13206274	-	42.4		-0.3	16	0.0	1.49	0	2898	16	124	
Aiken, Thomas	13206290	-	41.8		-0.243	16	0.0	1.49	0	2899	16	124	
Mace-Catlin	13206292	-	41.2		-6.114	16	-0.3	1.49	0	2895	16	124	
Mace & Mace	13206295	-	41.1		0	16	0.0	1.49	0	2896	16	124	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.49	0	2918	16	125	
Wroten, Jon Pump	13206308	-	40.8		0	16	0.0	13.61	0	2931	16	125	
Eagle Drain @ Eagle	13206400	+	40.7		49.886	27	3.6	13.61	0	2995	16	128	0.0
Hart-Davis	13208450	-	40.5		-7.643	16	-0.3	3.81	0	2991	16	128	
Middleton Irrigation	13208710	-	40.4		-123.8	16	-5.3	3.81	0	2871	16	123	
Barber Pumps	13208738	-	40.4		-0.5	16	0.0	3.81	0	2874	16	123	
Seven Suckers	13208740	-	40.4		-1.2	16	-0.1	3.81	0	2877	16	123	
Thurman Drain	13209450	+	40.0		26.057	9	0.7	3.81	0	2907	16	123	0.0
Phyliss	13209480	-	39.2		-359.914	16	-15.3	16.48	0	2563	16	108	
Eureka #1	82	-			-30	16	-1.3	16.48	0	2550	16	107	
Little Pioneer	13209630	-	38.0		-26.029	16	-1.1	16.48	0	2540	15	106	
Canyon County	13209990	-	32.9		-53.143	15	-2.2	16.48	0	2504	15	103.4	
Caldwell High Line	13210005	-	32.4		-47.743	15	-2.0	16.48	0	2472	15.2	101.39	
BR At Middleton	50	n/a	31.2		1298	19	66.5	16	0	2489	15.1	101.39	0.0
				Difference:	-1191	11	-35		Reset:	1298	19	66	
Fifteen Mile Drain	13210810	+	27.9		206	141	78.6	5.44	0	1509	36	145	0.0
Star Feeder*	13210826	+	26.4		66.829	31	5.6	3.51	0	1579	35	151	0.0
Long Feeder*	13210828	+	26.4		14.629	31	1.2	3.51	0	1598	35	152	0.0
Watts Creek*	13210829	+	26.4		20.886	31	1.7	3.51	0	1622	35	154	0.0
Mill Slough	24	+	24.8		174.771	41	19.4	3.51	0	1800	36	173	0.0
Willow Creek @ Middleton	13210835	+	24.6		58.857	74	11.8	0.91	0	1860	37	185	0.0
Mason Slough	13210849	+	23.2		36.286	57	5.5	6.34	0	1903	37	190	0.0
Mason Creek	13210980	+	22.5		201.229	158	85.8	3.17	0	2107	49	276	0.0
Riverside	13210984	-	22.6		-200.771	49	-26.3	0.68	0	1907	49	250	
Hartley (combined)	87	+	22.2		124	59	19.7	0.68	0	2032	49	270	0.0
Sebree	13210992	-	21.9		-207.571	49	-27.5	1.89	0	1826	49	242	
Campbell	13210993	-	21.9		-14.971	49	-2.0	1.89	0	1813	49	240	
Siebenberg	13210994	-	21.0		-9	49	-1.2	1.89	0	1806	49	239	
Shipley Pumps	13211001	-	20.8		-0.2	49	0.0	1.89	0	1807	49	239	
Wagner Pumps	13211003	-	20.4		-0.4	49	-0.1	1.89	0	1809	49	239	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	1.89	0	1818	49	239	
Indian Creek	13211445	+	18.8		129	58	20.1	4.08	0	1951	49	259	0.0
Simplot Pumps	13211603	-	17.9		-0.6	49	-0.1	4.27	0	1955	49	259	
Eureka No.2	13211725	-	17.6		-94.714	49	-12.5	4.27	0	1865	49	246	
Upper Center Point	13211735	-	17.6		-18.286	49	-2.4	4.27	0	1851	49	244	
McManus-Teater	13211745	-	17.6		-2.686	49	-0.4	4.27	0	1852	49	244	
Lower Center Point	13211825	-	15.2		-27.086	49	-3.6	4.27	0	1829	49	240	
Bowman & Swisher	13212548	-	14.1		-9.586	49	-1.3	4.27	0	1824	49	239	
Conway Gulch @ Notus	13212550	+	12.2		80.957	120	26.2	4.27	0	1909	51	265	0.0
Baxter	13212645	-	10.4		-10.414	51	-1.4	4.38	0	1903	51	264	
Andrews Ditch	13212832	-	9.4		-17.586	51	-2.4	4.38	0	1890	51	261	
Dixie Drain Near Wilder	90	+	9.3		269.771	120	86.9	4.38	0	2164	60	348	0.0
Mammon Pumps	13212896	-	8.0		-1.429	60	-0.2	3.75	0	2166	60	348	
Hass	13212936	-	7.5		-5.114	60	-0.8	3.75	0	2165	59	347	
Parma Ditch	13212954	-	6.5		-28.086	59	-4.5	3.75	0	2141	59	343	
Island High Line	13212966	-	4.3		-47.814	59	-7.7	3.75	0	2097	59	335	
Crawforth Pumps	13212992	-	4.1		-0.8	59	-0.1	3.75	0	2100	59	335	
McConnel Island	13212994	-	3.5		-26.157	59	-4.2	3.75	0	2077	59	331	
BR Near Parma	13213000	n/a	3.5		2710	58	423.8	4	0	2081	59	331	0.0
				Difference:	629	55	93		Measured:	2710	58	424	

Notes:

* Surrogate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data available for USGS station Boise River Below Diversion Dam.

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

Appendix D

Irrigation Flow Season Mass Balances—Existing Conditions Based on the Critical 30-Day (Chronic) Flow Period at Parma for: 1992, 1995, and 1996

1992 Irrigation Flow Season - Existing Conditions with No Reductions

30-day Avg. Minimum at Parma (start date 8/21/92)

To Input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	2	(1 = HF; 2 = IF; 3 = LF)	Irrigation Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	2	(1 = HF; 2 = IF; 3 = LF, 4=All)	Irrigation Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 50mg/L
Glenwood U.S.		3	
Glenwood Control pt.		5	27
Middleton U.S.		1	
Middleton Control pt.		3	20
Parma U.S.		22	
Parm Control Pt.		22	22

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam	13203510	n/a	61.2		414	3	3.3	0	0	414	3	3	0.0
Ridenbaugh	13203760	-	58.3		0.0	3	0.0	4	0	417	3	3	
Bubb	13204005	-	57.5		-3.0	3	0.0	4	0	418	3	3	
Meeves	13204020	-	56.8		-0.8	3	0.0	4	0	421	3	3	
Rossi Mill	13204060	-	56.4		-6.0	3	0.0	4	0	419	3	3	
River Run	13204070	-	56.1		-18.0	3	-0.1	4	0	404	3	3	
Boise City	13204190	-	56.0		0.0	3	0.0	4	0	408	3	3	
Boise Water Corp.	200	-	55.9		-2.0	3	0.0	4	0	410	3	3	
Settlers	13205515	-	52.0		0.0	3	0.0	4	0	413	3	3	
Davis	13205517	-	52.0		-2.2	3	0.0	4	0	415	3	3	
Boise City Parks	13205613	-	51.5		-0.2	3	0.0	4	0	418	3	3	
Drainage District #3*	13205617	+	51.0		4.0	47	0.5	4	0	426	3	4	0.0
Thurman Mill	13205622	-	51.0		-19.6	3	-0.2	4	0	410	3	3	
Farmers Union	13205640	-	50.4		-97.0	3	-0.8	4	0	317	3	3	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	4	0	334	3	3	
BR At Glenwood Bridge	13206000	n/a	47.4		290	7	5.5	11	0	345	3	3	0.0
				Difference:	-55	-17	2		Reset:	290	7	5	
Boise Valley	41	-			-46	7	-0.9	1.92	0	246	7	5	
Capitol View	43	-			-7	7	-0.1	1.92	0	241	7	4	
New Dry Creek	13206090	-	46.0		-31.133	7	-0.6	1.92	0	212	7	4	
New Union	92	-			-9	7	-0.2	1.92	0	205	7	4	
Lemp Ditch	13206205	-	45.4		-2.3	7	0.0	1.92	0	205	7	4	
Warm Springs Ditch	13206220	-	44.8		-3.25	7	-0.1	1.92	0	203	7	4	
Graham-Gilbert	13206260	-	44.2		-0.317	7	0.0	1.92	0	205	7	4	
Ballentyne	13206265	-	43.6		-9.583	7	-0.2	1.92	0	197	7	3	
Conway-Hamming	13206270	-	43.0		-0.817	7	0.0	1.92	0	198	6	3	
Eagle Island Park	13206274	-	42.4		-0.263	6	0.0	1.92	0	200	6	3	
Aiken, Thomas	13206290	-	41.8		-2.3	6	0.0	1.92	0	200	6	3	
Mace-Catlin	13206292	-	41.2		-6.217	6	-0.1	1.92	0	195	6	3	
Mace & Mace	13206295	-	41.1		0	6	0.0	1.92	0	197	6	3	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.92	0	219	6	4	
Wroten, Jon Pump	13206308	-	40.8		0	6	0.0	17.54	0	237	6	4	
Eagle Drain @ Eagle	13206400	+	40.7		21.71	32	1.9	17.54	0	276	8	6	0.0
Hart-Davis	13208450	-	40.5		-7.943	8	-0.2	4.91	0	273	7	6	
Middleton Irrigation	13208710	-	40.4		-76.017	7	-1.5	4.91	0	202	7	4	
Barber Pumps	13208738	-	40.4		-0.513	7	0.0	4.91	0	206	7	4	
Seven Suckers	13208740	-	40.4		-1.2	7	0.0	4.91	0	210	7	4	
Thurman Drain	13209450	+	40.0		18.467	12	0.6	4.91	0	233	7	5	0.0
Phyliss	13209480	-	39.2		-90.353	7	-1.8	21.24	0	164	6	3	
Eureka #1	82	-			-29	6	-0.5	21.24	0	156	5	2	
Little Pioneer	13209630	-	38.0		-18.763	5	-0.3	21.24	0	159	5	2	
Canyon County	13209990	-	32.9		-49.52	5	-0.6	21.24	0	131	4	1	
Caldwell High Line	13210005	-	32.4		-20.777	4	-0.2	21.24	0	131	3	1	
BR At Middleton	50	n/a	31.2		159	7	3.0	21	0	152	3	1	0.0
				Difference:	7	102	2		Reset:	159	7	3	
Fifteen Mile Drain	13210810	+	27.9		10.86	92	2.7	11.06	0	181	12	6	0.0
Star Feeder*	13210826	+	26.4		49.617	47	6.2	7.14	0	238	19	12	0.0
Long Feeder*	13210828	+	26.4		6	47	0.8	7.14	0	251	19	13	0.0
Watts Creek*	13210829	+	26.4		6.75	47	0.8	7.14	0	265	19	14	0.0
Mill Slough	24	+	24.8		96.173	33	8.6	7.14	0	368	22	22	0.0
Willow Creek @ Middleton	13210835	+	24.6		3.317	52	0.5	1.84	0	373	22	23	0.0
Mason Slough	13210849	+	23.2		12.343	96	3.2	12.91	0	398	24	26	0.0
Mason Creek	13210980	+	22.5		55.177	113	16.8	6.45	0	460	34	43	0.0
Riverside	13210984	-	22.6		-183.99	34	-17.0	1.38	0	277	34	26	
Hartley (combined)	87	+	22.2		57.027	57	8.8	1.38	0	336	38	34	0.0
Sebree	13210992	-	21.9		-199.573	38	-20.4	3.84	0	140	37	14	
Campbell	13210993	-	21.9		-22.577	37	-2.2	3.84	0	121	36	12	
Siebenberg	13210994	-	21.0		-8.753	36	-0.8	3.84	0	117	35	11	
Shipley Pumps	13211001	-	20.8		-0.2	35	0.0	3.84	0	120	33	11	
Wagner Pumps	13211003	-	20.4		-0.4	33	0.0	3.84	0	124	32	11	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	3.84	0	135	30	11	
Indian Creek	13211445	+	18.8		2.817	40	0.3	8.30	0	146	29	11	0.0
Simplot Pumps	13211603	-	17.9		-0.6	29	0.0	8.69	0	154	27	11	
Eureka No.2	13211725	-	17.6		-58.783	27	-4.3	8.69	0	104	25	7	
Upper Center Point	13211735	-	17.6		-14.717	25	-1.0	8.69	0	98	23	6	
McManus-Teater	13211745	-	17.6		-1	23	-0.1	8.69	0	106	21	6	
Lower Center Point	13211825	-	13.2		-15	21	-0.8	8.69	0	99	19	5	
Bowman & Swisher	13212548	-	14.1		-9.8	19	-0.5	8.69	0	98	17	5	
Conway Gulch @ Notus	13212550	+	12.2		23.763	139	8.9	8.69	0	131	38	14	0.0
Baxter	13212645	-	10.4		-7.85	38	-0.8	8.91	0	132	36	13	
Andrews Ditch	13212632	-	9.4		-7.917	36	-0.8	8.91	0	133	33	12	
Dixie Drain Near Wilder	90	+	9.3		126.967	51	17.5	8.91	0	269	41	29	0.0
Mammon Pumps	13212896	-	8.0		-5.483	41	-0.6	7.64	0	271	39	29	
Hass	13212938	-	7.5		-6.057	39	-0.6	7.64	0	272	38	28	
Parma Ditch	13212954	-	6.5		-16.86	38	-1.7	7.64	0	263	37	26	
Island High Line	13212966	-	4.3		-21.85	37	-2.2	7.64	0	249	36	24	
Crawforth Pumps	13212992	-	4.1		-0.8	36	-0.1	7.64	0	256	35	24	
McConnel Island	13212994	-	2.5		-27.717	35	-2.6	7.64	0	236	34	22	
BR Near Parma	13213000	n/a	3.5		160	52	22.4	8	0	243	33	22	0.0
				Difference:	-84	-4	1		Measured:	160	52	22	

Notes:

* Surragate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.

Eagle Drain @ Eagle	13206400	32
Thurman Drain	13209450	12
Mason Slough	13210849	96
	average	47

1995 Irrigation Flow Season - Existing Conditions with No Reductions

30-day Avg. Minimum at Parma (start 8/19/95)
To input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	2	(1 = HF; 2 = IF; 3 = LF)	Irrigation Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	2	(1 = HF; 2 = IF; 3 = LF, 4=All)	Irrigation Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 50mg/L
Glenwood U.S.		-6	
Glenwood Control pt.		16	[illegible]
Middleton U.S.		5	
Middleton Control pt.		7	[illegible]
Parma U.S.		95	
Parm Control Pt.		136	[illegible]

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	3	0.0	0	0	0	3	0	0.0
Ridenbaugh	13203760	-	58.3		-443.4	3	-3.6	4	0	-440	3	-4	
Bubb	13204005	-	57.5		-7.3	3	-0.1	4	0	-443	3	-4	
Meeves	13204020	-	56.8		-0.6	3	0.0	4	0	-440	3	-4	
Rossi Mill	13204060	-	56.4		-6.0	3	0.0	4	0	-443	3	-4	
River Run	13204070	-	56.1		-18.0	3	-0.2	4	0	-457	3	-4	
Boise City	13204190	-	56.0		-25.7	3	-0.2	4	0	-479	3	-4	
Boise Water Corp.	200	-	55.9		-3.9	3	0.0	4	0	-479	3	-4	
Settlers	13205515	-	52.0		-148.5	3	-1.3	4	0	-624	3	-5	
Davis	13205517	-	52.0		-6.7	3	-0.1	4	0	-627	3	-5	
Boise City Parks	13205613	-	51.5		-0.2	3	0.0	4	0	-623	3	-5	
Drainage District #3*	13205617	+	51.0		6.0	47	0.8	4	0	-614	3	-5	0.0
Thurman Mill	13205622	-	51.0		-23.5	3	-0.2	4	0	-633	3	-5	
Farmers Union	13205640	-	50.4		-175.0	3	-1.3	4	0	-805	3	-6	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	4	0	-788	3	-6	
BR At Glenwood Bridge	13206000	n/a	47.4		827	7	15.6	11	0	-776	3	-6	0.0
				Difference:	1603	5	21		Reset:	827	7	16	
Boise Valley	41	-			-46	7	-0.9	1.92	0	783	7	15	
Capitol View	43	-			-7	7	-0.1	1.92	0	778	7	15	
New Dry Creek	13206090	-	46.0		-38.767	7	-0.7	1.92	0	741	7	14	
New Union	92	-			-9	7	-0.2	1.92	0	734	7	14	
Lemp Ditch	13206205	-	45.4		-2.75	7	-0.1	1.92	0	733	7	14	
Warm Springs Ditch	13206220	-	44.8		-4	7	-0.1	1.92	0	731	7	14	
Graham-Gilbert	13206260	-	44.2		-1	7	0.0	1.92	0	732	7	14	
Ballentyne	13206265	-	43.6		-13.933	7	-0.3	1.92	0	720	7	13	
Conway-Hamming	13206270	-	43.0		-2.3	7	0.0	1.92	0	720	7	13	
Eagle Island Park	13206274	-	42.4		-0.257	7	0.0	1.92	0	721	7.	13	
Aiken, Thomas	13206290	-	41.8		-2.733	7	-0.1	1.92	0	720	7	13	
Mace-Catlin	13206292	-	41.2		-6.317	7	-0.1	1.92	0	716	7	13	
Mace & Mace	13206295	-	41.1		0	7	0.0	1.92	0	718	7	13	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.92	0	740	7	14	
Wroten, Jon Pump	13206308	-	40.8		-0.8	7	0.0	17.54	0	757	7	14	
Eagle Drain @ Eagle	13206400	+	40.7		27.5	32	2.4	17.54	0	802	7	16	0.0
Hart-Davis	13208450	-	40.5		-7.217	7	-0.1	4.91	0	799	7	16	
Middleton Irrigation	13208710	-	40.4		-111.237	7	-2.2	4.91	0	693	7	14	
Barber Pumps	13208738	-	40.4		-0.413	7	0.0	4.91	0	698	7	14	
Seven Suckers	13208740	-	40.4		-1.2	7	0.0	4.91	0	701	7	14	
Thurman Drain	13209450	+	40.0		22.167	12	0.7	4.91	0	728	7	14	0.0
Phyliss	13209480	-	39.2		-357.85	7	-7.0	21.24	0	392	7	7	
Eureka #1	82	-			-29	7	-0.5	21.24	0	384	6	7	
Little Pioneer	13209630	-	38.0		-24.543	6	-0.4	21.24	0	381	6	6	
Canyon County	13209990	-	32.9		-57.723	6	-1.0	21.24	0	344	6	5	
Caldwell High Line	13210005	-	32.4		-43.88	6	-0.7	21.24	0	322	5	5	
BR At Middleton	50	n/a	31.2		382	7	7.2	21	0	343	5	5	0.0
				Difference:	40	24	3		Reset:	382	7	7	
Fifteen Mile Drain	13210810	+	27.9		146.55	92	36.5	11.06	0	540	30	44	0.0
Star Feeder*	13210826	+	26.4		59.027	47	7.4	7.14	0	606	31	51	0.0
Long Feeder*	13210828	+	26.4		11.933	47	1.5	7.14	0	625	31	53	0.0
Watts Creek*	13210829	+	26.4		19.1	47	2.4	7.14	0	652	31	55	0.0
Mill Slough	24	+	24.8		147.873	33	13.2	7.14	0	807	31	68	0.0
Willow Creek @ Middleton	13210835	+	24.6		23.833	52	3.3	1.84	0	832	32	72	0.0
Mason Slough	13210849	+	23.2		16.75	96	4.3	12.91	0	862	33	76	0.0
Mason Creek	13210980	+	22.5		144.833	113	44.2	6.45	0	1013	44	120	0.0
Riverside	13210984	-	22.6		-259.967	44	-30.8	1.38	0	755	44	89	
Hartley (combined)	87	+	22.2		81.223	57	12.5	1.38	0	837	45	102	0.0
Sebree	13210992	-	21.9		-230.803	45	-28.1	3.84	0	610	45	74	
Campbell	13210993	-	21.9		-22.1	45	-2.7	3.84	0	592	45	71	
Siebenberg	13210994	-	21.0		-6.283	45	-0.8	3.84	0	590	44	70	
Shipley Pumps	13211001	-	20.8		-0.6	44	-0.1	3.84	0	593	44	70	
Wagner Pumps	13211003	-	20.4		-0.4	44	0.0	3.84	0	596	44	70	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	3.84	0	607	43	70	
Indian Creek	13211445	+	18.8		40.657	40	4.4	8.30	0	656	42	75	0.0
Simplot Pumps	13211603	-	17.9		-0.6	42	-0.1	8.69	0	665	42	75	
Eureka No.2	13211725	-	17.6		-103.743	42	-11.7	8.69	0	569	41	63	
Upper Center Point	13211735	-	17.6		-22.477	41	-2.5	8.69	0	556	40	61	
McManus-Teater	13211745	-	17.6		-2.733	40	-0.3	8.69	0	562	40	60	
Lower Center Point	13211825	-	13.2		-27.38	40	-2.9	8.69	0	543	39	57	
Bowman & Swisher	13212548	-	14.1		-16.673	39	-1.8	8.69	0	535	39	56	
Conway Gulch @ Notus	13212550	+	12.2		65.057	139	24.4	8.69	0	609	49	80	0.0
Baxter	13212645	-	10.4		-14.933	49	-2.0	8.91	0	603	48	78	
Andrews Ditch	13212832	-	9.4		-16.207	48	-2.1	8.91	0	595	47	76	
Dixie Drain Near Wilder	90	+	9.3		242.307	51	33.4	8.91	0	847	46	109	0.0
Mammon Pumps	13212896	-	8.0		-4.743	48	-0.6	7.64	0	850	47	109	
Hass	13212938	-	7.5		-7.373	47	-0.9	7.64	0	850	47	108	
Parma Ditch	13212954	-	6.5		-21.677	47	-2.7	7.64	0	836	47	105	
Island High Line	13212966	-	4.3		-42.427	47	-5.3	7.64	0	801	46	100	
Crawforth Pumps	13212992	-	4.1		-0.653	46	-0.1	7.64	0	808	46	100	
McConnel Island	13212994	-	3.5		-38.107	46	-4.7	7.64	0	777	45	95	
BR Near Parma	13213000	n/a	3.5		968	52	135.8	8	0	785	45	95	0.0
				Difference:	183	83	41		Measured:	968	52	136	

Notes:

* Surragate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data available for USGS station Boise River Below Diversion Dam.

Eagle Drain @ Eagle	13206400	32
Thurman Drain	13209450	12
Mason Slough	13210849	96
	average	47

1996 Irrigation Flow Season - Existing Conditions with No Reductions

30-day Avg. Minimum at Parma (start date 6/28/96)
To input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	2	(1 = HF; 2 = IF; 3 = LF)	Irrigation Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	2	(1 = HF; 2 = IF; 3 = LF, 4=All)	Irrigation Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 50mg/L
Glenwood U.S.		-7	
Glenwood Control pt.		23	83
Middleton U.S.		9	
Middleton Control pt.		10	40
Parma U.S.		111	
Parm Control Pt.		146	140

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	3	0.0	0	0	0	3	0	0.0
Ridenbaugh	13203760	-	58.3		-497.6	3	-4.0	4	0	-494	3	-4	
Bubb	13204005	-	57.5		-7.5	3	-0.1	4	0	-498	3	-4	
Meeves	13204020	-	56.8		-0.6	3	0.0	4	0	-495	3	-4	
Rossi Mill	13204060	-	56.4		-6.2	3	-0.1	4	0	-497	3	-4	
River Run	13204070	-	56.1		-18.0	3	-0.1	4	0	-511	3	-4	
Boise City	13204190	-	56.0		-27.7	3	-0.2	4	0	-535	3	-5	
Boise Water Corp.	200	-	55.9		-7.3	3	-0.1	4	0	-539	3	-5	
Settlers	13205515	-	52.0		-170.7	3	-1.5	4	0	-706	3	-6	
Davis	13205517	-	52.0		-7.3	3	-0.1	4	0	-710	3	-6	
Boise City Parks	13205613	-	51.5		-0.2	3	0.0	4	0	-706	3	-6	
Drainage District #3*	13205617	+	51.0		6.2	47	0.8	4	0	-696	3	-5	0.0
Thurman Mill	13205622	-	51.0		-29.4	3	-0.2	4	0	-722	3	-6	
Farmers Union	13205640	-	50.4		-191.6	3	-1.5	4	0	-910	3	-7	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	4	0	-893	3	-7	
BR At Glenwood Bridge	13206000	n/a	47.4		1239	7	23.4	11	0	-881	3	-7	0.0
				Difference:	2121	5	30		Reset:	1239	7	23	
Boise Valley	41	-			-46	7	-0.9	1.92	0	1195	7	23	
Capitol View	43	-			-7	7	-0.1	1.92	0	1190	7	22	
New Dry Creek	13206090	-	46.0		-46.603	7	-0.9	1.92	0	1145	7	22	
New Union	92	-			-9	7	-0.2	1.92	0	1138	7	21	
Lemp Ditch	13206205	-	45.4		-3	7	-0.1	1.92	0	1137	7	21	
Warm Springs Ditch	13206220	-	44.8		-4	7	-0.1	1.92	0	1135	7	21	
Graham-Gilbert	13206260	-	44.2		-1	7	0.0	1.92	0	1136	7	21	
Ballentyne	13206265	-	43.6		-16.933	7	-0.3	1.92	0	1121	7	21	
Conway-Hamming	13206270	-	43.0		-3	7	-0.1	1.92	0	1120	7	21	
Eagle Island Park	13206274	-	42.4		-0.283	7	0.0	1.92	0	1121	7	21	
Aiken, Thomas	13206290	-	41.8		-3.767	7	-0.1	1.92	0	1120	7	21	
Mace-Catlin	13206292	-	41.2		-6.94	7	-0.1	1.92	0	1115	7	21	
Mace & Mace	13206295	-	41.1		0	7	0.0	1.92	0	1117	7	21	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.92	0	1138	7	21	
Wroten, Jon Pump	13206308	-	40.8		-1	7	0.0	17.54	0	1155	7	21	
Eagle Drain @ Eagle	13206400	+	40.7		34.073	32	3.0	17.54	0	1207	7	24	0.0
Hart-Davis	13208450	-	40.5		-8.933	7	-0.2	4.91	0	1203	7	24	
Middleton Irrigation	13208710	-	40.4		-158.637	7	-3.1	4.91	0	1049	7	21	
Barber Pumps	13208738	-	40.4		-0.517	7	0.0	4.91	0	1053	7	21	
Seven Suckers	13208740	-	40.4		-1.2	7	0.0	4.91	0	1057	7	21	
Thurman Drain	13209450	+	40.0		21.393	12	0.7	4.91	0	1083	7	21	0.0
Phyliss	13209480	-	39.2		-455.833	7	-9.0	21.24	0	649	7	12	
Eureka #1	82	-			-29	7	-0.6	21.24	0	641	7	12	
Little Pioneer	13209630	-	38.0		-25.887	7	-0.5	21.24	0	636	7	11	
Canyon County	13209990	-	32.9		-74.93	7	-1.3	21.24	0	583	6	10	
Caldwell High Line	13210005	-	32.4		-57.517	6	-1.0	21.24	0	546	6	9	
BR At Middleton	50	n/a	31.2		545	7	10.3	21	0	568	6	9	0.0
				Difference:	-22	-21	1		Reset:	545	7	10	
Fifteen Mile Drain	13210810	+	27.9		154.923	92	38.6	11.06	0	711	25	49	0.0
Star Feeder*	13210826	+	26.4		62.737	47	7.9	7.14	0	781	27	57	0.0
Long Feeder*	13210828	+	26.4		10.477	47	1.3	7.14	0	799	27	58	0.0
Watts Creek*	13210829	+	26.4		21.78	47	2.7	7.14	0	828	27	61	0.0
Mill Slough	24	+	24.8		201.797	33	18.0	7.14	0	1037	28	79	0.0
Willow Creek @ Middleton	13210835	+	24.6		23.167	52	3.2	1.84	0	1062	29	82	0.0
Mason Slough	13210849	+	23.2		29.371	96	7.6	12.91	0	1104	30	90	0.0
Mason Creek	13210980	+	22.5		160.343	113	49.0	6.45	0	1271	40	139	0.0
Riverside	13210984	-	22.6		-239.95	40	-26.2	1.36	0	1032	40	112	
Hartley (combined)	87	+	22.2		91.693	57	14.1	1.38	0	1125	42	127	0.0
Sebree	13210992	-	21.9		-272.85	42	-30.7	3.84	0	856	42	96	
Campbell	13210993	-	21.9		-25.793	42	-2.9	3.84	0	834	41	93	
Siebenberg	13210994	-	21.0		-10.307	41	-1.1	3.84	0	828	41	92	
Shipley Pumps	13211001	-	20.8		-0.2	41	0.0	3.84	0	831	41	92	
Wagner Pumps	13211003	-	20.4		-0.4	41	0.0	3.84	0	835	41	92	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	3.84	0	846	40	92	
Indian Creek	13211445	+	18.8		48.37	40	5.2	8.30	0	903	40	97	0.0
Simplot Pumps	13211603	-	17.9		-0.6	40	-0.1	8.69	0	911	40	97	
Eureka No.2	13211725	-	17.6		-112.063	40	-12.0	8.69	0	808	39	85	
Upper Center Point	13211735	-	17.6		-25.523	39	-2.7	8.69	0	791	39	83	
McManus-Teater	13211745	-	17.6		-3	39	-0.3	8.69	0	796	38	82	
Lower Center Point	13211825	-	13.2		-33.467	38	-3.5	8.69	0	772	38	79	
Bowman & Swisher	13212548	-	14.1		-14.83	38	-1.5	8.69	0	765	37	77	
Conway Gulch @ Notus	13212550	+	12.2		66.52	139	25.0	8.69	0	841	45	102	0.0
Baxter	13212645	-	10.4		-11.277	45	-1.4	8.91	0	838	45	101	
Andrews Ditch	13212832	-	9.4		-16.663	45	-2.0	8.91	0	831	44	99	
Dixie Drain Near Wilder	90	+	9.3		205.12	51	28.2	8.91	0	1045	45	127	0.0
Mammon Pumps	13212896	-	8.0		-7	45	-0.9	7.64	0	1045	45	126	
Hass	13212938	-	7.5		-8.227	45	-1.0	7.64	0	1045	44	125	
Parma Ditch	13212954	-	6.5		-28.123	44	-3.4	7.64	0	1024	44	122	
Island High Line	13212966	-	4.3		-39.857	44	-4.7	7.64	0	992	44	117	
Crawforth Pumps	13212992	-	4.1		-0.783	44	-0.1	7.64	0	999	43	117	
McConnel Island	13212994	-	3.5		-47.177	43	-5.5	7.64	0	959	43	111	
BR Near Parma	13213000	n/a	3.5		1038	52	145.5	8	0	967	43	111	0.0
				Difference:	71	178	34		Measured:	1038	52	146	

Notes:

* Surragate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data for USGS station Boise River Below Diversion Dam.

Eagle Drain @ Eagle	13206400	32
Thurman Drain	13209450	12
Mason Slough	13210849	96
	average	47

Appendix E

Irrigation Flow Season Mass Balances—Existing Conditions Based on the Critical 7-Day (Acute) Flow Period at Parma for: 1992, 1995, and 1996

1992 Irrigation Flow Season - Existing Conditions with No Reductions

7-day Avg. Minimum at Parma (start date 8/29/92)
Acute TSS Target Concentration of 80 mg/L.

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	2	(1 = HF; 2 = IF; 3 = LF)	Irrigation Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	2	(1 = HF; 2 = IF; 3 = LF, 4=All)	Irrigation Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 80mg/L
Glenwood U.S.		3	
Glenwood Control pt.		6	[illegible]
Middleton U.S.		1	
Middleton Control pt.		3	[illegible]
Parma U.S.		18	
Parm Control Pt.		16	[illegible]

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam	13203510	n/a	61.2		444	3	3.6	0	0	444	3	4	0.0
Ridenbaugh	13203760	-	58.3		0.0	3	0.0	4	0	447	3	4	
Bubb	13204005	-	57.5		-3.0	3	0.0	4	0	448	3	4	
Meeves	13204020	-	56.8		-0.5	3	0.0	4	0	451	3	4	
Rossi Mill	13204060	-	56.4		-6.0	3	0.0	4	0	449	3	4	
River Run	13204070	-	56.1		-18.0	3	-0.1	4	0	435	3	3	
Boise City	13204190	-	56.0		0.0	3	0.0	4	0	436	3	3	
Boise Water Corp.	200	-	55.9		-2.0	3	0.0	4	0	440	3	3	
Settlers	13205515	-	52.0		0.0	3	0.0	4	0	444	3	3	
Davis	13205517	-	52.0		-1.4	3	0.0	4	0	446	3	3	
Boise City Parks	13205613	-	51.5		-0.2	3	0.0	4	0	449	3	3	
Drainage District #3*	13205617	+	51.0		4.0	47	0.5	4	0	457	3	4	0.0
Thurman Mill	13205622	-	51.0		-19.9	3	-0.2	4	0	441	3	4	
Farmers Union	13205640	-	50.4		-100.6	3	-0.8	4	0	344	3	3	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	4	0	361	3	3	
BR At Glenwood Bridge	13206000	n/a	47.4		306	7	5.8	11	0	372	3	3	0.0
				Difference:	-68	14	3		Reset:	306	7	6	
Boise Valley	41	-			-46	7	-0.9	1.92	0	262	7	5	
Capitol View	43	-			-7	7	-0.1	1.92	0	257	7	5	
New Dry Creek	13206090	-	46.0		-31.5	7	-0.6	1.92	0	227	7	4	
New Union	92	-			-9	7	-0.2	1.92	0	220	7	4	
Lemp Ditch	13206205	-	45.4		-2.571	7	0.0	1.92	0	220	7	4	
Warm Springs Ditch	13206220	-	44.8		-3.071	7	-0.1	1.92	0	218	7	4	
Graham-Gilbert	13206260	-	44.2		0	7	0.0	1.92	0	220	7	4	
Ballentyne	13206265	-	43.6		-10.214	7	-0.2	1.92	0	212	7	4	
Conway-Hamming	13206270	-	43.0		-0.214	7	0.0	1.92	0	214	6	4	
Eagle Island Park	13206274	-	42.4		-0.257	6	0.0	1.92	0	215	6	4	
Aiken, Thomas	13206290	-	41.8		-2.571	6	0.0	1.92	0	215	6	4	
Mace-Catlin	13206292	-	41.2		-6.071	6	-0.1	1.92	0	211	6	4	
Mace & Mace	13206295	-	41.1		0	6	0.0	1.92	0	213	6	4	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.92	0	234	6	4	
Wroten, Jon Pump	13206308	-	40.8		0	6	0.0	17.54	0	252	6	4	
Eagle Drain @ Eagle	13206400	+	40.7		22.143	32	1.9	17.54	0	292	8	6	0.0
Hart-Davis	13208450	-	40.5		-8	8	-0.2	4.91	0	289	7	6	
Middleton Irrigation	13208710	-	40.4		-87.429	7	-1.8	4.91	0	206	7	4	
Barber Pumps	13208738	-	40.4		-0.5	7	0.0	4.91	0	210	7	4	
Seven Suckers	13208740	-	40.4		-1.2	7	0.0	4.91	0	214	7	4	
Thurman Drain	13209450	+	40.0		18	12	0.6	4.91	0	237	7	5	0.0
Phyliss	13209480	-	39.2		-88.714	7	-1.7	21.24	0	170	6	3	
Eureka #1	82	-			-29	6	-0.5	21.24	0	162	5	2	
Little Pioneer	13209630	-	38.0		-19	5	-0.3	21.24	0	164	5	2	
Canyon County	13209990	-	32.9		-51.429	5	-0.7	21.24	0	134	4	1	
Caldwell High Line	13210005	-	32.4		-20.286	4	-0.2	21.24	0	135	3	1	
BR At Middleton	50	n/a	31.2		149	7	2.8	21	0	156	3	1	0.0
				Difference:	-8	-78	2		Reset:	149	7	3	
Fifteen Mile Drain	13210810	+	27.9		8.643	92	2.2	11.06	0	168	11	5	0.0
Star Feeder*	13210826	+	26.4		49.286	47	6.2	7.14	0	225	18	11	0.0
Long Feeder*	13210828	+	26.4		6	47	0.8	7.14	0	238	19	12	0.0
Watts Creek*	13210829	+	26.4		7	47	0.9	7.14	0	252	19	13	0.0
Mill Slough	24	+	24.8		93	33	8.3	7.14	0	352	22	21	0.0
Willow Creek @ Middleton	13210835	+	24.6		3	52	0.4	1.84	0	357	22	21	0.0
Mason Slough	13210849	+	23.2		10.214	96	2.6	12.91	0	380	24	24	0.0
Mason Creek	13210980	+	22.5		45.786	113	14.0	6.45	0	432	33	36	0.0
Riverside	13210984	-	22.6		-186.714	33	-16.5	1.38	0	247	33	22	
Hartley (combined)	87	+	22.2		55.571	57	8.6	1.38	0	304	37	30	0.0
Sebree	13210992	-	21.9		-201	37	-20.0	3.84	0	107	36	10	
Campbell	13210993	-	21.9		-23.429	36	-2.2	3.84	0	87	34	8	
Siebenberg	13210994	-	21.0		-6.786	34	-0.8	3.84	0	82	32	7	
Shipley Pumps	13211001	-	20.8		-0.2	32	0.0	3.84	0	86	31	7	
Wagner Pumps	13211003	-	20.4		-0.4	31	0.0	3.84	0	89	30	7	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	3.84	0	101	27	7	
Indian Creek	13211445	+	18.8		2.143	40	0.2	8.30	0	111	25	8	0.0
Simplot Pumps	13211603	-	17.9		-0.6	25	0.0	8.69	0	119	24	8	
Eureka No.2	13211725	-	17.6		-42.571	24	-2.8	8.69	0	84	21	5	
Upper Center Point	13211735	-	17.6		-13.543	21	-0.8	8.69	0	79	19	4	
McManus-Teater	13211745	-	17.6		-2.214	19	-0.1	8.69	0	86	17	4	
Lower Center Point	13211825	-	13.2		-13.943	17	-0.6	8.69	0	81	15	3	
Bowman & Swisher	13212548	-	14.1		-9.471	15	-0.4	8.69	0	80	13	3	
Conway Gulch @ Notus	13212550	+	12.2		23.629	139	8.9	8.69	0	112	39	12	0.0
Baxter	13212645	-	10.4		-7.471	39	-0.8	8.91	0	114	36	11	
Andrews Ditch	13212832	-	9.4		-6.957	36	-0.7	8.91	0	116	33	10	
Dixie Drain Near Wilder	90	+	9.3		101.886	51	14.0	8.91	0	226	40	24	0.0
Mammon Pumps	13212896	-	8.0		-7	40	-0.8	7.64	0	227	39	24	
Hass	13212938	-	7.5		-5.757	39	-0.6	7.64	0	229	37	23	
Parma Ditch	13212954	-	6.5		-16.043	37	-1.6	7.64	0	220	36	21	
Island High Line	13212965	-	4.3		-20.314	36	-2.0	7.64	0	208	35	19	
Crawforth Pumps	13212992	-	4.1		-0.8	35	-0.1	7.64	0	215	33	19	
McConnel Island	13212994	-	3.5		-19.029	33	-1.7	7.64	0	203	32	18	
BR Near Parma	13213000	n/a	3.5		113	52	15.9	8	0	211	31	18	0.0
				Difference:	-97	7	-2		Measured:	113	52	16	

Notes:

* Surrogate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.

Eagle Drain @ Eagle	13206400	32
Thurman Drain	13209450	12
Mason Slough	13210849	96
	average	47

1995 Irrigation Flow Season - Existing Conditions with No Reductions

7-day Avg. Minimum at Parma (start date 8/22/95)
Acute TSS Target Concentration of 80 mg/L.

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	2	(1 = HF; 2 = IF; 3 = LF)	Irrigation Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	2	(1 = HF; 2 = IF; 3 = LF, 4=All)	Irrigation Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 80mg/L
Glenwood U.S.		-6	
Glenwood Control pt.		16	[illegible]
Middleton U.S.		4	
Middleton Control pt.		7	[illegible]
Parma U.S.		75	
Parm Control Pt.		119	[illegible]

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	3	0.0	0	0	0	3	0	0.0
Ridenbaugh	13203760	-	58.3		-452.0	3	-3.7	4	0	-448	3	-4	
Bubb	13204005	-	57.5		-7.5	3	-0.1	4	0	-452	3	-4	
Meeves	13204020	-	56.8		-0.5	3	0.0	4	0	-449	3	-4	
Rossi Mill	13204060	-	56.4		-6.0	3	0.0	4	0	-451	3	-4	
River Run	13204070	-	56.1		-18.0	3	-0.2	4	0	-466	3	-4	
Boise City	13204190	-	56.0		-26.5	3	-0.2	4	0	-488	3	-4	
Boise Water Corp.	200	-	55.9		-4.6	3	0.0	4	0	-489	3	-4	
Settlers	13205515	-	52.0		-156.0	3	-1.3	4	0	-642	3	-6	
Davis	13205517	-	52.0		-7.0	3	-0.1	4	0	-645	3	-6	
Boise City Parks	13205613	-	51.5		-0.2	3	0.0	4	0	-641	3	-6	
Drainage District #3*	13205617	+	51.0		6.0	47	0.8	4	0	-632	3	-5	0.0
Thurman Mill	13205622	-	51.0		-23.5	3	-0.2	4	0	-652	3	-5	
Farmers Union	13205640	-	50.4		-180.8	3	-1.4	4	0	-829	3	-6	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	4	0	-812	3	-6	
BR At Glenwood Bridge	13206000	n/a	47.4		843	7	15.9	11	0	-800	3	-6	0.0
				Difference:	1643	5	22		Reset:	843	7	16	
Boise Valley	41	-			-46	7	-0.9	1.92	0	799	7	15	
Capitol View	43	-			-7	7	-0.1	1.92	0	794	7	15	
New Dry Creek	13206090	-	46.0		-43	7	-0.8	1.92	0	753	7	14	
New Union	92	-			-9	7	-0.2	1.92	0	746	7	14	
Lemp Ditch	13206205	-	45.4		-3	7	-0.1	1.92	0	745	7	14	
Warm Springs Ditch	13206220	-	44.8		-4	7	-0.1	1.92	0	743	7	14	
Graham-Gilbert	13206260	-	44.2		-1	7	0.0	1.92	0	743	7	14	
Ballentyne	13206265	-	43.6		-12	7	-0.2	1.92	0	733	7	14	
Conway-Hamming	13206270	-	43.0		-3	7	-0.1	1.92	0	732	7	14	
Eagle Island Park	13206274	-	42.4		-0.2	7	0.0	1.92	0	734	7	14	
Aiken, Thomas	13206290	-	41.8		-4	7	-0.1	1.92	0	732	7	13	
Mace-Catlin	13206292	-	41.2		-6.5	7	-0.1	1.92	0	727	7	13	
Mace & Mace	13206295	-	41.1		0	7	0.0	1.92	0	729	7	13	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.92	0	751	7	14	
Wroten, Jon Pump	13206308	-	40.8		-1	7	0.0	17.54	0	768	7	14	
Eagle Drain @ Eagle	13206400	+	40.7		23.5	32	2.0	17.54	0	809	7	16	0.0
Hart-Davis	13208450	-	40.5		-7.5	7	-0.1	4.91	0	806	7	16	
Middleton Irrigation	13208710	-	40.4		-116.143	7	-2.3	4.91	0	695	7	13	
Barber Pumps	13208738	-	40.4		-0.5	7	0.0	4.91	0	699	7	13	
Seven Suckers	13208740	-	40.4		-1.2	7	0.0	4.91	0	703	7	13	
Thurman Drain	13209450	+	40.0		19.5	12	0.6	4.91	0	727	7	14	0.0
Phyliss	13209480	-	39.2		-397.714	7	-7.7	21.24	0	351	7	6	
Eureka #1	82	-			-29	7	-0.5	21.24	0	343	6	6	
Little Pioneer	13209630	-	38.0		-24.643	6	-0.4	21.24	0	340	6	5	
Canyon County	13209990	-	32.9		-59.357	6	-0.9	21.24	0	302	5	4	
Caldwell High Line	13210005	-	32.4		-47.286	5	-0.7	21.24	0	276	5	4	
BR At Middleton	50	n/a	31.2		353	7	6.7	21	0	297	5	4	0.0
				Difference:	56	19	3		Reset:	353	7	7	
Fifteen Mile Drain	13210810	+	27.9		132.429	92	33.0	11.06	0	497	30	40	0.0
Star Feeder*	13210826	+	26.4		56.786	47	7.1	7.14	0	561	31	47	0.0
Long Feeder*	13210828	+	26.4		12	47	1.5	7.14	0	580	31	48	0.0
Watts Creek*	13210829	+	26.4		20	47	2.5	7.14	0	607	31	51	0.0
Mill Slough	24	+	24.8		132.571	33	11.8	7.14	0	747	31	63	0.0
Willow Creek @ Middleton	13210835	+	24.6		15.857	52	2.2	1.84	0	764	31	65	0.0
Mason Slough	13210849	+	23.2		16	96	4.1	12.91	0	793	32	69	0.0
Mason Creek	13210980	+	22.5		143.929	113	44.0	6.45	0	944	44	113	0.0
Riverside	13210984	-	22.6		-255.429	44	-30.6	1.38	0	690	44	82	
Hartley (combined)	67	+	22.2		74.857	57	11.5	1.38	0	766	45	94	0.0
Sebree	13210992	-	21.9		-262.143	45	-32.1	3.84	0	508	45	62	
Campbell	13210993	-	21.9		-23.214	45	-2.8	3.84	0	488	45	59	
Siebenberg	13210994	-	21.0		-6.529	45	-0.8	3.84	0	486	44	58	
Shipley Pumps	13211001	-	20.8		-0.6	44	-0.1	3.84	0	489	44	58	
Wagner Pumps	13211003	-	20.4		-0.4	44	0.0	3.84	0	492	44	58	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	3.84	0	503	43	58	
Indian Creek	13211445	+	18.8		27.5	40	3.0	8.30	0	539	42	61	0.0
Simplot Pumps	13211603	-	17.9		-0.6	42	-0.1	8.69	0	547	41	61	
Eureka No.2	13211725	-	17.6		-107.514	41	-12.0	8.69	0	449	41	49	
Upper Center Point	13211735	-	17.6		-24.186	41	-2.7	8.69	0	433	40	46	
McManus-Teater	13211745	-	17.6		-2.929	40	-0.3	8.69	0	439	39	46	
Lower Center Point	13211825	-	13.2		-29.186	39	-3.1	8.69	0	418	38	43	
Bowman & Swisher	13212548	-	14.1		-17.714	38	-1.8	8.69	0	409	37	41	
Conway Gulch @ Notus	13212550	+	12.2		60.956	139	22.9	8.69	0	479	50	64	0.0
Baxter	13212645	-	10.4		-15.471	50	-2.1	8.91	0	472	49	62	
Andrews Ditch	13212832	-	9.4		-17.771	49	-2.3	8.91	0	464	48	60	
Dixie Drain Near Wilder	90	+	9.3		211.7	51	29.1	8.91	0	684	48	89	0.0
Mammon Pumps	13212896	-	8.0		-6.829	48	-0.9	7.64	0	685	48	86	
Hass	13212938	-	7.5		-7.486	48	-1.0	7.64	0	685	47	87	
Parma Ditch	13212954	-	6.5		-21.243	47	-2.7	7.64	0	672	47	84	
Island High Line	13212966	-	4.3		-43.429	47	-5.5	7.64	0	636	46	79	
Crawforth Pumps	13212992	-	4.1		-0.6	46	-0.1	7.64	0	643	45	79	
McConnel Island	13212994	-	3.5		-34.529	45	-4.2	7.64	0	616	45	75	
BR Near Parma	13213000	n/a	3.5		852	52	119.5	8	0	624	44	75	0.0
				Difference:	229	73	45		Measured:	852	52	119	

Notes:

* Surrogate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data available for USGS station Boise River Below Diversion Dam.

Eagle Drain @ Eagle	13206400	32
Thurman Drain	13209450	12
Mason Slough	13210849	96
	average	47

1996 Irrigation Flow Season - Existing Conditions with No Reductions

7-day Avg. Minimum at Parma (start date 6/29/96)
Acute TSS Target Concentration of 80 mg/L.

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	2	(1 = HF; 2 = IF; 3 = LF)	Irrigation Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	2	(1 = HF; 2 = IF; 3 = LF, 4=All)	Irrigation Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reduction	Tons/day with 9999999.0 mg/L	Load Cap. at 80mg/L
Glenwood U.S.		-7	
Glenwood Control pt.		19	[redacted]
Middleton U.S.		5	
Middleton Control pt.		6	[redacted]
Parma U.S.		90	
Parm Control Pt.		111	[redacted]

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam**	13203510	n/a	61.2		0	3	0.0	0	0	0	3	0	0.0
Ridenbaugh	13203760	-	58.3		-495.7	3	-4.0	4	0	-492	3	-4	
Bubb	13204005	-	57.5		-7.5	3	-0.1	4	0	-496	3	-4	
Meeves	13204020	-	56.8		-0.9	3	0.0	4	0	-493	3	-4	
Rossi Mill	13204060	-	56.4		-6.8	3	-0.1	4	0	-496	3	-4	
River Run	13204070	-	56.1		-18.0	3	-0.2	4	0	-510	3	-4	
Boise City	13204190	-	56.0		-30.3	3	-0.3	4	0	-537	3	-5	
Boise Water Corp.	200	-	55.9		-6.8	3	-0.1	4	0	-540	3	-5	
Settlers	13205515	-	52.0		-169.0	3	-1.4	4	0	-706	3	-6	
Davis	13205517	-	52.0		-7.9	3	-0.1	4	0	-710	3	-6	
Boise City Parks	13205613	-	51.5		-0.2	3	0.0	4	0	-706	3	-6	
Drainage District #3*	13205617	+	51.0		6.7	47	0.8	4	0	-696	3	-5	0.0
Thurman Mill	13205622	-	51.0		-30.2	3	-0.2	4	0	-722	3	-5	
Farmers Union	13205640	-	50.4		-200.6	3	-1.5	4	0	-919	3	-7	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	4	0	-902	3	-7	
BR At Glenwood Bridge	13206000	n/a	47.4		1010	7	19.1	11	0	-891	3	-7	0.0
				Difference:	1900	5	26		Reset:	1010	7	19	
Boise Valley	41	-			-46	7	-0.9	1.92	0	965	7	18	
Capitol View	43	-			-7	7	-0.1	1.92	0	960	7	18	
New Dry Creek	13206090	-	46.0		-43.614	7	-0.8	1.92	0	919	7	17	
New Union	92	-			-9	7	-0.2	1.92	0	912	7	17	
Lemp Ditch	13206205	-	45.4		-3	7	-0.1	1.92	0	911	7	17	
Warm Springs Ditch	13206220	-	44.8		-4	7	-0.1	1.92	0	908	7	17	
Graham-Gilbert	13206260	-	44.2		-1	7	0.0	1.92	0	909	7	17	
Balientyne	13206265	-	43.6		-18	7	-0.3	1.92	0	893	7	17	
Conway-Hamming	13206270	-	43.0		-3	7	-0.1	1.92	0	892	7	17	
Eagle Island Park	13206274	-	42.4		-0.3	7	0.0	1.92	0	894	7	17	
Aiken, Thomas	13206290	-	41.8		-4	7	-0.1	1.92	0	892	7	16	
Mace-Catlin	13206292	-	41.2		-7.657	7	-0.1	1.92	0	886	7	16	
Mace & Mace	13206295	-	41.1		0	7	0.0	1.92	0	888	7	16	
West Boise WWTF	2	+	40.9		19.998	9	0.5	1.92	0	910	7	17	
Wroten, Jon Pump	13206308	-	40.8		-1	7	0.0	17.54	0	926	7	17	
Eagle Drain @ Eagle	13206400	+	40.7		39.786	32	3.5	17.54	0	984	8	20	0.0
Hart-Davis	13208450	-	40.5		-9	8	-0.2	4.91	0	980	8	20	
Middleton Irrigation	13208710	-	40.4		-157.1	8	-3.2	4.91	0	827	8	17	
Barber Pumps	13208738	-	40.4		-0.5	8	0.0	4.91	0	832	7	17	
Seven Suckers	13208740	-	40.4		-1.2	7	0.0	4.91	0	836	7	17	
Thurman Drain	13209450	+	40.0		23.257	12	0.7	4.91	0	864	8	18	0.0
Phyliss	13209480	-	39.2		-463.243	8	-9.4	21.24	0	422	7	8	
Eureka #1	82	-			-29	7	-0.6	21.24	0	414	7	8	
Little Pioneer	13209630	-	38.0		-26.743	7	-0.5	21.24	0	409	6	7	
Canyon County	13209990	-	32.9		-74.329	6	-1.3	21.24	0	355	6	6	
Caldwell High Line	13210005	-	32.4		-43.214	6	-0.7	21.24	0	333	6	5	
BR At Middleton	50	n/a	31.2		334	7	6.3	21	0	355	5	5	0.0
				Difference:	20	22	1		Reset:	334	7	6	
Fifteen Mile Drain	13210810	+	27.9		153.514	92	38.2	11.06	0	499	33	45	0.0
Star Feeder*	13210826	+	26.4		60.6	47	7.6	7.14	0	567	34	52	0.0
Long Feeder*	13210828	+	26.4		11.543	47	1.4	7.14	0	585	34	54	0.0
Watts Creek*	13210829	+	26.4		21.114	47	2.6	7.14	0	614	34	58	0.0
Mill Slough	24	+	24.8		193.571	33	17.3	7.14	0	814	33	74	0.0
Willow Creek @ Middleton	13210835	+	24.6		23.514	52	3.3	1.84	0	840	34	77	0.0
Mason Slough	13210849	+	23.2		32.143	96	8.3	12.91	0	885	36	85	0.0
Mason Creek	13210980	+	22.5		168.971	113	51.6	6.45	0	1060	48	137	0.0
Riverside	13210984	-	22.6		-236.657	48	-30.5	1.36	0	825	48	106	
Hartley (combined)	67	+	22.2		92.257	57	14.2	1.36	0	918	49	120	0.0
Sebree	13210992	-	21.9		-290.029	49	-38.0	3.84	0	632	48	82	
Campbell	13210993	-	21.9		-25.3	48	-3.3	3.84	0	611	48	79	
Siebenberg	13210994	-	21.0		-9.971	48	-1.3	3.84	0	605	48	78	
Shipley Pumps	13211001	-	20.8		-0.2	48	0.0	3.84	0	608	47	78	
Wagner Pumps	13211003	-	20.4		-0.4	47	-0.1	3.84	0	612	47	78	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	3.84	0	623	46	78	
Indian Creek	13211445	+	18.8		43.143	40	4.7	8.30	0	674	45	83	0.0
Simplot Pumps	13211603	-	17.9		-0.6	45	-0.1	8.69	0	683	45	83	
Eureka No.2	13211725	-	17.6		-101.857	45	-12.3	8.69	0	589	44	70	
Upper Center Point	13211735	-	17.6		-26.429	44	-3.1	8.69	0	572	44	67	
McManus-Teater	13211745	-	17.6		-3	44	-0.4	8.69	0	577	43	67	
Lower Center Point	13211825	-	13.2		-35.186	43	-4.1	8.69	0	551	42	63	
Bowman & Swisher	13212548	-	14.1		-15.129	42	-1.7	8.69	0	544	42	61	
Conway Gulch @ Notus	13212550	+	12.2		63.014	139	23.7	8.69	0	616	51	85	0.0
Baxter	13212645	-	10.4		-11.757	51	-1.6	8.91	0	613	50	83	
Andrews Ditch	13212632	-	9.4		-16.229	50	-2.2	8.91	0	606	49	81	
Dixie Drain Near Wilder	90	+	9.3		192.129	51	26.5	8.91	0	807	49	107	0.0
Mammon Pumps	13212896	-	8.0		-7	49	-0.9	7.64	0	808	49	106	
Hass	13212938	-	7.5		-9.7	49	-1.3	7.64	0	806	48	105	
Parma Ditch	13212954	-	6.5		-28.186	48	-3.7	7.64	0	785	48	101	
Island High Line	13212966	-	4.3		-42.714	48	-5.5	7.64	0	750	47	96	
Crawforth Pumps	13212992	-	4.1		-0.8	47	-0.1	7.64	0	757	47	95	
McConnel Island	13212994	-	3.5		-45.614	47	-5.8	7.64	0	719	46	90	
BR Near Parma	13213000	n/a	3.5		789	52	110.7	8	0	726	46	90	0.0
				Difference:	63	122	21		Measured:	789	52	111	

Notes:

* Surrogate TSS, average of Thurman Drain, Eagle Drain, Mason Slough.
** No flow data available for USGS station Boise River Below Diversion Dam.

Eagle Drain @ Eagle	13206400	32
Thurman Drain	13209450	12
Mason Slough	13210849	96
	average	47

Appendix F

1992 High Flow Season—Reduced Conditions Based on the Critical 30-Day (Chronic) Flow Period at Parma (Equal Percent Reduction and Equal Concentration Discharge)

1992 High Flow Season - Equal Percent Reduction

30 day Avg. Minimum at Parma (start date 3/24/92)
To input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All)	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reducton	Tons/day 34.0 Percent Red.	Load Cap. at 50mg/L
Glenwood U.S.		7	
Glenwood Control pt.		21	[illegible]
Middleton U.S.		6	
Middleton Control pt.		9	20
Parma U.S.		31	
Parm Control Pt.		36	31

Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	
BR Below Diversion Dam	13203510	n/a	61.2		749	5	10.1	0	0	749	5	10	
Ridenbaugh	13203760	-	58.3		-175.8	5	-2.4	1	0	575	5	8	
Bubb	13204005	-	57.5		0.0	5	0.0	1	0	576	5	8	
Meeves	13204020	-	56.8		-0.2	5	0.0	1	0	577	5	8	
Rossi Mill	13204060	-	56.4		-1.6	5	0.0	1	0	577	5	8	
River Run	13204070	-	56.1		-13.2	5	-0.2	1	0	565	5	8	
Boise City	13204190	-	56.0		-4.2	5	-0.1	1	0	562	5	7	
Boise Water Corp.	200	-	55.9		-1.5	5	0.0	1	0	562	5	7	
Settlers	13205515	-	53.0		-74.7	5	-1.0	1	0	489	5	6	
Davis	13205517	-	52.0		-1.2	5	0.0	1	0	489	5	6	
Boise City Parks	13205613	-	51.5		-0.1	5	0.0	1	0	490	5	6	
Drainage District #3*	13205617	+	51.0		4.9	20	0.3	1	0	497	5	7	34
Thurman Mill	13205622	-	51.0		-5.2	5	-0.1	1	0	493	5	7	
Farmers Union	13205640	-	50.4		-32.1	5	-0.4	1	0	462	5	6	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	1	0	477	5	7	
BR At Glenwood Bridge	13206000	n/a	47.4		475	16.0	20.5	4	0	481	5	7	0
					-5	-957	14		7	475	16	21	
Boise Valley	41	-			-23.4	16	-1.0	0.43	0	452	16	19	
Capitol View	43	-			-3.033	16	-0.1	0.43	0	450	16	19	
New Dry Creek	13206090	-	46.0		-19.793	16	-0.9	0.43	0	430	16	19	
New Union	92	-			-3.9	16	-0.2	0.43	0	427	16	18	
Lemp Ditch	13206205	-	45.4		-1.1	16	0.0	0.43	0	426	16	18	
Warm Springs Ditch	13206220	-	44.8		-2.7	16	-0.1	0.43	0	424	16	18	
Graham-Gilbert	13206260	-	44.2		-0.213	16	0.0	0.43	0	424	16	18	
Ballentyne	13206265	-	43.6		-2.77	16	-0.1	0.43	0	422	16	18	
Conway-Hamming	13206270	-	43.0		-0.6	16	0.0	0.43	0	422	16	18	
Eagle Island Park	13206274	-	42.4		-0.07	16	0.0	0.43	0	422	16	18	
Aiken, Thomas	13206290	-	41.8		-1	16	0.0	0.43	0	421	16	18	
Mace-Catlin	13206292	-	41.2		-2.827	16	-0.1	0.43	0	419	16	18	
Mace & Mace	13206295	-	41.1		0	16	0.0	0.43	0	419	16	18	
West Boise WWTF	2	+	40.9		19.998	9	0.5	0.43	0	440	15	18	
Wroten, Jon Pump	13206308	-	40.8		0	15	0.0	3.91	0	444	15	18	
Eagle Drain @ Eagle	13206400	+	40.7		13.998	18	0.7	3.91	0	462	15	19	34
Hart-Davis	13208450	-	40.5		-5.3	15	-0.2	1.09	0	458	15	19	
Middleton Irrigation	13208710	-	40.4		-66.733	15	-2.7	1.09	0	392	15	16	
Barber Pumps	13208738	-	40.4		-0.023	15	0.0	1.09	0	393	15	16	
Seven Suckers	13208740	-	40.4		-0.44	15	0.0	1.09	0	394	15	16	
Thurman Drain	13209450	+	40.0		12.086	6	0.2	1.09	0	407	15	16	34
Phyliss	13209480	-	39.2		-153.46	15	-6.1	4.74	0	258	15	10	
Eureka #1	82	-			-22	15	-0.9	4.74	0	241	14	9	
Little Pioneer	13209630	-	38.0		-16.23	14	-0.6	4.74	0	229	14	9	
Canyon County	13209990	-	32.9		-43.44	14	-1.6	4.74	0	191	14	7	
Caldwell High Line	13210005	-	32.4		-22.41	14	-0.8	4.74	0	173	13	6	
BR At Middleton	50	n/a	31.2		172	19	8.8	5	0	178	13	6	0
					-6	-176	3			172	19	9	
Fifteen Mile Drain	13210810	+	27.9		45.6	93	11.5	4.76	0	222	34	20	34
Star Feeder*	13210826	+	26.4		33.957	20	1.9	3.07	0	259	32	22	34
Long Feeder*	13210828	+	26.4		8.967	20	0.5	3.07	0	272	31	23	34
Watts Creek*	13210829	+	26.4		5.727	20	0.3	3.07	0	280	30	23	34
Mill Slough	24	+	24.8		96.157	27	7.1	3.07	0	380	29	30	34
Willow Creek @ Middleton	13210835	+	24.6		18.907	49	2.5	0.79	0	399	30	33	34
Mason Slough	13210849	+	23.2		12.763	37	1.3	5.55	0	418	30	34	34
Mason Creek	13210980	+	22.5		61.197	104	17.2	2.77	0	482	39	51	34
Riverside	13210984	-	22.6		-160.6	39	-17.0	0.59	0	322	39	34	
Hartley (combined)	67	+	22.2		41.567	39	4.4	0.59	0	364	39	36	34
Sebree	13210992	-	21.9		-145.67	39	-15.4	1.65	0	220	39	23	
Campbell	13210993	-	21.9		-13.713	39	-1.4	1.65	0	206	39	22	
Siebenberg	13210994	-	21.0		-5.4	39	-0.6	1.65	0	204	38	21	
Shipley Pumps	13211001	-	20.8		-0.2	38	0.0	1.65	0	205	38	21	
Wagner Pumps	13211003	-	20.4		-0.2	38	0.0	1.65	0	207	38	21	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	1.65	0	216	36	21	
Indian Creek	13211445	+	18.8		1	38	0.1	3.57	0	220	36	21	34
Simplot Pumps	13211603	-	17.9		-0.6	36	-0.1	3.74	0	224	35	21	
Eureka No.2	13211725	-	17.6		-71.21	35	-6.8	3.74	0	156	34	14	
Upper Center Point	13211735	-	17.6		-12.713	34	-1.2	3.74	0	147	34	13	
McManus-Teater	13211745	-	17.6		-1.413	34	-0.1	3.74	0	149	33	13	
Lower Center Point	13211825	-	13.2		-12.58	33	-1.2	3.74	0	140	32	12	
Bowman & Swisher	13212548	-	14.1		-8.163	32	-0.7	3.74	0	135	31	11	
Conway Gulch @ Notus	13212550	+	12.2		36.07	79	7.7	3.74	0	175	40	19	34
Baxter	13212645	-	10.4		-5.677	40	-0.6	3.83	0	173	39	18	
Andrews Ditch	13212832	-	9.4		-5.567	39	-0.6	3.83	0	171	38	18	
Dixie Drain Near Wilder	90	+	9.3		99.937	79	21.3	3.83	0	275	53	39	34
Mammon Pumps	13212896	-	8.0		-1.95	53	-0.3	3.28	0	276	52	39	
Hass	13212938	-	7.5		-7.323	52	-1.0	3.28	0	272	51	38	
Parma Ditch	13212954	-	6.5		-14.97	51	-2.1	3.28	0	261	51	36	
Island High Line	13212966	-	4.3		-12.723	51	-1.7	3.28	0	251	50	34	
Crawforth Pumps	13212992	-	4.1		0	50	0.0	3.28	0	255	49	34	
McConnel Island	13212994	-	3.5		-19.43	49	-2.6	3.28	0	238	49	31	
BR Near Parma	13213000	n/a	3.5		233	58	36.4	3	0	242	48	31	0
					-9	-209	5			233	58	36	

Notes:
TSS Concentrations for point source are based on permit limit discharge (single value for all seasons)
* Surragate TSS, Average of (Thurman Drain, Eagle Drain, Mason Slough)

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

1992 High Flow Season - Equal Concentration Discharge

30 day Avg. Minimum at Parma (start date 3/24/92)
To input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
TSS Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	1	(1 = HF; 2 = IF; 3 = LF)	High Flow
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	1	(1 = HF; 2 = IF; 3 = LF, 4=All)	High Flow
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometric Me

	Tons/day No Reduction	Tons/day with 77.0 mg/L	Load Cap. at 50mg/L
Glenwood U.S.		7	
Glenwood Control pt.		21	15
Middleton U.S.		6	
Middleton Control pt.		9	20
Parma U.S.		31	
Parm Control Pt.		36	31

Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	Concentration (mg/L)	Incremental Daily Mass Load (T/day)	Incremental Groundwater Flow (cfs)	Groundwater Concentration (mg/L)	River Flow (cfs)	River Concentration (mg/L)	River Load (T/day)	Percent Reduction
BR Below Diversion Dam	13203510	n/a	61.2		749	5	10.1	0	0	749	5	10	0.0
Ridenhaugh	13203760	-	58.3		-175.8	5	-2.4	1	0	575	5	8	
Bubb	13204005	-	57.5		0.0	5	0.0	1	0	576	5	8	
Meeves	13204020	-	56.8		-0.2	5	0.0	1	0	577	5	8	
Rossi Mill	13204060	-	56.4		-1.6	5	0.0	1	0	577	5	8	
River Run	13204070	-	56.1		-13.2	5	-0.2	1	0	565	5	8	
Boise City	13204190	-	56.0		-4.2	5	-0.1	1	0	562	5	7	
Boise Water Corp.	200	-	55.9		-1.5	5	0.0	1	0	562	5	7	
Settlers	13205515	-	52.0		-74.7	5	-1.0	1	0	489	5	6	
Davis	13205517	-	52.0		-1.2	5	0.0	1	0	489	5	6	
Boise City Parks	13205613	-	51.5		-0.1	5	0.0	1	0	490	5	6	
Drainage District #3*	13205617	+	51.0		4.9	31	0.4	1	0	497	5	7	0.0
Thurman Mill	13205622	-	51.0		-5.2	5	-0.1	1	0	493	5	7	
Farmers Union	13205640	-	50.4		-32.1	5	-0.4	1	0	462	5	6	
Lander Street WWTF	1	+	49.9		13.3	10	0.4	1	0	477	5	7	
BR At Glenwood Bridge	13206000	n/a	47.4		475	16	20.5	4	0	481	5	7	0.0
					-5	-949	14			475	16	21	
Boise Valley	41	-			-23.4	16	-1.0	0.43	0	452	16	19	
Capitol View	43	-			-3.033	16	-0.1	0.43	0	450	16	19	
New Dry Creek	13206090	-	46.0		-19.793	16	-0.9	0.43	0	430	16	19	
New Union	92	-			-3.9	16	-0.2	0.43	0	427	16	18	
Lemp Ditch	13206205	-	45.4		-1.1	16	0.0	0.43	0	426	16	18	
Warm Springs Ditch	13206220	-	44.8		-2.7	16	-0.1	0.43	0	424	16	18	
Graham-Gilbert	13206260	-	44.2		-0.213	16	0.0	0.43	0	424	16	18	
Ballentyne	13206265	-	43.6		-2.77	16	-0.1	0.43	0	422	16	18	
Conway-Hamming	13206270	-	43.0		-0.6	16	0.0	0.43	0	422	16	18	
Eagle Island Park	13206274	-	42.4		-0.07	16	0.0	0.43	0	422	16	18	
Aiken, Thomas	13206290	-	41.8		-1	16	0.0	0.43	0	421	16	18	
Mace-Catlin	13206292	-	41.2		-2.827	16	-0.1	0.43	0	419	16	18	
Mace & Mace	13206295	-	41.1		0	16	0.0	0.43	0	419	16	18	
West Boise WWTF	2	+	40.9		19.998	9	0.5	0.43	0	440	15	18	
Wroten, Jon Pump	13206308	-	40.8		0	15	0.0	3.91	0	444	15	18	
Eagle Drain @ Eagle	13206400	+	40.7		13.998	27	1.0	3.91	0	462	16	19	0.0
Hart-Davis	13208450	-	40.5		-5.3	16	-0.2	1.09	0	458	16	19	
Middleton Irrigation	13208710	-	40.4		-66.733	16	-2.8	1.09	0	392	15	16	
Barber Pumps	13208738	-	40.4		-0.023	15	0.0	1.09	0	393	15	16	
Seven Suckers	13208740	-	40.4		-0.44	15	0.0	1.09	0	394	15	16	
Thurman Drain	13209450	+	40.0		12.086	9	0.3	1.09	0	407	15	17	0.0
Phyliss	13209480	-	39.2		-153.46	15	-6.3	4.74	0	258	15	10	
Eureka #1	82	-			-22	15	-0.9	4.74	0	241	15	9	
Little Pioneer	13209630	-	38.0		-16.23	15	-0.6	4.74	0	229	14	9	
Canyon County	13209990	-	32.9		-43.44	14	-1.7	4.74	0	191	14	7	
Caldwell High Line	13210005	-	32.4		-22.41	14	-0.8	4.74	0	173	14	6	
BR At Middleton	50	n/a	31.2		172	19	8.8	5	0	178	13	6	0.0
					-6	-166	2			172	19	9	
Fifteen Mile Drain	13210810	+	27.9		45.6	77	9.5	4.76	0	222	30	16	45.6
Star Feeder*	13210826	+	26.4		33.957	31	2.8	3.07	0	259	30	21	0.0
Long Feeder*	13210828	+	26.4		8.967	31	0.7	3.07	0	272	30	22	0.0
Watts Creek*	13210829	+	26.4		5.727	31	0.5	3.07	0	280	30	22	0.0
Mill Slough	24	+	24.8		96.157	41	10.7	3.07	0	380	32	33	0.0
Willow Creek @ Middleton	13210835	+	24.6		18.907	74	3.8	0.79	0	399	34	37	0.0
Mason Slough	13210849	+	23.2		12.763	57	2.0	5.55	0	418	34	39	0.0
Mason Creek	13210980	+	22.5		61.197	77	12.7	2.77	0	482	40	51	51.3
Riverside	13210984	-	22.6		-160.6	40	-17.2	0.59	0	322	40	34	
Hartley (combined)	87	+	22.2		41.587	59	6.6	0.59	0	364	42	41	0.0
Senree	13210992	-	21.9		-145.67	42	-16.4	1.65	0	220	41	25	
Campbell	13210993	-	21.9		-13.713	41	-1.5	1.65	0	208	41	23	
Siebenberg	13210994	-	21.0		-5.4	41	-0.6	1.65	0	204	41	22	
Shipley Pumps	13211001	-	20.8		-0.2	41	0.0	1.65	0	205	40	22	
Wagner Pumps	13211003	-	20.4		-0.2	40	0.0	1.65	0	207	40	22	
Caldwell WWTF	3	+	19.7		7.403	12	0.2	1.65	0	216	39	23	
Indian Creek	13211445	+	18.8		1	58	0.2	3.57	0	220	38	23	0.0
Simplot Pumps	13211603	-	17.9		-0.6	38	-0.1	3.74	0	224	38	23	
Eureka No.2	13211725	-	17.6		-71.21	38	-7.2	3.74	0	156	37	15	
Upper Center Point	13211735	-	17.6		-12.713	37	-1.3	3.74	0	147	36	14	
McManus-Teater	13211745	-	17.6		-1.413	36	-0.1	3.74	0	149	35	14	
Lower Center Point	13211825	-	13.2		-13.58	35	-1.3	3.74	0	140	34	13	
Bowman & Swisher	13212548	-	14.1		-8.163	34	-0.7	3.74	0	135	33	12	
Conway Gulch @ Notus	13212550	+	12.2		36.07	77	7.5	3.74	0	175	41	20	35.8
Baxter	13212645	-	10.4		-5.677	41	-0.6	3.83	0	173	40	19	
Andrews Ditch	13212832	-	9.4		-5.567	40	-0.6	3.83	0	171	40	18	
Dixie Drain Near Wilder	90	+	9.3		99.937	77	20.7	3.83	0	275	53	39	35.6
Mammon Pumps	13212896	-	8.0		-1.95	53	-0.3	3.28	0	276	52	39	
Hass	13212938	-	7.5		-7.323	52	-1.0	3.28	0	272	51	38	
Parma Ditch	13212954	-	6.5		-14.97	51	-2.1	3.28	0	261	51	36	
Island High Line	13212966	-	4.3		-12.723	51	-1.7	3.28	0	251	50	34	
Crawforth Pumps	13212992	-	4.1		0	50	0.0	3.28	0	255	49	34	
McConnel Island	13212994	-	3.5		-19.43	49	-2.6	3.28	0	236	49	31	
BR Near Parma	13213000	n/a	3.5		233	58	36.4	3	0	242	48	31	0.0
					-9	-209	5			233	58	36	

Notes:
TSS Concentrations for point source are based on permit limit discharge (single value for all seasons)
* Surragate TSS, Average of (Thurman Drain, Eagle Drain, Mason Slough)

Eagle Drain @ Eagle	13206400	27
Thurman Drain	13209450	9
Mason Slough	13210849	57
	average	31

Appendix G

Summary of Point Source Data for the Sensitivity Analyses

Summary of Point Source Data for the LBRWQP

Municipal Facilities

Point Source Name	Permit No	Discharge Duration	Receiving Waters	Existing Permit Flow Volume (mgd)	Existing Permit Flow Volume (cfs)	Permit TSS Limit (mg/L)	Permit Existing Load (lb/day)	Permit Existing Load (T/day)	Permit Averaging Conditions	Calculated Permitted Load (T/day)	Buildout Year	Buildout Flow Volume (mgd)	Buildout Flow Volume (cfs)	Buildout TSS Conc (mg/L)	Buildout Load (lb/day)	Buildout Load (T/day)	Buildout Condition
City of Meridian - WWTP	ID0020192	cont	5 Mile Creek	2.820	4.37	30	705	0.353	monthly	0.353	2015	8	12.38	30.00	2004	1.002	max month
						45	1058	0.529	weekly	0.530							
City of Wilder - WWTP	ID0020265	cont	Boise R. via Wilder Ditch Drain	0.075	0.12	70	--	--	monthly	0.022	2007	0.16	0.25	70	93	0.047	peak month
						105	--	--	weekly	0.033							
Boise City - Lander St WWTP	ID0020443	cont	Boise River	15.000	23.22		3400	1.7	peak month			15.000	23.22	27.15	3400	1.7	peak month
City of Notus - WWTP	ID0021016	intermit	Conway Gulch	0.065	0.10	70	--	--	monthly	0.019							
						105	--	--	weekly	0.028							
City of Caldwell - WWTP	ID0021504	cont	Indian Creek	7.780	12.04	30	1125	0.563	monthly	0.974	2015	11.3	17.49	30	2830	1.415	peak month
						45	1690	0.845	weekly	1.461							
City of Parma - WWTP	ID0021776	intermit	Snake River via Sand Hollow	0.310	0.48												
City of Middleton - WWTP	ID0021831	cont	Boise River just d/s of Mill Slough	1.830	2.83	70	--	--	monthly	0.535	2018	0.838	1.30	30	210	0.105	max month
						105	--	--	weekly	0.802							
City of Nampa - WWTP	ID0022063	cont	Indian Creek	11.800	18.27	30	3000	1.500	monthly	1.478	2015	16.51	25.56	30	4135	2.067	
						45	4500	2.250	weekly	2.216	2020	17.58	27.21	30	4403	2.201	
Star Water & Sewer District	ID0023591	cont	Lawrence - Kennedy Canal which drains into Mill Slough (based on USGS quad)	0.330	0.51	70	--	--	monthly	0.096	2015	0.403	0.624	70	236	0.118	max month
						105	--	--	weekly	0.145							
Boise City - West Boise WWTP	ID0023981	cont	Boise River	16.000	24.77		3000	1.5				46	71.21	7.81	3000	1.5	peak month

Note:
Wilder - based on a 1990 permit application, plant design flow is 0.12 mgd. Buildout - per phone call w/ Brian Matson/JUB, 20 year buildout from 1987 design
Notus - based on an old application, design flow is 0.056 mgd
Middleton - based on an application, design flow is 1.83 mgd
Star - based on an old application, design flow is 0.33 mgd
For the sensitivity analysis, 0.019 T/day was used for the City of Notus, and 0.535 T/day was used for the City of Middleton to be conservative

Industrial Facilities

Point Source Name	Permit No	Discharge Duration	Receiving Waters	Existing Permit Flow Volume (mgd)	Existing Permit Flow Volume (cfs)	Permit TSS Limit (mg/L)	Permit Existing Load (lb/day)	Permit Existing Load (T/day)	Permit Averaging Conditions	Calculated Existing Load (T/day)	Buildout Year	Buildout Flow Volume (mgd)	Buildout Flow Volume (cfs)	Buildout Load (T/day)
Armour (ConAgra) Fresh Meats	ID0000787	cont	Indian Creek	0.475	0.74	--	100	0.050	daily avg					
						--	120	0.060	daily max.					
ID F&G, Nampa	ID0023779	cont	Wilson Drain and then into Indian Creek	20	30.96	5	--	--	monthly	0.417				
						15	--	--	inst. max					
ID F&G, Eagle Island	ID0022748	cont	Boise River	>1	>1.55	5	--	--	monthly	0.021				
						15	--	--	inst. max					

Note
The proposed ConAgra permit retains these numbers
For the sensitivity analyses, 0.060 T/day was used for Armour

APPENDIX I

Bacteria Loading Analysis

Task Order No. 8—Bacteria Load Allocation

PREPARED FOR: Lower Boise River Water Quality Plan

PREPARED BY: Tom Dupuis and Pat Nelson/CH2M HILL

DATE: July 15, 1998

Introduction

This technical memorandum (TM) was prepared to partially fulfill the requirements of Task Order 8 under CH2M HILL's contract with the Lower Boise River Water Quality Plan (LBRWQP). The objective of this task was to develop load allocations and wasteload allocations for bacteria for the Lower Boise River watershed. A companion TM has been prepared for sediment allocation.

Background

The Idaho Division of Environmental Quality (DEQ) recommended in its February 24, 1998 document entitled "A Review of Primary and Secondary Contact Recreation Beneficial Uses," that Total Daily Maximum Loads (TMDLs) be developed for bacteria for the main stem Boise River from Star to the Snake River (see Appendix B of DEQ's June 7, 1998 *Draft Subbasin Assessment*). DEQ's evaluation was based on measured exceedances of instantaneous criteria for fecal coliform bacteria.

TMDLs are normally expressed in the form of a Load Capacity (mass or numbers of bacteria per day) based on the critical river flow times the target "concentration" of the pollutant. In the case of bacteria, this target would be numbers of organisms per unit volume water rather than their mass (see Bacteria Sources and Loads TM). The Load Capacity is then apportioned to point sources (wasteload allocations) and non-point sources (load allocations), accounting for background levels and an implicit or explicit margin of safety. A reserve capacity for growth also can be included.

For bacteria, there is some flexibility in how the Load Capacity and allocations get translated into implementation requirements (e.g., NPDES permit limitations), in recognition of the fact that bacteria cannot be expressed as a mass per unit time. This is discussed in more detail later in this memorandum.

Instream Bacteria Targets

The instream targets for bacteria are defined by existing and possible future water quality criteria. The currently promulgated State criteria are based on fecal coliform levels and specific time frames for evaluation (Table 1). The primary contact recreation criteria apply from May through September and the secondary contact recreation criteria are applicable year-round. The primary contact criteria are applicable at all main stem river locations and the secondary contact criteria apply at all main stem locations except from Veteran's Parkway to Caldwell.

TABLE 1
Bacteria Targets

Type	Time Period	Fecal coliforms (CFU/100 mL)	E. coli (CFU/100 mL), [possible future]
Primary Contact (May through September)	May not exceed at any time	500	406
	More than 10% of samples over 30-day period may not exceed	200	NA
	Geometric mean of a minimum of 5 samples in a 30-day period may not exceed	50	126
Secondary Contact Recreation (all year)	May not exceed at any time	800	576
	More than 10% of samples over 30-day period may not exceed	400	NA
	Geometric mean of a minimum of 5 samples in a 30-day period may not exceed	200	126

The State of Idaho is currently conducting a negotiated rule-making process in which a change to E. coli criteria is being considered. Table 1 lists one possible way in which E. coli criteria may ultimately be expressed if adopted.

Seasonal Analyses

Because the applicable targets (i.e., promulgated criteria) already have specifically defined seasonal components of May through September for primary contact recreation and year-round for secondary contact recreation, these are the periods that were used for the bacteria evaluation and allocation.

Description of Available Data

Flows in the tributaries, drains, and main stem river have been recorded historically by a variety of agencies and organizations. Water quality sampling, including fecal coliform bacteria, has also been conducted over time, particularly since 1992 by the U.S. Geological Survey (USGS). USGS has been monitoring levels of fecal coliform bacteria at several locations in the main stem Boise River and at the mouth of most of the tributaries and drains. This work is being conducted under cost-share agreement with the LBRWQP.

Complete descriptions of the hydrology and other physical characteristics of the watershed, including monitoring programs and sources of data, can be found in the *Sediment Load Allocation* TM and DEQ's June 7, 1998 *Draft Subbasin Assessment*.

Existing and Critical Conditions Analysis

Characterization of Existing Conditions

Bacteria levels in the main stem river are shown in Figures 1 and 2 for the primary and secondary seasons, respectively. Table 2 shows the percent reductions in bacteria levels needed to meet geometric mean criteria at each main stem location, based strictly on instream values at those locations (i.e., not a mass balance analysis). Note that the geometric mean values for primary contact recreation are calculated from all data across all years of monitoring in the 1990's, but within that season. The formal geometric mean criteria (Table 1) require at least 5 samples within a 30-day period for compliance evaluation. Because sampling was generally conducted no more frequently than once per month, there are insufficient data available for rigorous comparison with the formal geometric mean criteria. The total number of samples available for the geometric mean calculations is summarized in Table 2 for the main stem stations.

Figure 3 illustrates the geometric mean bacteria levels for each wastewater treatment facility (WWTF) discharging to the main stem and at the mouth of each of the tributaries and drains for which monitoring data are available. Again, these tributary and drain locations have not been sampled frequently enough to meet the minimum criterion of 5 samples within a 30-day period. Figure 4 provides an estimate of the relative inputs of fecal coliform bacteria from point and non-point sources. This chart is based strictly on discharges to the main stem river and does not account for any losses of bacteria from the main stem due to the various diversions.

Given the possibility of a change to E. coli criteria, research was done under this Task Order to determine if a consistent factor or ratio exists that could be used to convert fecal coliform to E. coli data. However, our investigation showed that no such factor exists. Although E. coli is a sub-set of the fecal coliform group, the number of E. coli present will vary depending on the source of the fecal material. The amount of E. coli present will differ if the source is agricultural land, pastureland, or domestic wastewater.

Although a "rule of thumb" may be developed on a site-specific basis, this would require doing a side-by-side analysis. Even then, such a ratio would only provide an idea of the approximate magnitude of the number of E. coli colonies relative to fecal coliforms. It would not be precise enough to determine compliance with a standard.

For example, in "Bacterial Pollution of Waters in Pristine and Agricultural Lands" (Niemi and Niemi, 1991, Journal of Environmental Quality), a comparison is made between fecal coliform bacteria and E. coli. One of the conclusions of that study was that the more pristine the environment, the more closely related are fecal coliform and E. coli analyses.

The State of Colorado undertook a study to develop a ratio of fecal coliform to E. coli (personal communication, Phil Hegeman, Colorado Water Quality Control Division; with Pat Nelson, CH2M HILL, March 4, 1998). The purpose was to develop a ratio so that fecal coliform analysis could be used to determine if E. coli standards for swimming beaches were exceeded. When standards are exceeded, the State health department closes the beaches until levels are acceptable. The results of the study showed that there was too much

Figure 1. Lower Boise River Main Stem
Fecal Coliform Concentrations
May through September (1990 through 1997)

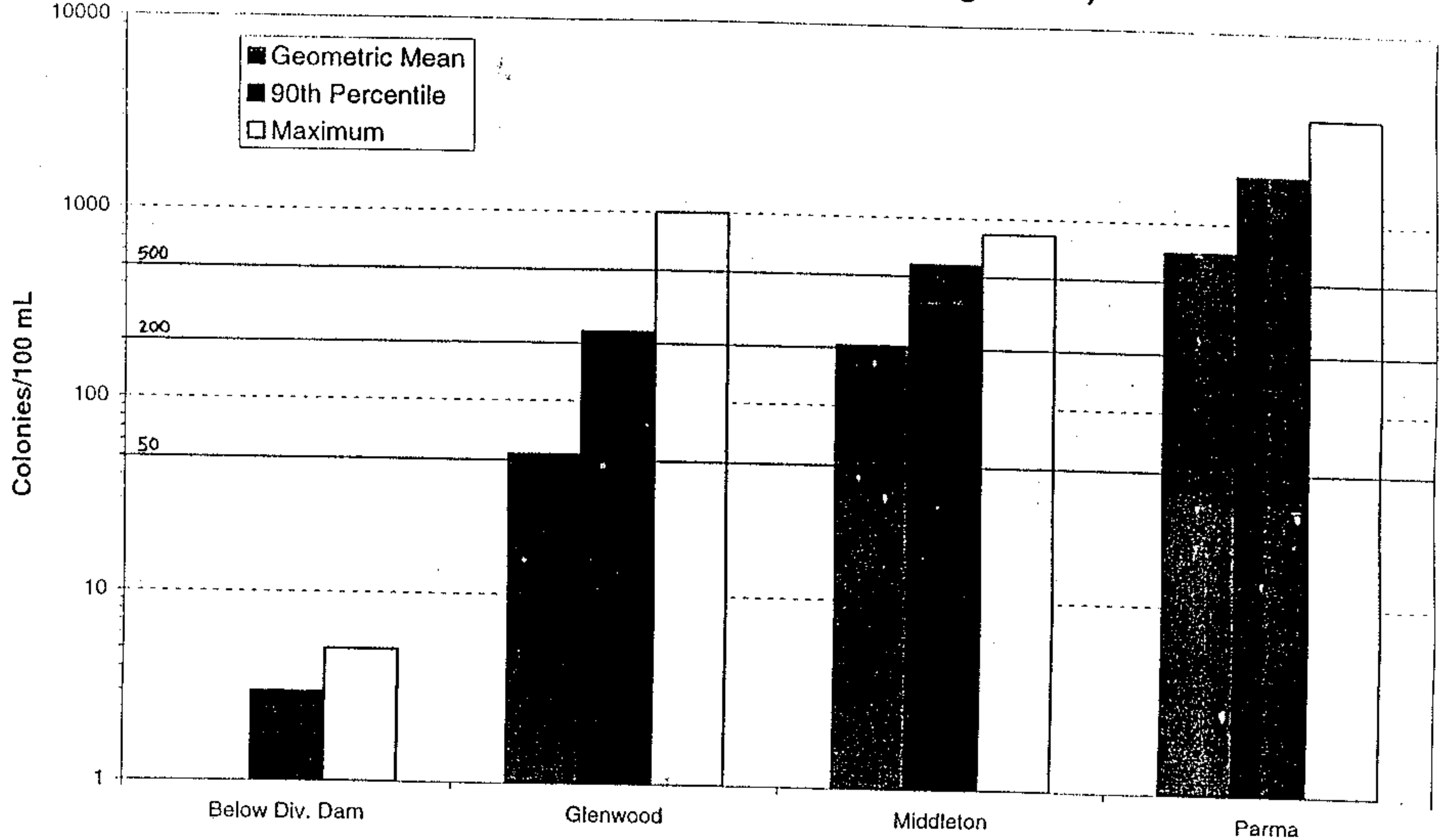
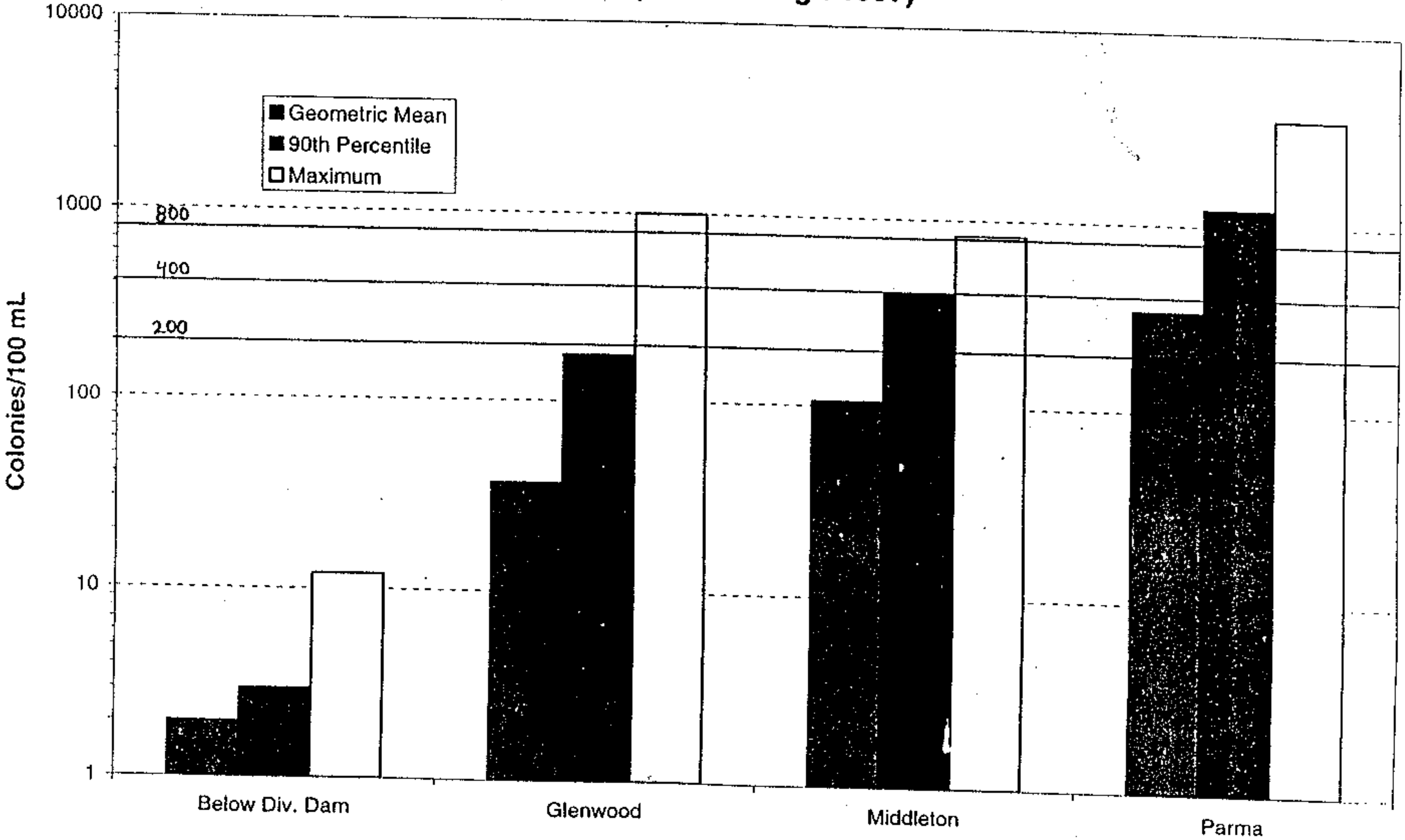


Figure 2. Lower Boise River Main Stem Fecal Coliform Concentrations Annual (1990 through 1997)



p:\137544\fecal\GM_90_Max Chart 4

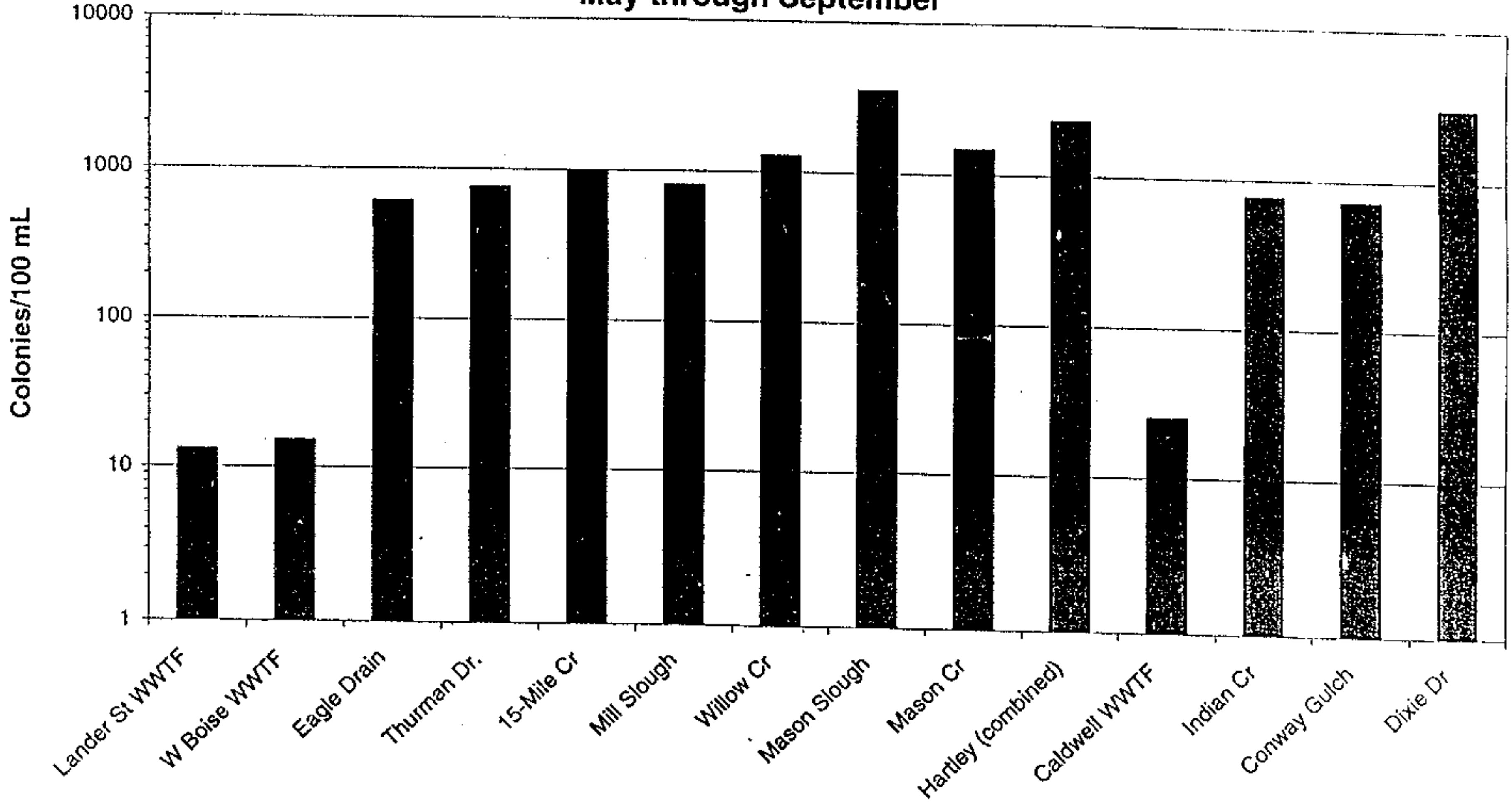
Table 2

Percent Reductions Needed to Meet Criteria Based Only on Concentrations

Boise River	Primary				Secondary			
Stations	Actual (CFU/100 mL)	# samples	Target (CFU/100 mL)	% Red.	Actual (CFU/100 mL)	# samples	Target (CFU/100 mL)	% Red.
Diversion Dam	1	15	50	0%	2	18	200	0%
Glenwood	53	30	50	6%	37	26	200	0%
Middleton	208	15	50	76%	106	16	200	0%
Parma	703	21	50	93%	344	25	200	42%

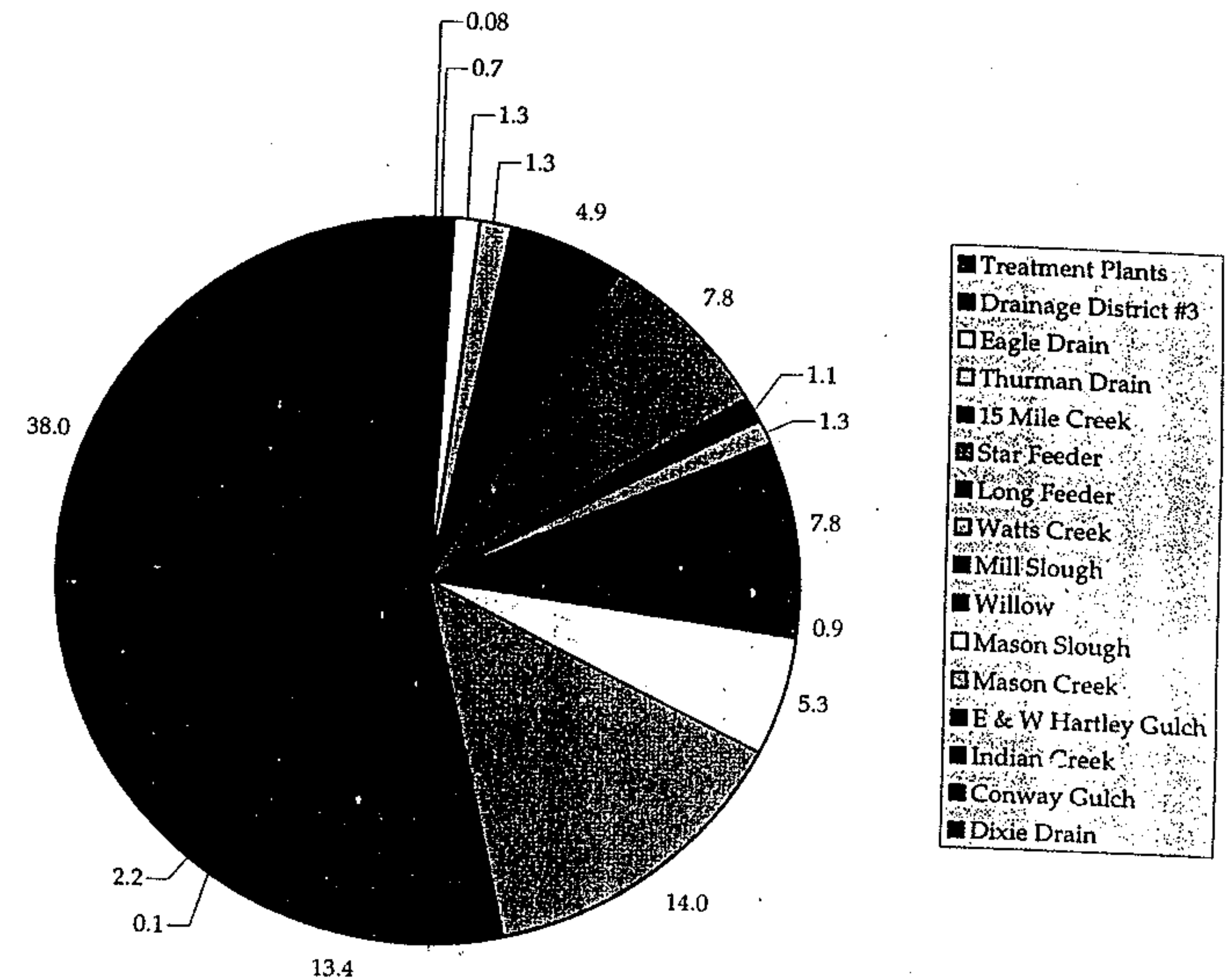
"Actual" is meaured geometric mean value

Figure 3. Lower Boise River Tributary and WWTF Fecal Coliform Geometric Mean Concentrations May through September



Note: Boise WWTF - 1993-96; Caldwell WWTF est.; tribs - 1990-97

Figure 4. 1992 Fecal Coliform Inputs to the Lower Boise River, Percent of CFU/day



variability in the ratio of fecal coliform to E. coli to be used to make such a decision on compliance with the E. coli standards.

A review of the USGS data indicated that results of only three E. coli analyses are available to date for the Lower Boise River. These values are shown in Table 3 obviously are insufficient to allow any conclusions to be drawn.

TABLE 3
E. Coli Results (CFU/100 mL)

Sampling Point	Date of Sample	E. coli	Fecal Coliform	Fecal Streptococcus
Boise River below Diversion Dam	4/14/97	0	1	1
Boise River below Diversion Dam	8/11/97	0	1	1
Indian Creek at Mouth	12/17/96	550	130	NA

NA – Data not available.

Additional discussion of the status of recreation use attainment can be found in DEQ's June 7, 1998 *Draft Subbasin Assessment*.

Mass Balance Considerations

A mass balance for bacteria similar to that developed for sediment (see *Sediment Load Allocation* TM) was attempted for the critical low-flow year of 1992. The balance sheet for the primary contact season is provided in the Appendix. It is clear that the errors in the mass balance are too great to allow for its reasonable use for bacteria evaluation or allocation purposes. The mass balance-derived geometric mean bacteria concentration at Parma for the was 2.7 times higher than the measured geometric mean at that location.

We considered whether incorporation of a bacteria die-off function in the main stem river would be sufficient to correct the mass balance error. The standard first-order decay equation, with a decay rate of 0.02 per hour (at 20°C), was used for this analysis. The decay rate is consistent with that used by Chen and Wells in 1975 for their modeling analysis of the Boise River (TetraTech, Inc.; *Rates, Constants, and Kinetic Formulations for Surface Water Quality Modeling*; 1985). These calculations indicated that about half of the bacteria in the river at Lucky Peak would die off before Parma (roughly a 36 hour travel time), but only one-third of those at Middleton would die off before Parma (roughly a 20 hour travel time). Given that there are significant inputs of bacteria well downstream of Middleton, it is clear that incorporation of die-off alone would not sufficiently correct the mass balance errors.

Critical Flow Conditions

An important consideration in the selection of the critical flow period is whether or not there is a definable relationship between river flow and bacteria levels. Figures 5 through 8 illustrate that there is no discernible relationship at any of the main stem river stations. Consequently, the critical flow should be selected based strictly on flow, without development of a statistical correlation between flow and concentration.

Figure 5. Boise River: Below Diversion Dam (With all Available Data)

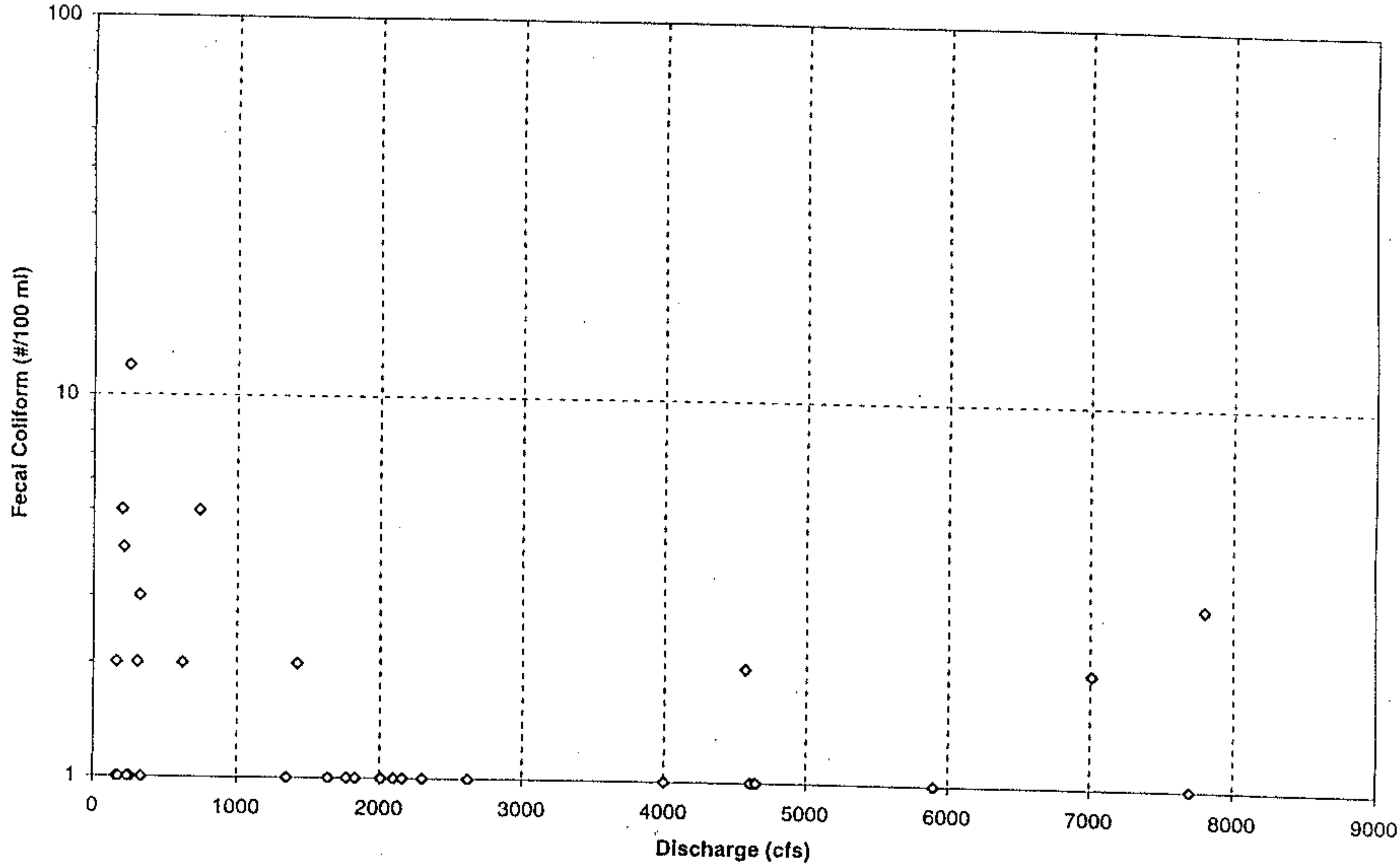


Figure 6. Boise River: Glenwood Bridge (With all Available Data)

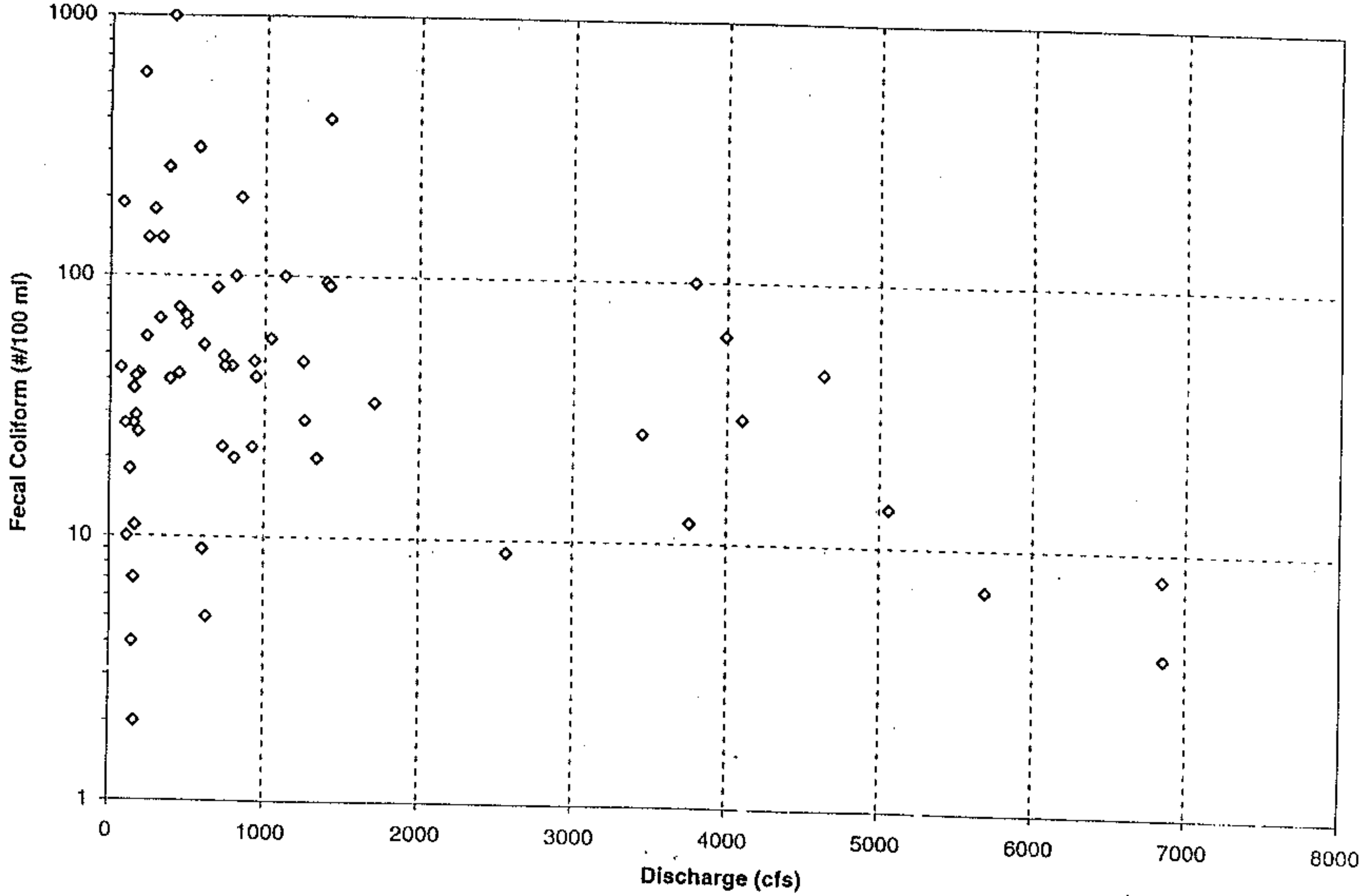


Figure 7. Boise River: Middleton (With all Available Data)

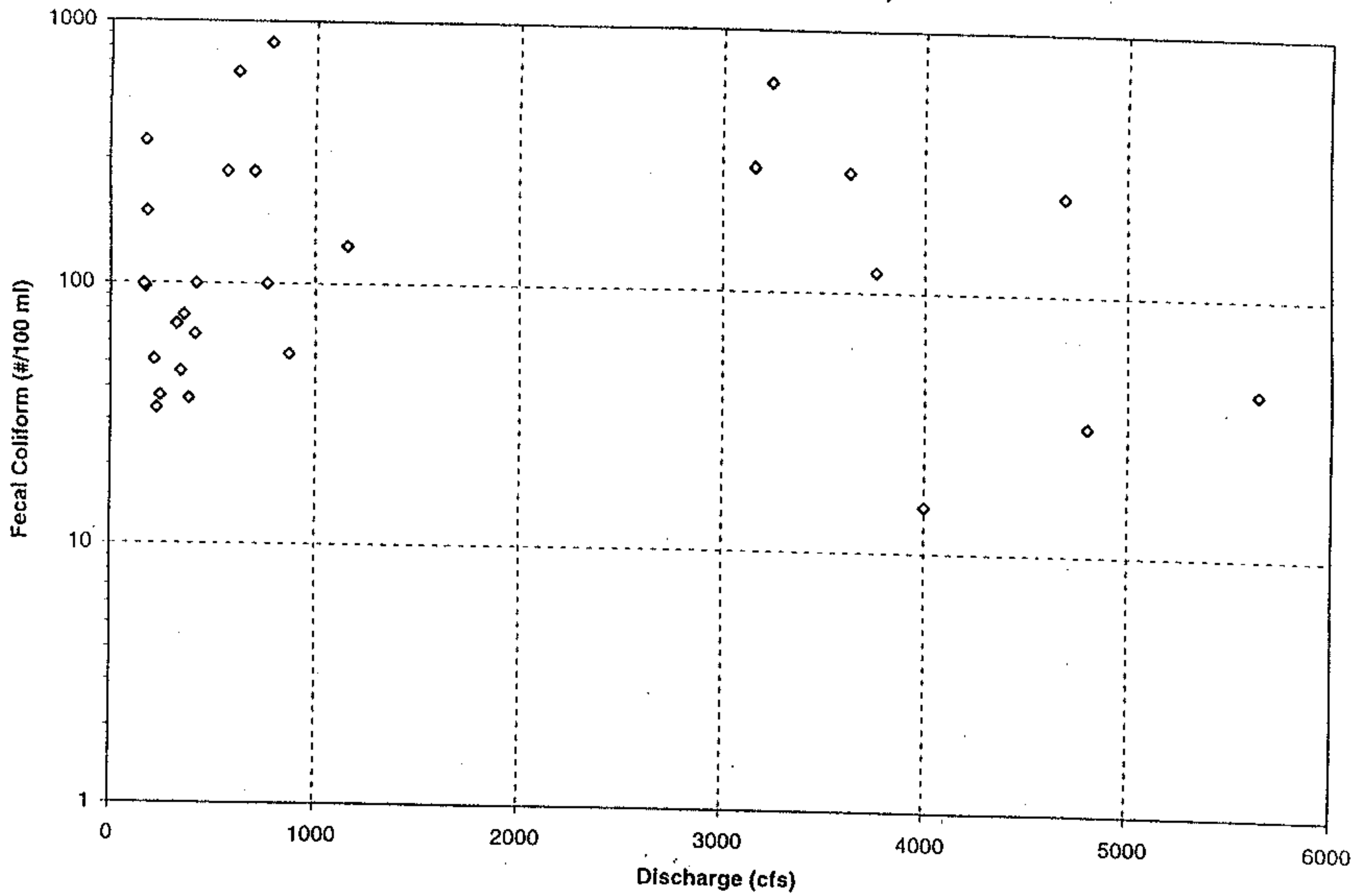
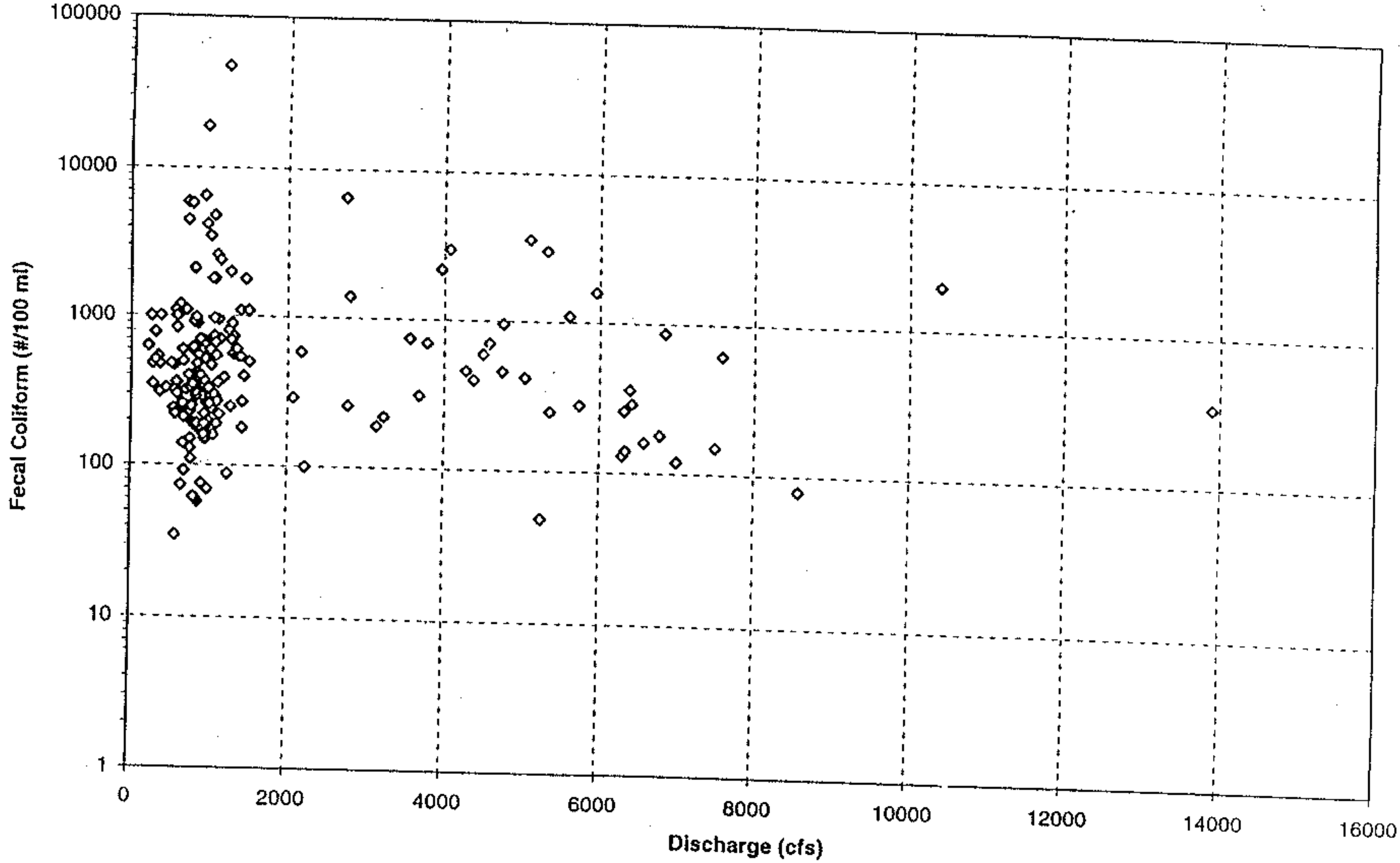


Figure 8. Boise River: Parma
(With all Available Data)



As discussed in more detail in the *Sediment Load Allocation* TM, 1992 was the benchmark driest year since the upstream reservoirs have been in place. Relevant thirty- and seven-day low flows for the applicable seasons are summarized in Table 4. The 10-year flow statistics were calculated by CH2M HILL using EPA's DFLOW program for the period of record shown for each station. It can be seen that the 1992 30-day minimum flows are lower than the 10-year recurrence interval flows at Glenwood and Parma.

TABLE 4
Critical Low Boise River Flows (all values in cfs)

Location	1992 30-day minimum (Primary)	30-day, 10-year (Primary)	7-day, 10-year (Primary)	30-day, 10-year (Annual)
Below Diversion Dam (1986-1994)	NA	417	267	83
Glenwood (1982-1997)	110	331	244	114
Middleton (1974-1997)	151	88	63	90
Parma (1971-1997)	160	295	218	254

Load Capacity Computations at Control Points

Table 5 shows the computed Load Capacities at Glenwood, Middleton, and Parma using the 1992 30-day low flows from Table 4. The Load Capacities are based on the 30-day geometric mean criteria for fecal coliforms for primary and secondary contact recreation. The same flows are used for both criteria because the secondary criteria apply year round.

TABLE 5
Load Capacity Calculations at Control Points for 1992 30-day Low Flows

	Primary Contact Recreation			Secondary Contact Recreation		
Control Point	Flow (cfs)	Target, CFU/100 mL	Load Capacity, CFU/day	Flow (cfs)	Target CFU/100 mL	Load Capacity, CFU/day
Glenwood	110	50	1.35E+11	110	200	5.38E+11
Middleton	151	50	1.85E+11	151	200	7.39E+11
Parma	160	50	1.96E+11	160	200	7.83E+11

The Load Capacity for any bacteria target varies with river flow at any control point as shown in the equation below:

$$LC = Q * T * UCF$$

Where:

LC = Load Capacity (CFU/day)
Q = River flow (cfs)
T = Bacteria target (CFU/100 mL); as fecal coliform (or E. coli if standards change)
UCF = Unit Conversion Factor = 24.46E+06

Future progress toward meeting the TMDL targets should be based on bacteria concentrations as determined through an ongoing monitoring program. Because the Load Capacity varies with flow, the values listed in Table 5 should not be viewed as fixed values irrespective of river flow.

Wasteload and Load Allocations

Summary of Other Bacteria TMDLs

Several other TMDLs have recently been developed for bacteria. These provide useful insight into the various acceptable ways in which wasteloads and loads can be allocated. These examples include:

- Paradise Creek—developed by Idaho DEQ, approved by EPA (*Water Body Assessment and Total Maximum Daily Load,* DEQ Lewiston Regional Office, December 24, 1997)
- Columbia Slough—developed by Oregon DEQ, pending EPA review and approval (*Total Maximum Daily Load (TMDL) for: Chlorophyll a, Dissolved Oxygen, pH, phosphorus, DDE, DDT, PCBs, Pb, fecal coliform and 2,3,7,8 TCDD in the Columbia Slough and phophorus and fecal coliform in Fairview Creek and phosphorus in Fairview Lake,* Oregon DEQ, Draft, January 5, 1998)
- Several lakes in Anchorage—EPA developed (*Total Maximum Daily Load for Fecal Coliform in Lakes Hood and Spenard, Anchorage, Alaska,* EPA Region 10, undated draft; *Total Maximum Daily Load (TMDL) for Fecal Coliform in Jewel Lake, Anchorage, Alaska,* EPA Region 10, undated draft)
- Georgia watersheds—EPA developed (excerpts of the final TMDL for Aycocks Creek watershed provided by Tom McGill, EPA Region 4, faxed to Tom Dupuis, CH2M HILL, May 27, 1998)

Paradise Creek—The Paradise Creek TMDL identified the Moscow WWTP, aquaculture, and non-point sources as sources of bacteria and developed an allocation approach that calls for a 18 percent reduction from the WWTP and a 75 percent reduction from non-point sources. The approach involved use of the geometric mean fecal coliform criterion as the instream target, a flow-variable Load Capacity, a single control point, an implicit margin of safety (recent monitoring data were available), and a lumping of all non-point sources for the load allocation.

Columbia Slough—The Columbia Slough TMDL identified urban storm water, combined sewer overflows (CSOs), and other sources of bacteria. The TMDL did not identify specific percent reductions for each source. The approach involved a flow-variable Load Capacity, best management practices (BMPs) to the maximum extent practicable (MEP) for urban storm water, and near elimination of CSOs from the Slough by the year 2002. There was no margin of safety identified in the TMDL report. The TMDL recommends bacteria management plans and long-term monitoring. Oregon has recently converted to E. coli criteria, and the uncertainties associated with this change factored into the TMDL approach.

Anchorage Lakes—EPA developed bacteria TMDLs for several water supply and recreational lakes in Anchorage. The primary sources of bacteria were geese in the park and beach areas, and for one of the lakes airport storm water runoff was a possible source. EPA targeted a 80 percent reduction in bacteria loading from the geese. The airport was not assigned a percent reduction but a concentration-based wasteload allocation of 18 CFU/100 mL was included in the TMDL. The approach used an organism per day load allocation for two of the lakes in one of the TMDLs and a concentration-only allocation for one of the lakes. The TMDL identified a phased approach to implementation that included activities by the Waterfowl Work Group and monitoring by the airport. A margin of safety of 10 percent was used.

Georgia Watersheds—EPA developed bacteria TMDLs for numerous streams in Georgia impacted strictly by non-point sources. The instream target was the 30-day geometric mean criteria. The load allocation relied on continuous modeling with very limited field data. The allocation strategy included iterative reductions in per acre bacteria loading assumptions until the models indicated that criteria would be met in the stream. Fecal coliform allocations were then set at the model determined numbers per acre per day for land sources. Groundwater and interflow sources were allocated on a concentration-only basis. A margin of safety of 12.5 percent was used in cases where stream flow data were available. Where flow data were not available, a 25 percent margin of safety was used. These margins were deducted from the applicable criterion.

Overall conclusions that can be drawn from the above examples are:

- The use of the 30-day geometric mean criterion is the most common instream target
- Use of flow-variable analysis and Load Capacity definition is common when non-point sources are predominant
- Margins of safety of 10 percent or less (often implicit) are common, especially when flow and/or bacteria data for the watershed are available
- A variety of allocation units can be used, including CFUs/day, concentration-only, and various hybrids of these.

Recommended Lower Boise River Allocation

Margin of Safety

An implicit margin of safety is appropriate for the Lower Boise River TMDL because reasonably extensive and reliable flow and bacteria data are available, the most conservative bacteria criteria (i.e., 30-day geometric mean) are recommended for the instream targets, and the Idaho criterion for primary contact recreation is 4 times more stringent than EPA guidance for fecal coliforms.

Background

The geometric mean background bacteria level at Diversion Dam, the upstream monitoring location in the watershed, is only 1 CFU/100 mL during the primary contact season and 2 CFU/100 mL on an annual basis. Consequently, background levels do not substantively affect allocations or anticipated implementation activities.

Point Source Wasteload Allocation

As required by Idaho regulations, permitted point source dischargers in the watershed must meet applicable bacteria criteria at the end-of-pipe (i.e., no dilution is factored into development of the permit limitations). Because it is not practical or even possible to express bacteria limitations on a mass basis, the numeric limits in the permits are expressed as number per 100 mL. It is recommended that this approach be continued for permits issued in the future to comply with the bacteria TMDL. The permits currently in place in the watershed, and the applicable bacteria limitations, are summarized in Table 6.

Note that EPA's limitations in a number of cases are more stringent than the applicable criteria (compare Table 1 to Table 6). For example, the monthly limitation for many of the municipal dischargers during the secondary contact recreation-only time of the year is 100 CFU/100 mL, or twice as stringent as the 30-day criterion for secondary contact recreation. In addition, EPA includes limitations of 100 CFU/100 mL on a weekly basis during the primary contact season for many municipal permits even though there is no corresponding weekly criterion in the State standards.

Reserve for Growth

A set-aside for growth for municipal point sources is not needed for this bacteria TMDL because these dischargers will continue to be required to meet applicable bacteria criteria, or even more stringent limitations if the current permits provide a forecast of the future, at the end-of-pipe. Consequently, increased effluent flow from these dischargers in the future in response to growth in their service areas will not cause standards violations or substantially affect the load allocation for non-point sources.

Non-point Source Load Allocation

The monitoring data collected to date indicate that geometric mean fecal coliform levels at Glenwood Bridge during the primary contact recreation season are about at the instream target value of 50 CFU/100 mL (Figure 1 and Table 2). Thus, there does not appear to be any dilution upstream of the Middleton and Parma control points that could be factored into load allocations downstream of Glenwood. In addition, the geometric mean fecal coliform level at the mouth of each of the tributaries and drains are at least an order of magnitude greater than the main stem target level of 50 CFU/100 mL (Figure 3 and Table 7). As a result, non-point sources should focus TMDL implementation activities on meeting the applicable target concentrations at the mouth of each of the tributaries and drains. Possible percent reductions needed to meet the existing fecal coliform criteria are listed in Table 7.

TABLE 6
Point Source Wasteload Allocations for Bacteria

Point Source	Averaging Period	F. Coliform Limits, CFU/100 mL
Caldwell (existing permit)	Monthly	50
	Weekly	100
Caldwell (draft new permit), (May - September)	Monthly	50
	Weekly	200
	Daily	500
Caldwell (draft new permit), (October - April)	Monthly	200
	Weekly	200
	Daily	800
Wilder	Monthly	100
	Weekly	200
Notus (May - September)	Monthly	50
	Weekly	100
Notus (October - April)	Monthly	100
	Weekly	200
Meridian (discharge to 5-Mile Creek)	Monthly	100
	Weekly	200
	Daily	800
Meridian (discharge to Boise River)	Monthly	50
	Weekly	100
	Daily	500
Nampa (existing permit)	Monthly	200
	Weekly	200
Nampa (draft new permit)	Monthly	200
	Weekly	200
	Daily	800
Star (May - September)	Monthly	50
	Weekly	100
Star (October - April)	Monthly	100
	Weekly	200

TABLE 6
Point Source Wasteload Allocations for Bacteria

Point Source	Averaging Period	F. Coliform Limits, CFU/100 mL
Armour (May - September)	Monthly	50
	Daily	400
Armour (October - April)	Monthly	200
	Daily	400
Boise, Lander St. (existing permit) (April - September)	Monthly	50
	Weekly	100
Boise, Lander St. (existing permit) (October - March)	Monthly	100
	Weekly	200
Boise, W. Boise (existing permit) (April - September)	Monthly	50
	Weekly	100
Boise, W. Boise (existing permit) (October - March)	Monthly	100
	Weekly	200
Boise, Lander St. (draft new permit) (May - September)	Monthly	50
	Weekly	200
	Daily	500
Boise, Lander St. (draft new permit) (October - April)	Monthly	200
	Weekly	400
	Daily	800
Boise, W. Boise (draft new permit) (May - September)	Monthly	50
	Weekly	200
	Daily	500
Boise, W. Boise (draft new permit) (October - April)	Monthly	200
	Weekly	400
	Daily	800
Idaho Fish and Game hatcheries at Nampa and Eagle Island	Not applicable	No limitations

TABLE 6

Point Source Wasteload Allocations for Bacteria

Point Source	Averaging Period	F. Coliform Limits, CFU/100 mL
Middleton (May - September)	Monthly	50
	Weekly	100
Middleton (October - April)	Monthly	100
	Weekly	200

(Source: Existing Boise permits provided by the City of Boise; draft new permits for Caldwell, Nampa, and Boise as public noticed by EPA on June 17, 1998; all others from letter from Nickie Arnold, EPA, Boise; to Steve Miller, CH2M HILL, June 4, 1998)

Table 7
Lower Boise River Tributaries
Percent Reductions Needed to Meet Bacteria Criteria at the Mouth

Tributary	Primary Contact (May-Sept)		Secondary Contact (Annual)	
	Geometric Mean (CFU/100mL)	Required Percent Reduction	Geometric Mean (CFU/100mL)	Required Percent Reduction
Eagle Drain	604	92	579	65
Thurman Dr.	758	93	512	61
15-Mile Cr	992	95	612	67
Mill Slough	803	94	528	62
Willow Cr	1282	96	556	64
Mason Slough	3507	99	1422	86
Mason Cr	1470	97	515	61
Hartley (combined)	2296	98	565	65
Indian Cr	770	94	384	48
Conway Gulch	723	93	177	0
Dixie Dr	2987	98	1156	83

Again, the monitoring program has not collected samples at any of these locations at a frequency that meets the formal requirement for at least 5 samples per month. Thus, the actual reductions needed are uncertain at this time and the values in Table 7 should be viewed as planning level estimates only. Moreover, if the State of Idaho revises the criteria for E. coli, the magnitude of the reductions needed will certainly change, but by how much is also unknown at this time. For illustrative purposes, if Idaho were to adopt EPA's recommended fecal coliform criterion of 200 CFU/100 mL for the 30-day geometric mean for primary contact recreation, the estimated percent reductions needed would range from 67 to 94 percent, depending on the tributary or drain. So in any case, implementation planning should recognize that substantial reductions in bacteria levels will likely be needed to meet existing and future criteria for bacteria, particularly in the most downstream portion of the watershed between Middleton and Parma.

Implementation Framework

Because the overwhelming majority of bacteria in the Boise River apparently derive from non-point sources, it is imperative that a pragmatic framework be established for implementation activities. Additional reductions by municipal WWTFs not only are not feasible but also would not materially affect bacteria levels in the tributaries, drains, or main stem river. The primary origins of bacteria from non-point sources are not well understood at present but may well be further elucidated through DNA fingerprinting of bacteria via a Section 319 grant to the LBRWQP. The likelihood of a criteria change to E. coli lends further uncertainty to this TMDL process. Thus, practical and implementable strategies should be pursued first, relying on cost-effective BMPs for non-point sources. This is not simply a status-quo approach because various programs and activities have recently been initiated or are likely to be instituted over the next several years that should lead to substantial reductions in bacteria in the river compared to historical conditions. These include:

- Urban storm water—EPA's Phase I storm water regulations require that the City of Boise and most categorical industries implement BMPs to the maximum extent practicable, including illicit connection elimination programs, BMPs for new development and significant redevelopment, and development of public education and involvement activities. EPA recently proposed Phase II regulations that will cover municipalities not currently regulated under Phase I. These EPA regulations are mandated by the Clean Water Act and are not voluntary.
- Septic systems—The district health departments currently have a permitting and regulatory program for septic systems in the watershed. Additional sewering to accommodate growth and increased density of development will be addressed by the health departments and other local governments as needed and required by State and local regulations.
- Agricultural sources—As discussed in the *Bacteria Sources and Loads* TM and DEQ's *Draft Subbasin Assessment*, the agricultural community is expected to implement or be subject to additional water pollution control programs. These include permitting of dairies, additional scrutiny and waste management at confined animal feeding operations (CAFOs), and other programs actively administered by various federal, state, and local agencies. Measures that control or eliminate storm water runoff or illicit discharge of concentrated animal wastes, prevent animal access to waterways, result in agronomic

application of animal wastes, and minimize erosion of lands on which manure has been applied are likely to most improve the bacterial quality of the Boise River.

An iterative and adaptive approach to the bacteria TMDL is needed to accommodate the key data gaps and future uncertainties (e.g., new E. coli criteria). A dedicated monitoring program will be essential to tracking progress and reformulating implementation strategies as needed. This approach is consistent with the needs in this watershed, but also conforms to recent recommendations made the Federal Advisory Committee on TMDLs, whose recommendations are expected to be incorporated into EPA TMDL regulations in the near future.

Appendix

Mass Balance

1992 Data (Flows)
To input target concentration goto --> Cell BS1

INPUT:		CHOICES:	
Fecal Concentration Table:	1	(1 = Measured; 2 = Target (see cell BS1))	Measured
Flow Season:	2	(1 = Annual; 2 = May-Sept; 3 = Oct-April)	May-Sept.
Flow Magnitude:	2	(1 = 10% exceeds; 2 = Median; 3 = 90% exceeds; 4 = Mean)	Median
Conc. Season	2	(1 = Annual; 2 = May-Sept; 3 = Oct-April)	May-Sep
Conc. Magnitude:	1	(1 = Geometric Mean; 2 = 90th Percentile)	Geometr

	Tons/day No Reducton	Tons/day with 9999999.0 mg/L	Load Cap. at 50mg/L
Glenwood U.S.		0	
Glenwood Control pt.		1	[illegible]
Middleton U.S.		0	
Middleton Control pt.		1	[illegible]
Parma U.S.		10	
Parm Control Pt.		4	[illegible]

Mainstem Gaging Location	Station No.	Inflow or Outflow -/+	River Mile	Basin	Measured Flow (cfs)	oncentrati ount/100n	Incremental Daily Mass Load terra bact. /day	Incremental Groundwater Flow (cfs)	Groundwater Concentration (count/100ml)	River Flow (cfs)	River Concentration (count/100ml)	River Load terra bact. /day	Percent Reduction
BR Below Diversion Dam	13203510	[illegible]	[illegible]	[illegible]	1210	[illegible]	[illegible]0.0	[illegible]10	[illegible]0	1210	[illegible]	[illegible]0	0.0
Ridenbaugh	13203760	-	58.3		-391.0	1	0.0	1	0	820	1	0	
Bubb	13204005	-	57.5		-6.0	1	0.0	1	0	815	1	0	
Meeves	13204020	-	56.8		-0.7	1	0.0	1	0	816	1	0	
Rossi Mill	13204060	-	56.4		-8.0	1	0.0	1	0	811	1	0	
River Run	13204070	-	56.1		-18.0	1	0.0	1	0	794	1	0	
Boise City	13204190	-	56.0		-20.3	1	0.0	1	0	775	1	0	
Boise Water Corp.	200	-	55.9		-2.0	1	0.0	1	0	775	1	0	
Settlers	13205515	-	52.0		-80.7	1	0.0	1	0	695	1	0	
Davis	13205517	-	52.0		-7.0	1	0.0	1	0	689	1	0	
Boise City Parks	13205613	-	51.5		-0.2	1	0.0	1	0	690	1	0	
Drainage District #3*	13205617	+	51.0		4.8	1623	0.2	1	0	696	12	0	0.0
Thurman Mill	13205622	-	51.0		-23.2	12	0.0	1	0	674	12	0	
Farmers Union	13205640	-	50.4		-122.0	12	0.0	1	0	554	12	0	
Lander Street WWTF	1	+	49.9		8.2	13	0.0	1	0	563	12	0	
BR At Glenwood Bridge	13206000	[illegible]	[illegible]	[illegible]	[illegible]567	[illegible]53	[illegible]10.7	[illegible]	[illegible]0	567	12	0	0.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]0	######	[illegible]	[illegible]	[illegible]	567	[illegible]53	[illegible]1	

p:\137544\sedment\8296bshgw junk.xls concentration constant

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APPENDIX J

No Net Increase Load Proposal for Total Phosphorus

No Net Increase Total Phosphorus Loads for the Lower Boise River Watershed

A Discussion of Issues and Proposed Loads for Sources

Introduction

A review of Boise River water quality conditions shows that the river is highly enriched with phosphorus. Between Middleton and Caldwell, attached algae growth significantly exceeds quantities observed at the upper end of the watershed, and exceeds suggested nuisance thresholds for other rivers. The Boise River nutrient data and productivity in the lower Snake River indicate the need to cap phosphorus loading to the Boise River until basin wide phosphorus limits protective of water quality are established. The no net increase proposal for total phosphorus described in this paper provides the temporary cap that is needed.

The proposed no net increase TMDL for phosphorus for the lower Boise River watershed would establish seasonal load limits for total phosphorus for point sources, non point sources, the Boise River near Middleton, and the river near Parma. The river sites will serve as benchmarks to ensure that the no net increase requirements are met. DEQ expects that the no net increase goal can be achieved using methods including (but not limited to) pollutant trading, best management practices, and nutrient removal technologies.

The no net increase TMDL for total phosphorus in the lower Boise River watershed is likely to be temporary. The proposals outlined below are expected to apply for two years, from the effective date of the lower Boise River TMDL until the effective date of the Brownlee Reservoir TMDL. The expected date of completion for the Brownlee TMDL is the year 2000. The Brownlee Reservoir TMDL may require reductions based on either concentrations or loads of phosphorus species (total and/or dissolved) from the Boise River.

Baseline Year Selection

The proposed no net increase TMDL for the lower Boise River watershed uses the 1996 calendar year as the baseline time period for sources of phosphorus and the river itself. The year selected is consistent with the Watershed Advisory Group's recommendation to use 1996 as the date after which water quality controls could be credited toward TMDL requirements.

Pollutant of Concern

Total phosphorus is the species proposed for the no net increase TMDL in the lower Boise River watershed. Literature describing studies of attached algae growth indicates that total, rather than dissolved ortho-phosphorus, has the best correlation with periphyton productivity. Analysis of periphytic algae growth in the Clark Fork River produced the same conclusion about total phosphorus.

Time Period for No Net Increase

DEQ calculated the proposed no net increase loads shown below based the standard irrigation season, from April 15 to October 15. A date between March 1 and April 15 is another possible choice for the start of a seasonal time period, recognizing that algae growth may begin before irrigation activity. Other time periods, such as the typical high flow season, from

February 15 to June 14, or a calendar year can also be considered. DEQ welcomes any comments or suggestions related to the most appropriate time period.

Proposed Loads - Seasonal Average with Mass Total

The seasonal average and mass total concept for no net increase loads provides a way to limit the mass of phosphorus moving through the river and ensure that load inputs are evenly distributed by the seasonal average limit. A seasonal average has the added benefit of reducing monitoring demands in comparison to an average applied over a shorter time frame. DEQ is open to discussion of other strategies, such as multiple monthly averages, or annual averaging. The methods used to establish the loads shown in Table 1 are described below.

Boise River near Middleton	888 lbs/day	163,415 lbs mass total
Boise River near Parma	2295 lbs/day	422,369 lbs mass total

Table 1. Proposed No Net Increase Total Phosphorus Loads by Source

Facility Name	Seasonal Average TP Load, lbs/day	Seasonal Total Load lbs		Tributary Name	Seasonal Average TP Load, lbs/day	Seasonal Total Load lbs
Lander St	440	80939		Eagle Drain	30	5566
West Boise	778	143088		Thurman Drain	19	3563
Meridian	68	12579		Fifteenmile Creek	241	44411
Nampa	498	90713		Mill Slough	197	36277
Caldwell	230	42300		Willow Creek	30	5438
				Mason Slough	59	10863
Minor Muni.	14	2373		Mason Creek	340	62539
				East Hartley Gulch	96	17707
				West Hartley Gulch	40	7302
				Indian Creek	164	30219
				Conway Gulch	101	18648
				Dixie Drain	444	81672

Characteristics of 1996 Flows

The Boise River carried a larger than average annual total volume of water during 1996. However, during the irrigation season, 1996 flows, while above average, were only modestly larger than irrigation season flows in 1995. Thus the 1996 flows for the season during which the no net increase proposal would have effect are not extreme. The table below compares 1996 loads to 1995 and to 1992 (the lowest flow year on record since 1955). The lowest year on record, 1992, clearly has much smaller loads, as would be expected for an extreme event. The annual load of total phosphorus in 1996 is larger than annual total loads in 1995 or 1992. However, for the irrigation season, the 1996 loads at Middleton and Parma are not very different from 1995 loads. The selection of the 1996 irrigation season as a baseline seems like a sound choice for the purpose.

1996 Loads Compared to Average and Low Flow Years

Table 2. Load Comparison

Site	1996 Proposed Load	1995 Average Load	1992 Average Load
Boise River near Middleton	888 lbs/day	817 lbs/day (1996 is 9% larger)	222 lbs/day (1996 is 300% larger)
Boise River near Parma	2295 lbs/day	2346 lbs/day (1996 is 2% *smaller*)	513 lbs/day (1996 is 350% larger)

Tributary Flows in 1996 Relative to Other Years

Tributary flows during the irrigation season of 1996 are close to long term averages, and are similar to 1995 flows. In fact, although 1995 was an average flow year for the Boise River, during the 1995 irrigation season flows in tributaries are similar or slightly higher on average than in 1996. Irrigation season average flows in Table 3 show that 1996 is not an extreme year for some of the large tributaries to the lower Boise River. Figure 1, (attached to this document), shows Mason Creek flows in 1992, 1995, and 1996, providing an example of the fact that 1996 was not an extreme year for Mason Creek.

Table 3. Irrigation Season Average Flows in Tributaries, cfs

Year	Fifteenmile Creek	Mason Creek	Dixie Drain
Long term Average	118	130	206
1992	51	91	154
1995	163	164	248
1996	143	152	212

Methodology

The general methodology for establishing baseline loads includes these steps:

1. Create best fit model to predict total phosphorus concentration, using FLUX software or non-linear model. Use seasonal or flow stratification, if necessary, to minimize error.
2. Use daily 1996 flow data and the model from step 1 to predict daily total phosphorus concentrations
3. Calculate daily total phosphorus loads for the entire 1996 calendar year.
4. Summarize the daily loads seasonally, annually, by averages, and by mass totals.

The FLUX model is an Army Corps of Engineers program that uses three averaging and three linear regression techniques to predict nutrient loads based upon sample data and daily flow information. The model provides goodness of fit and error analysis information for each method of estimating load. Data can be quickly stratified into groups by flows or by dates to improve the predictive power of the six modeling techniques. For every source to which the FLUX model was applied, DEQ selected one method (of the six available) that provided the best fit to measured data, minimum coefficient of variation, and minimum variance. The best method was then used to calculate daily loads for the entire 1996 calendar year. Specific details of the method selected for a given source are available upon request, but are too numerous to list here.

River Sites

To define the total phosphorus loads that occurred in the Boise River at Middleton and Parma during 1996, all of the available data from the USGS form the basis of models that predict total phosphorus concentration. Daily flow records from USGS gage site at each site are applied to the models to predict the daily total phosphorus concentrations for 1996. Daily loads are calculated using the daily flows and predicted concentrations. Summary statistics of the type shown above are based upon the predicted daily loads for 1996.

Middleton

At Middleton, the US Army Corps of Engineers FLUX model provided the best fit model for total phosphorus, given a stratification of the data by the irrigation and non-irrigation seasons. A linear regression on natural log adjusted data points provided a good fit with a 0.080 coefficient of variation and an error of +- 82 pounds for the annual total load.

Parma

For the Parma river site, USGS data showed a distinct non-linear relation between flow and concentration that cannot be made linear with natural log adjustment of the data. To predict total phosphorus concentrations based upon flow, two no linear models are fit based on a date stratification of the available measured data. The models are as follows:

Total Phosphorus Predictive Equations

Dates: February 15 to October 15
[TP] = 0.032 + 0.38*exp(-0.00045*Flow^0.95)

Dates: October 16 to February 14
[TP] = 0.18 + 0.68*exp(-0.00045*Flow^1.12)

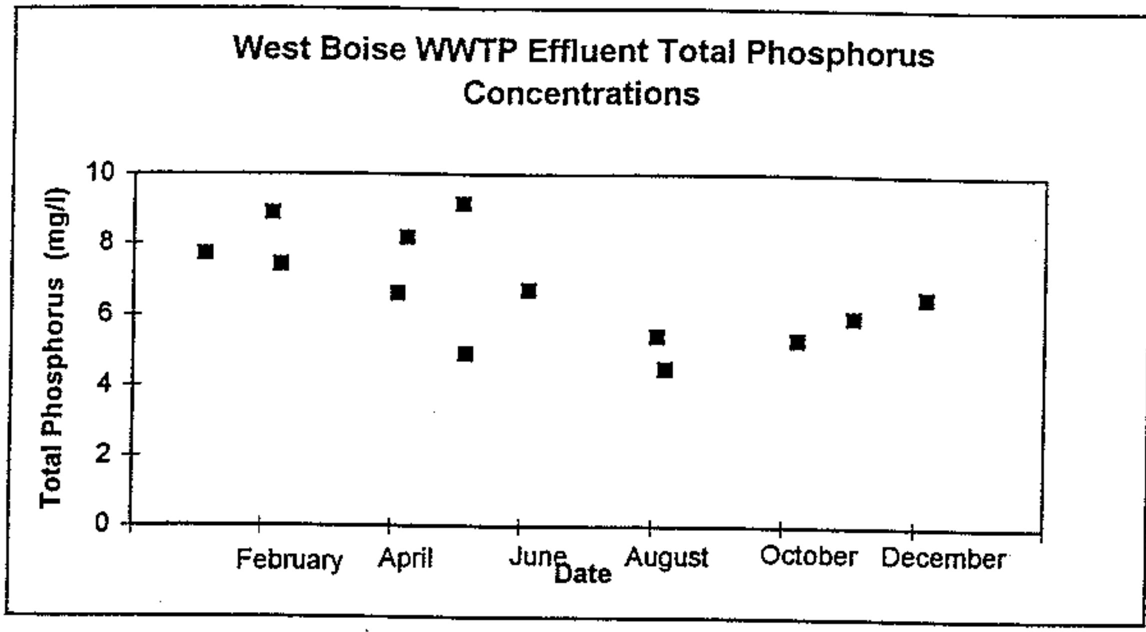
The models shown predict total phosphorus in the Boise River at Parma quite well, with about 7% under-prediction on average. A detailed report on the development of the Parma models, titled "Summary of 1996 Total Phosphorus Loads at Parma", is available upon request.

Waste Water Treatment Plants

In order to appropriately characterize waste water treatment facility effluent characteristics, DEQ used the FLUX program to create models that predict total phosphorus concentrations. From the daily total phosphorus concentration estimates generated by the model, daily loads are calculated using effluent flow data supplied by the facilities. Since operations and inputs to the treatment plants change for year to year, only flow and total phosphorus measurements from 1996 form the basis of the modeling. The Lander Street, West Boise, Meridian, Nampa, Caldwell, and Middleton phosphorus estimates are all based upon FLUX.

West Boise provides a good case example of FLUX modeling for a waste water treatment plant. For 1996, 13 total phosphorus measurements are available to characterize the effluent for the year. An initial estimation of loads without any adjustment shows that coefficients of variation are 0.060 or greater for the six methods. Figure 2, a graph of concentrations versus month, suggests that breaking the data into two groups would improve the fit of the model.

Figure 2. West Boise 1996 Effluent Total Phosphorus Concentrations



A stratification of the West Boise into two groups, split by August 1, 1996, yields a much better fit for the six FLUX methods of load estimation. After the stratification, Method 2, the flow weighted average, has an improved coefficient of variation of 0.048, and an error of +- 38 pounds for the annual load.

The smaller facilities did not have sufficient data available to run the FLUX software. For Star and Wilder, a single average total phosphorus concentration is applied to monthly average data to approximate the load from the two facilities. There are no phosphorus measurements available for Wilder during the 1990s, but the facility has a design similar to that of the Star WWTP. Thus, the average total phosphorus concentration from the Star plant was applied to the Wilder average flow data to roughly estimate the load from the facility. The Notus WWTP did not discharge during the standard irrigation season. The Notus facility typically discharges only twice per year for periods of time less than two weeks. The quantity of phosphorus generated by Notus in 1996 is estimated to be about 23 pounds, all discharged during the non-irrigation season.

Tributaries

The total phosphorus load for any tributary is based upon FLUX model results similar to those for treatment plants. In the case of tributaries, the complete USGS monitoring data provides the basis for creating a predictive model for total phosphorus concentration. Since tributaries do not have the kind of rapid operational and input changes that occur in treatment plants, the full record of data best characterizes the phosphorus loads from drains. The tributary modeling proceeded according to the same methods described for the treatment plants, using date and flow stratification as needed to provide the best fit to the measured data. Specific details of the method used for each tributary and associated coefficients of variation are available upon request, but are too numerous to list here.

Questions for Your Consideration

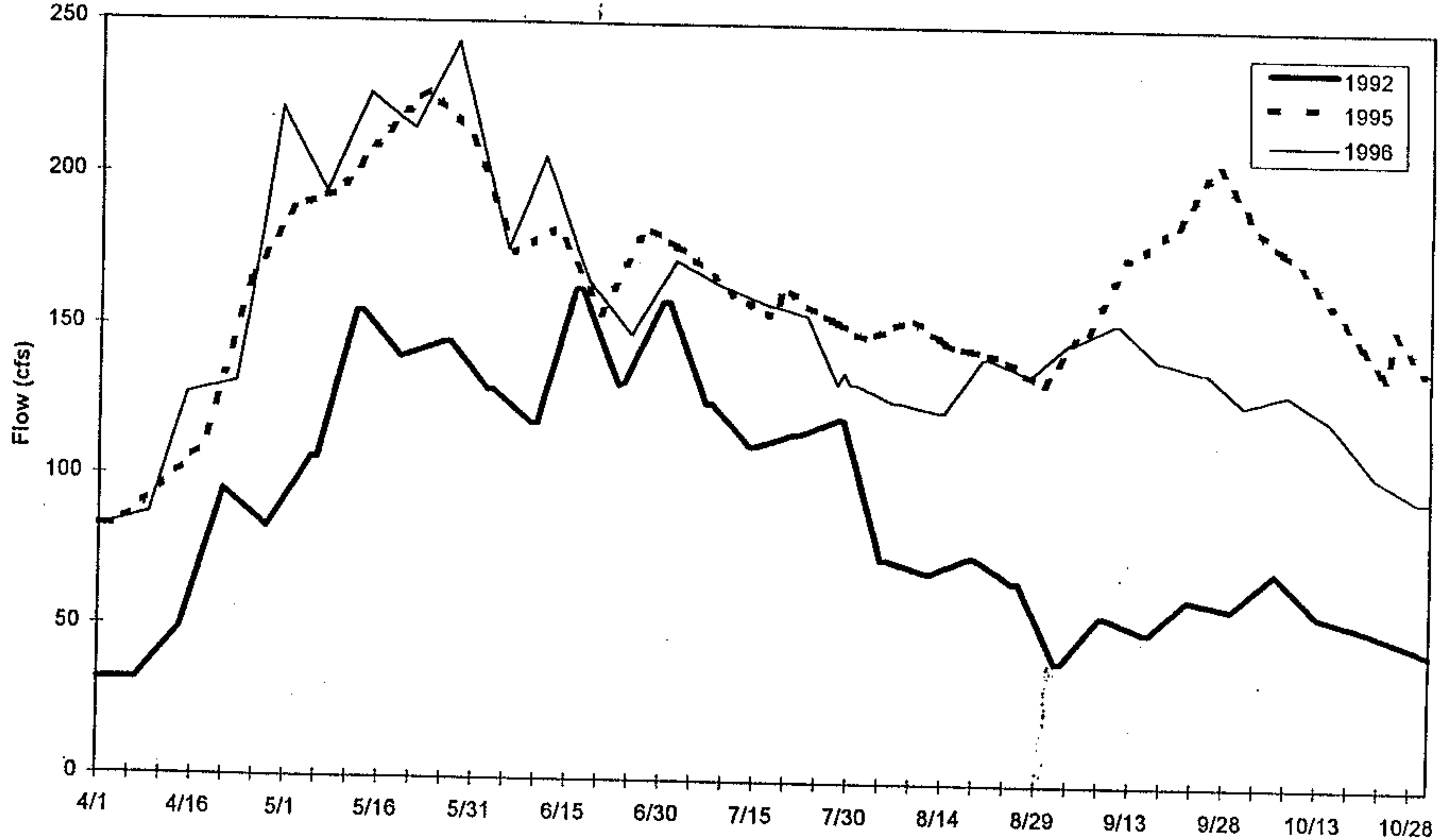
- Is 1996 an appropriate baseline year?
- Is a seasonal versus and annual approach the best choice for establishing total phosphorus no net increase loads?
- If a seasonal approach is selected, what is the appropriate date for the beginning of the season?
- What are appropriate strategies for assessing compliance with no net increase requirements?

References

Dodds, Walter K., and Val H. Smith, Managing Excess Chlorophyll Levels in the Clark Fork River with Nutrient Controls, Report for the Montana Department of Health and Environmental Sciences, April, 1995, p. 5.

Walker, William, Simplified Procedures for Eutrophication Assessment and Prediction: User Manual, U.S. Army Corps of Engineers Waterways Experiment Station, W-96-2, September, 1996.

Irrigation Season* Average Daily Flow in Mason Creek
Calendar Years 1992, 1995, and 1996



*Irrigation Season: April 1 - October 31

Figure 1.

d:\joy\Allmason.xls

JMA 5/15/98

APPENDIX K

City of Boise and Ada County Highway District Best Management Practices for Stormwater

Storm Water BMPs for Sediment Control

The following elements of the Ada County Highway District Management Plan address the reduction of sediment loads to the Boise River and its tributaries.

BMP No. ED1: Develop and implement a comprehensive public education program

The District participates in ongoing educational activities. Activities the District has participated in include: dissemination of brochures, storm drain stenciling, and Water Awareness Week activities.

BMP No. ED2: Develop educational program and technical guidance for design practices

The District is using the City's professional advisory group discussions to aid in the development of water quality design standards. The standards will be implemented through ACHD Development Policy. The District is currently assisting the City in the development of a storm water seminar scheduled for February 1999.

BMP No. ED6: Stencil Storm Drain Inlets

ACHD supports the City's stenciling program. In addition, ACHD is currently working on a new method of stenciling which entails stamping the stencil design into the concrete of new drain inlets. The stamping method will be done on a trial basis. If results of the trial are positive, the new method will be done on a regular basis.

BMP No. IE1: Program to reduce and eliminate illegal dumping

ACHD is currently working with Boise City in developing an Inspection and Investigation Manual. ACHD inspectors are being trained to investigate complaints involving illicit discharges and construction site sediment/erosion control problems.

BMP No. IE3: Implement comprehensive pollutant discharge control program for construction sites

ACHD Construction Division is currently working closely with Boise City to deal with construction site sediment/erosion control issues. ACHD insures sediment discharges are minimized during the road construction phase; Boise City assumes jurisdiction during the home building phase. Boise City has one full-time employee devoted to this effort. The District has four subdivision inspectors addressing this issue as part of their daily work.

BMP No. OM2: Require Operations and Maintenance plans for private development (post construction)

The District requires all private facilities, that are to be maintained by the District, to have Maintenance and Operations plans according to Section 8019.2 of the ACHD Development Policy Manual.

BMP No. OM3: Develop comprehensive maintenance plan for all public stormwater facilities

Currently, the Maintenance and Operations (M & O) Division follows a general plan of cleaning all facilities at least two times per year. In conjunction with this current effort, the District is working toward placing all storm drains and stormwater facilities in a GIS. At this time, stormwater monuments are being installed in all new and replaced drop inlets (DIs) in the county. The DIs are GPS'd and the unique monument number is recorded. Once this system is fully developed, the M & O Division will be able to determine problem areas and devise a comprehensive maintenance plan for the county.

BMP No. OM5: Improve street sweeping and strategies for de-icing roadways

The District has increased its street sweeper fleet to 14 in the last three years. The District is also working toward compliance with the PM10 standards.

BMP No. OM6: Program for proper storage of de-icing materials and research alternative "safe" products.

De-icing materials are stored in a covered, enclosed area. The District is also using magnesium chloride in place of sodium chloride for de-icing.

BMP No. REG1: Develop legal authority to prevent/eliminate improper disposal of pollutants to storm system

The legal authority has been developed through Boise City and civil action against offenders will be taken if warranted. ACHD staff are trained to implement the Boise City Storm Water Discharge Control Ordinance. The Boise City Storm Water Discharge Control Ordinance , Title 8, Chapter 15 — Boise's storm water ordinance "regulates or prohibits any discharges into streets or drainage facilities that are not composed entirely of storm water."

BMP No. REG2: Develop regulations requiring storm water facilities in significant source areas

ACHD and Boise City are working to identify significant source areas. Areas identified as significant source areas will be required to adhere to more stringent stormwater standards.

BMP No. REG3: Develop on-site detention standards for new development

The standards have been developed as part of ACHD's policy manual. The standards are being implemented on new developments and ACHD roadway projects.

CITY OF BOISE

INTER-DEPARTMENT
CORRESPONDENCE

Date: August 27, 1998

To: Erica Anderson Maguire

From: Joan Meitl

Subject: Storm Water Program BMPs for Sediment Control

The following elements of the Boise City Storm Water Management Plan, once implemented, will result in the reduction of sediment loads to the Boise River and its tributaries.

BMP No. ED1: Develop and Implement a Comprehensive Public Education Program

The City is implementing a comprehensive public education program to disseminate information about nonpoint pollution and source controls. This has been accomplished to date by the use of sewer bill inserts, brochures, a storm water video, storm drain stencilling, Water Awareness Week activities, and development of a school age education program.

BMP No. ED2: Develop Educational Program and Technical Guidance for Design Practices

In 1997, the City developed a Guidebook of Storm Water Best Management Practices which has been made available to the design and development community. Numerous presentations have also been made to professional organizations regarding the Storm Water Program and related activities. A storm water seminar targeted at the development community was held in February 1998 and a workshop is planned for February 1999.

BMP No. IE3: Implement a Comprehensive Pollutant Discharge Control Program for Construction Sites

In June 1998, Boise City hired a new staff person to develop a pollutant discharge control program for construction sites. He is actively working to educate the construction industry about water quality issues and to develop new requirements for erosion and sediment control on construction sites.

BMP No. OM2: Require O&M Plans for Private Storm Water Facilities in New Development

The City will enact a requirement for O&M Plans for private storm water facilities in new development through the design standards development process. See BMP No. REG3 below.

BMP No. OM3: Develop and Strengthen Current Maintenance Program for Public Storm Water Facilities

In the past two years, the City has conducted an inventory of all storm water facilities associated with City property. Operation and maintenance plans have been developed for these facilities and a schedule of regular maintenance has been initiated. Source controls are a key component of the plans.

BMP No. REG1: Develop and Strengthen Legal Authority to Prevent and Eliminate Improper Disposal of Pollutants

In 1994, Boise City enacted the Storm Water Management and Discharge Control Ordinance. The City has an ongoing complaint response program to assure compliance with this Ordinance.

BMP No. REG2: Review Regulations Requiring Storm Water Quality Treatment Facilities in Significant Source Areas

As part of BMP No. REG3 (below), the City is identifying and developing requirements for "significant source areas".

BMP No. REG3: Develop On-site Detention Standards for New Developments

Boise City continues to implement the on-site detention (ODI) Program, which requires that new development detain runoff on-site at pre-development levels. In April 1998, Public Works in conjunction with the Storm Water Public Advisory Group (PAG), initiated the process of developing design standards, including water quality requirements, for the ODI Program. The treatment standard that has been tentatively approved by the PAG is 80% removal of TSS for all new development.

BMP No. STR2: Determine Feasibility of Retrofitting Existing Flood Control Facilities

Existing foothills flood control ponds have been enlarged and new ponds have been constructed on Stuart Gulch and the East Fork of Crane Creek to contain higher sediment loads from the Boise Front in the aftermath of the 1996 Foothills fire.

APPENDIX L

Riparian Corridor Sediment Load Allocation

Riparian Corridor Sediment Load Allocation

DRAFT Technical Memorandum

Lower Boise River

Prepared for
State of Idaho

by
Idaho Division of Environmental Quality, Boise Regional Office
July 1, 1999

Lower Boise River Riparian Corridor Sediment Load Allocation

Total Acres in riparian corridor: 100,973

Rangeland, irrigated cropland (surface and sprinkler), and pasture account for 68% of the land use in the Lower Boise River riparian corridor (Table 1). Of the remaining 32%, 26% have natural or anthropogenic measures in place to significantly reduce or prevent the direct transport of sediment to the river. Furthermore, much of the sediment derived from these riparian land uses is delivered to the tributary or drain in which the land use lies and is ultimately accounted for in the load allocation for the respective tributary or drain. Table 2 lists the land uses that encompass this 26%.

The delivery coefficients shown in Table 1 for rangeland, irrigated cropland and pasture were derived using data from the NRCS Environmental Policy Integrated Climate (EPIC) model for an average year. (Appendix A).

Table 1. Major land uses in riparian corridor (68%)

Land Use	# of Acres	Delivery Coefficient (tons/acre/year)
Rangeland	34729	9.0×10^{-5}
Irrigated Cropland (sprinkler)	1836	.01
Irrigated Cropland (surface)	16520	.16
Pasture	15680	1.5×10^{-3}
	Total: 68765 acres 68% of land use in riparian corridor	

Table 2. Other land uses in the riparian corridor (26%)

Land Use	# of Acres	Delivery Coefficient (tons/acre/year)
Riparian Wetland	7320	na
Residential, farmstead	298	na
Residential, high density	3844	na
Residential, subdivision	5852	na
Residential, rural	2243	na
Commercial, industrial	3460	na
Public	912	na
Recreation	1647	na
Transport	371	na
Sewage Treatment	134	na
Tank Farm	20	na
	Total: 26101 acres 26% of land use in riparian corridor	

The land uses in Table 3 account for the remaining 6% of the land use in the riparian corridor. While this area may be delivering a minute amount of sediment to the river, it accounts for only 0.7% of the total land use in the Lower Boise River watershed. The DEQ does not feel that allocating a load to this 6% is feasible or necessary.

Table 3. Remaining land uses in the riparian corridor (6%)

Land Use	# of acres	Delivery Coefficient (tons/acre/year)
Water	1933	na
Barren	857	na
Canals	212	na
Nurseries/Orchards/Vineyards	101	na
Idle	999	na
Land in Transition	741	na
Feedlots/Stockyards	336	na
Abandon Agriculture	496	na
Other Agriculture	420	na
Unknown	12	na
	Total: 6107 acres 6% of land use in riparian corridor	

Based on these data, a typical sediment load for the Lower Boise River riparian corridor is 7.36 tons/day (Table 4). The 37% percent reduction called for in the TMDL is not applied to this load due to a variety of factors. The shallow groundwater in the riparian corridor is not conducive to growing low residue row crops such as beets and onions. For this reason, nearly all of the cropland in the corridor is occupied by high residue crops such as wheat and hay. The soils on which these types of crops grow exhibit very little sediment loss. More importantly, the USDA-NRCS's current maximum soil loss target for maintaining a productive field is 5 tons/acre/year. Based on the fact that high residue crops dominate the cropland in the corridor, and most of the fields are well below USDA-NRCS's soil loss target, implementing a 37% reduction for the cropland would be very difficult. Furthermore, the SCC has indicated that the riparian corridor is a low priority area for BMP implementation based on it's effective agricultural practices and the flat topography.

The Lower Boise River WAG is supportive of this decision.

Table 4. Sediment Load Allocation for the Boise River Riparian Corridor

Land Use	# of acres	Delivery Coefficient tons/acres/year	Load Allocation
Rangeland	34729	9.0×10^{-5}	3 tons/year
Irrigated Cropland (sprinkler)	1836	.01	18 tons/year
Irrigated Cropland (surface)	16520	.16	2643 tons/year
Pasture	15680	1.5×10^{-3}	24 tons/year
			2688/365 = 7.36 tons/day

Determining the number and location of sediment delivery points to the river via the riparian corridor is virtually impossible. Recognizing this fact, the load of 7.36 tons/day is divided into three portions and equally allocated at three locations along the corridor. Locations near Glenwood bridge, Middleton, and Parma have been chosen as sediment delivery points. These locations were chosen because they are equidistantly spaced along the river and they represent check points in the TMDL proper. The total suspended sediment mass balance spreadsheet (Figure 1) shows the specific river miles at which the sediment load is allocated. The flow component for the riparian corridor, which is used in the mass balance spreadsheet (Figure 1), is explained below.

Explanation of the flow component derivation, based on July 6, 1994 flow data.

- Flow Component:
  Acres in the Lower Boise River watershed = 839,479
  June 6, 1994 flow at Parma = 667 cfs

  $667 \text{ cfs} \div 839{,}479 \text{ acres} = 7.9\text{x}10^{-4} \text{ cfs/acre*}$

- 839,479 acres in basin

Rangeland:	34,729 acres
Irrigated Cropland (sprinkler):	1836 acres
Irrigated Cropland (surface):	16,520 acres
Pasture:	15,680 acres

	68,765 total acres

- 68,765 acres x $7.9\text{x}10^{-4}$ cfs/acre = **54.6 cfs** for the riparian corridor

*Assumptions:

1) Equal flow from every acre in the watershed. While this is likely not the case, a lack of data prevents us from making an exact estimation.
2) Consistent flow from Lucky Peak Reservoir.

<u>Summary</u>

The mass balance spreadsheet (Figure 1) shows that after allocating an additional 7.36 tons/day to the riparian corridor, the balanced load at Parma increases three tons/day to 53 tons/day. The maximum mixed concentration in the river increases to 30 mg/l at river miles 6.5 to 9.4, but does not change at Parma. This increase in load reduces the margin of safety at at Middleton from 87% to 85% and at Parma from to 41%, from 45%. The overall margin of safety, given the critical flow, remains high.

Appendix A. Riparian Corridor Delivery Coefficients.

The values generated using the NRCS Environmental Policy Integrated Climate (EPIC) are Soil Erosion Rates. These rates describe the susceptibility of a soil particle to detach and move to the perimeter of a field, but do not describe the actual delivery of soil to the river from the field. To characterize the movement of sediment using these rates they must be converted into delivery coefficients. Unfortunately, no data exist, nor has an explicit modeling technique been identified that allows for the conversion of these rates into sediment delivery coefficients. In this instance, a ratio of erodibility to transportability has been estimated to account for the lack of data. It has been estimated that 3% of the sediment eroded from each acre of soil per year in the riparian corridor is transported to the river via the riparian corridor. While there is no definitive method of validating this estimate, it is a reasonable assumption based on a variety of factors.

- Low residue row crops such as onions and beets do not grow well in the riparian corridor due to the shallow water table. Therefore, high residue crops such as wheat and hay dominate the cropland portion of the corridor. The soils on which these types of crops grow exhibit very little sediment loss, primarily due to extensive root systems and the sheer surface density of the crop itself.

- There is very little gradient in the majority of the riparian corridor. In areas such as these, rill and gully development are the primary mechanisms by which sediment is transported. However, it takes a large amount of precipitation over a short period of time to produce rill or gully erosion on low gradient, covered and stable soils. The climatic pattern in the Lower Boise River watershed is such that events of this nature are rare.

- The soil erosion rates were modeled using the highest (worst case scenario) erodibility factor (K) appropriate for the riparian soils, as derived from USDA soil surveys. The K factor, when integrated into the EPIC model, describes the erodibility of the soil based on the structural geology of the top few inches of soil stratum. In this instance, the erosion rates were modeled using a K factor of 0.49. The K factor typically ranges from 0.10 for highly stable soils to 0.60 for highly erodible soils. While unstable soils do exist in the riparian corridor, they do not typify the majority of the corridor. Therefore, the erosion rate that has been modeled is presumably higher than actual conditions.

- The EPIC model generates a value that characterizes the amount of sediment displaced from it's original position. It does not characterize sediment movement and hence does not account for the likelihood of re-deposition during movement, which is a critical element of sediment transport.

- The Boise Public Works storm water plan, which encompasses all riparian development (roads, subdivisions, etc.) in the City of Boise, outlines management plans that use BMPs to control riparian drainage and it's associated sediment load within urban/suburban developed areas. The majority of the urban/suburban riparian development that has or is occurring is within Boise city limits.

- Based on the estimation that 3% of the sediment eroded from each acre of soil per year in the riparian corridor is transported to the river, the load for the riparian corridor is 7.36 tons/day. The total sediment load for the watershed (point and non-point sources) including the riparian load is 172.92 tons/day (without 37% reduction, based on June 6, 1994 mass balance). These figures indicate the riparian corridor, which accounts for 11% of the land in the watershed, is contributing 4.2% of the total sediment load, which is a reasonable estimation.

Table 1. Erosion rates and estimated delivery coefficients for surface and sprinkler irrigated cropland, pasture and rangeland (erosion rates modeled using NRCS EPIC)

	Surface	Sprinkler	Pasture	Rangeland
Erosion Rate tons/acre/year (96 yr ave)	5.2	.38	.05	.003
Delivery Coefficient tons/acre/year at 3% of erosion rate	.16	.01	1.5×10^{-3}	9.0×10^{-5}