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MIDDLE SNAKE RIVER WATERSHED

Ecological Risk Assessment Planning and Problem Formulation

RISK ASSESSMENT FORUM
U. S. ENVIRONMENTAL PROTECTION AGENCY
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ACKNOWLEDGMENTS

This risk assessment was prepared by a diverse team representing organizations and agencies interested in management and protection of the biota of the Middle Snake River watershed. The risk assessment was sponsored by the U.S. Environmental Protection Agency's Office of Water and Office of Research and Development under a Risk Assessment Forum Technical Panel. Dr. Jeroen Gerritsen of Tetra Tech, Inc. provided technical assistance to the team. The conclusions and recommendations presented herein are those of the Middle Snake River Watershed Ecological Risk Assessment Team.

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The Snake River Watershed

The Snake River is the tenth longest river in the United States. Prior to the 1960s, it was the most important drainage in the Columbia River system for the production of native anadromous fishes, including salmon, trout, and sturgeon. The Snake River extends 1,667 kilometers from its origins in western Wyoming to its union with the Columbia River at Pasco, Washington. Its watershed encompasses an area of approximately 267,000 square kilometers (km^2) in Idaho, Oregon, Wyoming, Nevada, Utah, and Washington. The river reach of concern, hereafter referred to as the Mid-Snake River, spanning roughly 100 km, lies in the west-central Snake River Plain of southern Idaho (Figure 4). The contributing watershed includes 22,326 square km^2 of land below the Milner Dam and adjacent to the study reach. Beneath the Snake River Plain is the largest and most productive aquifer in the Northwest, which supplies most local municipal water systems

As a result of human activities spanning the past century, water quality and biological resource problems have developed in the Mid-Snake River and its tributaries. The rapid rate of human population growth projected for the southern Idaho region, as well as an increasing demand for energy, irrigation resources, springs, and dairy feedlots, place additional burdens on an ecosystem that already has been substantially changed by human activity during this century. This ecological risk assessment, one of five EPA case studies, was undertaken to address such concerns by analyzing the Mid-Snake River's stressors and resulting ecological effects and to stimulate broader public awareness and participation in decision-making for reducing ecological risks.

Historically, this portion of the Snake River has been valued as a source of water for irrigation, for the generation of hydroelectric power, and for the production of fish in commercial hatcheries. Water quality and quantity have historically supported native benthic and pelagic biota requiring cold, swiftly flowing water that is low in sediment, including migrating salmonids and other fish species, as well as invertebrates.

The demands on the water resources have transformed this once free-flowing river segment to one with multiple impoundments, flow diversions, and increased chemical and microbiological pollutant loadings. Physical changes include significant alterations to rapids and pool areas of the river. Resulting biological changes include loss of native macroinvertebrate species, an invasion and dominance of exotic species, an expansion of pollution-tolerant organisms, and excessive growth of macrophytes and algae. Reducing and mitigating impacts to the watershed cannot return the Mid-Snake River to its original state, but they can provide a better environment for the natural heritage resources which have

Management Goals

Several agencies and organizations have been identified as active in decision making and management activities for the Mid-Snake River—including federal state, county, and private organizations, academic researchers, and interested citizens. The perspective with which local, state, and federal planning agencies, scientists, and the general public view this watershed is changing as the community becomes more aware of the impacts of the activities in the watershed on the ecology of the river.

This risk assessment was designed with several long term goals in mind:

- Develop an ecosystem perspective for environmental planning that can be used in other river basins throughout the region.
- Increase the knowledge of the and function of the Mid-Snake River ecosystem.
- Expand the scope of our simulation methods to include more complex compartments in the ecosystem.

A series of management subgoals, were developed for this risk assessment in order to move the process toward attainment of the long term goals. The general management goals for this project include several specific objectives:

- Attainment of State Water Quality Standards
- Designation as a protected area
- Sustained economic activity in the region
- Water for hydropower
- Water for irrigation needs
- Conservation of wildlife and game species
- Recovery of endangered species
- Recreational uses

The short-term objectives for this project are associated with, and largely driven by, the specific requirements of state and federal environmental legislation and the development of comprehensive land-use plans at the county level:

- The establishment of total maximum daily loadings for water quality limited segments of the river.
- The review of permits for licensing existing and proposed hydroelectric projects
- The evaluation of management plans for identification and control of nonpoint source pollution
- Assisting in the writing of permits for National Pollution Discharge Elimination System

Assessment Endpoints

Three assessment endpoints were selected for the Mid-Snake River risk analysis:

- Reproduction and recruitment of cold water fish, such as trout and sturgeon.
- Reproduction and recruitment of threatened and endangered macroinvertebrates.
- Extent of open water free from macrophytes.

The three assessment endpoints are related to several of the management subgoals. Coldwater fish, in addition to being valuable sport fish, are top predators of the river ecosystem. In addition to the restoration of invertebrate and fish species, the reduction in vascular macrophyte biomass is essential to assure the restoration of cold water biota.

Conceptual Model

Conceptual model development requires an evaluation of the ecological resources of value (assessment endpoints), the stressors affecting them, and the interactive relationships between resources and stressor effects. The conceptual model for this ecological risk assessment of the Mid-Snake River watershed incorporates the descriptions of the ecological components, stressors, ecological effects, and exposure scenarios to assist in developing hypotheses regarding how each stressor may affect the watershed.

Prior to the development of hydropower on the Snake River, the Mid-Snake was host to a variety of anadromous fish species extending up to Shoshone Falls, which acted as a natural barrier for Snake River fish and fauna. The anadromous salmonids were first severely impacted by the construction of Swan Falls Dam. Several major hydroelectric events severely impaired, and finally terminated, lamprey, salmon and steelhead migration into the Mid-Snake area. The Snake River runs of fall chinook salmon and spring/summer chinook salmon were listed as endangered in 1994. According to the US Fish and Wildlife Service draft Recovery Plan, remedial actions to protect fish and wildlife endangered snails in the Mid-Snake may also benefit the recovery of these fish stocks in the lower Columbia River.

The historic diversity of molluscs in the Snake River won exceptionally high for western North America. Most cold-water native molluscs now survive only in limited spring fed areas in the Mid-Snake River. Several Snake River invertebrates are listed as threatened, endangered, extinct or candidate. Several of these species—including the Banbury Springs limpet, Snake River *Physa*, the Bliss Rapids snail, and the Idaho Spring snail—are found nowhere else outside of the Mid-Snake River.

Currently, vascular macrophytes cover up to 40% of the benthic habitat in some reaches of the Mid-Snake. The dominant species, *Ceratophyllum demersum* and *Potamogeton pectinatus* 1979 are generally associated with well buffered, nutrient rich waters. Blooms of planktonic, periphytic, and epiphytic algae, occur continuously during the spring and summer.

Three primary stressors have been identified for this risk assessment: flow alteration, sediment loading, and nutrient loading. Although there are many other physical, chemical, and biological stressors in the watershed, the hypothesis is that their importance will be minimized or eliminated if the key primary stressors are removed. Sources of stressors are directly and indirectly related to land use activities within the contributing watershed and from hydrologic modifications to the river segment of concern. Each of the primary stressors has a profound impact on the assessment endpoint resources (fish, invertebrates, and macrophytes).

Flow Alteration

Flow alterations in the Mid-Snake River result from multiple impoundments and flow modifications in the mainstem, tributaries, and ground-water outfalls. Consequently numerous hydroelectric facilities are located in this area. Flow alteration, resulting in both periodic increases and/or decreases in the usual supply of fresh water to a river, include diversions, withdrawals, and impoundments (USEPA, 1993). The results of flow alterations, such as those on the Mid-Snake River, contribute to many sources of nonpoint pollution, including:

- Changes in the timing and quantity of freshwater inputs downstream;
- Reduced downstream flushing;
- Sediment deposition—siltation of gravel bars and riffle complexes;
- Erosion of the streambed and scouring in tailwater reaches;
- Increased deposition in areas of low water velocity resulting in formation of vascular macrophyte beds and loss of fish spawning habitat;
- Increased downstream temperature;
- Reduced downstream dissolved oxygen; and
- Velocity changes.

Since there is considerable competition among the various users for water withdrawal rights, the ecological integrity of the Mid-Snake River ecosystem is severely stressed by reductions in flow. This is a particularly acute problem in the spring and summer months because of irrigation diversions which remove a considerable volume of water from the Mid-Snake River.

The dynamics of flow influences the process of sediment suspension and deposition. Altered flows change the pattern of sediment scouring and deposition by reducing downstream flushing and increase the siltation of gravel bars and riffle complexes. Clear water released from dams results in increased erosion of the riverbed and bank scouring occurs below dams, particularly in the littoral shoreline areas. These habitats are most often altered in ways that are not compatible with the survival of benthic communities.

Sediment Loading

Sediment has direct ecological effects on macroinvertebrates by blanketing important habitat and smothering species that depend upon aerobic sediments. Fine sediments may clog the gills or feeding apparatus of species adapted for living in coarser sediments and is not functional as a spawning substrate for most species. Sediment deposition may promote vascular macrophyte growth, alter the underlying sediments, and make them unsuitable for indigenous macroinvertebrates. Sediment in suspension may reduce light, coat vegetation, alter food resources for filter feeding benthic invertebrates, clog gills. In addition, sediment deposition may smother important spawning habitat, and adversely affect the abundance of food resources (benthic invertebrates).

Nutrient Loading

Nitrogen and phosphorus, present in inorganic forms, provide a fundamental source of nutrients for the growth of algae and vascular macrophytes. Nitrogen contributions to the Mid-Snake River include nitrates in spring flows, limited instances of nitrogen fixation by blue-green algae, ammonia and nitrates in irrigation returns; animal wastes from feedlots and hatcheries; and municipal and industrial point-source discharges. The phosphorus mines and generally phosphorus-rich rock formations in southeastern Idaho are a source of phosphorus for the Snake River. Increased productivity in the stream results in some decrease of oxygen concentrations in pools within the mainstem.

Analysis Plan

For this risk assessment, the focus will be on water quality, including temperature, dissolved oxygen, nutrients, coliform bacteria, and ammonia toxicity. Idaho's water quality standards will be used as measurement endpoints.

The ecological risk assessment methodology will be based on a mass balance water quality model. Elements of risk will be derived from uncertainty and variability in driving forces and from uncertainty in the mass balance model. The water quality model developed by Yearsley (1991), uses material and energy flows, and employs standard kinetics to simulate temperature, dissolved oxygen, nitrogen, phosphorus, and primary productivity for time scales of hours to decades, vertical length scales of 1 to 10 meters and horizontal length scales of hundreds of meters to hundreds of kilometers. The methodology will be used to develop measures of the risk of exceeding the state's water quality standards before and after source control or mitigation. The probability densities are estimated by Monte Carlo simulation, using variability and determined from available data. Model uncertainty will be determined by comparing simulation results with measurements obtained in comprehensive field studies.

INTRODUCTION

The Snake River is the tenth longest river in the United States, extending 1,667 kilometers from its origins in Western Wyoming to its union with the Columbia River at Pasco, Washington (Figure 1). Along the way, it undergoes an elevation drop of about 2,895 meters. Its watershed encompasses an area of approximately 267,000 square kilometers (km^2) in the States of Idaho, Oregon, Wyoming, Nevada, Utah, and Washington. Before the 1960s, the Snake River was the most important drainage in the Columbia River system for the production of anadromous fishes.

The river reach of concern, hereafter referred to as the Mid-Snake River, spanning roughly 100 km, lies in the west-central Snake River Plain of southern Idaho. This reach was selected by the local counties and the state as the most severely degraded stretch of the Snake River in Idaho. The upper end was defined by Milner Dam. Since, almost the entire flow of the Snake River is diverted at this point it seemed like a reasonable point to characterize the river system. The downstream point is a natural change in the river system, where flow direction changes from a northly direction to a westerly direction.

The contributing watershed includes 22,326 square km (Figure 2) of land below the Milner Dam and adjacent to the study reach. As a result of human activities spanning the past century, water quality and biological resource problems have developed in the Mid-Snake River and its tributaries. The demands on the water resources have transformed this once free-flowing river segment to one with multiple impoundments, flow diversions, and increased chemical and microbiological pollutant loadings. Physical changes include significant alterations to rapids and pool areas of the river. Resulting biological changes include loss of native macroinvertebrate species, an invasion and dominance of exotic species, an expansion of pollution-tolerant organisms, and excessive growth of macrophytes and algae.

The rapid rate of human population growth projected for the south Idaho region, as well as an increasing demand for energy, irrigation resources, springs, and dairy feedlots, will place additional burdens on an ecosystem that already has been substantially changed by human activity during this century.

This ecological risk assessment was undertaken to address such concerns by analyzing the Mid-Snake River's stressors and resulting ecological effects and to stimulate broader public awareness and participation in decision-making for reducing ecological risks.

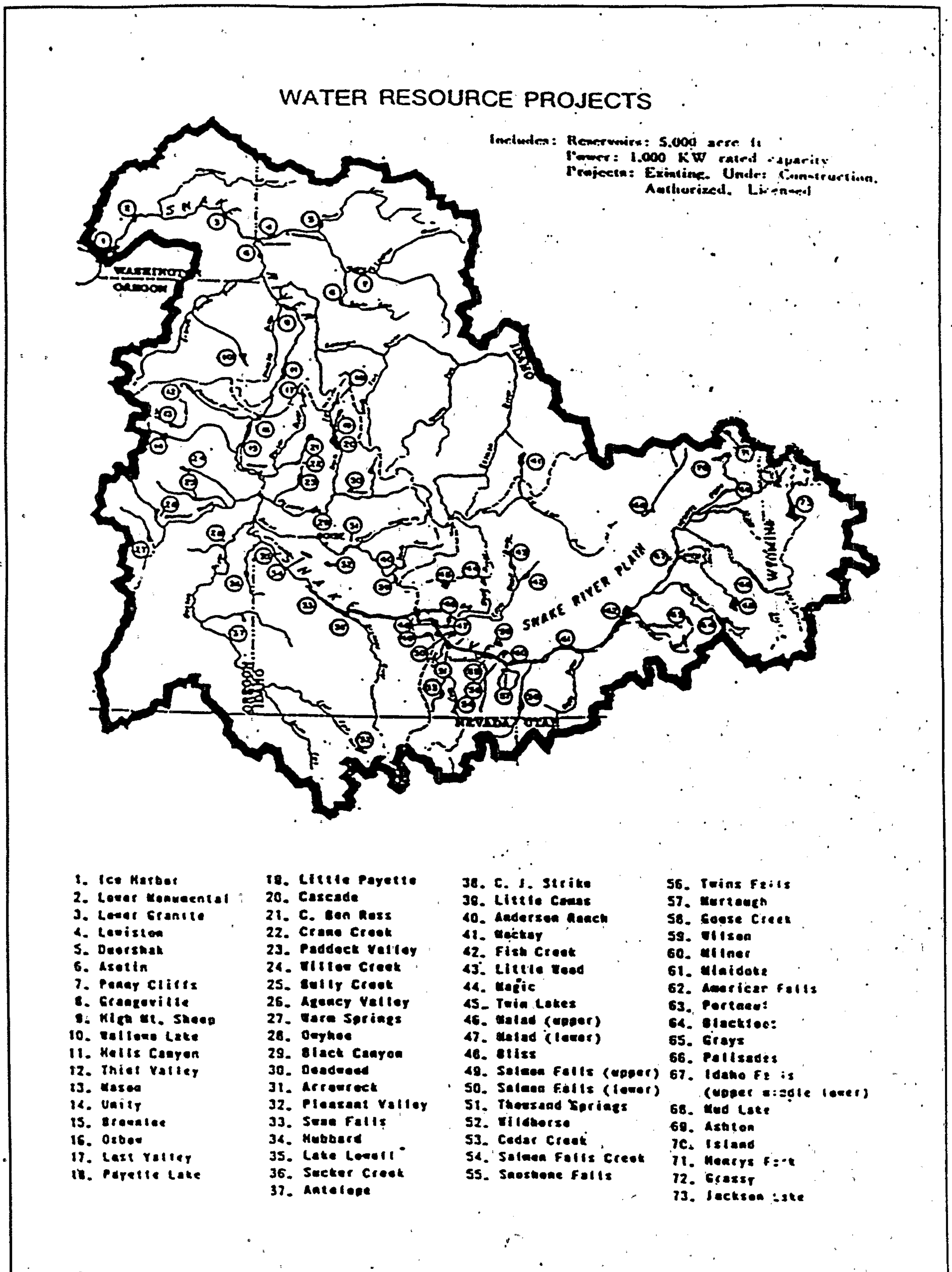

Figure 1. Water Quality Control and Management of the Snake River Basin: 1968 (reference -).

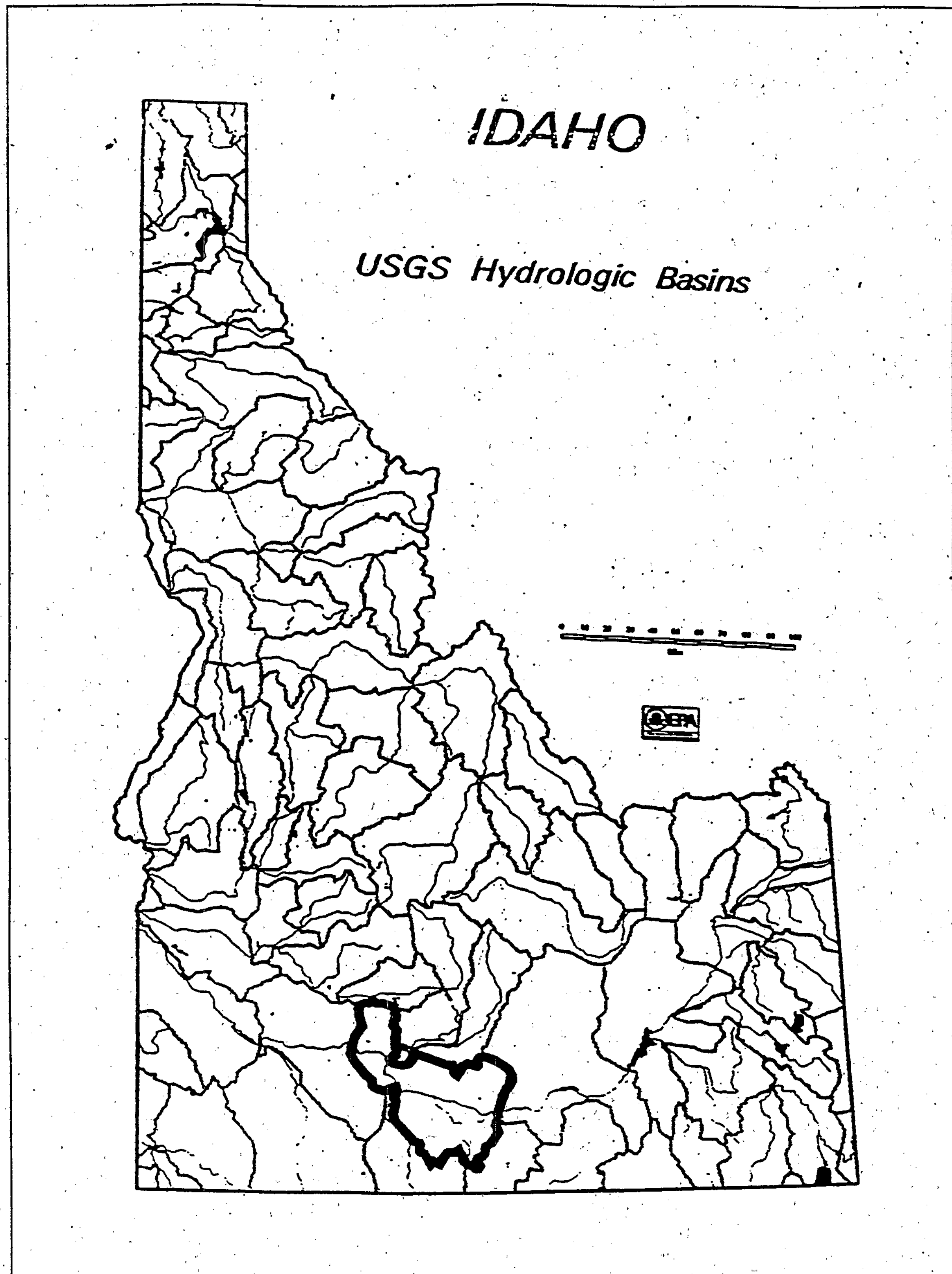

Figure 2. Mid-Snake River Basin showing the outline of the U.S. Geological Survey Hydrologic Unit for the Mid-Snake River Watershed.

1.0 PLANNING

The ecological changes in this watershed have been observed by local, state, and federal agencies, by academic researchers, by private organizations and businesses, recreational users, and by individuals concerned about the loss of a species-rich lotic environment, an important cold water fishery, and general water quality degradation in the Mid-Snake River. The perspective with which local, state, and federal planning agencies, scientists, and the general public view this watershed is changing as the community becomes more aware of the impacts of the activities in the watershed on the ecology of the river.

A number of specific short term objectives and long term goals have been identified for the purpose of designing the watershed ecological risk assessment. The assessment was also designed to ensure that assumptions, methodologies, and conclusions are scientifically valid. This section describes the risk management team, regulatory, and non-regulatory activities that are currently underway in this watershed, as well as management goals and objectives.

1.1 Public Private And Governmental Groups Active in the Mid-snake River Watershed

The development of a comprehensive watershed management plan involves close coordination of government, public, and private interests. Several working groups have been formed to address both regulatory and nonregulatory issues. The agencies and organizations which have been identified as active in decision making and management activities for the Mid-Snake River include federal state, county, and private organizations, academic researchers, and interested citizens. The complete list of active interests are given in Appendix A.

1.2 Planning Process

During preliminary development of the watershed ecological risk assessment for the Mid-Snake River, a variety of programs were undertaken to identify those interested in the area and to help identify pivotal considerations and ecological conditions needing protection in the watershed. A number of planning efforts have been initiated by county officials (Mid-Snake River Planning Group)and state agencies. Most of the planning efforts are directed toward restoration of the cold water biota and a reduction in aquatic plant biomass in the Mid-Snake River. Details of these activities are described in Appendix B.

Since 1969, several programs have been implemented to improve water quality in the Snake River Basin. The activities have included the advancement of best available technology at the municipal sewage treatment plant, regulation of waste handling at cattle feedlots and food processing industries, and the initiation of best management practices on agricultural land through both state and federal programs. Important federal, state and county regulations affecting the Mid-Snake River watershed are discussed in Appendix B.

1.3 Management Concerns And Goals For The Ecological Risk Assessment

In addition, to advancing the science of risk analysis, this assessment is also undertaken to ensure that the public and special interest users, government agencies, and scientists understand the problems and that they develop a sense of partnership in reaching solutions for the recovery and protection of the Mid-Snake River ecosystem. Too often, when such groups act in isolation, the problems remain unresolved and each group becomes entrenched in its own rhetoric and territoriality. Such a consensus-building method of reaching shared solutions is inherently slow but fundamentally democratic. Recognizing deadlines, limited resources, and the continued decline of the habitat it is important that progress be apparent. Therefore, the immediate plan calls for meeting the short term goals, as well as holding periodic workshops to provide a forum for reaching some resolution of long term goals.

The short-term goals for this watershed are associated with, and largely driven by, the specific requirements of state and federal environmental legislation and the development of comprehensive land-use plans at the county level. The reduction of aquatic macrophytes which interfere with recreation (boating and fishing is the goal of the people in the watershed.

The short-term objectives for this watershed are:

- The establishment of total maximum daily loadings for water quality limited segments of the river
- The review of permits for licensing existing and proposed hydroelectric projects
- The evaluation of management plans for identification and control of nonpoint source pollution
- Assisting in the writing of permits for National Pollution Discharge

The general management goals for this watershed include several specific objectives: 1) attainment of State Water Quality Standards (described in Appendix), 2) designation as a protected area, 3) sustained economic activity in the region, 4) water for hydropower needs, 5) water for irrigation, 6) conservation of wildlife and game species, 7) recovery of endangered species, and 8) recreation. These managment goals and objectives are also determined by the state of our knowledge of the ecosystem and our ability to develop simulation models for the flow of energy, materials, and information between ecosystem compartments. At present we are able to apply the methodology to a limited part of the ecosystem only.

The long-term goals for the risk analysis are to 1) develop an ecosystem perspective for environmental planning that can be used in other river basins throughout the region, 2)increase the knowledge of the structure and function of the Mid-Snake River ecosystem, and 3)expand the scope of our simulation methods to include more complex compartments in the ecosystem.

1.4 Scope, Complexity, And Focus of The Ecological Risk Assessment

The approach used to understand the interaction of sources, stressors, and resources on the Mid-Snake River includes (1) field studies and experiments to increase our understanding of the Mid-Snake River ecosystem, (2) characterization of ecological risk using mathematical modeling methods, and (3) development of comprehensive management plans through the cooperative efforts of local, state, and federal agencies, academic researchers, and an informed public. These measures alone cannot return the Mid-Snake River to its original state, but they can provide a better environment for the natural heritage resources which have survived. Furthermore, if this approach is successful, the Snake River can provide an example for environmental stewardship in other river basins.

Problem formulation for watershed-level risk assessments includes characterization of the watershed and description of the stressors, ecological resources potentially at risk, and the array of ecological effects. A critical component of the problem formulation is the identification of policy goals, societal and natural resource values, assessment endpoints, and measures of exposure and effect. These are linked in a manner that supports evaluation of the watershed's susceptibility to impacts, as well as the development of a conceptual model of stressors and their effects with hypotheses that can be evaluated and adjusted after the implementation of solution strategies. In the case of the Mid-Snake River, the qualitative relationships between predominant stressors and their ecological effects were known before initiation of this study and a variety of measures to counteract or alleviate their ecological effects were in progress. Development of the problem formulation was substantially aided by consolidating and reordering existing data from a risk assessment perspective.

The focus of this ecological risk assessment is to define the interactions and interrelationships between four principal stressors and their ecological effects. The stressors are:

- Physical stressor - loss and alteration of the lotic habitat
- Physical stressor - flow alteration (volume and rate)
- Physical stressor - sediment loading
- Chemical stressor - nutrient loading

The remainder of the problem formulation discusses linkages among these stressors, ecological effects of these stressors, and the rationale for assessment and measures that will be analyzed to provide direction for management activities in the watershed.

2.0 ASSESSMENT OF AVAILABLE INFORMATION

This section describes the physical, chemical, and biological characteristics of the Mid-Snake River, including its hydrology and uses of the resources found within the watershed. A discussion of ecological effects observed in the watershed and known or potential stressors that may be related to those effects is also included in this section.

Throughout 1992, 1993, and 1994, Idaho State University and the University of Idaho have been conducting field surveys and in-stream testing to describe the present physical, chemical, and biological condition of the Mid-Snake River. These studies are targeting previously identified stressors to quantify their impacts on the river.

2.1 Characterization of Ecosystem at Risk

The Mid-Snake River as discussed in this study extends from Milner Dam (Rkm 1,028) to King Hill (Rkm 877.6). Figure 3 shows a schematic diagram of the Mid-Snake River, including the locations of all dams, tributaries, inflows, and water withdrawals.

2.1.1 Demographics

The geographic boundaries of the study area includes five Idaho counties (Twin Falls, Jerome, Gooding, Owyhee, and Elmore). This area is commonly referred to as the Magic Valley. About 136,831 people (85 percent of the population of the State of Idaho) live along the Snake River through the southern portion of the state. The five largest municipalities in the Mid-Snake study area are Twin Falls (27,951), Burley (8,984), Jerome (6,529), Rupert (5,455) and Hailey (3,687) (Figure 4). The remaining population (42.1 %) lives in unincorporated areas.

2.1.2 Land Use

Early settlers used water from the Snake River tributaries for irrigation. In the summer of 1903, the Twin falls south side Land and Water Company tract was opened to farmers (IDEQ, NMP, 1994) for irrigation of their crops. The Twin Falls North Side Land and Water Company was granted permission to construct canal systems under the provisions of the Federal Carey Act in 1907.

Today, agriculture and grazing are the predominant land uses along the Mid-Snake River (Figure 5). Irrigated crop production is made possible by the canal system originating at Milner Dam. Hay, grain, potatoes, beans, and sugar beets are the principal crops produced on the irrigated croplands, while wheat is the major dryland crop. Forest and urban land make up less than 7% of the total land use. About 26 percent of the land is privately owned, 70 percent is federal land, and the remaining 4 percent is state land.

Idaho is one of the primary rainbow trout producers in the U.S. The trout farms along the Mid-Snake River between the cities of Twin Falls and Hagerman produce 70-80 percent of the commercial trout in the United States. Primary and secondary recreation in the area includes fishing, boating, and swimming in some limited areas.

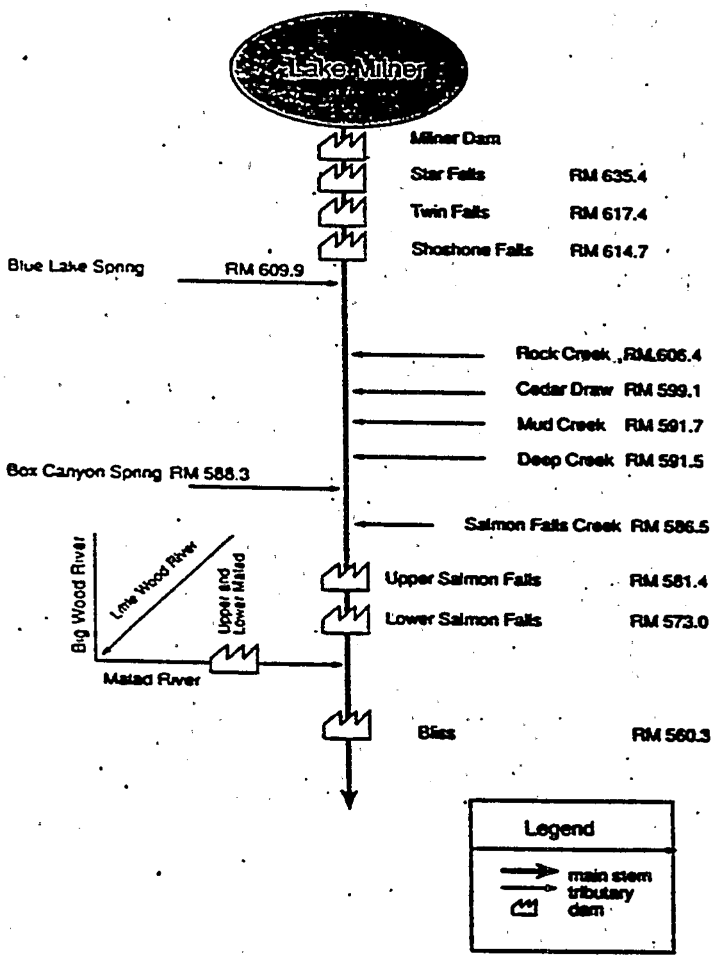

Figure 3. Schematic Diagram of the Middle Snake River.

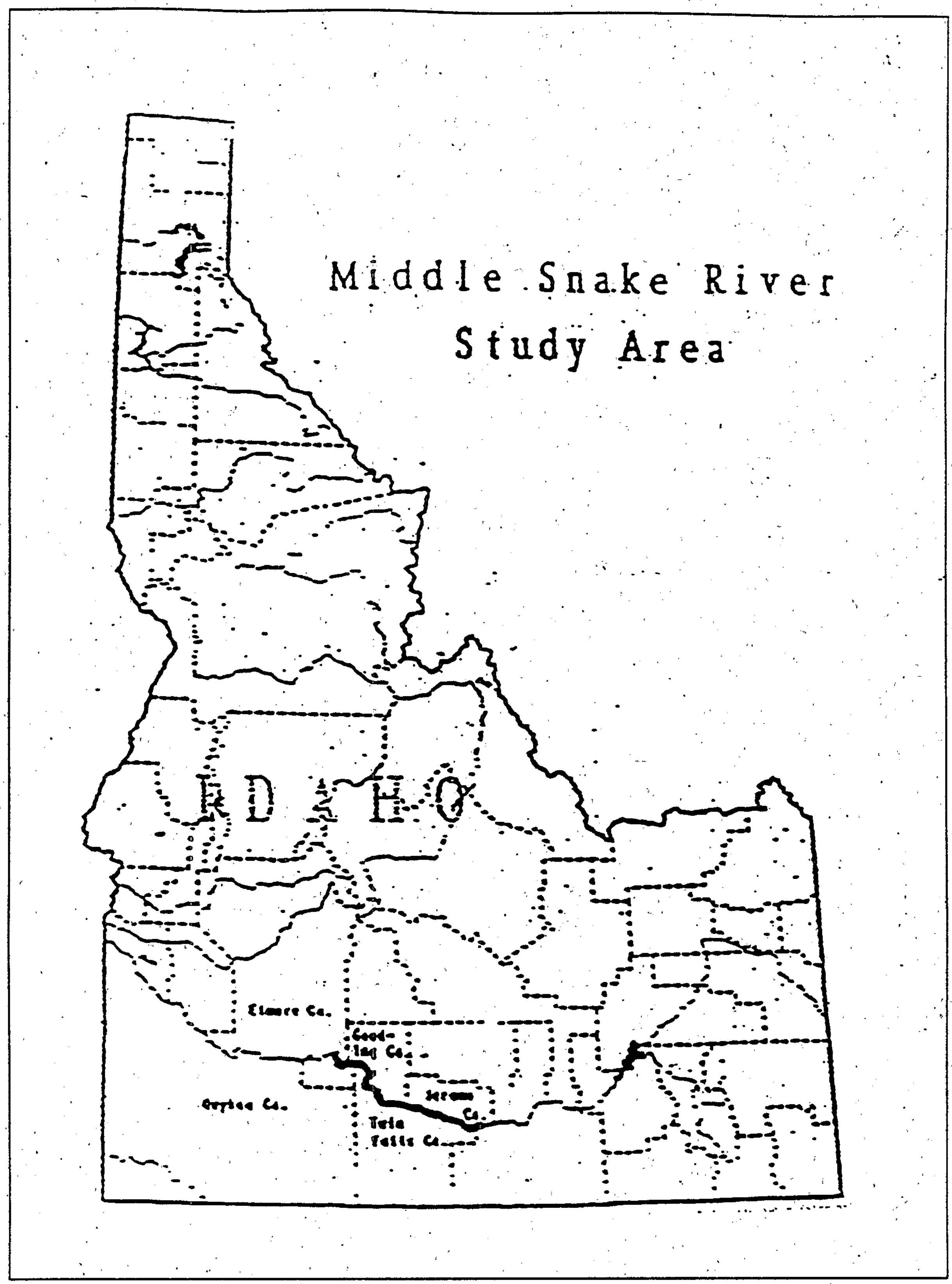

Figure 4. Map of Idaho showing the five counties surrounding the Middle Snake River study area (highlighted).

2.1.3 Meteorology

The climate of the region is semiarid, characterized by low annual rainfall, moderately hot summers and cold winters. Mean air temperatures for the period 1951-73 at Twin Falls, Idaho (Rkm 982) were -1.4°C for January and 22.6°C for July, respectively. In the summer, air temperatures in the Snake River canyon in the Mid-Snake segment are commonly in excess of 38°C. Annual precipitation averages 26.67 cm ± 13.3 cm. Precipitation is fairly evenly distributed throughout the year, except for July, August, and September when mean monthly rainfall is .635 cm, 1.067 cm, and 1.397 cm, respectively. Since 1988, the area has experienced 6 years of low rainfall resulting in drought conditions.

2.1.4 Geology

The Snake River Plain comprises approximately 41,000 square kilometers of the Snake River Basin in southern Idaho. The Snake River Plain (Kjelstrom, 1992) is subdivided into two geographic units, the eastern plain and the western plain. The boundary between eastern and western plains is near King Hill, Idaho (Snake Rkm 877.6). The Mid-Snake River segment (Rkm 1028 to Rkm 923) lies entirely within the eastern unit of the Snake River Plain..

The Snake River Canyon was scoured by overflow from the Lake Bonneville during the Pleistoene approximately 15,000 years ago. The flood waters deposited sand bars and gravel with boulders of over 3 meters in diameter. Many rapids and waterfalls are formed by these boulders. Four major waterfalls occur in the Mid-Snake reach over basalt ledges: 1) Shoshone Falls at 65 meters, 2) Twin Falls at 130 meters , 3) Star Falls at 36 meters and Auger Falls, a cascade which drops 55 meters. The Snake River then enters a deep (20-90 m) canyon cut through lava and overlying sedimentary deposits and continues for 151 km to King Hill. The geologic units include pleistocene and older basaltic lava flows, pillow lavas (formed by lava flowing into water) alluvial deposits, and lake deposits from ancient lakes.

Downstream of Twin Falls, Idaho, the Snake River canyon widens into small areas of bottom land and terraces. The largest of these areas is the Hagerman Valley, approximately 10 kilometers long and from 2 to 6 kilometers in width.

2.1.5 Hydrology

The Mid-Snake River is a managed system. The hydrology of this system is both the problem and potential solution to biological changes which have evolved since it was a large lake. The hydrologic units of the Mid-Snake River study area are shown in Figure 2. Water resources in the Mid-Snake include precipitation, flow below Milner Dam, tributaries within the reach, ground water flow and irrigation return flows.

The upstream boundary of the Mid-Snake is at Milner Dam (Rkm 1,028) where until recently the entire river was diverted for agricultural use during the irrigation season (April to October). In 1992, an operating license issued by the Federal Energy Regulatory Commission (FERC) to Idaho Power required that Milner Reservoir be kept full and a target flow of 6 cubic meters per second (cms) be released, if available. Long term average annual flows at Milner, just downstream from the diversion and prior to the issuance of the FERC license, were 97 cubic meters second. The Snake River above

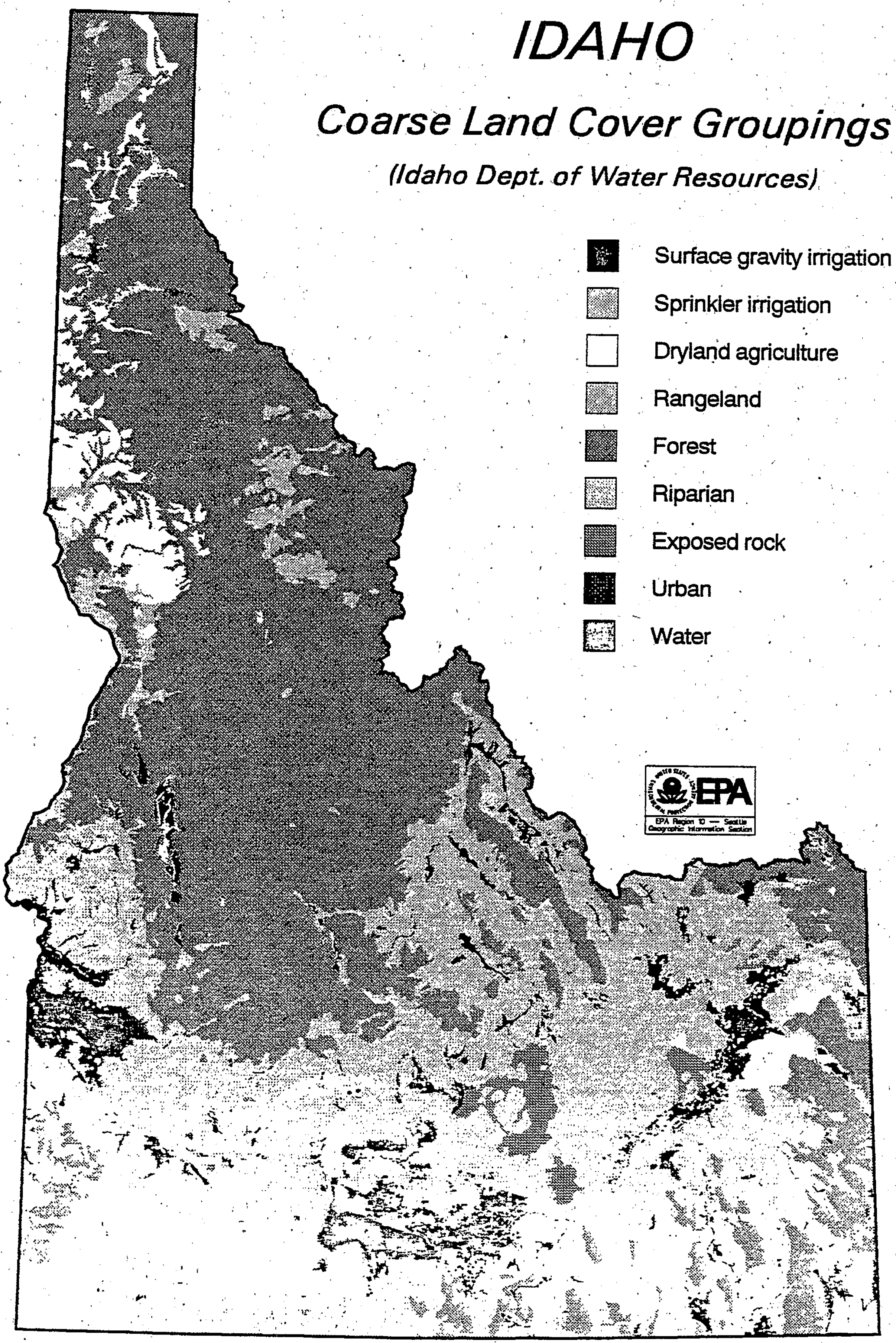

Figure 5. Land Management on the Snake River, Idaho.

Milner has an average annual flow of about $6x10^9$ m^3/year. Below Milner diversions, however, the average flow is $3x10^9$ m^3 per year, ranging from several million to $0.6x10^9$ m^3/year. In drought years, the flow at Milner is comprised almost entirely of withdrawal from American Falls Reservoir (about 8.5 m^3/sec). With some gain from ground water and irrigation returns, the flows at Milner range from 11.3m^3/sec to 25.5m^3/sec. When Lake Walcott and Milner Reservoir are being filled or when diversions begin, flows passing Milner are negligible (IDEQ NNM 1994). Flows at Milner are regulated by climate (droughts) and irrigation withdrawals.

Downstream from Milner, flows increase substantially due to ground water discharge. The eastern plain is underlain by a thick sequence of volcanic rocks that store and yield large volumes of water, comprising the largest and most productive aquifer in the Northwest. The Snake River incises the Snake River Plain Aquifer just upstream of Twin Falls, near Kimberly. Greater than 80 percent of the aquifer emerges as spring water in the Thousand Springs area breaking through hundreds of seams or cracks in the basalt layers of the canyon walls (Travis and Waite, 1964). Mundorff et al. (1964) found that the total gain from the aquifer to the Snake River between Milner Dam and King Hill about two thirds of the discharge measured at the U.S. Geological Survey gage at King Hill. During the irrigation season when most of the river is diverted, the springs are the primary contribution to flow.

Water budget analysis for the entire Snake Plain has been described by Kjelstrom (1992). Kjelstrom (1992) estimates that in water year 1980 ground water contributed 146 cubic meters second of flow to the Mid-Snake River segment. This represents more than 50% of the average annual flow at Lower Salmon Falls. Kjelstrom (1992) reports, however, that ground water discharge to the Snake River has varied as recharge conditions have changed. From 1902 to the early 1950's, ground water discharge to the Mid-Snake River segment increased due to recharge from flood irrigation on the north side of the Snake River.

In the 1950's the estimated average annual ground water flow to the Mid-Snake exceeded an estimated 190 cubic meters per second. Since that time flows have declined due to drought conditions in the basin and increases in ground water pumpage from the Snake plain aquifer (Kjelstrom, 1992).

2.1.6 Fish

Prior to the development of hydropower on the Snake River, the Mid-Snake was host to a variety of anadromous fish species extending up to Shoshone Falls. Shoshone Falls acted as a natural barrier for Snake River fish and fauna. There were approximately 24 native fishes below Shoshone Falls (Rkm 984) in the subbasin and 14 above the falls (Appendix C). Runs of fall and summer chinook salmon (*O. tschawytscha*), steelhead trout (*O. mykiss*), and schools of pacific lamprey (*Lampetra tridentatus)* migrated upriver as far as Shoshone Falls each year. The anadromous salmonids were first severely impacted by the construction of Swan Falls Dam (RKm 736.9. The final major hydroelectric events resulting in the termination of migrating fishery stocks were the sequential closures of the Bliss Dam (RKm 902.8; 1949), C. J. Strike Dam (Rkm 792.1; 1952), and ultimately the Hell's Canyon Projects. The completion of these facilities terminated lamprey, salmon and steelhead migration into the Mid-Snake area. (Smith 1978, Bowler 1992). The Snake River runs of fall chinook salmon and spring/summer chinook salmon were listed as endangered USFWS, 1995. According to the US Fish and Wildlife Service draft Recovery Plan (1994), it is hoped that remedial actions to protect fish and wildlife endangered snails in the Mid-Snake may also benefit the recovery of these fish stocks in the lower Columbia River.

The large (> 68 kg) white sturgeon (*Acipenser transmontanus*) which is distinct from sea-run stock found in the lower Columbia River also was extremely abundant prior to dam construction. The race of white sturgeon is now confined to tailwater reaches behind the many large hydroelectric dams. The Shoshone sculpin (*cottus greenei*) and white sturgeon are federal candidate species for listing and Idaho state species of special concern, respectively.

The majority of the remaining fish in the Mid-Snake are impoundment or eutrophic tolerant species, such as some catostomids (suckers), northern squawfish (*Ptychocheilus oregonensis*), the non-native European carp, and various other cyprinids (see Appendix C).

2.1.7 Invertebrates

The historic diversity for native molluscs in the river was high at 42 species including 27 species of snails in seven families and 15 species of clams in 3 families (USFS Draft Recovery Plan). Most cold water natives only survive in limited spring-fed areas in the Mid-Snake River. The preferred habitat for cold water biota is temperatures less than 17° C with minimal sediment in free-flowing water. Research by Frest & Johannes 19.. indicates that cold water invertebrates were most likely to be found adjacent to rapids, near spring-influenced sites or near the mouth of major tributaries.

The following species are listed under the Endangered Species Preservation Act as threatened, endangered, extinct or candidate:

Threatened:

(1) the Bliss Rapids snail, *Taylorconcha serponticola* (Hershler, et al., 1994)

(2) the Utah valvata snail, *Valvata utahensis* (Call)

Endangered:

(3) the Snake River physid snail, *Physa natricina*

(4) *Pyrgulopsis idahoensis*

(5) the Banbury Springs limpet (undescribed *Lanx* sp.)

Candidate:

(6) the California Floater, *Anodonta californiensis*

(7) the Giant Columbia River Limpet, *Fisherola nuttalli*

(8) the Columbia River Spire Snail, *Fluminicola columbiana*

The Banbury Springs limpet, Snake River *Physa*, the Bliss Rapids snail, and the Idaho Spring snail are found nowhere else outside of the Mid-Snake River. They are endemic to the ancient Lake Idaho, which once covered most of the area during the Pliocene. The exotic hybrid *Potamopyrgus antipodarum* is now the dominant mollusc as well as the dominant benthic organism in the reach. The benthic community (see Appendix C) is dominated by a few taxa indicative of degraded conditions (Dey and Minshall 1992). These taxa include *Potamopyrgus*, Chironomidae, Oligochaeta, and *Hyallela*.

The large freshwater clam, *Margaritifera falcata*, once a food staple for Native Americans along the River, is now virtually eliminated from the Mid-Snake. This is a direct result of the extinction of salmon runs in the area, as *M. falcata* larvae require salmon as a preferred host during their brief glochidial attachment stage. The decline in the population in Mid-Snake may be due to sedimentation. Vannote and Minshall 1982. Although *M. falcata* is common in the Bigfoot River and elsewhere in the Upper Snake, the species has been replaced by the smaller pelecypod, *Gonidea angulata* (Bowler and Frest 1992) in the Mid-Snake.

2.1.8 Vascular Macrophytes and Algae

The vascular macrophytes cover up to 40% of the benthic habitat in some reaches. The dominant species are *Ceratophyllum demersum* and *Potamogeton pectinatus*. These species are generally associated with well buffered, nutrient rich waters (Filbin and Barko, 1984; Best and Mantai 1978).

Blooms of planktonic (*Microcystis*, *Cyclotella* (the spring dominant), and *Ceratium*), periphytic, and epiphytic algae *Cladophora*, and *Hydrodyction*, occur continuously during the spring and summer. The total epiphytic algae and vascular macrophytes biomass may exceed 2,000 g/m^2 dry weight with the epiphytic alga (*Cladophora*) averaging 50% of the plant biomass in summer months (Falter, et al. 1995).

Massive growth of vascular macrophytes and epiphytic algae may be restricted by factors such as flow, velocity, sediment composition, and nutrient availability. The changes if these parameters in the Mid-Snake are believed to be the reseason for the uncontrolled growth of macrophytes. Chapman Consultants (1991) and Chambers et al (1991) observed that flows of greater than 1-2 meters per second will limit vascular macrophyte growth. A reduction in sediment deposition (substrate), increased light and associated nutrients would result in decreased plant growth. *Ceratophyllum* has very limited below ground biomass and appears to absorb most of its nutrients through its leaves and stems.

2.1.9 Wetland and Riparian Vegetation and Waterfowl

A brief description of the wetlands and riparian ecosystems is described. However, they were not addressed in this phase of the risk assessment. The short term goals of the community are associated with restoration of the open water system . Further iterations of the assessment will address the long term goals. Most of the land adjacent to the Mid-Snake River has been used for agriculture, roads, golf courses, small cattle operations, private homes, boat docking facilities, and fish hatcheries. The remaining narrow band of riparian vegetation is dominated by two major plant communities (IDEQ, Nutrient Management Plan, 1994). These are the sagebrush/grass cold-desert community and the scrub wetlands associated with free-flowing rivers and streams (B&C Energy 1984). There are bands of cottonwood groves, especially on the islands. A list of plnat species identified in the watershed is included in Appendix C.

The Mid-Snake River watershed is a waterfowl breeding and nesting habitat for white pelicans, herons, cormorants, redtailed hawk, and kestrel. It is a major winter breeding area and migration corridor for waterfowl using the Pacific flyway. The riparian area is a critical habitat for waterfowl, upland game birds and raptors because of the lack of extensive forests.

The area provides wintering and nesting habitat for bald eagles (*Haliaeetus leucocephalus*) (Final Environmental Impact Statement, Federal Energy Regulatory Commission, July 1990). According to the Bureau of Land Management the number of Bald Eagles in the Milner Dam to Bliss, Idaho area ranged from 0 to 10 adults and juveniles.

2.2 Ecological Effects

A number of ecological effects resulting from the individual or synergistic influences of the principal stressors (loss of habitat, flow, and volume;;and increased sediment and nutrient loading) pose significant secondary stress to the ecological integrity of the Mid-Snake River. These are:

- Excessive algal and vascular macrophyte production
- Exceedance of water quality standards for phosphates and temperature
- Decline in native aquatic species
- Growth of pollution tolerant and exotic aquatic species

The decrease in flow due to agricultural irrigation diversion and hydropower has resulted in both direct habitat disturbance (e.g., loss of riffles, rapids, and pools that were important habitat to cold water fauna) and secondary habitat disturbance (e.g., sedimentation in benthic habitats previously scoured). This results in aquatic macrophyte invasion and dominance in waters that were previously too deep or swift to support significant macrophyte growth).

Development of the watershed has also resulted in changes to the physical environment within the stream as well. Impoundment with numerous dams has blocked the free run of the river to anadromous salmonid species and has resulted in creation of landlocked populations of Pacific sturgeon as well. Figure 6 shows a conceptual diagram of the river continuum of alternating lotic and lentic habitats typically found in unimpounded streams of this region.

Several species of fish and benthic invertebrate species are becoming increasingly rare or have disappeared from pools or rapids within the stream. Included among these are several indigenous cold water species (see Appendix C).

While a number of impoundments presently block the migration of anadromous salmonids, a number of resident coldwater species including trout and sturgeon have survived in the river and tributaries. However their numbers are dwindling because of habitat losses. Critical habitat for spawning and the forage base required for their survival are disappearing as a result of dewatering, sedimentation, diminished flow, low dissolved oxygen, and elevated water and benthic temperatures.

Impoundments and flow modifications create additional water quality problems. The combination of slower velocities and higher temperatures creates an optimal environment for the growth of plankton and vascular macrophytes.

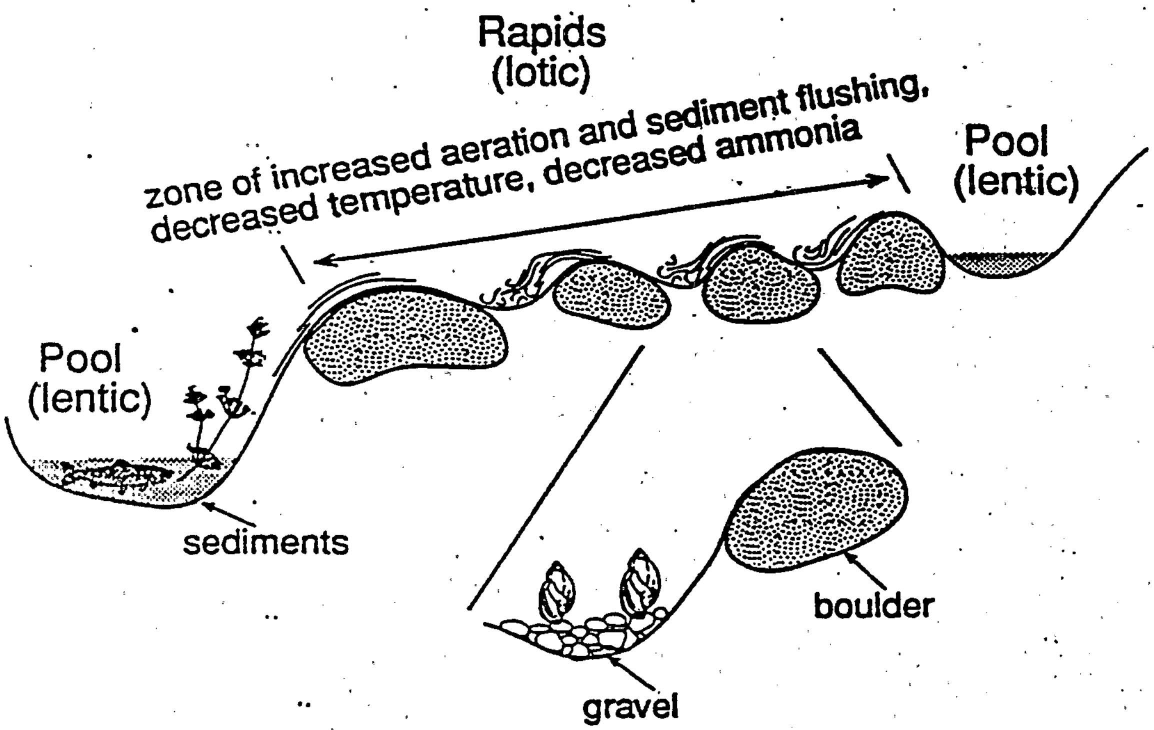

Figure 6. Illustrations of rapids and pools in a river system.

The vascular macrophytes provide substrate for the growth of filamentous algal epiphytes, *Cladophora sp.* and *Hydrodycton sp.*, which now form dense mats, and obstruct gas exchange with the atmosphere. The dense growth of the vascular macrophytes, epiphytes, periphyton, and even phytoplankton are all indicative of a system that has been overly enriched with nutrients. Diminished water flow and increased sediment deposition have resulted in shallower depths, lower turbidity and increased light penetration. These are conditions which are highly conducive to vascular macrophyte growth.

Decreased flow velocities, loss of cobblestones and an increase in temperature have contributed to a decrease in species diversity of benthic invertebrates. They are being lost as a result of alteration of their habitat from dewatering, sedimentation, diminished flow, low dissolved oxygen, elevated temperatures, and pollution - all of which are incompatible with the survival of species acclimated to cold water.

Eutrophication is defined as the artificially enhanced or increased productivity of an aquatic system. One of the main contributing factors of accelerated eutrophication is an overabundance of a limiting nutrient such as phosphorus.

Signs of eutrophication are particularly conspicuous during the summer when daylight is long in the Twin Falls and Thousand Springs reaches of the Snake River, the area that is the focus of this report. In this reach, water flows are so slow that the lotic environment is transformed into a lenthic or lake-like condition. The much longer hydraulic residence times permit development of planktonic algae and accumulation of soft bottom sediments, two conditions normally not associated with swift-flowing streams.

With the increased degradation of the Mid-Snake River ecosystem there has been a concurrent rise in the population of exotic species. The presence of these "biological interlopers" has severely impacted the ecosystem. These include hatchery-raised rainbow trout (*Oncorhynchus mykiss*), channel catfish(*Ictalurus punctatus*), carp (*Cyprinus carpio*), and *Tilapia mozambiea*, *T. zillei*, and *T. nilotica* as well as non-native freshwater invertebrates (*Potamopyrgus antipodarum* and *Corbicula*).

2.3 Stressors

This section provides an overview of the primary and secondary stressors that are most likely responsible for the degradation of the Mid-Snake River ecosystem. Of the three primary stressors identified, two of them are physical (flow alteration, sediment loading) and one is chemical (nutrient loading). Although other physical, chemical, and biological stressors are mentioned in Table 1, it is assumed that their importance will be minimized or eliminated if the key primary stressors are removed.

2.3.1 Source of Stressors

Sources of stressors are directly and indirectly related to land use activities within the contributing watershed and from hydrologic modifications to the river segment of concern. Table 1 summarizes the primary sources of ecological stressors in the watershed. Table 2 characterizes the physical, chemical and biological effects of these stressors.

2.3.2 Stressor Characteristics

There are four stressors (habitat alteration, sediment loading, nutrient loading, and flow alteration) which cause primary or direct affects on the biota of the Mid-Snake River.

Habitat Alteration. Almost any physical human activity can alter or destroy habitat with serious consequences for the watershed. Physical habitat both in-stream and on adjacent lands is altered or destroyed by activities associated with dam construction and operation. Riparian vegetation that provides shading and overhanging habitat for invertebrate forage base is destroyed by urbanization, clearing for agriculture and silviculture, livestock, and grazing. Riffles and rapids are usually altered or destroyed by reduced flow levels due to operation and construction of dams and diversions. Roads and their construction disturb both in-stream and watershed habitat. Sediment deposition and scouring may alter habitat, obliterating or radically altering fish spawning habitats. Cattle grazing can destroy both upland and in-stream habitat by the action of cattle trampling on destabilized land or in streambeds. Dams fragment a river system, isolating resident fish in side channel (tailwater) reaches. They may be stranded here and die or they are unable to reproduce because of inadequate habitats.

Table 1. Primary Anthropogenic Stressors Sources on the Snake River between Milner Dam and King Hill, Idaho.

STRESSOR	SOURCE
Irrigated Agriculture	227,000 hectares irrigated with water withdrawn from the Snake River 150,000 hectares irrigated with water withdrawn from the Snake River aquifer Return flow from 13 streams and >50 surface drains
Fish Hatcheries	140 privately-owned 4 state and federal
Hydroelectric Facilities	5 existing on mainstem 7 proposed on mainstem Many on tributaries
Point Sources	1 municipal sewage treatment plant
Confined Animal Feeding Operations	600 dairies and feedlots with waste equivalent to a population of 5,000,000 humans

Table 2. Stressor Sources and Characterization in the Mid-Snake River.

Table 2 (continued). Sources and Characterization in the Mid-Snake River.

SOURCE	TYPE: PHYSICAL	TYPE: CHEMICAL	TYPE: BIOLOGICAL
Agricultural			
Livestock Grazing	Habitat loss/alteration Sedimentation Stream temperature Increase	Nutrient loading BOD loading	Pathogens Increased algal/macro-photic production Loss of riparian vegetation Decreased macro invertebrate richness and equitability
Feedlots	Habitat loss/alteration Sedimentation	Nutrient loading BOD loading	Pathogens Increased algal/macro-photic production Loss of riparian vegetation Decreased macro invertebrate richness and equitabilitly
Dryland Farming	Sedimentation	Nutrient loading Chemical contamination	Increased algal/macro-photic production Loss of riparian vegetation Decreased macro invertebrate richness and equitability
Irrigated Agriculture	Sedimentation Flow alteration	Nutrient loading BOD loading Chemical contamination Habitat alteration	Increased algal/macro-photic production Loss of riparian vegetation Decreased macro invertebrate richness and equitability
Urban			
Land Development	Sedimentation Habitat loss/alteration Stream temperature increase		Exotic species Loss of riparian vegetation Decreased macro invertebrate richness and equitability
Road Construction	Sedimentation Habitat loss/alteration Stream temperature increase	Chemical contamination	Exotic species Loss of riparian vegetation Decreased macro invertebrate richness and equitability
Combined Sewer Overflow (CSO) and Surface Runoff	Sedimentation	Chemical contamination Nutrient loading BOD loading	Exotic species Increased algal/macro-photic production Loss of riparian vegetation Decreased macro invertebrate richness and equitability

TYPE			
SOURCE	PHYSICAL	CHEMICAL	BIOLOGICAL
Industrial/Point Source			
Municipal Wastewater Treatment	Stream temperature alteration Flow alteration	Nutrient loading BOD loading Chemical contamination	Loss of ecologically significant species; decreased algal/macro-phyte production
	Stream temperature alteration Flow alteration	Nutrient loading Industrial BOD loading Chemical contamination	Loss of ecologically significant species; Increased algal/macrophyte production
Aquaculture	Sedimentation	Nutrient loading BOD loading Chemical contamination	Exotic species Pathogens Increased algal/macro-photic production Loss of ecologically significant species
Hydroelectric Power	Flow alteration Stream temperature alteration Habitat loss/alteration	Loss of reaeration capacity; Nitrogen super saturation; Lowered dissolved oxygen	Loss of ecologically significant species

Flow Alteration. Flow alteration results in both periodic increases and/or decreases in the usual supply of fresh water to a river. Flow alterations include diversions, withdrawals, and impoundments. The results of flow alterations, such as those on the Mid-Snake River, can be a variety of sources of nonpoint pollution, including:

- Changes in the timing and quantity of freshwater inputs downstream
- Reduced downstream flushing
- Sediment deposition—siltation of gravel bars and riffle complexes
- Erosion of the streambed and scouring in tailwater reaches
- Increased deposition in areas of low water velocity resulting in formation of vascular macrophyte beds and loss of fish spawning habitat
- Increased downstream temperature

- Reduced downstream dissolved oxygen
- Velocity changes

Since there is considerable competition among the various users for water withdrawal rights, the ecological integrity of the Mid-Snake River ecosystem is severely stressed by reductions in flow. This is a particularly acute problem in the spring and summer months because of irrigation diversions. During the irrigation season (April through September) water above Milner Dam is diverted, resulting in a minimum discharge of approximately 200 - 300 cfs from Milner. Some flow is returned from irrigation during years of average rainfall; during low rainfall years, however, this return flow may stop altogether. Other sources of flow downstream from Milner Dam include springs in the river bed and several tributaries.

Impoundments which store and divert water for hydropower and irrigation result in flow modifications in the mainstem and tributaries. There are five existing impoundments on the Mid-Snake River: Milner, Shoshone Falls, upper Salmon Falls, Lower Salmon Falls, and Bliss Dam (Figure 1). Additionally, new impoundments, weirs, and diversions are proposed at Star Falls, Kanaka Rapids, and Auger Falls (Figure 3). Falls or rapids in these areas are drowned by the elevated water surface upstream of the dam, and aeration capacity of the falls is lost. The backwater upstream of these dams is slowed and may become stratified under relatively stagnant flow conditions.

Flow alterations in the Mid-Snake River result from multiple impoundments and flow modifications in the mainstem, tributaries, and ground-water outfalls. In the Mid-Snake River, the river drops 488 meters over the 30Km distance of the river segment. Consequently numerous hydroelectric facilities are located in this area. There are five existing impoundments on the Mid-Snake River: Milner, Shoshone Falls, Upper Salmon Falls, Lower Salmon Falls, and Bliss Dam. Additionally, new impoundments, weirs, and diversions are proposed at Star Falls, Kanaka Rapids, and Auger Falls. These impoundments store and divert water for agricultural irrigation and hydropower generation.

Diversion dams and their associated impoundments for electric power production are installed at many falls or rapids sites to increase the hydraulic head to power hydroelectric turbines. The backwater upstream of these dams is slowed and often becomes stratified under relatively stagnant flow conditions. Falls or rapids in these areas are drowned by the elevated water surface upstream of the dam, and aeration capacity of the falls is lost.

The dynamics of flow influences the process of sediment suspension and deposition. Altered flows change the pattern of sediment scouring and deposition by reducing downstream flushing and increase the siltation of gravel bars and riffle complexes. Clear water released from dams results in increased erosion of the riverbed and bank scouring occurs below dams, particularly in the littoral shoreline areas. These habitats are most often altered in ways that are not compatible with the survival of benthic communities.

Sediment Loading. Sediment deposition has direct ecological effects on macro invertebrates by blanketing important habitat with sediments and smothering species that depend upon aerobic sediments. Finer sediments may clog the gills or feeding apparatus of species adapted for living in coarser sediments. Sediment deposition may promote vascular macrophyte growth, alter the underlying sediments, and make them unsuitable for indigenous macro invertebrates. Fine sediment is not functional as a spawning substrate for most species.

Sediment in suspension may reduce light, coat vegetation, alter food resources for filter feeding benthic invertebrates, clog gills. Sediment deposition may smother important spawning habitat, and adversely affect the abundance of food resources (benthic invertebrates).

Sediment transport capacities are lower upstream of impoundments since the velocity and turbulence of river currents is dissipated in the slowly moving backwaters of impoundments. Downstream of the dams, the higher-velocity discharges erode banks and the river bottom and carry suspended sediment to the backwaters of the next impoundment. The net result is deposition of suspended material upstream of a dam and scouring of the river bottom and shallow shoreline areas downstream of the dam.

Poor agricultural practices from crop production and cattle feedlots can result in increased sediment loading. The Soil Conservation Service's River Basin Reports of 1976, 1979, and 1981 identified substantial areas of serious erosion on surface-irrigated lands in the Upper Snake River basin. Gooding and Jerome Counties each had more than 20,000 hectares with erosion rates exceeding 1.8 metric tons/year, while Twin Falls County had between 2,000 and 20,000 hectares exceeding 1.8 metric tons/year.

Sediment loads have been shown to increase dramatically as runoff flow rates from cropland increase (Carter, 1976). Greater rates of flow off the land into irrigation returns increase the amount of the sediment inputs into the streams and river. Therefore, over-irrigation tends to exacerbate soil erosion losses from tilled land. Irrigation return flows may carry pesticides, nutrient-rich fertilizers, and sediment loads to the river. Runoff from individual fields, especially those irrigated by furrow irrigation, carries sediment into drainage canals, which eventually drain into the river. Different crops yield different levels of sediment, e.g. sediment loss from alfalfa fields is fairly low while that from dry-bean production is fairly high.

Most of the smaller canals that flow over the precipitous canyon wall percolate through talus debris piles formed from rock falling off the canyon wall. As the water percolates through these debris piles it drops much of its sediment load. Accumulated sediment and rock debris tend to remove many of the other pollutants associated with irrigation wastewaters in a fashion similar to wastewater treatment by land treatment systems. During heavy rains or after snow melt, the overflow into the river occurs with little or no percolation through debris piles. Most larger irrigation return flows are much more damaging to the river. For example, irrigation return flows at the Perrine Coulee hydroelectric facility at the canyon wall are conveyed through a penstock to a hydroelectric turbine. Thus, the water bypasses the talus slope and is discharged directly to the river, creating a sediment-laden pollutant plume in the river.

The most recent estimates of irrigation erosion are from the Soil Conservation Service (SCS) River Basin Reports from 1976, 1979, and 1981. The reports identified substantial areas of serious erosion on surface-irrigated lands in the Upper Snake River Basin. Gooding and Jerome Counties each had more than 20,000 hectares with erosion rates exceeding 1.8 metric tons/ year, while Twin Falls County had between 2,000 and 20,000 hectares exceeding 1.8 metric tons/ year.

Though some farmers have incorporated low till and other best management practices as part of their cultural practices, implementation of best management practices is not widespread in the region. Farmers who incorporate low tillage practices may compensate for their assumed loss of high quality growing conditions by heavy use of pesticides and fertilizers. Soil losses by irrigation runoff often result in severe soil losses from poorly managed lands and accumulations of soil on properly managed lands (Carter, 1976). Other sources of sediments in the Mid-Snake River include urban nonpoint sources and stormwater runoff, cattle feedlots, housing and commercial development, road construction, and sand and gravel operations. Chemical Stressors

Nutrient Loadings. Nitrogen and phosphorus, present in inorganic forms, provide a fundamental source of nutrients for the growth of algae and vascular macrophytes. Phosphorus is generally the limiting nutrient in freshwater systems. Phosphorus must be available as soluble inorganic orthophosphate. Nitrogen may be present as nitrate (NO_{3-}), nitrite (NO_{2-}), ammonia (NH_3), ammonium ion (NH_{4+}), or gaseous nitrogen (N_2). Though some organisms have developed extracellular enzymes or other means of liberating orthophosphate from organic matter, most vascular macrophytes and algae must rely on the availability of inorganic orthophosphate in their environment. In a river environment, available orthophosphate is quickly assimilated by plant life and converted to tissue or is adsorbed onto soil particles, forming relatively insoluble complexes. Death of an organism eventually results in its deposition on the bottom of a quiescent portion of the river along with other phosphorus bound to soil particles. The phosphorus remains bound to soil particles until it is chemically or biologically liberated under anaerobic conditions.

Nitrogen contributions to the Mid-Snake River include nitrates in spring flows, limited instances of nitrogen fixation by blue-green algae, ammonia and nitrates in irrigation returns; animal wastes from feedlots and hatcheries; and municipal and industrial point-source discharges.

The phosphorus mines and generally phosphorus-rich rock formations in southeastern Idaho are a source of phosphorus for the Snake River.

Increased productivity in the stream, results in some decrease of oxygen concentrations in pools within the mainstem.

Toxics. Chemical pesticides from agricultural operations (although not examined closely in this assessment) may be potential stressors of aquatic and terrestrial organisms in the watershed as well. Pesticides are widely used on tillage crops in the watershed.

Antibiotics (e.g., sulfa drugs) are routinely added to feed and raceway waters as part of standard management practice in fish farming. These antibiotics are used to protect the fish from routine infections, which may stunt growth, increase mortality, or affect the marketability of the fish. Little information has been collected on their adverse ecological effects on natural biota in the Mid-Snake River although published information suggests a detrimental effect on natural bacteria and fungi occurring in sediments and the water column.

2.3.3 Secondary Stressors

Secondary stressors are an indirect effect of the primary stressor. Increases in temperature, oxygen decreases, increases of macrophyte and algal biomass are the result of the interaction of the primary stressors.

The three principal stressors are substantially linked in the way they work together to change the ecosystem in the Snake River. Because sediment loading and transport are ultimately linked to overland flow and stream velocity; the rate of flow is critical in influencing sediment affects and ecological models should reflect these inter-relationships.

Attempts to control or mitigate any one of these stressors to sustain the ecological endpoints must involve management of the other two. Similarly, management of the secondary stressors, such as habitat impairment will require careful management of all three of the principal stressors.

Each of the three principal stressors (flow, sediment deposition and nutrient loading) contributes to the development of one or more secondary stressors. For instance, all three of the primary stressors can have a direct ecological effect on the ecological assessment endpoint but the stressors also may create yet another tier of stressor-effect (e.g.,vascular macrophyte growth, sedimentation, and decreased flow alter habitat for both cold water fish and benthic macro invertebrates). Table 2 summarizes the stressor sources and categorizes resulting stressors for both primary and secondary sources by type—physical, chemical, or biological.

Increased Stream Temperatures. Water temperatures tend to fluctuate over a greater annual range because of the presence of numerous impoundments on the Snake River. The increase in surface area exposes more water to solar radiation which tends to raise summer surface water temperatures. Maximum water temperatures have been established for impoundments along the river by state and federal regulatory agencies to protect fish populations which have a low tolerance for warm water temperatures. Temperature ecological effects are often cumulative along the river. Heat absorbed at one site may not cause temperatures to exceed the allowable temperature at that site, but the cumulative effect of heat gained at successive reservoirs could raise temperatures beyond maximum tolerable levels in the river. A secondary effect of warmer water is lowered dissolved oxygen carrying capacity relative to cold water. Destruction of riparian vegetation and the shading it provides can cause an increase in stream temperatures.

Biological Stressors. Over the last 30 years river flow and water quality have changed sufficiently so that there are now frequent stands of vascular macrophytes and attached algae throughout the Mid-Snake, including epiphytic and epipelic varieties. Rampant growth of vascular macrophytes which peak during May to July has occurred as a result of nutrient loading and other agricultural nonpoint source pollution. At least three species of vascular macrophytes, *Ceratophyllum demersum, Elodea canadensis*, and *Potamogeton pectinatus*, now grow in dense and obstructive stands in quiet pools within the segment of interest. These species are associated with eutrophic waters even in the lotic environment.

A number of biological changes in the stream and watershed have resulted from the physical and chemical perturbations of human use. These biological changes may, in turn, function as stressors to the remaining biological community. There has been a loss of endemic species of both fish and macro invertebrates, as well as a concomitant appearance of exotic macro invertebrate and invertebrate fauna, especially *Potamopyrgus*. The loss of riparian vegetation, which historically provided shade and habitat along the water's edge has a detrimental affect on the Mid-Snake River ecosystem. There has been a profound increase in phytoplankton and vascular macrophytes as well, altering patterns of flow, characteristics of habitat, and availability of forage base by competitive exclusion of high quality food preferred forage species. Inflow of man-made antibiotics from fish farm effluents may be a source of stress on the endemic microbiota within the stream and natural sediments.

3.0 ASSESSMENT ENDPOINTS

Assessment endpoints are explicit expressions of the actual ecological value that is to be protected (USEPA, 1992) and thus form a basis for linkage to management concerns, measures of exposure and effect, and risk management activities in the watershed. Assessment endpoints must reflect ecological relevance. That is, an assessment endpoint should focus on an ecological component that is important to the structure and function of the watershed ecosystem.

Endpoint selection is critical to the ecological risk assessment process because endpoints must complete a sequence linking environmental values, which are often abstract, to specific management actions that will reduce risks to these values. The starting point of this logical sequence is the recognition of values that need protection, expressed as management concerns.

Three assessment endpoints for the Mid-Snake River risk analysis are:

- The reproduction and survival of coldwater fisheries - particularly the trout and sturgeon
- The reproduction, survival, and diversity of native benthic fauna
- The growth of vascular macrophytes and green and bluegreen algae

Attainment of these ecological endpoints will protect much of the ecological system. Restoration of a migratory salmonid fishery is not considered feasible because of the number of downstream impoundments that block migration (Figure 1).

Coldwater biota life support is selected as an assessment endpoint, for several reasons. The ecological significance of this endpoint includes the fact that endangered species in the Mid- Snake River are coldwater invertebrates and fish. The invertebrates and fish exhibit marked sensitivity to the stressors affecting the Mid- Snake River, and a coldwater biota endpoint can be linked quantitatively to several environmental parameters (e.g., numeric criteria) to document stressor/ecological response relationships.

In addition to the restoration of invertebrate and fish species, the reduction in vascular macrophyte biomass is essential to assure the restoration of cold water biota. The nuisance growths are ecologically significant in displacing and/or stressing desired coldwater periphyton, phytoplankton, fish, and macro invertebrates.

4.0 ANALYSIS PLAN

To achieve this assessment's objectives within the framework of the ecological risk assessment, we are using a strategy that could be characterized as source-based control. While this strategy has elements of the traditional approach to the allocation of waste loadings, it will contain elements of risk analysis. The focus will be on water quality, including temperature, dissolved oxygen, nutrients, coliform bacteria, and ammonia toxicity. The State of Idaho's water quality standards will be used as measures of effect. The analysis plan for the ecological risk assessment of the Mid-Snake Watershed relies on probalistic models.

4.1 Assumptions

The modeling and analysis of ecological risks in the Snake River are based on a number of key assumptions. These include the following:

- Major features of the Snake River ecosystem can be described in terms of compartments between which there can be flows of energy, material, and information.
- The flows of energy, material, and information between ecosystem compartments can be described mathematically within given bounds of uncertainty.
- There is sufficient information to characterize the variability of environmental forcing functions such as meteorology, hydrology, and water chemistry.
- There is sufficient information to characterize the variability of forcing functions associated with important types of human development on the Snake River.
- Assessment endpoints for biological systems included in the risk analysis are known within given bounds of uncertainty. Where endpoints are not known, surrogates, such as water quality standards, can be applied.
- The principal components of risk arise from uncertainty or variability in driving forces and from uncertainty in the models used to describe the state of the ecosystem.

4.2 Conceptual Model

The conceptual model of the river and associated areas will characterize the biological communities and their relation to the specific water quality parameters to be examined in the ecological risk assessment. This conceptual model would ideally include all levels of biological organization (organism, population, community, and ecosystem), as well as physical and chemical descriptions of the habitats.

The conceptual model for this ecological risk assessment of the Mid-Snake River watershed incorporates the descriptions of the ecological components, stressors, ecological effects, and exposure scenarios to assist in developing hypotheses regarding how each stressor may affect the watershed. Several submodels of water quality, river flow, and the aquatic communities were generated.

Figure 7 illustrates some of the critical interactions and the likely ecological effects on ecosystem function. In this model flow controls the loading of both sediments and nutrients which in turn influence macrophytic and algal productivity, detrital sedimentation, and habitat alteration for both fishery and benthic fauna. Increased flow often increases sediment and nutrient loading but it also may resuspend sediment deposits, and scour the streambed, and reduce the residence time of dissolved nutrients. Decreased flow, while reducing the loading of sediments and nutrients, often results in new net sediment deposition and greater nutrient retention times in the system, resulting in higher rates of vascular macrophyte and algal productivity. Substantial deposits of sediments or large, dense vascular macrophyte beds can slow downstream rates of water flow.

Figure 8 illustrates the collective action of several stressors on the cold water fishery. In this illustration, flow modification arising from a variety of diversions for anthropogenic use results in habitat alteration, chemical stress, and thermal stress on sensitive life stages of sensitive species.

Figures 9 and 9b describe in detail the ecological effects of sediment and nutrient loading on the benthic invertebrate fauna.

Figure 10 illustrates the conceptual model of macrophyte growth in the Snake River. The model describes the role of sediments on algal and vascular macrophyte growth, through increased surface area for colonization, and increased fertility of the vascular macrophyte beds resulting in nuisance growth of vascular macrophytes, periphyton, and epiphytes.

4.3 Measures of Exposure and Effect

Measures of exposure and effect are those characteristics or parameters of an ecological system that may be measured to determine the status of an assessment endpoint or to provide information to predict ecological effects on an assessment endpoint, when the assessment endpoint itself is not amenable to direct measurement (USEPA, 1992). Measures of exposure and effect endpoints are chosen to quantify the Mid-Snake's stressor-ecological effects relationships, to determine loadings and the magnitude of loading reductions needed to reduce risk; to develop defensible total maximum daily loads, and to attain water quality standards.

The measures of exposure and effect listed below will be assessed relative to the two assessment endpoints. Many of the measures of exposure and effect apply to both assessment endpoints.

Measures of exposure and effect related to survival and reproduction of coldwater biota (sturgeon, trout, benthic macroinvertebrataes are:

- Numeric water quality criteria for
  —dissolved oxygen, temperature, ammonia, phosphorus, nitrogen, suspended sediments

- Physical measures of habitat structure and suitability

—channel morphology

- Flow (volume, seasonal timing, and duration)

- Presence, absence and abundance of cold water fish species

- Benthic community diversity metrics
  —macroinvertebrate populations, periphyton populations

Measures of exposure and effect related to growth of aquatic macrophytes and algae are:

- Numeric water quality criteria for
  —dissolved oxygen, temperature, ammonia, phosphorus, nitrogen, suspended sediments

- Metrics of vascular macrophyte community
  —vascular macrophyte populations, abundance, biomass, composition, epiphytic communities-biomass and composition

- Metrics of plankton and periphyton communities
  —phytoplankton abundance, composition, periphyton abundance, composition, zooplankton abundance

- Physical measures of habitat structure and suitability
  —channel morphology, sediment volume, flow (volume, seasonal timing, and duration), substratum characteristics

4.4 Simulation Modeling

The ecological risk assessment methodology will be based on a mass balance water quality model. Elements of risk will be derived from uncertainty and variability in driving forces and from uncertainty in the mass balance model. The water quality model developed by Yearsley (1991), uses material and energy flows as shown in Figure 10. This model uses standard kinetics to simulate temperature, dissolved oxygen, nitrogen, phosphorus, and primary productivity for time scales of hours to decades, vertical length scales of 1 to 10 meters and horizontal length scales of hundreds of meters to hundreds of kilometers.

This methodology will be used to develop measures of the risk of exceeding the state's water quality standards before and after source control or mitigation. The concept is illustrated in Figure 11 where the probability density of total phosphorus is shown schematically before and after total maximum daily loadings have been developed for nutrient sources. The probability densities are estimated empirically by Monte Carlo simulation, using variability and uncertainty in driving forces as determined from available data. Model uncertainty will be determined by comparing simulation results with measurements obtained in comprehensive field studies such as those reported by Brockway and Robison (1992).

The ecological risk analysis for the middle Snake River is developed from the stressor characteristics and ecological effects identified in the formulation of the problem. Stressor characsteristics are defined in terms of probability models for point source loadings, nonpoint source loadings, and meteorologic and hydrologic conditions. These characteristics are used as forcing functions for a mathematical model of the river ecosystem to develop cumulative distribution functions for environmental factors such as dissolved oxygen, temperature and macronutrients. The cumulative distribution functions will be used to determine the risk associated with ecological effects to coldwater species of fishes and benthic invertebrates. This will be done by overlaying the cumulative distributions functions for environmental factors on the environmental requirements of important coldwater species.

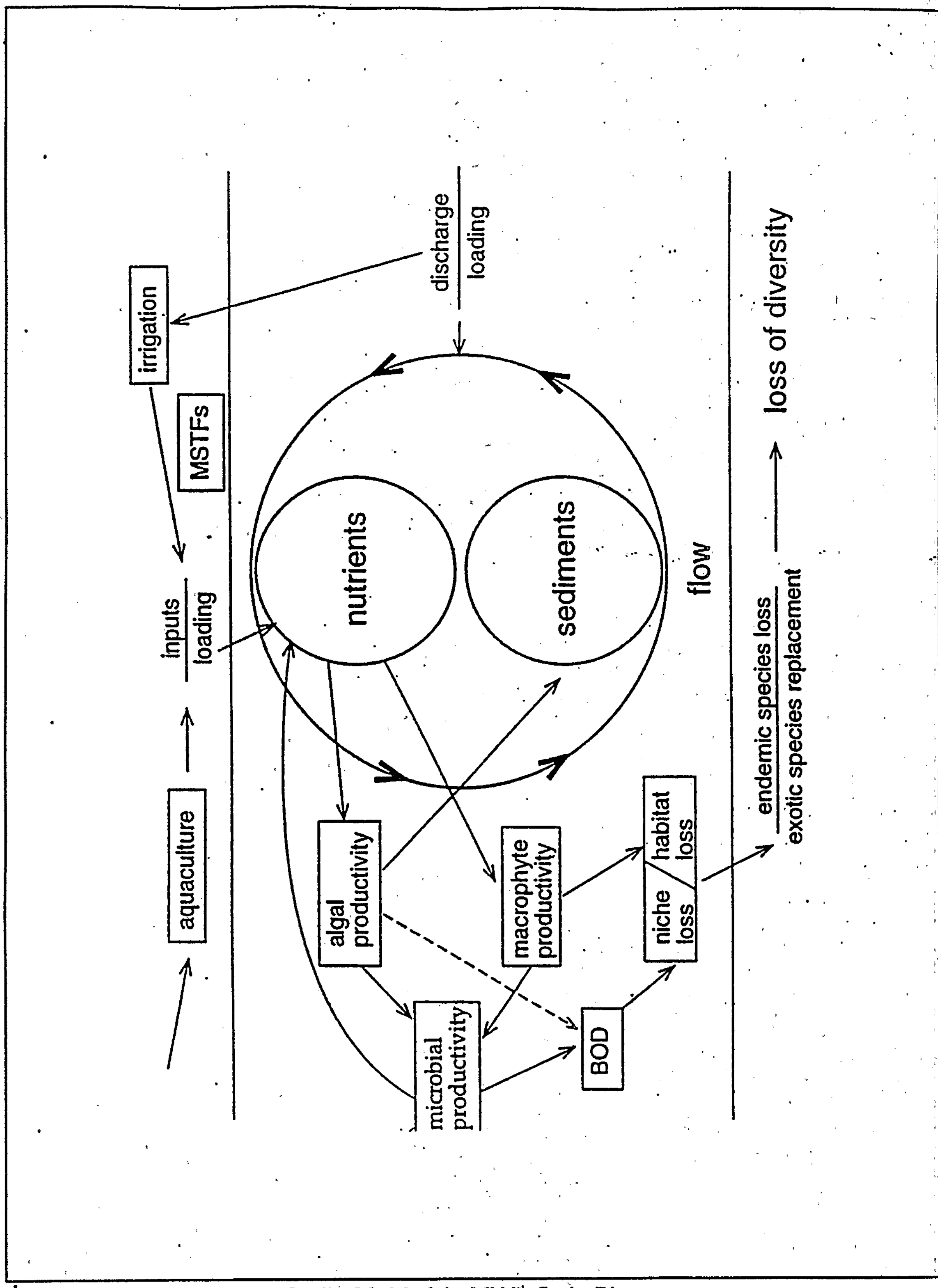

Figure 7. A Conceptual Water Quality Model of the Middle Snake River.

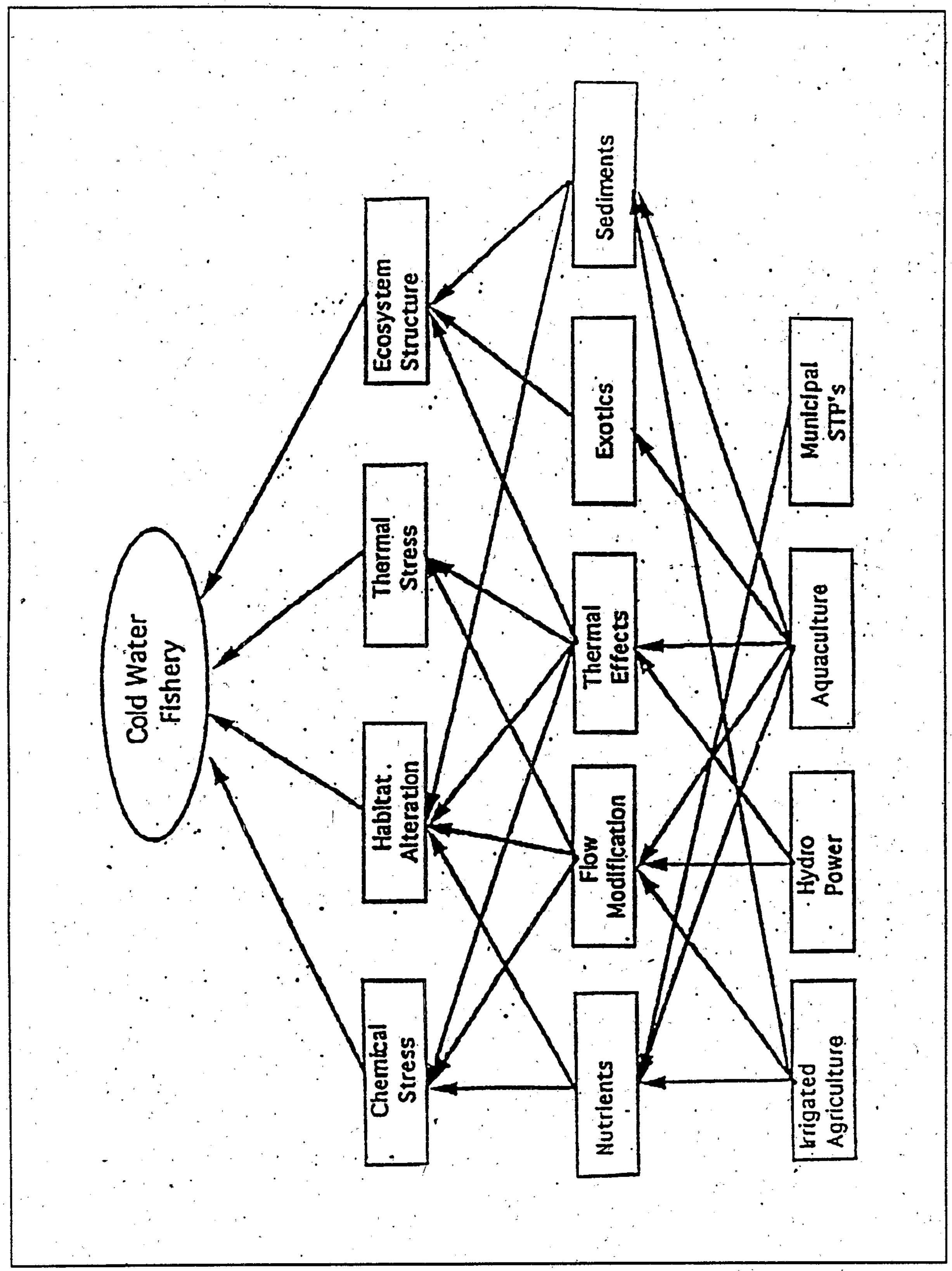

Figure 8. Conceptual Model Describing Interactions of Stressors and the Effects on Cold Water Fishery in the Middle Snake River.

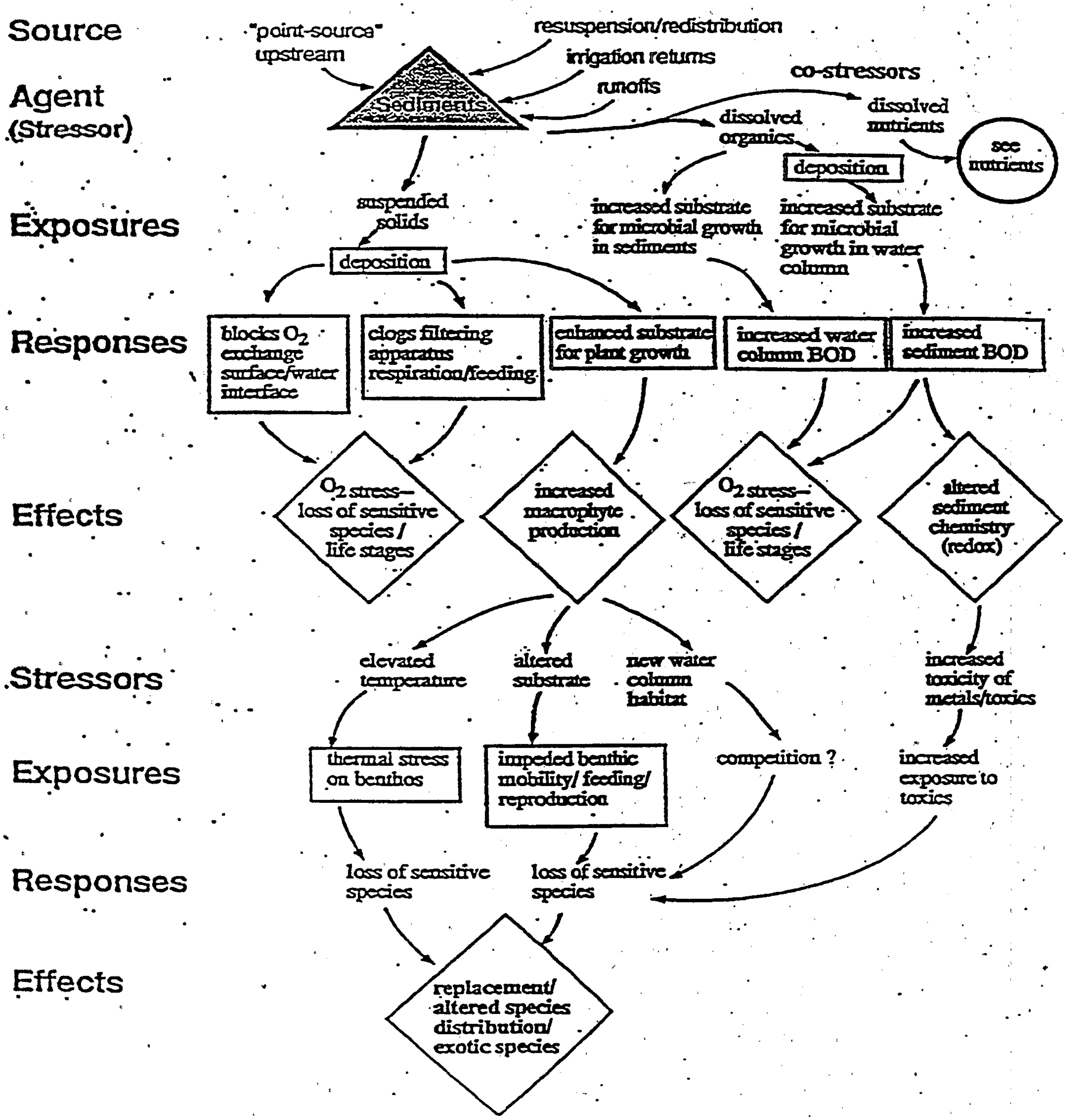

Figure 9a. Protection of Endangered and Other Ecologically Important Benthic Invertebrate Species (sediments).

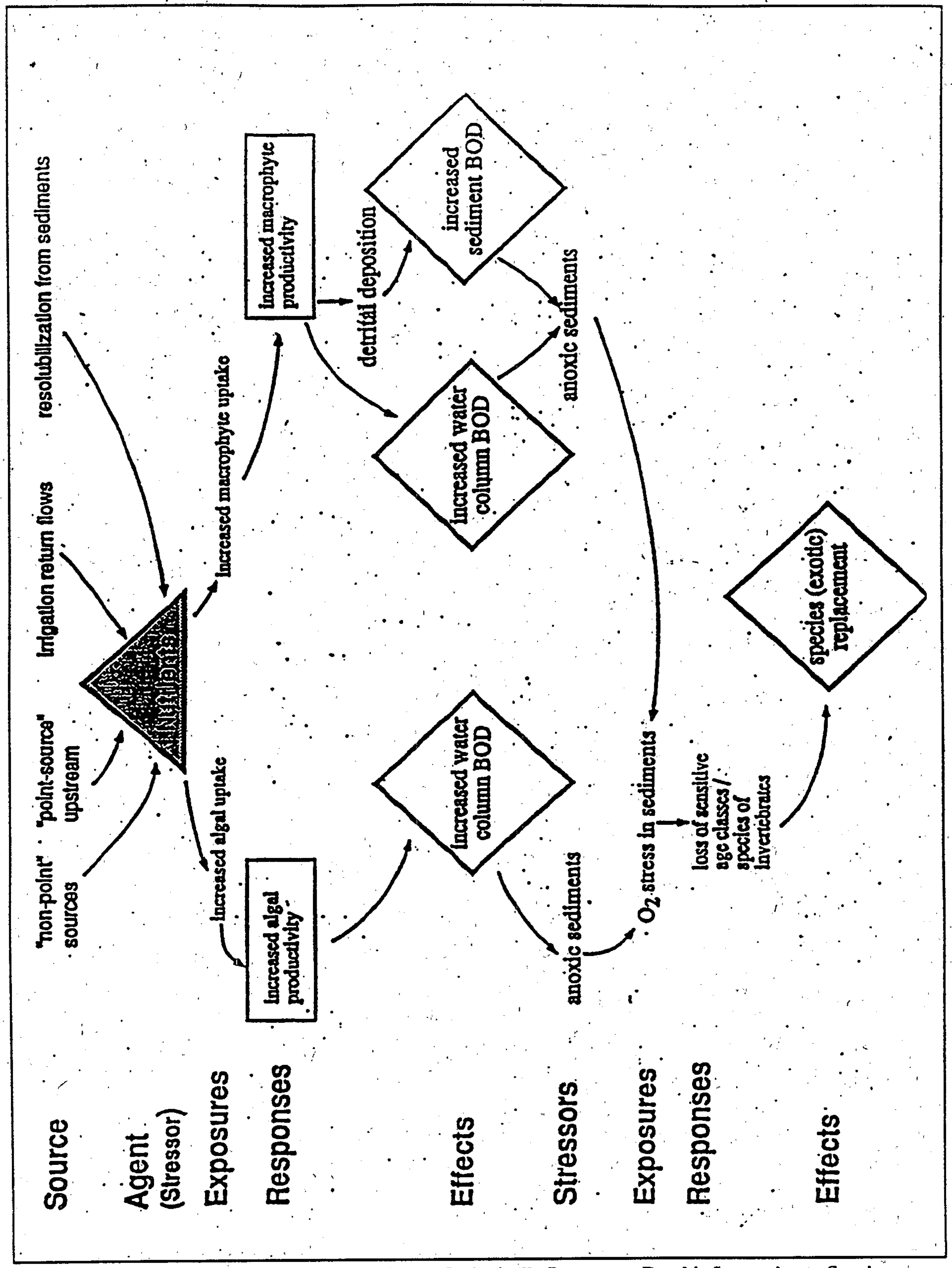

Figure 9b. Protection of Endangered and Other Ecologically Important Benthic Invertebrate Species (nutrients).

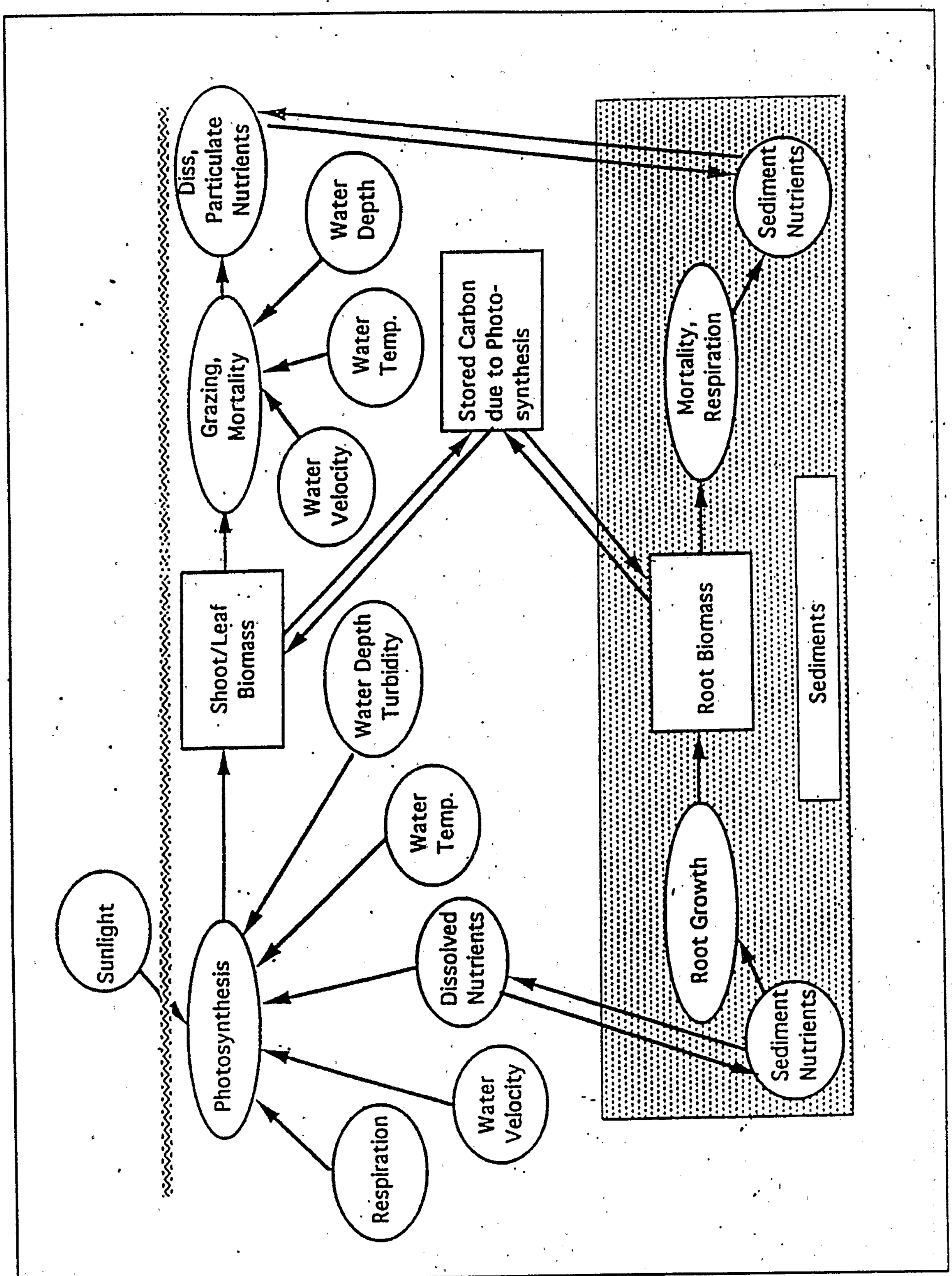

Figure 10. Conceptual Model for Macrophyte Growth in RBM10 as Applied to the Snake River.

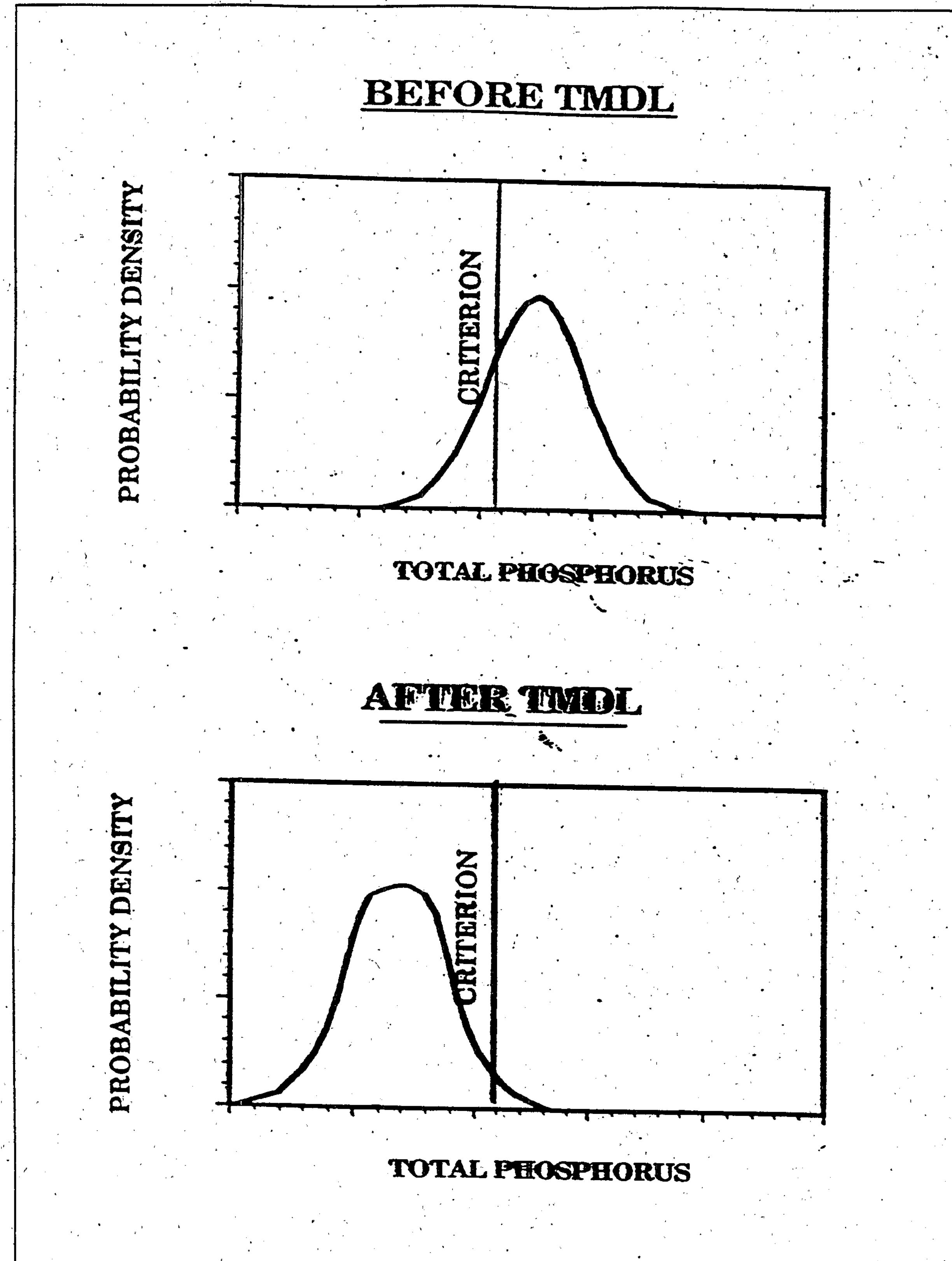

Figure 11. A Conceptualization of Risk Outcome as Applied to the Development of a TMDL for Total Phosphorus.

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APPENDIX A: PARTICIPANTS IN THE PROTECTION OF THE MID-SNAKE RIVER

Federal

U.S. Environmental Protection Agency (USEPA)

Department of the Interior
- U.S. Fish and Wildlife Service
- Bureau of Land Management/Minerals

Management Service
- National Biological Survey

Department of Energy
- Federal Electric Regulatory Commission

Department of Agriculture
- National Park Service

U.S. Geologic Survey

Northwest Power Planning Council

State

Idaho Department of Health and Welfare
- Division of Environmental Quality

Idaho Department of Water Resources

Idaho Department of Fish and Game

Idaho Fish and Game Commission

Idaho Water Board

Idaho Department of Parks and Recreation

County/Local

Mid Snake River Planning Group

Private Organizations

Idaho Power Company

North Side Canal Company

The Nature Conservancy

Natural Heritage Program

The Research Community

The University of Idaho

Idaho State University

University of California at Irvine

APPENDIX B : REGULATORY (PART 1) AND NON-REGULATORY (PART 2) FRAMEWORK

FEDERAL

U.S. Environmental Protection Agency

Clean Water Act (CWA): National Pollutant Discharge Effluent Permits

The USEPA is responsible for the National Pollutant Discharge Elimination System (NPDES) program in Idaho. The NPDES program provides for the issuance of permits for discharges and the establishment of minimum treatment requirements as permit conditions. The Idaho Department of Health and Welfare assists EPA in administering and enforcing the effluent discharge limitations and issuing discharge permits for waste discharges in the state. The *point sources* of greatest concern in this study area include municipal facilities, fish hatcheries, and confined animal feeding operations (primarily dairies and feedlots).

Permits issued by EPA in 1990 include a provision that requires hatchery operators to monitor their effluent for nutrients over a 1-year period. Hatcheries have been, and will continue, monitoring solids. These permits include a reopener clause that allows EPA to modify permit requirements based on the results of this sampling effort. The Idaho Department of Health and Welfare, Division of Environmental Quality (IDHW-DEQ) currently assists EPA in regulating hatchery effluents, principally on the basis of suspended solids and biochemical oxygen demand loadings.

The USEPA has established regulations for waste disposal practices at stockyards and feedlots. Essentially, these regulations prohibit the discharge of animal wastes to streams and water bodies except during particularly large runoff events. Even with these regulations, however, accidental or illegal discharges of the wastes persist (M. McMasters, IDEQ, personal communication to P. Cirone, 1989).

There is one municipal treatment facility in the Mid- Snake River Watershed at Twin Falls.

CWA: Section 303 (d) Total Maximum Daily Loads

Currently, nutrient management plans have been prepared to address CWA Section 303(d)requirements for development of total maximum daily loading for Billingsly Creek, and the Snake River from Shoshone Falls to Lower Salmon Falls will be listed as water quality limited in the next 305(b) report. The Sierra Club has filed an "Intent to Sue" proceeding over the development of a total maximum daily loading for this reach.

Federal Electric Regulatory Commission

Developers of proposed new hydroelectric projects in the Snake River are being asked to provide environmental information about the impacts of the project at the site. In addition, they are required to evaluate the cumulative impact of the proposed project on the system downstream from the site.

Relicensing of an existing hydroelectric facility raises issues different from those raised in the licensing of a new project. In most instances, older hydroelectric facilities coming up for relicensing were constructed with little or no regard for environmental values. Relicensing provides an opportunity to conduct a proper environmental review of a completed project and to change its structure or operation to protect, mitigate, and enhance environmental and recreational values. Some relatively common relicensing requirements that benefit fisheries include the installation of fish passage facilities, or new controls on the amount and timing of flow releases below a dam, so that dewatered stretches of river can once again be productive (Echeverria et al., 1989).

The comprehensive water block and target flow concept developed by the Federal Electric Regulatory Commission will be explored in conjunction with the licensing and relicensing of hydroelectric projects. Opportunities to increase flows in the reach of concern will be explored with the Department of Water Resources through the Upper Snake River Water Bank. Other alternatives for increasing flow in the river will be developed as the opportunity arises.

U. S. Army Corps of Engineers
The Corps of Engineers has primary responsibility for wetlands protection and permitting.

U.S. Geological Survey

U.S. Fish and Wildlife Service

STATE

Idaho Division of Health and Welfare - Department of Environmental Quality

State Water Quality Criteria

Under the CWA, Section 401 certification provides that federally permitted and licensed water-related activities meet water quality standards established under the act. Unacceptable impacts that cannot be adequately mitigated will result in denial of 401 certification for the project.

The general water quality criteria state that "waters of the state must not contain floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may adversely affect designated beneficial uses" (IDAPA 16.01.2200,04).

The general water quality criteria further state that "waters of the state must not contain . . . excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated or protected beneficial uses" (IDAPA 16.01.2200,05). Specific water quality criteria for waters designated for cold-water biota must exhibit "dissolved oxygen concentrations exceeding 6 mg/l at all times" (IDAPA 16.01.2250,04.a).

According to state law, the designated uses of the Snake River from Milner Dam to King Hill are listed as agricultural water supply, cold water biota, salmonid spawning, and primary and secondary contact recreation (fishing, boating and swimming).

Beneficial uses found to be potentially at risk by the most recent nonpoint source assessment are agricultural water supply and secondary contact recreation. Beneficial uses that are inadequately supported include cold-water biota, salmonid spawning, and primary contact recreation. The primary pollutants are sediment, nutrients, bacteria, and ammonia from agricultural activities, as well as flow alteration from hydrologic/habitat modifications (IDHW, 1989).

State of Idaho Nutrient Management Act
The Idaho Division of Environmental Quality (IDEQ) addresses nutrient (nitrate and phosphate pollution) concerns through the development and implementation of a nutrient management plan for the basin, under the authorities of the State Nutrient Management Act. The objective of the act is the formulation and adoption of a comprehensive state nutrient management plan through the development of individual basin plans. The plan must identify nutrient sources, dynamics, and preventive or remedial actions to protect surface waters.

As part of this effort the Mid-Snake River Nutrient Management Planning Group, consisting of two committees, has been formed:

- **Executive Committee,** a public advisory committee with representatives from canal companies, the Mid-Snake Study Group, Hagerman Valley Citizen's Alert, Inc., food processors, Idaho Conservation League, aquaculture, dairy/feedlot industry, Soil Conservation Districts, municipal discharges, hydroelectric facilities, and Idaho Rivers United, and

- **Technical Advisory Committee,** which, in addition to members of the Executive Committee, includes the Water Quality Modeling Group and scientists with appropriate expertise from several universities.

Wetlands Protection Grant
Development of a 401 certification process with a wetlands protection grant from EPA will allow formal consideration of wetland impacts.

Idaho Department of Water Resources

Idaho Division of Fish and Game

LOCAL

Counties
Counties in the area have enacted ordinances designed to protect the Snake River Canyon and water quality, and there are a number of proposed or existing regulations that influence water quality. Twin Falls County zones land within the canyon for outdoor recreation, and all but industrial or commercial development is permitted in this zone. The plan encourages development and enhancement of recreational opportunities in the Snake River Canyon (Twin Falls County Planning Department, 1987). The county requires a 30.5 meter building setback from the canyon rim unless an engineer certifies that the rim is stable; with certification, a 9.1 meters setback is allowed.

Jerome County has established a preservation zone along the north side of the Snake River Canyon. This preservation zone generally extends from the river to 0.5 mile north of the river for public lands.

Caldron Linn, Milner Dam reservoir, and the Snake River Canyon are included in the preservation zone. Lands in this zone are to be preserved in their natural state for future public access (Jerome County Planning Department, 1984). Present building regulations require a 30.5 meter scenic setback from the canyon rim, and activities within the canyon are closely regulated. The Jerome Comprehensive Plan includes a provision for conserving surface water for irrigation, recreation, and wildlife uses.

Jerome County is in the process of developing a Livestock Confinement Ordinance that will establish a twofold permit process. If livestock concentrations are greater than five animal units per acre, the landowner is required to obtain a permit. In addition, if the activity is located within 0.4km of a stream drainage or in a ground-water area with a soils capability rating of "severe," the landowner is required to notify adjacent landowners, the Soil Conservation Service, EPA, the Department of Water Resources, and the Department of Health and Welfare. A public hearing will be held prior to issuance of a permit.

NON REGULATORY ACTIVITIES

Mid-Snake River Planning Group

A regional planning group was organized in spring 1990 by the four counties in the Mid-Snake area—Gooding, Twin Falls, Lincoln, and Jerome. The group also includes local state and federal agency representatives in a nonvoting capacity. The purpose of the Mid-Snake River Planning Group is sustaining the economic activity of the region and development of a management plan to prioritize problems in the basin and to provide direction for solving them. The primary focus of the plan is the protection and enhancement of water quality in the Snake River. The plan was completed in Spring 1992. The group is serving as the policy advisory committee for development of a Mid- Snake River nutrient management plan.

Water Quality Modeling Group

A Memorandum of Understanding (MOU) has been developed among the state and federal agencies with management concerns related to the Mid- Snake River. This MOU will facilitate the development and use of a water quality model originally developed by EPA.

Idaho Department of Water Resources/State Water Plan Activities

As a result of the Idaho Department of Water Resources' planning efforts, a portion of the Snake River has been granted interim protected status by the Idaho Water Resources Bloard. (Subject to legislative approval, the Board has the authority to designate protected rivers, thereby prohibiting certain activities within the stream bed.)

The purpose of this authority is that "selected rivers possessing outstanding fish and wildlife, recreational, aesthetic, historic, cultural, natural or geologic values should be protected for the public benefit and enjoyment." Pursuant to section 42-1734D, Idaho Code, the Snake River, from Section 5, Township 11 South, Range 20 East, B.M. to King Hill is under *interim protected status* for 2 years (1991-1993). [It's 1996- this needs to be updated]

Once a waterway has been designated as an interim protected river, the Board is required to prepare a comprehensive state water plan for the waterway. According to Frank Sherman, chief planner, "The single overriding consideration in developing a comprehensive water plan for this reach of river will be water quality." After the completion of the reach plan, the Water Resources Board will hold a public meeting to determine whether this stretch of river or a portion of it should be given *permanent protected status*. As set out in Idaho Code 42-1734A, with this designation the Board can prohibit certain activities within the streambed:

- Construction or expansion of dams or impoundments
- Construction of hydropower projects
- Construction of water diversion works
- Dredge or placer mining
- Alterations of the streambed
- Mineral or sand and gravel extraction within the streambed.

Agriculture Projects

An important component of the Nonpoint Source (NPS) Program in Idaho is the State Agriculture Water Quality Program. The State Agriculture Water Quality Program and the *Idaho Agricultural Pollution Abatement Plan* (1983) have been developed to address nonpoint pollution that originates on agricultural lands. The State Agriculture Water Quality Program, created in 1980, makes grants to Soil Conservation Districts to assist in the development of water quality plans and to provide cost-sharing with farmers who apply best management practices. The State Agriculture Water Quality Program projects are funded with dollars from the Water Pollution Control Fund and are intended to be demonstration projects that encourage farmers to adopt best management practices. Projects are selected based on their water quality benefits. In the Mid- Snake River area, there are currently three agricultural water quality projects funded under the State Agriculture Water Quality Program—Cedar Draw, Vineyard Creek, and East Upper Deep Creek (planning only). Knowledge of the relative contaminant contribution of the agricultural lands in the basin will enable IDEQ, in conjunction with the Soil Conservation Districts and the Soil Conservation Commission, to prioritize watersheds in this area. State Agriculture Water Quality Program funds can then be targeted to those areas contributing the greatest load to the Snake River.

The Idaho Division of Environmental Quality will perform consistency reviews of resource management plans as they are developed for BLM districts in the area. This will ensure that the permitted land use activities are conducted using appropriate best management practices to protect water quality.

National Rural Clean Water Program on Rock Creek

The Rock Creek project, federally funded by the National Rural Clean Water Program, is a long-term monitoring and evaluation project to provide information and experience in controlling agricultural nonpoint pollution. Federal programs such as the Rural Clean Water Program have attempted to improve water quality, largely by controlling sediment loads in agricultural irrigation runoff. Soil erosion control programs have been instituted by the Soil Conservation Service and other agencies in many of the Snake River's tributaries. A wealth of information on soil loss, erosion control, and the effectiveness of best management practices has been collected as part of the Rock Creek Rural Clean

Water Program. Turbidity and sediment loads have been reduced in the Rock Creek watershed, and fish kills in the mainstem Snake River appear to have been eliminated within the study area (IDHW-DEQ-WQB, 1989; W. Poole, personal communication to P. Cirone, 1989).

Idaho Power
Environmental studies have been undertaken by Idaho Power and federal and state agencies associated with the relicensing of several Idaho Power projects.

Idaho Department of Fish and Game
Preservation of game species.

The Canal Companies
Diversion practices for irrigation needs.

National Park Service
The Hagerman Fossil Bed National Monument abuts the reach. The Hagerman Reach was identified as a potential Wild and Scenic River.

Northwest Power Planning Council
The Mid-Snake River is a "protected area" in the NPPC habitat Plan.

Idaho Department of Parks and Recreation
Malad Gorge State Park, Mokey P? State Park and other instream flow concerns.

Bureau of Land Management
Resource Management Plans for Bureau of Land Management districts adjacent to the river.

The Nature Conservancy

APPENDIX C: ECOLOGICAL COMPONENTS OF MID-SNAKE RIVER ECOSYSTEM

Aquatic and shoreline vegetation of the Snake River (Stanford 1942).
(Asterisks indicate common species)

Wetland plants

- **Salix lasiandra* Benth.
- **Populus trichocarpa* Torr. & Gray
- **Nepeta cataria* L.
- **Solanum triflorum* Nutt.
- *Veronica americana L.*
- *Solidago missouriensis Nutt*
- *Rumex persicaroides L.*
- *Vicia americana Muhl.*
- *Glychrrizia lepidota Pursch*
- *Apocynum cannabinum L.*
- *Verbena hastata L.*
- *Mentha arvensis L. var Lanta Piper*
- *Helenium autumnale L.*
- *Xanthium pennsylvanicum Wallr.*
- *Bidens cernua L.*
- *Artemisia sp.*
- *Sarcobatus sp.*
- *Phragmites communis trin.*
- *Paspalum distichum L.*
- *Polypogon montspelliensis L.*
- *Cyperus strigosus L.*
- *Eleocharis paluilstris L.*
- *Scirpus validus Vahl*
- *Typha latifolia L.*
- *Polygonon natans A. Eaton*
- *Polygonon lapathifolium L.*
- *Sagittaria*
- *Potamogeton epihydrous*
- *Potamegeton pectinatus*
- *Ceratophpyllum demersum*
- *Rorippa nasturtium L.*
- *Anacharis*
- *Lemna minor*
- *Azolla*
- *Toxicodendron diversiloba (Torr. & Gray) Greene*

Additions from 1992 observations (Dey and Minshall 1992)

Potomogeton crispus
Potomogeton foliosus
Elodea nuttali
Elodea canadensis
Ranunculus spp.
Meriophyllum spicatum

Other plants found in the area include (Draft Nutrient Management Plan, 1994):

willow
cottonwood
juniper
water birch
netleaf hackberry
russian olive (introduced)
chokecherry
black locust
squabush
golden current
dogwood
wood's rose
nettle
solomon's seal

Some of the animals identified in the riparian areas include (Idaho DEQ Nutrient Management Plan, 1994):

mule deer
cottontail
shrew deer mouse
coyote
bobcat
muskrat
mink
warsel
otter
raccoon
jackrabbit
marmot
pygmy rabbit
badger

Amphibians and reptiles identified in the riparian areas include (Idaho DEQ Nutrient Managment Plan, 1994):

- sideblotched lizard
- western whiptail
- westernfence lizard
- gopher snake
- rubber boa
- western rattlesnake

Fish species in Mid-Snake River between King Hill and Milner Dam (personal communication, Idaho Dept of Fish and Game 1993 and Idaho DEQ draft Nutrient Management Plan, 1994, Dey and Minshall, 1992)

Scientific name	Common name
Family: Acipenseridae - Sturgeons	
[1,2,4,5] *Acipenser transmontanus*	White Sturgeon
Family: Salmonidae - Trouts	
[1] *Oncorhynchus clarki*	Cutthroat trout
[1,5] *Oncorhynchus mykiss*	Rainbow trout
[6] *Oncorhynchus mykiss gairdneri*	Redband trout
[1,5] *Prosopium williamsonii*	Mountain whitefish
[3,5] *Salmo trutta*	Brown trout
Family: Cyprinidae - Carps & Minnows	
[3,5] *Cyprinus carpio*	Common Carp
[5] *Ptychocheilus oregonensis*	Northern squawfish
[5] *Mylocheilus caurinus*	Peamouth
[5] *Acrocheilus alutaceus*	Chiselmouth
[5] *Richardsonius balteatus*	Redside shiner
[5] *Rhinichthys osculus*	Speckled dace
[3] *Gila atraria*	Utah chub
[5] *Rhinichthys cataractae*	Longnose dace
[5] *Rhinichthys falcatus*	Leopard dace
Family: Catostomidae - Suckers	
[5] *Catostomus columbianus*	Bridgelip sucker
[5] *Catostomus macrocheilus*	Largescale sucker
[5] *Catostomus platyrhynchus*	Mountain sucker
[7] *Catostomus ardens*	Utah sucker
Family: Ictaluridae - Bullhead catfish	
[1,2,3,5] *Ictalurus punctatus*	Channel Catfish
[3,5] *Ameiurus nebulosus*	Brown bullhead
[3,5] *Ameiurus melas*	Black bullhead

Family: Centrarchidae - Sunfishes	
[1,2,3,5]*Micropterus dolomieu*	Smallmouth bass
[1,3,5]*Micropterus salmoides*	Largemouth bass
[3,5]*Lepomis gibbosus*	Pumpkinseed
[3,5]*Pomoxis nigromaculatus*	Black crappie
[3,5]*Lepomis macrochirus*	Bluegill
Family: Percidae - Perches	
[1,3,5]*Perca flavescens*	Yellow perch
[3,5]*Stizostedion vitreum*	Walleye
Family: Cottidae - Sculpins	
[5]*Cottus bairdi*	Mottled sculpin
[4,5]*Cottus greenei*	Shoshone sculpin
[5]*Cottus beldingi*	Paiute Sculpin
[5]*Cottus confusus*	Shorthead sculpin
[5]*Cottus rhotheus*	Torrent sculpin
Family: Sciaenidae - Drums	
[3,5]*Aplodinotus grunniens*	Freshwater drum

[1] Game fish in the Mid-Snake River (IDEQ Nutrient Management Plan, 1994)

[2] Spawning fish (IDEQ Nutrient Management Plan, 1994)

[3] Non-native species. Five additional non-native species likely present are: *Tilapia mossambica, T. Zellei, T. nilotica (*the Mozambique, Redbelly and Nile Tilapias, respectively*), Lepomis cyanellus*, and *L. microlophus* (Green and Redear sunfishes).

[4] Considered a Species of Special Concern by the State of Idaho.

[5] Fish fauna of the Snake River drainage below Shoshone Falls (Bowler, et al. 1992 and Bowler and Frest 1992).

[6] The only pure surviving population of Redband trout is in King Hill Creek; hybrids are found in other tributaries.

[7] Federal Energy Regulatory Commission, 1990 (FEIS for the Milner, Twin Falls, Auger Falls, and Star Falls hydroelectric projects in Idaho, FERC/EIS-0048F).

Native fish species no longer present in the Mid-Snake River include *Onchorhynchus tshawystcha*, Chinook salmon, *O. kisutch*, Coho salmon, the anadroumous form of *O. mykiss*, Steelhead trout, and *Lampetra tridentata*, the Pacific lamprey.

Class Gastrioida (Snails)
26 Native
2 Exotic (non-native)
Ancylidae
Bulinidae
Hydrobiidae
Fluminicola columbiana
candidate endangered, cold water
Potamopyrgus antipodarum
non-native)
Pyrgulopisis idahoensis
endemic to Mid-Snake and Lake Idaho, endangered, cold water
Preferred habitat: sediment, beneath rocks
Bliss Rapids Snail
endemic to Mid-Snake and Lake Idaho, endangered, cold, fast flowing water
Lancidae
Fisherola nuttalli
candidate endangered, cold water
Lanx sp.
endangered, cold water
Lymnaeidae
Radix auricularia
non-native
Physidae
Physa natricina
endangered, cold water
Planorbidae
Valvatidae
Valvata utahensis
endangered, cold water
Class Pelecypoda (Clams)
17 Native
Candidate or Proposed Endangered
1 Exotic (non-native)
Corbiculidae
Corbicula fluminea
non-native
Margaritiferida
Sphaeriidae
Unionidae

Anodonta Californiensis (California Floater)
candidate endangered, cold water

Invertebrates identified as part of kick samples collected during September 1992 (Minshall and Robertson 1992).

AUGER FALLS

Turbellaria (abundant)
Baetis tricaudatus (abundant)
Potamopyrgus (abundant snail)
Prosimulium (abundant)
Hydropsyche
Hydroptila
Musculium (abundant clam)
Chironomidae
Oligochaeta

KANAKA RAPIDS
Coenagrionidae
Turbellaria
Baetis tricaudatus (abundant)
Potamopyrgus (abundant snail)
Hydropsyche
Hydroptila (abundant)
Ostracoda
Chironomidae (abundant)
Oligochaeta
Simulium
Amiocentrus
Helicopsyche (abundant)
Rhycophila vaccua
Hydracarina

POOL UPSTREAM OF KANAKA RAPIDS
Glossophinia (leech)
Piscicolidae (leech)
Caecidotea (Isopoda)
Potamopyrgus (abundant snail)
Chironomidae (abundant)
Oligochaeta
Anodonta (mussel)