FEASIBILITY OF LARGE-SCALE MANAGED RECHARGE OF THE EASTERN SNAKE PLAIN AQUIFER SYSTEM

Prepared by

Idaho Department of Water Resources

In Cooperation with:

U.S. Bureau of Reclamation

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December 1999

Acknowledgements

This report on the feasibility of large-scale managed recharge of the Eastern Snake River Plain aquifer was a cooperative effort, made possible only thorugh significant allocation of time and resources by personnel in the following agencies and organizations.

Idaho Department of Water Resources
Hal Anderson
Paul Castelin
Wayne Haas
John Lindgren

U.S. Bureau of Reclamation
Richard Rigby
Robert Schmidt
Joseph Spinazola

Idaho Department of Fish and Game
Eric Leitzinger
Tracey Trent

Idaho Power Company
Jon Bowling

Navigant Consulting and JUB Engineers
Jeffery Lefkoff
Rex Harding

The Idaho Department of Water Resources wishes to expressly acknowledge the contributions of three organizations that provided major input to this report: the U.S. Bureau of Reclamation, Idaho Department of Fish and Game, and the Idaho Power Company. Without the support and critique from staff of these three entitities this document would not have been possible. In addition, sincere thanks are due the following individuals who provided information germane to this report or participated in its review:

Dave Parrish, IDFG
Jerome Hanson, IDFG
Will Reid, IDFG
Bob Martin, IDFG
Sonny Buuhidar, IDEQ
Scott Short, IDEQ
Ed Hagan, IDEQ
Dean Yashan, IDEQ
Eileen Salenik, USBR
Richard Prang, USBR
Jim Esch, USFWS
Rich Graves, NMFS
H. W. Young, USGS
Marti Bridges, Idaho Rivers United
Terry Huddleston, Idaho Water Alliance
Donna Cosgrove, IWRRI
Gary Johnson, IWRRI

Special thanks to Cody Kinney (IDWR) for her dedication of time and effort in preparing this report.

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EXECUTIVE SUMMARY

This report, *Feasibility of Large-Scale Managed Recharge of the Eastern Snake Plain Aquifer System,* describes the potential of a managed recharge program to enhance conjunctive management of water resources in the Eastern Snake River Plain (ESRP). Large-scale managed recharge is evaluated in the context of institutional, environmental, hydrologic, and engineering factors that influence and characterize the feasibility of operational implementation. Restoring ground-water levels in the central part of the Plain and spring discharges in the Thousand Springs and American Falls reaches of the Snake River are two key hydrologic objectives of large-scale managed recharge in the ESRP.

Managed recharge would include the diversion of water from the Snake River or tributaries at several locations during periods of surplus streamflow, for delivery to infiltration sites at key locations on the ESRP. Typically, water would be conveyed through irrigation canals to sites where depressions in the land surface allow for ponding and infiltration of water. Control structures in the canal would divert, measure, and control the rate of water flow into the infiltration site. Water would percolate to the underlying aquifer, raising ground-water levels and increasing ground-water storage. The increase in water levels would produce increased return flows from the ground-water system back to the Snake River, particularly at spring discharge locations in the Thousand Springs and American Falls reaches. Because of the nature of ground-water flow, periodic diversions of recharge water would result in a steady, sustained increase in spring discharge.

The hydrology of the Snake River and water rights administration determines the availability of streamflow that could potentially be diverted for recharge. However, a number of institutional controls, with associated environmental concerns, may also limit diversions.

The most significant institutional constraints on managed recharge are the water rights claimed by Idaho Power Company (IPCo). IPCo flow rights have the potential to dramatically restrict or prevent recharge diversions. The magnitude of restrictions will depend on the ultimate impact of recharge on IPCo power generation in the middle and lower Snake River, as well as the legal status of recharge diversions under Idaho law and the Swan Falls Agreement. Diversions for managed recharge will require water right permits from the Idaho Department of Water Resources. Issuance of a permit is subject to protests, administrative hearings, and other challenges, and must, under any conditions, consider the local public interest.

The foremost environmental concerns stem from the potential impact of managed recharge on fish and wildlife in the Snake River. Diversions to recharge may have negative impacts on fish and wildlife during the November to March period in reaches affected by the diversions. Recharge may have a positive impact on these resources in reaches and periods of the year when flow is increased by recharge. The greatest potential impacts during that period are on white sturgeon, several species of trout, possibly endangered snails in the middle Snake River, and on fall chinook salmon in the Snake River below Hells Canyon Dam. Potential impacts of managed recharge on ground-water quality, such as the introduction of pathogens into the aquifer, can be addressed through site- and source-specific monitoring programs developed in consultation with the Idaho Division of Environmental Quality.

Since there is the need in some cases to use federal facilities for conveying recharge water and the use of federal lands for recharge pond locations, environmental review of a managed recharge program would likely be conducted in accordance with the National Environmental Policy Act (NEPA). The USBR Palisades Winter Water Savings contracts may require such review before canals subject to their restrictions can be used for recharge. An Environmental Assessment, rather than an Environmental Impact Statement, may be sufficient if the proposed design addresses the major environmental concerns prior to initiation of the formal review. Due to the presence of threatened and endangered species in the Snake River, environmental review must also comply with the Endangered Species Act (ESA).

A ground-water flow model was used to predict the hydrologic benefits that would be derived from four possible large-scale managed recharge scenarios located in different areas of the Plain: 1) Thousand Springs, 2) Lake Walcott, 3) Hells Half Acre, and 4) Egin Lakes. The modeled recharge scenarios integrate many of the environmental, institutional, and operational restrictions likely to be imposed on recharge diversions, including minimum stream flow recommendations developed by Idaho Department of Fish and Game. Estimates of water availability and expected recharge rate for the four scenarios varies greatly, depending on the diversion location.

The “Thousand Springs” recharge scenario, which makes maximum use of excess diversion capacity of both the Milner-Gooding and North Side Canals, is most effective in meeting the two key hydrologic objectives of managed recharge. After 20 consecutive years of recharge at the rate of 416,000 acre-feet per year, springflows in the Kimberly to Bliss reach could be expected to increase between 350 and 450 cfs. Ground-water levels in the central part of the plain could be expected to increase between 10 and 15 feet.
In all four scenarios there is a strong motivation to conduct recharge mainly during winter months. The motivation stems from a combination of factors, including greater availability of surplus flows, greater excess canal capacity during these months, and lower instream flow requirements of resident fisheries. Wintertime recharge also affords the opportunity to demonstrate a net positive impact on Snake River flows below Milner Dam during critical summer months.

The four scenarios provide a new perspective on the longstanding assumption that aquifer recharge conducted high up in the basin would have the greatest overall benefit because it would impact the entire aquifer downgradient. While there clearly exists a regional south-westward ground-water flow gradient that influences the movement of recharge water, there is also a substantial degree of aquifer compartmentalization with respect to the influence of managed recharge activity. The compartmentalization of recharge effects is due mainly to the distribution of transmissivity in the aquifer. However, the practical necessity of developing recharge scenarios that take advantage of existing diversion facilities is also a factor.

The final major factor affecting the potential for managed recharge is economic costs, defined by direct expenditures to construct, improve, and operate recharge facilities. The cost of constructing new canals to recharge sites is prohibitive; therefore, managed recharge must rely on the use of existing canals to deliver surface water to the recharge sites. The report presents engineering costs needed to develop specific sites into operational recharge facilities. Specific costs are presented for five sites. Costs vary from about $800,000 to $5,000,000, depending on specific construction requirements at each site. Requirements for water quality monitoring, including drilling of monitoring wells and site preparation were identified, but not quantified. In addition to water quality monitoring, an enhanced network of stream gages and water-level monitoring wells may be required in order to quantify and monitor the benefits of managed recharge for operational purposes.

Interviews with owners and operators of canals indicate a willingness to participate in a managed recharge program when canals are not fully devoted to irrigation deliveries, including use of the canal during winter months when freezing conditions present operational challenges. A primary concern among canal company representatives is protection from any liabilities associated with managed recharge.

The broadest conclusion that can be drawn at this point regarding the feasibility of managed recharge of the ESPA is that, hydrologically and economically, large-scale managed recharge appears feasible. However, institutional and environmental issues will have to be resolved prior to project implementation. The primary uncertainties which would have to be addressed before large-scale managed recharge could be initiated are:

- costs associated with mitigating impacts on hydropower water rights,
- the mechanism and process which would be required in order to use federal project canals and facilities for large-scale diversion of recharge water during winter months,
- mnimizing environmental impacts (including those associated with ESA listed species), and
- Uncertainties associated with how managed recharge would be integrated into basin-wide conjunctive water resources management.

Future efforts regarding managed recharge on the Eastern Snake Plain will focus on specific projects as they are proposed. With those proposals will come the opportunities to clarify, address, and resolve the issues identified in this report, in order to insure that managed recharge is a viable tool for water resources management in Idaho.

I. INTRODUCTION

In January of 1997, the Idaho Department of Water Resources (IDWR) published a report entitled, "Upper Snake River Basin Study" that addressed issues related to ground-water development on the Eastern Snake River Plain and its effect on the aquifer system. It looked at the effects of ground-water pumpage, changes in irrigation method and efficiency, and several managed recharge study scenarios on surface water availability, springflows, and ground-water levels using simulations based on the University of Idaho (UofI)/IDWR ground-water model.

Spring discharges in the Milner to King Hill reach of the Snake River had peaked in the mid-50's at about 6,500 cfs and had been in decline since, with current (1998) discharge being about 5,800 cfs. Similarly, springflows in the Shelley to Neeley reach, which had been relatively constant at about 2,500 cfs, were showing signs of decline. Further, large areas of the Eastern Snake River Plain were showing continuing ground-water level declines. Reasons for these changes are attributed to declining diversions of surface water into areas that had been flood-irrigated and were now being irrigated using more efficient methods, cessation of winter diversions by most of the Snake River canals beginning in about 1960, combined with the rapid growth since 1950 of ground-water pumpage. The net effect of efficiency improvements and pumpage alone by 1992 was that more than 2.1 million acre-feet per year less recharge was entering the aquifer system, leading to ground-water level and springflow declines.

Managed recharge was seen as one of the key mechanisms for reversing these declining trends, but its economic, engineering, institutional issues, and environmental framework was not well understood. This study was commissioned to answer the broad questions related to the feasibility of large-scale managed recharge.

The purpose of a managed recharge program for the Eastern Snake Plain Aquifer (ESPA) is to sustain or increase ground-water levels and the outflow from springs discharging to the Snake River. The general design calls for the aquifer system to be used as a storage reservoir that would capture excess flows in the Snake River during high-flow periods, mainly winter and spring, and release the stored water back to the river throughout the remainder of the year. Water would be diverted from the river only when streamflow exceeds irrigation demand, hydropower rights, and instream flow requirements. The excess water would be conveyed to recharge basins, via existing canals, where it would infiltrate the subsurface and enter the regional aquifer system, raising ground-water levels. The subsequent release of stored water as spring discharge would raise the base flow rate in the river during low-flow periods.

This report represents the completion of the first stage of what is expected to be a multi-stage managed recharge evaluation and design process, that may ultimately lead to implementation of a large-scale managed recharge program for the ESPA. The report identifies the hydrologic, environmental, institutional, and economic considerations that will determine the feasibility of large-scale managed recharge. These considerations are used in a screening evaluation of possible large-scale managed recharge scenarios. They are also used to identify candidate sites for pilot-scale testing of possible managed recharge scenarios, in order to verify assumptions and to confirm results and conclusions from the first stage investigation.

Four general types of screening criteria were used in the evaluation:

- Water availability
- Hydrologic impact
- Institutional controls, including water rights, environmental concerns and land use
- Economic cost

These criteria are used in the screening analysis to identify recharge scenarios that present optimal combinations of recharge effectiveness, institutional and environmental compatibility, and economy of cost:

- **Water Availability**. The source of recharge water is the Snake River or its tributaries. In order for water to be available for recharge, the water must be physically present in the river at the point of diversion, all water rights and instream flow requirements must be satisfied, and sufficient unused canal capacity must be present. Water availability varies considerably from month to month and year to year. Water availability to recharge sites will differ with the point of diversion associated with the site.

- **Hydrologic Impact**. The goal of managed recharge is to increase ground-water levels in the aquifer, and the outflow from springs. Managed recharge effectiveness in generating and distributing these benefits throughout the plain depends greatly on the hydrogeology of the ESPA, as well as on the location and timing of managed recharge activity. Hydrologic models are the main tools used in this study for estimating the magnitude and distribution of hydrologic benefit to be derived from managed recharge.

- **Institutional Controls**. The use of potential sites for recharge must be compatible with the existing institutional controls on water and land use in the Eastern Snake Plain. Several of the institutional controls stem from laws and regulations associated with environmental protection, such as ground-water quality, surface-water quality, and fish and wildlife habitat. Other controls include water rights, property ownership, and land management policy. Recharge sites differ in their point of diversion, current property owner, and land-use governance. Environmental impacts vary with location and timing of diversions relative to flow conditions in the Snake River.

- **Economic Cost**. Costs are defined here as direct expenditures for construction and operation of recharge facilities. Capital costs include improvements to existing canals used to convey water to the sites, land acquisition for the sites, and construction of the recharge ponds. Operational costs include labor, maintenance, and power.

The development of these screening criteria and their application to large-scale managed recharge scenarios is described in detail in Sections III through V of this report. Candidate sites for pilot scale testing and engineering costs for specific pilot test sites are developed in Section VI.

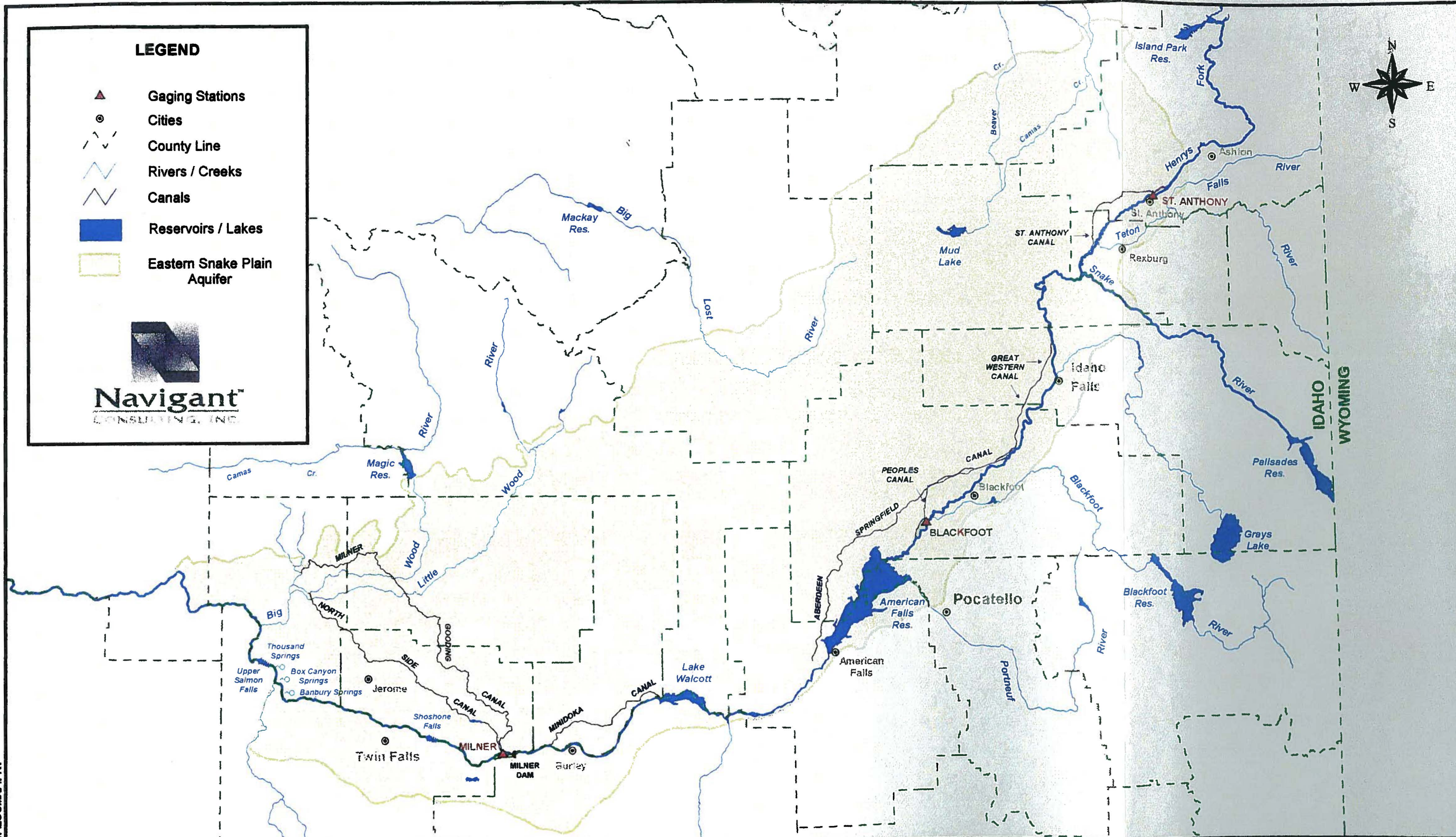
II. GROUND-WATER RESOURCES OF THE EASTERN SNAKE RIVER PLAIN

The Eastern Snake River Plain covers an area of approximately 10,800 square miles, entirely within the Snake River drainage basin. Average annual precipitation is 8 to 10 inches over most of the plain. Although the climate is generally semiarid, the Snake River and smaller streams carry an annual average of 10.2 million acre-feet of water into the plain. Streams extend to mountainous watersheds on the east, north, and south sides of the plain. Higher elevations in the basin receive as much as 60 inches of precipitation per year, most of which is winter snowfall. Of the total stream inflow, approximately 49 percent is from the Snake River above Heise, 23 percent is from the Henrys Fork, 10 percent is from streams on the north side of the plain, and 18 percent is from all tributaries to the Snake River below the Henrys Fork confluence with the Snake (Lindholm, 1996). Figure 2-1 shows the main surficial hydrologic features of the Eastern Snake River Plain.

A. THE EASTERN SNAKE RIVER PLAIN AQUIFER

Beneath the Eastern Snake River plain lies the Eastern Snake River Plain Aquifer (ESPA). The hydrogeology of the ESPA has been described by numerous investigators including Stearns et al. (1938), Mundorff et al. (1964), Lindholm (1988), and Whitehead (1992). The ESPA is composed of thick sequences of Quaternary age basalt flows. The aggregate thickness of basalts that make up the system is estimated to be more than 5,000 feet, however most horizontal movement of ground water occurs within the upper 300 to 500 feet of the aquifer. The ESPA is a highly productive aquifer. Interconnected pore spaces, mainly in the rubbly tops of basalt flows, transmit very large quantities of ground water. Well yields above 3,000 gallons per minute (gpm) are not uncommon (Lindholm, 1996). Goodell (1988) reports that 66 percent of irrigation wells in the plain have yields that exceed 1,500 gpm. Median pumping drawdown on the plain is about 6 feet. Lindholm (1996) estimates total ground-water storage in the upper 500 feet of the aquifer system to be 200 to 300 million acre-feet.

In most areas of the plain, a free (unconfined) water-table surface marks the top of the regional flow system, although there are some areas on the periphery of the plain where basalts are overlain by sedimentary layers, resulting in localized perched aquifer conditions and/or underlying confined flow conditions within the basalts. Downward vertical flow in the regional system is significant in the northeastern portions of the plain, where recharge from the land surface is high. Upward vertical flow occurs in the discharge areas along the southwestern portion of the plain (Lindholm, et al., 1988).



SCALE

10 0 10 20 Miles

EASTERN SNAKE PLAIN AQUIFER MANAGED RECHARGE PROJECT

MAJOR HYDROLOGIC FEATURES - EASTERN SNAKE PLAIN

IDAHO DEPARTMENT OF WATER RESOURCES

FIGURE 2-1

Aquifer tests conducted in the unconfined ESPA typically yield transmissivity values between 100,000 and 1,000,000 feet^2 per day. The range of aquifer transmissivity values in ESPA ground-water models is even greater. More than five orders of magnitude separate the highest transmissivity values representing basalts in the central part of the plain, from the lowest values representing sedimentary deposits on the periphery of the plain (Norvitch et al., 1969), (deSonneville, 1974), (Garabedian, 1986).

The water-table gradient in the ESPA also varies greatly, across the plain. The average gradient is about 12 feet per mile, but the range is from 3 feet to over 100 feet per mile (figure 2-2). In the central part of the plain, the closely spaced water-table contour lines, north and slightly west of American Falls are associated with a series of partially healed or filled fractures known as the Great Rift Fault Zone (figure 2-3). On the eastern end of the plain, another narrow band of closely spaced contour lines is associated with the thick, deeply buried, fine-grained sediments of the Mud Lake deposits (figure 2-3). In figure 2-2, the steeper gradient that is associated with these two features is evidence that they offer much greater resistance to the south-westward regional flow of ground water than do the surrounding basalts (Mundorff, Crosthwaite et al., 1964), (Kjelstrom, 1992). In ground-water models of the ESPA system, these two hydrogeologic features are represented by narrow bands of much lower aquifer transmissivity.

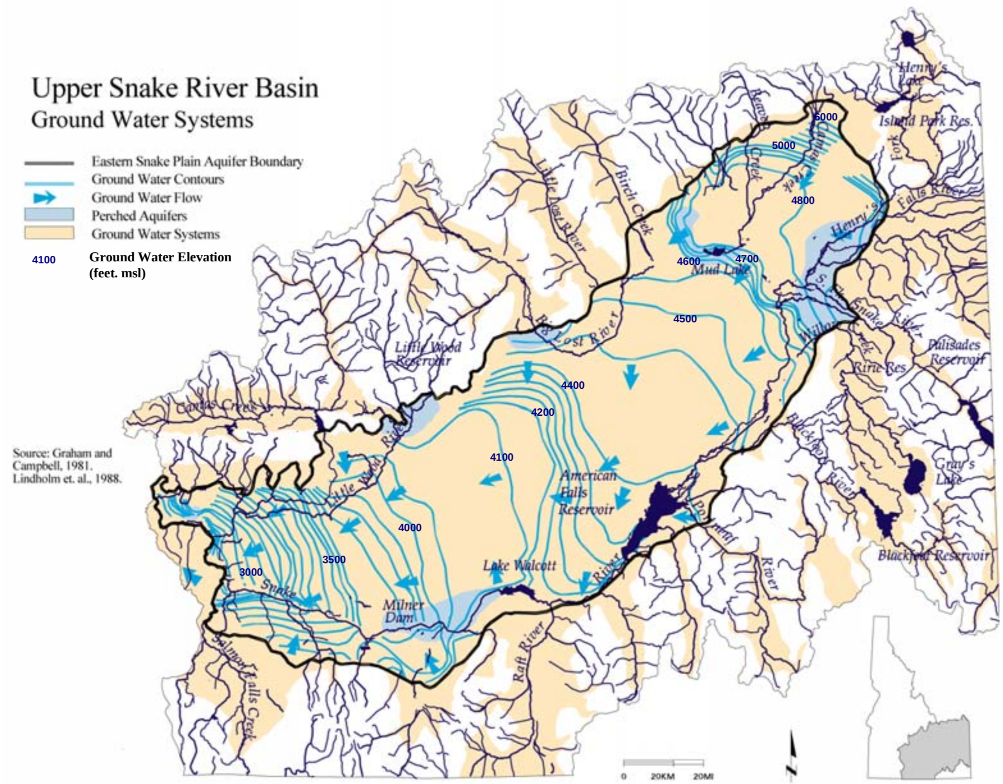
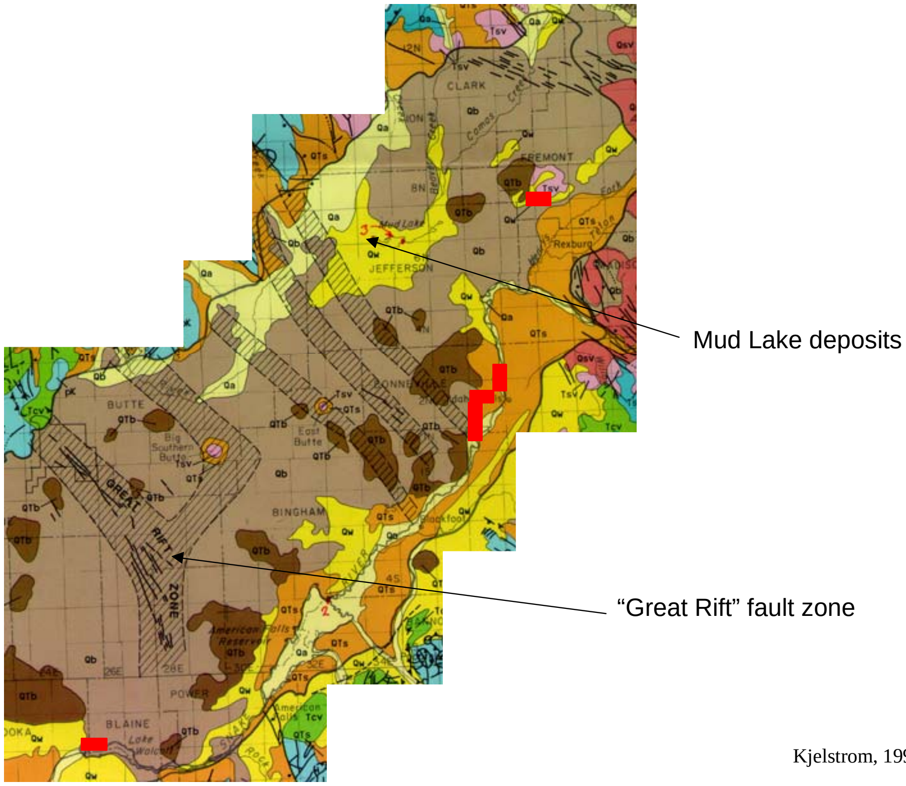


Figure 2-2. Ground-Water Flow Gradient in the ESPA



Kjelstrom, 1992

Figure 2-3. Geologic Map of ESPA Showing Two Important Features

Several studies of ground-water chemistry conclude that the overall quality of water in the aquifer is quite high, except for localized areas of high nitrate. Low (1987) concludes that most ground water in the Snake River Plain is suitable for most uses. Low (1987) reports a median concentration of dissolved solids of 293 mg/L, measured in 1,123 wells spread throughout both the western and eastern plain. Concentrations are lowest in the Eastern Snake Plain where basalt is at or near land surface. Wood and Low (1988) determined that the geochemical composition of ground water is similar to that of the Snake River and tributary basins, which provide the major source of recharge to the aquifer system.

B. Components of Ground-Water Recharge and Discharge

Table 2-1 shows the components of ESPA recharge and discharge for water year 1980 (Garabedian, 1992). The main component of recharge is *incidental* to current irrigation practices. About sixty percent of total aquifer recharge occurs as a result of irrigation in excess of crop consumptive use, in areas irrigated with surface water. Water also enters the aquifer from precipitation, from tributary underflow along the northern and eastern boundaries of the plain, and through losses from the Snake River, tributary streams, and canals.

Ground water that is not pumped from the aquifer is discharged to the Snake River in one of three gaining reaches. Most ground water exits the aquifer between Kimberly and Bliss via springs along the north side of the Snake River Canyon. Presently over 3.7 million acre-feet flows from these springs annually (IDWR, 1998). The American Falls reach of the Snake River, between Blackfoot and Neeley, accounts for approximately 1.8 million acre-feet of discharge annually (Kjelstrom, 1986). Discharge to the Henrys Fork below St. Anthony is approximately 80,000 acre-feet per year (Spinazola, 1994).

Table 2-1. Recharge and Discharge to the ESPA Ground-water System, 1980 (Garabedian, 1992)

	Quantity (million acre-feet)	Percentage of total
Recharge		
Surface water irrigation	4.84	60
Tributary basin underflows	1.44	18
Precipitation on the plain	0.70	9
Snake River losses	0.69	8
Tributary stream and canal losses	0.39	5
Discharge		
Snake River gains	7.08	86
Net pumpage	1.14	14

C. HISTORICAL CHANGE IN GROUND-WATER LEVELS AND SPRING DISCHARGES

As indicated by Table 2-1, irrigation practices currently have a major impact on water resources of the Eastern Snake River Plain. Goodell (1988) provides a historical summary of irrigation on the Eastern Snake Plain. Irrigated acreage and volumes of surface water irrigation increased dramatically through World War II. Prior to 1950, annual surface application rates were as high as 14 acre-feet per acre, though average crop consumptive use is only about 2 feet per year. Mundorf et al. (1964), reported on the response of the ESPA system to these irrigation practices. Ground-water levels north of the Snake River between Kimberly and Bliss rose by 60-70 feet on average during the period 1907-1959. During the same period ground-water storage increased by about 400,000 acre-feet per year, a cumulative increase of more than 15 million acre-feet.

During the 1950s and 1960s acreage continued to increase, but most new land was irrigated with ground water. Water-use efficiency also increased through the use of sprinkler irrigation methods and implementation of various conservation programs. The higher efficiency dramatically reduced incidental recharge of the aquifer, at the same time as irrigation sources were shifting from surface to ground water. Declines in ground-water levels were reported in the eastern and central parts of the plain during the 1970's and early 1980's. Declines of up to 5 feet in Madison County were attributed to conversion from flood to furrow and sprinkler irrigation in that part of the basin. Ground-water declines of 10 feet or more in Minidoka County were attributed to increased ground-water pumping in that area (Lindholm et al, 1988).

Since the mid-1960s irrigation sources have continued to shift from surface water to ground water. Between 1975 and 1995 it was estimated that total ground-water storage declined on average about 350,000 acre-feet per year, a cumulative decrease of 7 million acre-feet (Johnson, Cosgrove, 1997). The locus of ground-water level declines during the last twenty years has been in the central part of the plain, in a roughly 1,300 square miles area that includes much of Minidoka County, and parts of Jerome, Lincoln, and Blaine counties (figure 2-4). The A & B Irrigation District, and the Magic Valley Ground Water District have a total of 754 wells in this area of the plain, and together pump about 460,000 acre-feet of water per year (IDWR, 1998). As much as 12 feet of ground-water decline has occurred within this area, and the average has been about 8 feet.

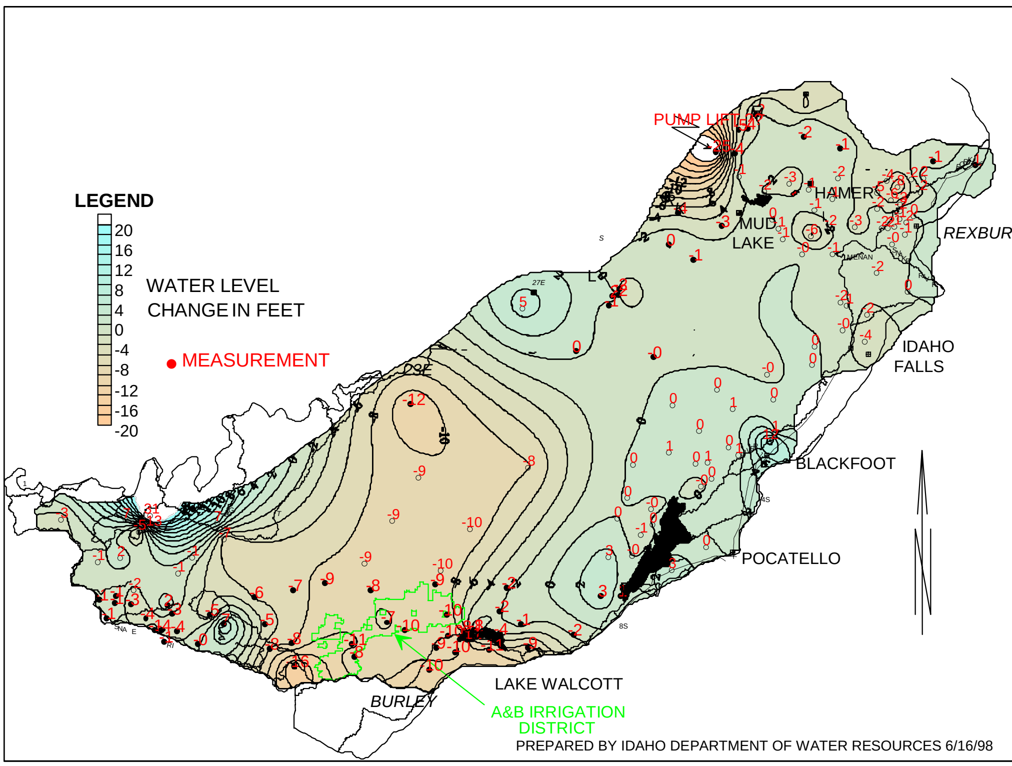


Figure 2-4. Change in Ground-Water Level 1980-1998

Elsewhere on the plain there is less consistent evidence of ground-water level declines. A small area with decline that averages 2 to 3 feet appears in Madison County near St. Anthony, and there are isolated points within this area that exhibit declines as high as 8 feet. In other areas of the plain, for instance north of Blackfoot, ground-water levels appear to have remained constant or even increased slightly.

Spring discharge to the Snake River also increased in response to increased incidental aquifer recharge during the first half of the century (figure 2-5). Prior to 1912, spring discharge between Kimberly and King Hill was estimated to be less than 4,300 cfs. Between 1912 and 1950 spring discharge climbed steadily, reaching 6,800 cfs in the early 1950's. The increase in Thousand Springs discharge has been attributed to increased ground-water recharge in surface water irrigated areas north and east of the springs (Kjelstrom, 1992). After 1950, a period of uneven decline in Thousand Springs discharge began with the low point occurring in 1996, when average annual discharge fell to about 5,200 cfs (figure 2-5).

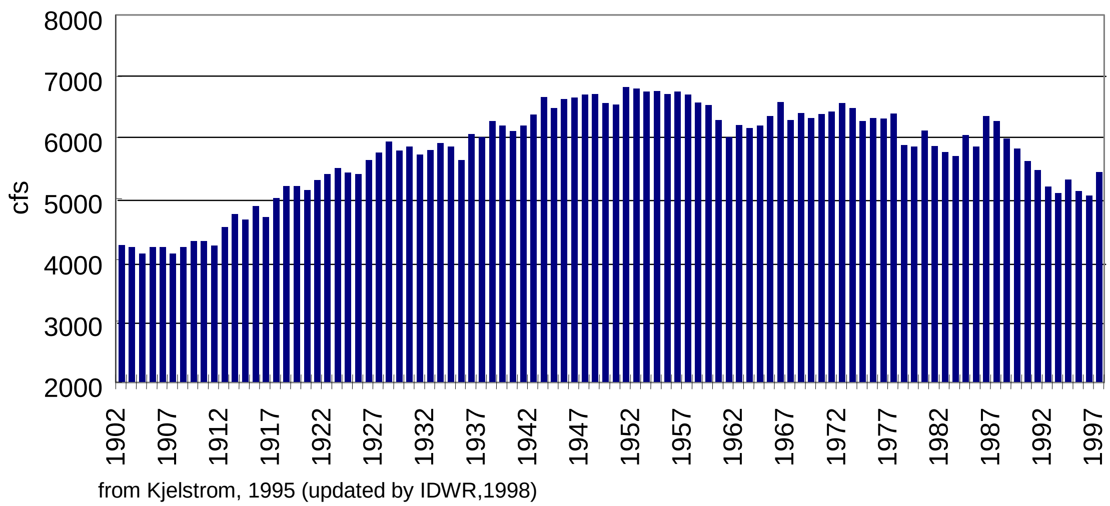


Figure 2-5. Discharge from the ESPA at Thousand Springs (Kimberly to Bliss reach)

Generally speaking, declines in spring discharge and ground-water levels can be attributed to increased ground-water withdrawals, to more efficient irrigation practices, and reduced diversions due to recent drought conditions (Kjelstrom, 1986). However, it is apparent that in certain areas of the plain, declines may be predominantly the result of a single factor, such as increased ground-water pumping.

D. PRIOR INVESTIGATIONS OF MANAGED RECHARGE IN THE ESPA

During the past four decades, there have been several investigations of managed aquifer recharge of the ESPA. Among the earliest was a special project report by the U.S. Bureau of Reclamation (USBR, 1962). The report provided a general discussion of artificial recharge, detailing irrigation, power, and flood control benefits. No hydrologic modeling was conducted, however, based on examination of water-table contours, the study recommended that aquifer recharge be conducted mainly in the eastern part of basin, in order to maximize the subsurface flow path of recharge water.

A subsequent U.S. Geological Survey (USGS) study (Norvitch, Thomas et al., 1969) was the first aquifer recharge investigation to include modeling. The study also demonstrated the use of annual flow-rate recurrence relationships to determine expected water availability for recharge projects. These results were then used as input to an analog hydrologic model of the ESPA. Recharge sites near Blackfoot, Shoshone, and St. Anthony were modeled with recharge rates of up to 186,000 acre-feet, during 3 months of the year, for 5 consecutive years. Model results indicated that of the 3.7 million acre-feet of water recharged, 3.3 million acre-feet would go into aquifer storage, and 0.4 million acre-feet would be discharged by springs. The expected ground-water level rise due to artificial recharge was between 1 and 5 feet. The authors concluded that the hydrologic impacts of artificial recharge at the scale being modeled would be masked by seasonal fluctuations of water levels and spring flows.

In 1975, an Idaho Water Resource Board report presented the results of a two-year aquifer recharge demonstration project (Anderson, 1975) at the Egin Lakes. The project reportedly recharged 20,000 acre-feet of water during 1973 and 1974, into a 320-acre basin. Observation wells revealed ground-water mounding of 6 to 10 feet directly beneath the recharge basin, however, no impact on ground-water elevations was observed beyond the immediate recharge area. The report concluded that computer models of artificial recharge are better for assessing effects of long-term, large-scale recharge projects.

The Southwest Irrigation District recharge project was initiated in 1991 (Wayment, 1999). The project was one of 13 demonstration projects implemented by the USBR and local sponsors as part of the High Plains Ground Water Recharge Program. The Southwest Irrigation District project was intended to demonstrate the technical feasibility and economic potential of ground-water recharge using injection wells. Thirteen wells and a siltation pond were located in the Murtaugh area between Burley and Twin Falls. Between 1992 and 1997, a total of 23,000 acre-feet of water was pumped from Murtaugh Lake and injected into the aquifer using these wells. An increase in ground-water levels ranging from 1.5 to 65 feet were observed at distances of up to 1/2 mile from the recharge wells, however, the duration of the project was deemed to short to clearly demonstrate the long-term impact on ground-water levels. No adverse impacts on ground-water quality were reported. The investigators concluded that recharge project proposals have many stakeholders, and many of the issues surrounding large-scale managed recharge projects cannot be resolved with existing institutions and practices.

Two recent modeling related investigations of managed aquifer recharge were conducted by the Idaho Water Resources Research Institute (IWRRI) (Sullivan, Johnson et al, 1996), and the Idaho Department of Water Resources (IDWR) (IDWR, 1997). The IWRRI study provided an assessment of the capabilities of existing canal companies to deliver water to recharge sites independent of actual water availability for recharge. The IDWR study combined canal capacity information from the IWRRI report with estimates of water availability, in order to estimate the maximum annual recharge rate. Assuming complete subordination of hydropower rights, and a downstream priority of recharge water use, maximum annual recharge was estimated to be 346,000 acre-feet. The IDWR report presents model results that show the aquifer and river response to recharge conducted concurrently at seven different locations on the Eastern Snake River Plain. However the truncated model did not include the Henrys Fork tributary basin. The study concluded that upstream or downstream prioritization of water use for recharge produces little difference in results, and that existing canals limit flexibility to achieve specific recharge objectives.

Several relatively small recharge projects were initiated following the 1978 legislative authorization of the Lower Snake River Recharge District and the 1994 legislative authorization of purchase of storage water for opportunistic recharge activities. In 1995, according to Idaho Water District 1 records, twelve canal companies and irrigation districts recharged over 180,000 acre-feet of water. The largest single portion (48,000 acre-feet) was recharged by American Falls Reservoir District 2, near Shoshone, using the Milner Gooding Canal. In 1996, ESPA projects recharged 169,000 acre-feet of water, and in 1997, recharge totaled 230,000 acre-feet.

III. INSTITUTIONAL CONTROLS: ENVIRONMENTAL CONCERNS, WATER RIGHTS, AND LAND USE

This section describes the institutional controls that will affect the design and implementation of a managed recharge program. Institutional control is generally associated with statutory authority for resource management, public health and safety, and environmental protection. In cases where institutional jurisdiction stems from resource management concerns, such as water rights, agreements, and land use, institutional control includes permits or authorizations required to proceed. We have attempted to determine the level of effort needed to apply for and obtain the necessary permits. In cases where institutional jurisdiction stems from environmental issues, such as fish and wildlife habitat or water quality, background is provided on the current scientific understanding of associated conditions. Institutional control in these cases often takes the form of environmental review and regulatory oversight. We attempt to forecast the scope of review that will be required by each institution to allow project approval. Institutional involvement will generally focus on procedures for evaluating and monitoring environmental impacts.

As this section was being prepared, it became apparent that certain key entities could better express the issues related to managed recharge and its potential impact from their own perspective. As a result, narratives were invited from the U.S. Bureau of Reclamation (USBR), the Idaho Department of Fish and Game, and Idaho Power Company (IPCo). They are included verbatim in this document as Appendices A, B, and C, respectively. The narratives were to include issues important to the entity involved and to help identify what issues will need to be addressed and resolved in order to move toward implementation of large-scale managed recharge. No attempt has been made to edit the narratives themselves. It is important to note, however, that there are differences in perspective regarding some of the issues expressed in the narratives. Those specific issues are highlighted and discussed in the following sections in an effort to frame the issues within a broader perspective.

Each institutional issue is characterized by its potential to constrain a large-scale managed recharge program. Modifications to the program are suggested to minimize impacts associated with high-priority constraints. The result, presented in other sections of this report, is a conceptual design that minimizes adverse impacts given the current level of understanding. The following analysis cannot, however, substitute for the formal review that will eventually be required by regulatory agencies prior to implementing a large-scale managed recharge program.

A. Federal Regulatory Authority

Before evaluating individual environmental concerns and institutional controls, a distinction is needed regarding the role of federal agencies as mandated by the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA). While other federal environmental laws, including the Clean Water Act, may affect managed recharge, at this time however, the most significant institutional controls will derive from NEPA and ESA. The scope of environmental analysis and regulatory review will be determined, in large part, by whether a managed recharge program for the Eastern Snake Plain falls within the jurisdiction of NEPA. The determination hinges on the concept of a *federal action*.

A federal action is any activity permitted, funded, or conducted by a federal agency. In the case of managed recharge on the Eastern Snake Plain, any one of the following potential design components would likely constitute a federal action:

- If the project uses facilities owned or controlled by a federal agency. The USBR owns the Milner-Gooding Canal and the Minidoka Canal, which are operated by the American Falls Reservoir District #2 and the Minidoka Irrigation District, respectively. The USBR also owns pumping and conveyance facilities within the A & B Irrigation District. Authorization from the USBR would be needed to use these facilities for managed recharge. The USBR has also indicated that the use of canals subject to the Winter Water Savings provisions of the Palisades contract may be subject to review as a federal action (Appendix A).

- If the project uses federal land. Many of the potential recharge sites are located adjacent to existing canals located on land owned by the U.S. Bureau of Land Management (BLM). A permit issued by BLM would be needed to construct and operate recharge facilities at these sites.

- If the project requires amendment or interpretation of the Palisades contracts.

A federal action may or may not occur if a state, local, or private entity has primary responsibility for designing, operating, or financing the project. A final determination of whether a federal action occurs will depend upon the project design and interpretation by the federal resource management agencies, the USBR and BLM. If a federal action is needed for managed recharge, environmental review will follow the NEPA process described below. If a federal action is not needed, environmental review will still occur, but may follow a simpler process. The occurrence of a federal action also determines how biological analyses will be performed in accordance with the ESA.

1. The NEPA Process

The intent of the NEPA process is to ensure that actions by the federal government in support of a project are adequately reviewed prior to project initiation, where the review provides sufficient understanding of project impacts, both adverse and beneficial, to the environment and the public interest. The NEPA process begins when the project proponent applies for a federal action to be taken, such as authorizing use of federal facilities. A federal agency is then designated as the *lead agency*; this agency will have the primary responsibility for determining the degree and type of environmental review to be performed for the proposed project. The lead agency will also be responsible for the conclusions reached by the review. An extremely important consideration is to have informal consultations with the applicable federal management and regulatory agencies from the inception of the project proposal process. This provides for ongoing review and analysis, with the result that a higher likelihood of a favorable outcome can be achieved.

For a managed recharge project, the lead agency would probably be either the USBR or the BLM. Informal consultation between these agencies and the project proponent, such as the Idaho Water Resource Board (IWRB), would determine which will serve as the lead agency. Factors that would affect the determination are the magnitude of the agency's involvement with the managed recharge program, the agency's authority to approve or disapprove the project, the expertise within the agency to evaluate the environmental impacts, and the sequence of the agency's involvement in the project. In the unlikely event a conflict should arise, the selection of the lead agency may be referred to the Department of the Interior or the Council on Environmental Quality for resolution.

The lead agency generally solicits input from the public, from other federal, state, and local agencies, and from Indian tribes that may be affected by the proposed project. On the basis of concern expressed from this solicitation, the lead agency decides on the need for an Environmental Assessment (EA) or a more complex Environmental Impact Statement (EIS). The lead agency will often judge whether an EA or an EIS is required on the basis of the agency's own knowledge of the potential project impacts. Occasionally, the lead agency will decide, after a brief evaluation, that the proposed action does not have a significant effect on environmental quality and neither an EA nor an EIS is required. In this case, a *Categorical Exclusion* is issued. This type of action is rare and is usually applied to more passive projects that do not physically affect the environment.

In fulfilling its obligations to implement the intent of NEPA, the lead agency may contact other federal agencies to determine their role as *cooperating agencies.* Cooperating agencies generally have jurisdiction by law or special expertise in evaluating environmental impacts resulting from the proposed project. The lead agency may also designate a state or local agency as a cooperating agency. The lead agency often requests cooperating agencies to participate in the scoping and preparation of an EA or EIS and to provide review of draft documents prior to release. Occasionally, an agency will decline to be a cooperating agency and will conduct its own analysis and issue its own Record of Decision independently of the lead agency. Conflicts of this kind are to be avoided, because they may result in untimely delays and potential legal proceedings.

The lead agency is responsible for the preparation of the EA or EIS, either through the use of their staff or, more commonly, with a contractor. The lead agency often requests that the cooperating agencies and the project proponent participate in the selection of a contractor. All costs incurred by the lead agency, including contracting for EA or EIS services, may be charged to the project proponent applying for federal action.

Scope of the Environmental Assessment

The scope of an EA is to present sufficient scientific, environmental, economic, and societal data with analyses that will allow the lead agency to reach one of two conclusions. The lead agency may conclude that the proposed project has no significant impact on the environment and issue a Finding of No Significant Impact (FONSI). Alternatively, the lead agency may conclude that additional work and more detailed analyses are required in the form of an EIS. While an EA must be adequate in scope to support the agency's conclusion, the EA is less detailed and less costly than an EIS. In addition, an EIS undergoes further review by the U.S. Environmental Protection Agency.

For a managed recharge program on the Eastern Snake Plain, an EA would describe the hydrogeology of the aquifer system and its relationship to the Snake River, define the proposed managed recharge program within that framework, and evaluate impacts to the river and ground-water system. Fish and wildlife issues associated with threatened or endangered species would likely receive particular attention, in accordance with the ESA. The EA would also define the need for managed recharge and its benefits, discuss possible alternative actions that would provide similar benefits, and define the environmental impacts of the proposed alternatives. A no action alternative must also be evaluated. All stakeholders in the EA process are solicited for their views, data, and interpretations. Stakeholders would include federal, state, and local agencies, Indian tribes, the environmental community, the public, and, of course, the project proponents.

Scope of the Environmental Impact Statement

The lead agency may determine if an EIS is required, as either the initial evaluation or a follow-up to an EA. To determine the specific scope of the EIS, the lead agency issues a *Notice of Intent*, which advises interested or affected persons or agencies of the proposed federal action and formally solicits their input through public meetings and written statements. Issues identified in this manner become the scope for the EIS. In reality, issues will be well known to project proponents, but the scoping is important because it brings together diverse interests, which is useful in resolving conflicts.

While the final scope is specific to the project, federal rules define certain requirements of the EIS. The general scope of the EIS will include:

- Definition of proposed action
- Definitive statement of purpose and need
- Reasonable alternatives to be considered
- Environmental resources to be analyzed

- Analysis of impacts
- Mitigation measures
- Selection of preferred alternative

The range of alternatives must be sufficiently broad to encompass meaningful consideration of other means to achieve the stated goals of the project. Analyses must be reasonably detailed and use the best available analytic tools, such as hydrologic models and biologic surveys. Depending on the specific scope determined by the lead agency, the EIS process may require a great deal of time and expense. The outcome of the process is uncertain and may result in the proposed project being rejected for federal action by the lead agency because of its unacceptable environmental impacts or a superior alternative project.

The project proponent can avoid some of the uncertainties, and particularly the potential time delays and high costs associated with an EIS, by initiating informal consultations with stakeholders. It is possible to enter into a series of cooperative programs with regulatory agencies and the environmental community to evaluate the potential impacts to the environment and jointly develop a mitigation strategy or modifications in the project design. This requires the ongoing involvement of stakeholders. Even if these groups are asked to participate late in the project formulation, their input can be valuable to modifying the project design and may encourage the lead agency to choose an EA rather than an EIS. This type of approach has had widespread support in recent years.

2. The Endangered Species Act

The ESA and related federal regulations establish processes for evaluating the impact of any proposed project, such as managed recharge, on all species listed as endangered or threatened. Because ESA-listed species reside in the Snake River, ESA rules will apply. Like NEPA, the ESA distinguishes projects involving a federal action from those that do not. The distinction is primarily procedural, however, and has less effect on the scope of effort for ESA compliance than for NEPA compliance. If a federal action occurs as part of the proposed project, the ESA evaluation process is determined by Section 7 of the ESA; otherwise, Section 10 applies.

Section 7 Consultation

If a federal action is involved, the management agencies enter into a "consultation" process with the federal regulatory agency. In the case of anadromous fish, the regulatory agency is the National Marine Fisheries Service (NMFS). For other ESA-listed species, the regulatory agency is the U.S. Fish and Wildlife Service (USFWS). In both cases, the federal regulatory agency would work with the Idaho Department of Fish and Game (IDFG), whose recommendations would be an important factor in the federal deliberations throughout the consultation process.

Section 7 consultations are "informal" and "formal" in structure. Informal consultations precede formal consultation and may be requested by the federal agency, an applicant, or a designated non-federal representative. Discussions during this phase may include whether and which species may occur in the proposed action area and what effect the action may have on listed species or critical habitats. Informal consultation often concludes with written concurrence by the USFWS with the management agency's determination that its action is not likely to adversely affect listed species or their critical habitat, i.e., an exception to formal consultation (USFWS, 1996).

Formal consultation is conducted when the federal management agency determines the proposed action may affect a listed species or its critical habitat and submits a written request to initiate formal consultation. These consultations follow statutory and regulatory time frames and procedures and result in a written Biological Opinion of whether the proposed action is likely to result in jeopardy to a listed species or adverse modification of designated critical habitat. The action agency(-ies) involved must prepare a biological assessment to determine the effects on listed or proposed species. The assessment is submitted to NMFS and/or USFWS for their review. The Biological Opinion results from this review.

Under Section 7 of the ESA, the federal agency must ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. Following the issuance of the Biological Opinion, the federal agency determines whether and in what manner to proceed with the action regarding its Section 7 obligations and the Biological Opinion issued by the regulatory agency (USFWS, 1996).

Habitat Conservation Plan

If no federal action is involved, the process for evaluating impacts on listed species is generally described by Section 10 of the ESA. Section 10 allows for creation of a Habitat Conservation Plan (HCP), designed to protect a species while allowing a development project to be implemented. The HCP accounts for the incidental "take" that is likely to occur with the project, where *take* is defined as an adverse impact on the species or its habitat. The ESA requires that the project be operated within the terms of an incidental take permit, as issued by the NMFS or the USFWS.

The HCP is developed by the non-federal entity responsible for the proposed project and must be approved by the NMFS or USFWS. The HCP includes an assessment of project impacts on listed species, the measures the project will undertake to monitor, minimize, and mitigate impacts, and an analysis of alternatives to the project. Public comments must be included within the HCP. Once approved, the HCP and associated incidental take permits have the force of federal law and the project must be operated accordingly.

Biologists and attorneys were interviewed for this report concerning their experience with both the Section 10 and Section 7 processes. Given the potential impacts of managed recharge on listed species, a Section 10 analysis will likely be required. The lead agency will determine whether compliance with Section 7 or 10 is required. Again, this is best achieved through the initial process of informal consultation with at least the lead agency(-ies) from the project planning inception. Both Sections 7 and 10 of the ESA encourage informal consultations early in the process. The process of developing an HCP can be lengthy and expensive, ultimately requiring a broader scope of biological analysis and habitat management than the Section 7 consultation process. The presence or absence of a federal action does not, on its own, complicate or simplify the process for evaluating project impacts on ESA-listed species.

B. FISH AND WILDLIFE HABITAT

In order for large scale managed recharge to be feasible, the needs of fish and wildlife in the Snake River system must be considered and addressed. Large-scale managed recharge will decrease flows during the winter, changing existing flow conditions provided recharge objectives are achieved annually over a period of years. Increased base flows in the river during the summer and during extended droughts will also result. The question is how to design and implement a recharge program that preserves existing fish and wildlife resources in an already highly-modified river system. This question requires ongoing consultation with the agencies responsible for protecting fish and wildlife.

The following discussion identifies the major fish and wildlife concerns, summarizes the status of each species, and indicates the potentially adverse impacts managed recharge diversions may have. The impact potential indicated here are estimates that may not include all limitations associated with an operational managed recharge program. A definitive statement on fish and wildlife impacts of specific recharge proposals must await a formal process of biologic analysis to be performed by regulatory agencies.

1. ESA-Listed Anadromous Fish

Four species of anadromous fish that migrate through the lower Snake River have been listed as endangered or threatened under the ESA. Those species are spring/summer run chinook salmon, fall run chinook salmon, sockeye salmon, and steelhead trout (USBR, 1998). The National Marine Fisheries Service (NMFS, 1995) has recommended stream flow augmentation in the lower Snake River to improve fish survival. The USBR adopted those recommendations (USBR, 1995), in accordance with required approvals from Idaho state agencies, and now releases 427,000 acre-feet per year from the upper Snake River to augment flows for the listed species in the lower Snake River.

Historically, anadromous fish were found throughout the Snake River system up to Shoshone Falls. Hells Canyon Dam is now the physical barrier that limits the range of anadromous fish migration within the watershed. Despite this fact, managed recharge has the potential to affect their habitat by altering flow regimes in the lower Snake River.

The life cycles of these species are summarized in Table 3-1. Note that all species use the Snake River during migrations, but three of the species spend their spawning and juvenile stages only in tributaries to the Snake River, primarily the Salmon and Clearwater Rivers. Only fall chinook reside in the Snake River channel during spawning and juvenile stages. The Idaho Power Company (IPCo) maintains a minimum release of 9,000 cfs from Hells Canyon Dam from October through April to protect spawning and juvenile habitat for fall chinook.

Table 3-1. Life History of ESA-Listed Anadromous Fish in the Lower Snake River

	In-Migration*	Spawning	Juveniles	Out-Migration*
Spring/Summer Chinook	Spring run: prior to mid-June Summer run: mid-June to mid-August.	In tributaries, at higher elevations	1 year, in tributaries	April to June
Fall Chinook	Aug. to Oct.	Oct. to Dec., in Snake River and lower reaches of main tributaries	April to May emergence, followed by out-migration	June to Sept.
Sockeye	April to Oct.	Redfish Lake	Redfish Lake, 1-2 years	May to June
Steelhead Trout	Sept. to Oct.	In tributaries, at higher elevations	1-4 years, mainly in tributaries	April to June
*Migration periods shown are dates of passage at Lower Granite Dam. Note: Adult steelhead over-winter in the mainstem Snake River below Hells Canyon Dam.				

Migrating adult steelhead reach the lower Snake River in mid-September to late October, then remain in the Snake, Salmon, and Clearwater rivers through the winter months, finally heading into upstream tributaries during February to April (Dave Parrish, oral communication). The IPCo minimum release from Hells Canyon Dam, intended to protect fall chinook habitat, also protects the migratory steelhead that remain in the lower Snake River.

It appears that if diversions for managed recharge are restricted to the November to March period, two of the four listed species will not be affected. The fall chinook may be affected during the spawning and juvenile stages and a portion of the steelhead population may be affected during in-migration and over-wintering in the Snake River. There would be no potential effects if diversions for managed recharge do not compromise the IPCo's ability to maintain minimum releases at Hells Canyon Dam.

2. ESA-Listed Snails

Five species of snail that reside in the middle Snake River are listed as endangered or threatened under the ESA: Idaho springsnail, Utah valvata, Snake River physa, Bliss Rapids snail, and Banbury Springs lanx. The lanx resides in three alcove spring complexes at Banbury Springs, Box Canyon, and Thousand Springs (USFWS, 1995). The other four species reside in the main stem of the Snake River between Milner Dam and C. J. Strike Reservoir. The Utah valvata is also found above Milner.

The decline of these species has been attributed to degradation of aquatic habitat, including reduced flows that isolate segmented populations, warmer temperatures, and high nutrient loading that creates algae blooms that reduce dissolved oxygen (USBR, 1998). Diversions for managed recharge have the potential to impact the four species that reside in the main stem.

A recovery plan for the snails developed by the USFWS recommends a maximum average annual water temperature of 64.4^{o}F and minimum dissolved oxygen concentrations of 6.0 parts per million (USFWS, 1995). The recovery plan establishes specific criteria for down-listing or de-listing the snails.

The IPCo has completed recent surveys of snail populations as part of its applications to FERC for relicensing its hydropower projects (IPCo, 1997). The survey found marked increases in snail populations relative to surveys conducted in the early 1990s during an extended drought. The higher populations are likely attributable to wetter conditions in the Snake River basin in recent years (USBR, 1998). According to the USBR, of the four snail species that reside in the main stem of the middle Snake River, three have met the recovery criteria established by the USFWS. Colonies of the Bliss Rapids snail, the Idaho springsnail, and the Utah valvata are found in increasing, self-producing colonies in non-threatened habitats (USBR, 1998). The colonies are increasing in distribution and density in the middle Snake River.

The status of the Snake River physa, however, remains uncertain. Few were found in the recent IPCo survey. It is not known whether the small sample size reflects a small population or the inadequacy of the sampling methods used. Empty physa shells are difficult to recover because they collect gas (from decomposition of tissue) and float away (USBR, 1998). Live specimens have not been found recently.

3. Other ESA-Listed Species

In addition to anadromous fish and resident snails, other species whose habitat includes the Snake River are listed or proposed for listing under the ESA:

- Peregrine falcon
- Bald eagle
- Grizzly bear
- Ute ladies'-tresses
- Bull trout

Additional listed species reside in the Snake Basin, but reside in upland or isolated habitats that are not affected by activities within the Snake River corridor (USBR, 1998).

Peregrine Falcon

Peregrine falcons usually build nests on ledges or cliffs near bodies of water. Rivers are also significant as habitat to prey species. Nesting sites have been identified within the South Fork of the Snake River downstream from the Wyoming state line to the Henrys

Fork. No nesting sites have been found between Henrys Fork and Brownlee Dam, although peregrine falcons have been seen as winter migrants.

The USBR has concluded that its current operations on the Snake River have little impact on peregrine falcons (USBR, 1998). It appears the same would be true of managed recharge.

Bald Eagle

Numerous bald eagles live along the Henrys Fork and the Snake River corridor from the Wyoming state line to Brownlee Dam. Mature cottonwood stands near the river above American Falls Reservoir provide nesting habitat and roosting opportunities. Nesting sites are generally located above American Falls Reservoir, but IDFG has documented nesting of bald eagles near Twin Falls, Milner Dam, and Minidoka Dam (IDFG, written correspondence). Bald eagles use the entire reach of the river for winter foraging.

It appears that diversions for managed recharge have the potential to negatively affect bald eagles. The USBR identifies two mechanisms by which bald eagle might be affected by reservoir operations: reducing cottonwood habitat and restricting access to prey (USBR, 1998). Studies in other parts of the western U.S. indicate that phreatophytes like cottonwood trees are generally sensitive to dry streambed conditions, but not to reductions in stream flow under high flow conditions (Ball, et al., 1994). If diversions for managed recharge are limited to surplus winter flows, cottonwood trees may not be affected if increased streambed drying is not significant. The USBR has concluded that its current operations on the Snake River have had little impact on the bald eagle's prey of waterfowl and fish, which are abundant, but no assessment has been made relating to the potential effect of managed recharge. Flow reductions due to managed recharge may result in negative impacts on bald eagles if those reductions reduce fish populations in the river or reduce ice-free areas where eagles forage for fish or waterfowl, since fish are the eagle's primary food source.

Grizzly Bear

Grizzly bears reside in the Greater Yellowstone Ecosystem, upstream of any potential diversion locations for managed recharge. Grizzly bear would not be affected.

Ute Ladies'-Tresses

Ute ladies'-tresses is an orchid that grows in riparian wetland meadows. They are found in the Snake River corridor between the Wyoming state line and the Henrys Fork confluence. Since the conceptual design for managed recharge includes no activities on this portion of the river, the orchid will not be affected.

Bull Trout

Bull trout were recently listed as threatened under the ESA. It is recognized as a species of special concern by the IDFG. Bull trout historically existed in the Snake River up to Shoshone Falls (IDFG, written correspondence), but now reside in tributaries to the lower Snake River. Because they do not live in the main stem, bull trout would not be affected by managed recharge on the Eastern Snake River Plain.

4. Other Species with Management Priority

The Idaho Department of Fish and Game (IDFG) is the primary fish and wildlife management agency in Idaho. The IDFG is concerned about the impacts of a managed recharge program on several species not currently listed under the federal Endangered Species Act. The species most likely to be negatively impacted by large scale managed recharge are: white sturgeon, Yellowstone cutthroat trout, redband trout, brown trout, rainbow trout, trumpeter swans, waterfowl, and sage grouse.

White Sturgeon

White sturgeon are found in the mainstem Snake River downstream of Shoshone Falls. They are long-lived fish. Evidence suggests that sturgeon can live in excess of 100 years. The mid Snake River population (upstream of Brownlee Dam) that once had access to the ocean is now fragmented into five small populations between Idaho Power Company hydroelectric dams: Brownlee, Swan Falls, C. J. Strike, Bliss, Lower Salmon Falls, and Upper Salmon Falls.

Most of these isolated populations are very depressed. Populations in three of the five reaches are so low that it was not possible to catch enough fish to obtain a population estimate in recent surveys. The population between C. J. Strike and Bliss Dams appears stable over that past 10 to15 years at about 2,200 to 2,500 fish (Cochnauer 1983, Lepla and Chandler 1995). However, both of these studies on the most robust white sturgeon population in the upper Snake found very few young sturgeon, indicating poor reproductive success. Given that sturgeon can live 100 years or more, it is difficult to draw any conclusions on the viability of a population with two studies covering a period of only 10 to 15 years.

White sturgeon spawn in the springtime and have very specific spawning and early life history requirements. They depend on a rising hydrograph in the early spring to trigger spawning behavior. High velocities and cool water temperatures are necessary for successful spawning and egg and larval survival. They will spawn from March through early June. Sturgeon eggs and larvae develop through June and into July. The lack of adequate springtime flows reduces and in many years entirely precludes successful spawning and survival of larvae. Lack of recruitment and the fragmented nature of the habitat are currently limiting sturgeon populations.

A large-scale aquifer recharge program that diverts water out of the Snake River at Milner Dam has the potential to negatively impact white sturgeon by reducing the frequency and magnitude of high flows needed for successful reproduction. The major impact would be in the reach between Shoshone Falls and Thousand Springs, the zone between the point of diversion and the return flow from the aquifer, although the impact of flattening the hydrograph will be observed much farther downstream.

Flow reductions resulting from recharge would be partially offset by increased spring discharge from Thousand Springs in the area downstream of the springs. It is important to note that increased discharge from the springs occurs throughout the year, while the reduction in spawning habitat occurs in a relatively short period of the year when recharge is taking place. If the fish and wildlife maintenance flows recommended by IDFG are provided, negative impacts to sturgeon would be reduced but not completely eliminated.

Managed recharge has the potential to provide water quality benefits to the Snake River immediately downstream of Thousand Springs. If the increased spring discharge is not used (i.e., for agriculture, aquaculture, municipal, and industrial uses) prior to entering the Snake River, then this water will most likely be cooler and cleaner than the Snake River, especially during the summer when water quality problems are the worst.

<u>Redband Trout</u>

Redband trout are the wild, native rainbow trout found in the Snake River drainage downstream of Shoshone Falls. Like most native fishes, redband have been heavily impacted by human activities. Their current distribution in the study area is restricted to the unaltered springs, tributaries, and seasonal use of the mainstem and side channel habitats.

Redband trout spawn in the spring. Spawning and early development occurs primarily in side channels and spring-fed creeks. As is the case throughout most of the basin, redband trout population size and viability is determined primarily by survival of juveniles through the non-irrigation season. Low flows during the non-irrigation season have been identified as a major factor limiting survival of juvenile redband trout.

Side channel habitats are critical to the survival of juvenile trout and are typically the first to dry up as flows decrease. A managed recharge program that results in drying up of these side channels would have a negative impact to redband trout and other aquatic organisms that use these habitats. The major impact would be in the reach between Shoshone Falls and Thousand Springs. Fish and wildlife maintenance flows would reduce but not completely eliminate the negative impacts.

If the increased spring discharge resulting from managed recharge is not used (i.e., for agriculture, aquaculture, municipal, and industrial uses) then recharge would benefit redband trout by increasing the quantity and quality of habitat in the springs and spring-fed creek systems as well as the mainstem Snake River downstream of Thousand Springs during the summer months.

Yellowstone Cutthroat Trout

Yellowstone cutthroat trout inhabit the Snake River and tributaries upstream of Shoshone Falls including: the South Fork of the Snake River, Henrys Fork, Henrys Lake, the mainstem Snake River from the mouth of the Henrys Fork down to and including American Fall Reservoir, the river downstream of the reservoir, and several tributaries of these rivers. The furthest known downstream population resides in Vineyard Creek and in the Snake River in the pool formed by the Twin Falls hydroelectric project.

The overall distribution and numbers of this species have declined due to human caused changes in the basin (Appendix B). It is an economically and recreationally important sport fish. Harvest restrictions have been implemented to protect cutthroat populations and to provide a variety of fishing opportunities. This species has been petitioned for listing on the Endangered species list. Within the study area populations are generally depressed but population sizes vary considerably from one area to another.

Yellowstone cutthroat spawn in the spring. Spawning and early development occurs primarily in side channels and tributaries. Throughout the study area population size is heavily influenced by survival of juveniles through the non-irrigation season. Low flows during this period have been identified as a major factor limiting non-irrigation season survival.

As noted, above side channel habitats are typically the first to dry up as flows decrease. Recharge activities that reduce flow during the non-irrigation season will have a negative impact to Yellowstone cutthroat trout. The fish and wildlife maintenance flows would reduce but not completely eliminate these impacts.

During the irrigation season, cutthroat trout habitat in the Henrys Fork downstream of St. Anthony is adversely affected when the following are excessively high: water temperature, pesticide concentration, pH, ammonia, nitrogen, and phosphorous. Flow reductions due to managed recharge in the summer months could exacerbate the problems that are presently occurring in this reach.

Rainbow Trout and Brown Trout

Rainbow trout defined here are either hatchery origin or they were introduced into areas they were not found historically (i.e., in the Snake River and tributaries upstream of Shoshone Falls) and have developed naturally reproducing, self-sustaining populations. They are also spring spawners, but due to the mixing of the wide variety of rainbow trout stocked by IDFG, commercial producers, and other entities, spawning can occur anywhere between September and May.

These game fish are found throughout the study area. They are recreationally and economically important sport fish to the region. Due to the declines in many of the native fish populations, these species provide a significant portion of the fishing opportunities in the basin. This is particularly true in the Henrys Fork of the Snake, where a world class and economically significant fishery is based on naturally reproducing populations of these species.

The same factors that limit redband and Yellowstone cutthroat populations also limit rainbow and brown trout populations. Recharge activities will have a similar impact to rainbow and brown trout populations.

<u>Trumpeter Swans</u>

Within the river reaches potentially affected by managed recharge, trumpeter swans winter on the Henrys Fork and on the mainstem Snake River in the vicinity of the Fort Hall Bottoms and from Milner Dam to C. J. Strike Dam. The tri-state trumpeter swan population is the only population in North America that has declined in the last decade.

The management emphasis for this population of swans has been to increase the size of the wintering area utilized by the swans to reduce the likelihood of catastrophic loss of the population due to winter mortality. Wintering populations of swans have been increased through hazing and transplants on the Henrys Fork downstream of Ashton and on the main Snake River in the vicinity of the Fort Hall bottoms.

Swans winter in relatively shallow, slow moving reaches of the river where aquatic vegetation is available. Icing over of the winter foraging areas poses a serious threat to the swans. Foraging areas are typically the first to freeze over in the winter. This problem would be exacerbated by recharge activities that further reduce flow in the winter. Foraging areas could potentially dry up or be subject to increased icing.

The fish and wildlife maintenance flow recommendations including the temperature requirement that no recharge diversions take place in the Henrys Fork when the daily mean air temperature is below 10° F.

<u>Waterfowl</u>

Waterfowl provide an important recreational and economic benefit to the basin. Duck and goose hunting is popular throughout the study area. The icing problems described for trumpeter swans in the Henrys Fork also apply to other waterfowl. Icing also causes ducks and geese to leave the area, thereby reducing waterfowl hunting opportunities, particularly on the Henrys Fork.

Flooding of recharge basins during the fall and winter months may provide additional waterfowl hunting areas and opportunities if public access is allowed. It is unlikely that any year round or nesting season waterfowl habitat will be created in the recharge basins because it appears they will only be flooded during a relatively short period of the year.

Sage Grouse

Sage grouse numbers have declined steadily and significantly in the last 40 years due primarily to the loss of sagebrush habitat. Currently sage grouse populations in Idaho are depressed, perhaps at an all time low. In response to the declining numbers, IDFG has reduced hunting seasons significantly. It is likely that the sage grouse will be petitioned for listing under the Endangered Species Act in the next year.

Flooding at recharge sites will kill sagebrush. Sage grouse could be affected by large scale managed recharge through loss of habitat at the recharge sites. The size of the area flooded and the presence of sage grouse on the site or adjacent areas should be an important consideration in selecting recharge sites.

5. Idaho Department of Fish and Game

The IDFG will have an important role in evaluating the impacts of a large-scale managed recharge program. Although it has no statutory authority to directly regulate water management activities, it will influence regulatory agencies through consultation processes (Will Reid, oral communication). It seems apparent that the IDFG will need to continue to consult with the IDWR and the IDEQ, in particular, on a wide variety of issues related to water rights, conjunctive management, streamflow/water quality, river hydrology, and other topics as all parties attempt to scope the needs of fish and wildlife in a riverine environment that is now highly regulated for a variety of purposes. Interviews with personnel at the USFWS and the NMFS confirm the influence that the department's consultations have had on federal regulatory decisions regarding the ESA.

Beyond the concern with specific species listed under the federal ESA, state law assigns responsibility for protecting general fish and wildlife to the IDFG. Idaho Code 36-103 states the IDFG mandate:

> "All wildlife, including all wild animals, wild birds, and fish within the state of Idaho, is hereby declared to be the property of the state of Idaho. It shall be preserved, protected, perpetuated, and managed. It shall be only captured or taken at such times or places, under such conditions, or by such means, or in such manner, as will preserve, protect, and perpetuate such wildlife, and provide for the citizens of this state and, as by law permitted to others, continued supplies of such wildlife for hunting, fishing, and trapping".

IDFG has no statutory authority to directly regulate water management activities, including no permitting authority over managed recharge projects, beyond requiring fish screens on diversions and requiring fish passage over dams, but fish and wildlife issues are addressed in the water-right permitting process, whether or not the water right application is protested. Fish and wildlife issues are part of the "local public interest" criteria discussed in more detail in part "E" of this section and must be balanced against other public interest issues. While analyses of the potential impacts of managed recharge will focus on the specific listed and non-listed species described above, consideration of general habitat impacts in the Eastern Snake River Plain will also need to occur prior to project implementation.

C. SNAKE RIVER WATER QUALITY

Water quality in the middle Snake River from Shoshone Falls to King Hill does not meet Idaho water quality standards (USFWS, 1995), and EPA, in consultation with the IDEQ, has designated this reach of the river as "water quality limited." During the summer months, eutrophic conditions occur. Problematic pollutants and stressors include phosphorus, nitrogen in several forms, sediment, temperature, pathogens, and low levels of dissolved oxygen (IDEQ, 1996). The IDEQ is required to review any change in water management practice, including a managed recharge project that may affect these pollutants and stressors in a river reach that is water quality limited. According to the IDEQ, other reaches that have been designated

IDEQ may have direct regulatory authority over the discharge of water from a pit, pond or lagoon, such as a recharge site, but does not have direct regulatory control over the water-right permitting process, including the diversion of water from a surface-water source. However, as in the case of fish and wildlife issues, water quality issues must be considered under the "local public interest" criterion of the water right permitting process. The water right permitting process and criteria that must be considered are discussed in more detail in part "E" of this section.

A managed recharge program has the potential to affect water quality in the Snake River in several ways. Reduced flows resulting from diversions for managed recharge may degrade water quality in the middle Snake River; reduced flow may increase temperature and decrease the capacity of the river to assimilate pollutant loading that occurs downstream of the diversion. Higher returns from the aquifer system may carry additional pollutant loads or, conversely, may improve water quality in the river by adding water characterized by cooler temperatures, higher dissolved oxygen levels, and lower sediment concentrations. Where this appears to be of particular benefit to fisheries is in reservoirs receiving the benefit of stable river baseflows derived from return flows of cooler aquifer water during a season characterized by generally higher-temperature, more turbid surface water. For example, the Department of Fish and Game, in their narrative (Appendix B) indicate that American Falls Reservoir and the reach immediately below the dam is a very productive fishery for sportsmen during much of the year. In this case, an influx of recharge water from the aquifer offsets drawdown in the pool.

1. Water Quality Standards

Section 303 of the federal Clean Water Act requires each state to establish water quality standards and to identify water bodies that do not meet state standards as water quality limited segments. As part of the 303(d) process, each state is further required to develop total maximum daily loads for water quality limited segments. Besides the mid-Snake reach of the river mentioned in the first paragraph of "Snake River Water Quality", IDEQ lists the following reaches that are designated "water quality limited":

- Snake River from the Bonneville County line south of Idaho Falls downstream to American Falls Reservoir;
- American Falls Reservoir;
- Snake River from American Falls Dam to Lake Walcott;
- Milner Lake;
- Snake River from Milner Dam downstream to Twin Falls Reservoir;
- Shoshone Falls Reservoir.

The IDEQ has primary responsibility for fulfilling the state's obligations under the Clean Water Act. For the Snake River from Milner Dam to King Hill, the IDEQ has established water quality standards, determined water quality limited segments, and has developed a total maximum daily load for total phosphorous through the Middle Snake River Watershed Management Plan. Additionally, the Upper Snake River Watershed Management Plan will address other parameters in water bodies that include the Middle Snake River segments (IDEQ, written communication).

The water quality standards consist of three components: designated beneficial uses, general and numeric water quality criteria necessary to protect designated uses, and an anti-degradation policy (IDEQ, 1996). Beneficial uses and classes of applicable criteria for the Snake River from Milner Dam to King Hill are listed in Table 3-2. Note that each standard is referenced to the IDAPA, Chapter 16.01.02, which is titled "Water Quality Standards and Wastewater Treatment Requirements."

The applicable criteria, in numeric or narrative form, for each water quality standard is described in the IDAPA, as referenced in Table 3-2. Some criteria are complicated, depending on other water quality conditions. For instance, the numeric criteria for ammonia to support cold water biota and salmonid spawning varies with pH and temperature. Rather than reporting the criteria here, the following subsection describes which standards are being violated in the middle Snake River.

2. Non-Compliance with Water Quality Standards

An evaluation of the water quality impacts of a managed recharge program will likely focus on standards that are not being met. Non-compliance with adopted standards is the basis for the IDEQ designation of the middle Snake River as water quality limited and, therefore, subject to regulatory restrictions on management practices.

Table 3-2. Beneficial Uses and Applicable Criteria for the Middle Snake River

Beneficial Uses	Applicable Criteria
Agricultural Water Supply	Waters that are suitable or intended to be made suitable for the irrigation of crops or as drinking water for livestock (IDAPA 16.01.02.100.01.a). Numeric criteria as needed are derived from the EPA's Blue Book (IDAPA 16.01.02.250.03.b).
Cold Water Biota	Waters that are suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species that have optimal growing temperatures below 18^{o}C (IDAPA 16.01.02.100.02.a). Numeric criteria are established for pH, DO, gas saturation, residual chlorine, water temperature, ammonia, turbidity, and toxics (IDAPA 16.01.02.250.02.a and c).
Salmonid Spawning	Waters that provide or could provide habitat for active self-propagating populations of salmonid fishes (IDAPA 16.01.02.100.02.c). Numeric criteria are established for pH, gas saturation, residual chlorine, dissolved oxygen, intergravel dissolved oxygen, water temperature, ammonia, and toxics. (IDAPA 16.01.02.250.02.a and d).
Primary Contact Recreation	Surface waters that are suitable or are intended to be made suitable for prolonged and intimate contact by humans or for recreational activities when the ingestion of small quantities of water is likely to occur. Such waters include, but are not restricted to, those used for swimming, water skiing, or skin diving (IDAPA 16.01.02.100.03.a). Numeric criteria are established for fecal coliform bacteria applied between May 1 and September 30 (recreation season) (IDAPA 16.01.02.250.01.a).
Secondary Contact Recreation	Surface waters that are suitable or are intended to be made suitable for recreational uses on or about the water and that are not included in the primary contact category. These waters may be used for fishing, boating, wading, and other activities where ingestion of raw water is not probable (IDAPA 16.01.02.100.03.b). Numeric criteria are established for fecal coliform bacteria (IDAPA 16.01.02.250.01.b).
Wildlife Habitats	Waters that are suitable or are intended to be made suitable for wildlife habitats. This use applies to all surface waters of the state (IDAPA 16.01.02.100.04). Numeric criteria are categorized as general surface water quality criteria (IDAPA 16.01.02.200).
Aesthetics	This use applies to all surface waters of the state (IDAPA 16.01.02.100.05). Numeric criteria are categorized as general surface water quality criteria (IDAPA 16.01.02.200).

NOTE: All waters are protected through general surface water quality criteria. Narrative criteria water quality standards include excess nutrients, oxygen-demanding materials and sediment (see IDAPA 16.01.02.200).
SOURCE: Idaho Division of Environmental Quality (1996)

Table 3-3 lists the narrative and numeric criteria that are currently not attained in the middle Snake River (IDEQ, 1996). Only shown are those criteria that may be adversely or beneficially affected by a managed recharge program.

The IDEQ has determined these instances of non-compliance based upon its own water quality monitoring program and numerous other studies of water quality in the Snake River. The IDEQ began a water quality monitoring study in 1990. Data collected from that study are summarized in Table3-4. The original samples were collected from several locations on the middle Snake River at irregular intervals throughout the period 1990-1997. Monthly values shown in Table 3-4 are arithmetic means of all samples, computed without weighting for the number of samples obtained during any particular month or from any particular location. Individual measurements vary considerably around the average values shown.

Table 3-3. Water Quality Standards Not Currently Being Met in the Middle Snake River

Criteria	Beneficial Use	Type	Season[1]
Excess nutrients[2]	Cold water biota Salmonid spawning Wildlife habitat	Narrative	Spring-Summer
Sediment	Cold water biota Salmonid spawning Wildlife habitat	Narrative	Irrigation season
Dissolved oxygen	Cold water biota Salmonid spawning	Numeric	Summer
	Wildlife habitat	Narrative	
Temperature	Cold water biota Salmonid spawning	Numeric	Summer
	Wildlife habitat	Narrative	
Turbidity	Cold water biota	Numeric	Summer
	Aesthetics	Narrative	
Fecal coliforms	Contact recreation (primary, secondary)	Numeric	Spring-Summer

[1] Season during which most violations occur.
[2] Phosphorus and nitrogen

Table 3-4. Monthly Average Water Quality Parameters, Middle Snake River, 1990 – 1997

Month	Total Phosphorus [mg/L]	Ammonia [mg/L]	Nitrate + Nitrite [mg/L]	Total Kjeldahl Nitrogen [mg/L]	Total Suspended Solids [mg/L]	Dissolved Oxygen [mg/L]	Temperature [degrees C]	Turbidity [NTU]	Fecal Coliform [#/100 mL]
January	0.08	0.06	1.13	0.33	9.0	12.1	3.1	14.4	4.0
February	0.10	0.07	0.89	0.33	20.4	12.8	3.1	14.4	60.6
March	0.13	0.11	1.30	0.59	27.4	11.4	7.5	18.8	5.3
April	0.13	0.04	1.05	0.62	24.9	11.1	10.7	17.2	7.1
May	0.12	0.07	1.03	0.56	36.4	10.5	14.5	19.6	21.2
June	0.12	0.06	0.81	0.53	47.3	9.4	17.5	20.3	11.3
July	0.11	0.05	1.13	0.42	19.6	8.3	19.2	15.3	46.3
August	0.13	0.05	1.27	0.41	20.2	8.3	19.5	15.7	40.2
September	0.12	0.05	1.67	0.36	15.8	8.9	16.7	13.5	22.0
October	0.12	0.04	1.74	0.40	11.4	9.4	12.9	10.3	18.0
November	0.13	0.04	1.24	0.57	16.7	10.6	8.0	11.9	12.8
December	0.13	0.06	1.35	0.42	13.0	11.3	5.4	12.1	N/A

Other studies used by the IDEQ determined seasonal and spatial patterns to some of the water quality conditions. Loading of sediments, phosphorus, and nitrogen increases from Milner Dam to King Hill (Brockway and Robinson, 1992). The source of sediments is surface inflows to the middle Snake River, while nutrient loading occurs from upstream inflow, tributary inflow, and ground-water springs (USEPA, 1975; Parametrix, Inc., 1979; Clark, 1994). Under low flow conditions, the high density of aquatic plants and algae make the river unsuitable for several beneficial uses. The high density could be reduced by lowering the organic nitrogen content of the sediments (Falter and Carlson, 1994).

3. Impacts of Recharge on River Water Quality

Table 3-3 indicates that diversions for managed recharge are likely to have the greatest impact on water quality conditions of concern if the diversions occur in the spring, except perhaps during flood-flows, and during summer. This is consistent with the seasonal differential in potential impacts on fish and wildlife described above. Most of the instances of non-compliance with the water quality standards are associated with fish and wildlife uses of the river. Exceptions to the link with fish and wildlife are the effects of turbidity and fecal coliforms on aesthetic and recreational uses of the river, respectively; these parameters are not likely to be affected by river diversions.

Whatever impacts from recharge diversions occur, they may be mitigated by improvements to water quality conditions resulting from increased ground-water returns to the river, particularly during low-flow periods. Higher returns will likely add water characterized by cooler temperatures, higher dissolved oxygen levels, lower turbidity, and lower sediment concentrations relative to the river. Because managed recharge will increase ground water returns, the returns may contain higher nutrient loads, but concentrations will likely be less than those in the river. The influence of higher spring flows on river water quality will need to be assessed at the locations where the flow enters the river after it has been subject to any intervening use, such as agriculture or aquaculture.

Ultimately, the final design of a managed recharge program must be evaluated to ensure consistency with the Watershed Management Plan total maximum daily loads developed by IDEQ. Since the plan is iterative, re-evaluation of all sources and influences on the management of the watershed will be conducted periodically by IDEQ and its watershed advisory group to ascertain whether beneficial uses and water quality standards are being met. If standards are not met, more stringent criteria may be imposed (IDEQ, written communication).

D. GROUND-WATER QUALITY

A managed recharge program has the potential to affect water quality in the ground-water system if recharge water reaching the aquifer is lower in quality than the receiving ground water. It appears, however, that with some exceptions the chemical quality of surface recharge water during high streamflow periods will exceed the quality of the receiving ground water. Concentrations of potential chemical contaminants in the river are generally lower at diversion locations during the high-flow periods when diversions will likely occur. Biological quality of recharge water, however, is likely to be a concern, because concentrations of potential pathogens tend to be higher in surface water than in ground water.

A managed recharge program will be subject to review regarding potential impacts on ground-water quality. To maintain the quality of ground water and confirm that ground-water quality is not degraded by aquifer recharge activities, the IDEQ has authority under Idaho Water Quality Standards and Wastewater Treatment Requirements Land Application of Surface Water(s) or Recharge Waters (IDAPA 16.01.02.600) to require ground-water monitoring at recharge facilities that land-apply surface water. As described below, the IDEQ will conduct the review in accordance with the Idaho Ground-Water Quality Plan (IGWQP). A monitoring plan is likely to be a component of the review.

1. Idaho Ground-Water Quality Plan

In 1989 the Idaho State Legislature enacted the Ground-Water Quality Protection Act. The law established a multi-agency process for developing a "master plan to manage protection of ground-water quality, prevention of ground-water contamination, and remediation of contaminated ground water" (Ground-Water Quality Council, 1996). The legislature adopted the IGWQP in 1992.

The IGWQP contains policies and implementation strategies that address a broad range of ground-water quality issues. While the IGWQP is not a set of regulations per se, state and local agencies are required by law to incorporate applicable provisions of the IGWQP, into the administration of all programs. Thus, the IGWQP provides a single reference for state regulatory guidance regarding any program, such as managed recharge, that may affect ground-water quality. The IGWQP includes four policies applicable to a managed recharge program, including one that specifically addresses managed recharge:

- *Policy I-A:* "The policy of the state of Idaho is to maintain and protect the existing high quality of the state's ground water."

- *Policy I-B*: "The policy of the state of Idaho is that existing and projected future beneficial uses of ground water shall be maintained and protected, and degradation that would impair existing and projected future beneficial uses of ground water and interconnected surface water shall not be allowed."

- *Policy II-A:* "The policy of the state of Idaho is to prevent contamination of ground water from all regulated and nonregulated sources of contamination to the maximum extent practical."

- *Policy V-C:* "The policy of the state of Idaho is that any program designed specifically for the artificial recharge of ground water, existing or proposed, be consistent with the policies and management objectives for water quality and quantity as defined in the Ground-Water Quality Plan and the Idaho State Water Plan."

The stated rationale supporting Policy V-C is that "…artificial recharge has the potential to significantly impact the quality of ground water. As competition for Idaho water resources continues to escalate, artificial recharge of aquifers can provide an effective method of protecting existing and future beneficial uses."

2. Idaho Ground-Water Quality Rule

State law authorizes the Idaho Department of Health and Welfare to promulgate regulations to protect ground-water quality, consistent with the IGWQP. These regulations have been codified as the "Ground-Water Quality Rule" (IDAPA 16.01.11). Enforcement of the rule is generally the responsibility of the IDEQ.

The rule defines the institutional control the IDEQ will exercise for a managed recharge program. Section 301.02 states that "activities with the potential to degrade General Resource aquifers shall be managed … through the use of best management practices and best practical methods to the maximum extent practical." This appears to describe the scope of IDEQ oversight. Except for the monitoring plan described below, no permit or direct approval from the IDEQ will be required to implement a managed recharge program (Dean Yashan, oral communication).

If significant degradation of ground-water quality occurs after a recharge program is in place, however, Section 400.02 of the rule directs the IDEQ to require modification of the program or to implement prevention measures. The IDEQ is directed to consider practical management limitations and regional economic impacts in determining appropriate actions.

3. Monitoring Requirements

In accordance with state law, the Idaho Department of Health and Welfare has also promulgated regulations governing land application of recharge waters (IDAPA 16.01.02, section 600). IDEQ staff has stated that these regulations will apply to a managed recharge program on the Eastern Snake Plain.

The regulations require a plan for monitoring ground-water quality in proximity to a recharge site. The monitoring plan must be approved by the IDEQ, which has been given discretion regarding the appropriate nature and frequency of data collection established by the monitoring plan. Sampling data must be submitted to the IDEQ.

Several factors need to be considered prior to establishing monitoring requirements for any proposed recharge facility, including:

- Hydrogeologic characteristics of the recharge site, including surficial soil, depth to ground water, vadose zone lithology, and hydrogeology of the aquifer,
- Surrounding land use (type and location of ground-water uses),
- Characteristics of the recharge water,
- Potential sources of contamination of the recharge water, and
- Contingency plan to address potential degradation of ground-water quality due to recharge.

In accordance with IDAPA 16.01.02.600.05b, the project sponsor must provide reasonable assurance that the soils and site geology will provide the required levels of treatment and will not allow the movement of pollutants into the underlying ground water. In actual implementation, the appropriate regulatory agency, e.g. Idaho Division of Environmental Quality (if the recharge site is a pit, pond, or lagoon), should be contacted early in the project-planning process to cooperatively develop an acceptable water-quality monitoring plan. A recharge facility contemplating the use of injection wells should follow the same course of action with the Idaho Department of Water Resources.

4. Other Institutional Controls

The IDWR is also responsible for program consistency with the IGWQP. In the area of managed recharge, the department is the lead agency for recharge by well injection, while the IDEQ is the lead regulatory agency for recharge through surface impoundment.

The federal Clean Water Act assigns responsibility to the U.S. Environmental Protection Agency to protect ground-water quality for aquifers designated as “sole source” for domestic drinking supply. The main purpose of this federal mandate is to protect public health when a federal action is taken, such as development of a water project using federal facilities. Although the Eastern Snake Plain Aquifer is a designated sole source aquifer, the agency will likely provide minimal oversight in the managed recharge project, recognizing the IDEQ as the lead agency for ground-water quality protection. As long as the project conforms to state regulations, the agency is not likely to have a large regulatory role.

5. Impacts of Recharge on Ground-Water Quality

Several studies of water quality indicate that a managed recharge program is not likely to affect ground-water quality. Clark and Ott (1996) compared nitrate concentrations measured at three wells in the western portions of the aquifer, nine spring vents in the reach from Milner Dam to King Hill, and six locations on the Snake River. Dissolved nitrate concentrations range from 0.56 to 0.70 milligrams per liter (mg/L) in the three wells and from 0.83 to 2.8 mg/L in the springs. Two of the river samples were taken from locations at or upstream of potential points of diversion for managed recharge; nitrate at both locations was 0.05 mg/L. It appears that a managed recharge program would add water containing lower concentrations of nitrate than currently exists in the ground-water system.

The Lower Snake River Aquifer Recharge District has been operating a recharge pond near the town of Shoshone since 1984. EHM Engineers (1997) conducted a monitoring study of ground water near the site during a two-year period. Total heterotrophic bacteria, fecal coliform bacteria, total dissolved solids, and chlorides were measured in recharge water and in several monitoring wells. While heterotrophic and coliform bacteria were present in the recharge water, no significant amounts appeared in the monitoring wells. Concentrations of dissolved solids and chlorides did increase in some monitoring wells; however, final concentrations were quite low.

As part of a recharge demonstration project, Young (1997) measured the impacts of recharge on ground-water quality at seven sites located on the Eastern Snake Plain in northeastern Twin Falls County and northwestern Cassia County. Water from the Snake River and from two tributaries was delivered to 13 injection wells and one recharge pond. A total of 23,100 acre-feet was recharged from 1992 through 1997. Water from the Snake River, which was diverted at Milner Lake by the Twin Falls Main Canal, contained various levels of nutrients and fecal coliform. Numerous water quality parameters were measured at 15 monitoring wells. Results indicate that recharge has no measurable impact on some ground-water quality parameters, including coliform bacteria, and actually improves quality conditions for other parameters, such as total salinity. No adverse impacts on ground-water quality were observed (Bill Young, oral communication).

The potential for managed recharge to detrimentally affect ground-water quality is dependent upon the quality of the recharge water and site-specific hydrogeology. Aquifer recharge with surface water has proven to be a valuable water management tool that often improves ground-water quality. However, without proper safeguards, it has the potential to degrade ground-water quality and to adversely impact human health. Regulatory concerns of IDEQ are likely to focus on monitoring sites for pathogens, including bacteria, viruses, and protozoa.

E. WATER RIGHTS FOR RECHARGE DIVERSIONS

Diversions for managed recharge can only occur within the established system of water rights administered by the IDWR. By state law, every diversion from a stream channel must comply with the terms of a specific water right associated with that diversion. Terms include the beneficial use of the diverted water, the location and timing of the diversion, the diversion rate and volume, and the priority date.

If a large-scale managed recharge program involves a new withdrawal from the Snake River, it will require a new water right. In accordance with Idaho state law (Title 42, Chapter 2), a new water right may be established by filing an application with the IDWR for a water right permit. The application must contain specific terms of the desired water right. Following public notice by the IDWR, the application is subject to protests by affected parties, including agencies and organizations responsible for environmental quality. If no protests are filed, the IDWR issues a permit upon satisfactory review and analysis of the application. Whether protested or not, IDWR must determine that the new use must comply with specific approval criteria. Idaho Code Section 42-203A states it as follows:

> *… The director of the department of water resources shall find and determine from the evidence presented to what use or uses the water sought to be appropriated can be and are intended to be applied. In all applications whether protested or not protested, where the proposed use is such (a) that it will reduce the quantity of water under existing water rights, or (b) that the water supply itself is insufficient for the purpose for which it is sought to be appropriated, or (c) where it appears to the satisfaction of the director that such application is not made in good faith, is made for delay or speculative purposes, or (d) that the applicant has not sufficient financial resources with which to complete the work involved therein, or (e) that it will conflict with the local public interest, where the local public interest is defined as the affairs of the people in the area directly affected by the proposed use, or (f) that it is contrary to conservation of water resources within the state of Idaho; the director of the department of water resources may reject such application and refuse issuance of a permit therefor, or may partially approve and grant a permit for a smaller quantity of water than applied for, or may grant a permit upon conditions.*

Further, the Idaho Administrative Procedures Act 37.03.08.045 (Rules for Water Appropriation) state more specifically what criteria IDWR must use in considering an application for permit, whether for recharge purposes or any other beneficial use.

If protests to the application are filed, the IDWR's procedures allow time for the applicant and protestants to negotiate a mutually agreeable settlement regarding specific terms and conditions to be incorporated into the water right permit. Terms and conditions may include a variety of limitations on the rate of allowable diversion, such as restricting diversions to specific times of year or to specific flow conditions. If the applicant and protestants fail to settle their differences, the IDWR appoints a hearing officer to conduct an administrative hearing. At the hearing, the parties may present exhibits, give testimony, and conduct cross-examination. After review of all evidence presented, the hearing officer issues a recommended order on whether to issue the permit. A final order is then issued by the director of the IDWR. A final order is subject to review in district court.

The IWRB filed applications in March 1998 to establish 19 water rights for use in its ongoing aquifer recharge program. Each application is associated with an existing diversion structure and irrigation canal; most of the canal companies that own these facilities have entered into agreements with the IWRB to allow the use of the facilities for managed recharge. While the filings do not apply to the new managed recharge program addressed in this report, the application and review process will provide information applicable to the new program. If the applications filed by the IWRB are approved in some form, they could be used for the new managed recharge program, following an amendment of the water right. A change in point of diversion or place of use would require filing an application and responding to protests.

The water rights permitting process provides a formal opportunity for interested parties to influence a managed recharge program. Any protests raised by the parties regarding potential impacts on fish and wildlife, water quality, or water use must be considered in the permitting process. Whether resolution occurs through negotiated settlement or the issues addressed in an administrative hearing, the permitting process comprises a distinct institutional control on managed recharge. Given the potential for a permitting decision to be appealed and eventually challenged in court, the extent of institutional control provided by the water rights system is considerable.

F. HYDROPOWER

The IPCo and other power interests claim water rights for hydropower generation at several locations in the upper and middle Snake River. These can call for water year round and have the potential to restrict diversions for managed recharge. Two of the three potential diversion locations evaluated in Section IV of this report, have associated claimed hydropower rights that may affect diversions. These two rights are listed in Table 3-5.

Table 3-5. Selected Hydropower Rights Claimed by the Idaho Power Company

Location	Flow Rate (cfs)
American Falls	9,000
Lower Salmon Falls	17,250

Hydropower rights in the middle Snake River, with the exception of City of Idaho Falls power plants, are now subject to the Swan Falls Agreement, signed in 1984 by the IPCo and the State of Idaho. Terms of the agreement have been incorporated into the Idaho State Water Plan and Idaho statutes. Policy 5A of the State Water Plan states that the Swan Falls Agreement "establishes the framework for water management in the Snake River basin."

The agreement establishes minimum flows at the Murphy gage near Swan Falls and recognizes that during low-water years, river flow between Milner Dam and Swan Falls consists almost entirely of ground-water discharge from the Eastern Snake Plain Aquifer. Minimum flows are 3,900 cfs from April 1 to October 31 and 5,600 cfs from November 1 to March 31.

The Swan Falls Agreement, in conjunction with State of Idaho Statutes (Section 42-203), subordinates hydropower uses above the minimum flows to other beneficial uses upstream. The IPCo claimed water rights above the minimum flows at Swan Falls Dam are held in trust by the State of Idaho, and can be diverted upstream if the director of the IDWR determines that these diversions are "in the public interest," in accordance with specific criteria. While diversions for managed recharge would likely satisfy the public interest criteria, Section 42-4201, Idaho Code as amended in 1994, of the statutes specifically subordinates diversions for recharge to hydropower rights, including those subordinated to other uses by the Swan Falls agreement. However, Section 42-203B excludes rights above Milner Dam from being regulated to satisfy rights below Milner Dam.

Idaho Power, in its narrative (Appendix C, page 1), states that recharge was not recognized as a beneficial use prior to the Swan Falls agreement. That statement does not agree with information obtained from the IDWR, which establishes that recharge has been a statutorily-recognized beneficial use since 1978. Issuance of a permit was restricted to only recharge or irrigation districts until 1994. While subordinated to other rights, including hydropower, distribution calls cannot be made by any water right below Milner Dam against a water right above Milner Dam (Sec. 42-203B, Idaho Code).

If downstream hydropower rights must be satisfied before water can be diverted for recharge purposes, the availability of water for a managed recharge program will decrease dramatically. As demonstrated in Section IV of this report, if the downstream hydropower right of 17,250 cfs at Lower Salmon Falls must be met before water is available for diversion at Milner Dam, recharge diversions could occur only once in about every 50 years.

The IPCo may be willing to accommodate managed recharge diversions if a hydrologic and economic analysis demonstrates sufficient benefits to power operations. Even if hydropower were subordinate to managed recharge, IDWR would consider the public interest in balance to determine whether hydropower flows should be reduced. The return flows from managed recharge will at times increase base flow in the river, which may enhance power generation at all IPCo facilities, including the Hells Canyon complex during dry periods. In its narrative in Appendix C, last paragraph, page 1, Idaho Power presents one of many possible analyses, based on information supplied by IDWR for one set of conditions. In order to provide a more comprehensive view of potential impacts to Idaho Power operations, future analyses need to include <u>all</u> IPCo facilities, a variety of other recharge scenarios, and needs to include the specific potential benefits to all IPCo facilities due to increased baseflows resulting from recharge.

On page 2 of the narrative, IPCo also questions the current predictive reliability of the Eastern Snake River Plain Aquifer model for quantifying the impacts of proposed recharge scenarios. The IDWR, in conjunction with the University of Idaho and others, has developed the model over approximately 25 years, continually refining and improving it in the process. While some uncertainties exist in the present model, it is generally recognized as the best available tool for the purpose. IDWR states that there is a proactive effort, and a published strategy for enhancing the current model, as evidenced by a copy of the *Strategy for Enhancement of the Eastern Snake River Plain Aquifer Model* included as an attachment to the IPCo narrative. IPCo is an active member of the committee seeking a coordinated approach to that enhancement effort.

IPCo's narrative on page 3 raised issues that seemed to be in conflict with the way that water rights are typically administered, as described in detail on page 34 and following.

To the issue that increased flows in the river during low-flow or drought years could simply be available for diversion before passing through IPCo's facilities, IDWR indicates that all water rights for consumptive use from the springs and in the middle Snake River reach aided by recharge currently receive the water authorized and that there is no opportunity for existing rights to circumvent the additional flows provided by recharge.

To the issue of the existing moratorium on ground-water pumpage from the Snake Plain aquifer, the moratorium was intended to suspend the issuance of any new surface- and ground-water rights while addressing the issue of declining ground-water levels and reduced streamflows and aquifer recharge due to multi-year drought conditions.

To the statement that as aquifer levels rise [due to aquifer recharge] existing pumps will pump more water, pumping rates may increase under those conditions, but a water right is also limited by the total volume pumped based upon consumptive use, the same factor used in the ground-water model. The consumptive use will not change, nor will net water use.

G. PALISADES CONTRACTS

When the USBR constructed Palisades Reservoir in the 1950s, contracts were amended with the participants in the Minidoka Project regarding storage of winter stream flow. Prior to the construction of Palisades Reservoir, water users diverted river water during the winter for stock ponds. Although the amounts of stock water consumed were low, high seepage losses in the canal required significant diversions. Under the contracts, the water users agreed to forego winter diversions during a 150-day period in exchange for an earlier storage priority in Palisades or American Falls Reservoir. The Palisades contracts are thus the basis for the Winter Water Savings Program (USBR, 1996).

Four canals considered in this study are subject to the Palisades contracts: People's, Minidoka, Milner-Gooding (operated by American Falls Reservoir District #2), and North Side. An amendment to the contracts may be needed for these canals to participate in a managed recharge program during the winter months. Opinions differ among federal and state officials familiar with the contracts. Some officials believe that winter diversions would be allowed under the current contracts if diversions occur during wet and normal years when Palisades Reservoir fills. This opinion is based on the District Watermaster's interpretation of the contracts, upheld by court rulings, that winter diversions are allowed if Palisades Reservoir fills. Other officials believe that the contract language will require amendment and that previous rulings do not apply to recharge diversions.

Forty-three districts entered into a contract with the USBR concerning the Winter Water Savings Program for storing water in Palisades Reservoir (Appendix A). In order to divert recharge water into these canals during the winter months, the Palisades contracts may need to be amended, or a specific interpretation of the contracts by federal authorities may be needed regarding managed recharge.

In the portion of the U.S. Bureau of Reclamation's narrative regarding the Palisades Contracts, it is stated that the contracts would preclude any diversion of water into contract canals during the 150-day period identified in the contract. The Department of Water Resources views the contracts as providing for the subordination of existing senior water rights to junior storage rights in Palisades Reservoir. Further, the Department views any new water rights as being junior to the senior rights described in the Palisades Contracts and therefore not constrained by the contracts, but only by the senior water rights involved, which should not prevent a private canal or sponsor from entering into new activities involving the canal under a junior water right; e.g. diversion of flood flows during that 150-day period for managed recharge purposes. This issue will need to be resolved as the State continues to implement conjunctive management alternatives, including managed recharge.

Amendment of the contracts would constitute a federal action and would be subject to consultations under Section 7 of the ESA, described above. A federal action would also initiate environmental review in accordance with NEPA, also described above.

H. LAND USE REGULATIONS

In addition to canal facilities that divert and convey water, a managed recharge program will include recharge ponds or basins. The basins will be constructed or use natural depressions in the land surface. When recharge water is available, it will be delivered to the basins and allowed to infiltrate through the bed of the basin into the subsurface. Large parcels of undeveloped land in the Eastern Snake Plain are well-suited for basin recharge.

Some potential sites for recharge basins are owned by private parties while others are owned by the public. Use of a site located on privately owned lands would require a contract or agreement with the owner to purchase or lease the site. Regulatory approval will be needed only in the unlikely event that use of the site for recharge conflicts with local land use ordinances. Most of the sites on private, as well as public, land are undeveloped sagebrush-steppe or range. Use of public land, whether state or federal, will require permits from the appropriate land-managing agency. Besides the issues listed above, recharge sites have the potential to alter the vegetation in the vicinity of the pond, perhaps with the unintended consequence of introducing noxious weeds, therefore weed control in recharge basins may be necessary.

1. Right-of-Way Grant from BLM

As described in Section VII of this report, over half of the potential sites for recharge basins are located on publicly owned land administered by the BLM. The parcel sizes of the potential sites under BLM jurisdiction range from 10 to 700 acres. Most of these public lands are currently considered undeveloped and are in their natural state of desert and range. Managed recharge on these lands will require access with the right to use the land for basins. A right-of-way grant will be needed.

The process for obtaining a right-of-way grant begins with a formal application to BLM by the project proponent. A standard application form, titled "Application for Transportation and Utility Systems and Facilities on Federal Lands," is submitted. Submission of the application initiates the NEPA process described in Section IV of this report. The application is not acted upon until the NEPA process, including environmental review and documentation, has been completed. If BLM approves the application, a right-of-way grant is generally issued for up to 30 years for projects that last indefinitely. A right to renew is included as long as the terms and conditions have not significantly changed.

Informal interviews with BLM personnel indicated that all recharge sites may be grouped into a single application. Compliance with NEPA may be possible by conducting a programmatic-level EA that would include all sites in a single environmental review. It appears that the primary effort to complete the EA would be surveys of cultural resources and threatened and endangered species in the vicinity of the recharge sites. The cultural resource of concern is lava caves, which generally occur at the edge of basalt flows. Although it is unlikely that any of the potential sites are located near a lava cave, confirmation would be needed as part of the EA.

I. RECREATION

The Snake River provides a variety of recreational uses, including boating, fishing, and viewing. Float boating in rafts and kayaks is a popular activity during the spring and summer, particularly during the high flow months of April through June, when white-water conditions are at their peak. Several commercial outfitters rely on recreational boating for their livelihood (Idaho Rivers United, oral communication). Motorized boats are used on reservoirs and on several reaches of the river.

As part of its Snake River Resources Review program (SR^3), the U.S. Bureau of Reclamation has assembled detailed information on boating uses of the river (Chris Jansen Lute, written communication). Preferred, maximum, and minimum flows are reported for float boating in specific river reaches. Maximum and minimum reservoir elevations, which affect access to boat ramps, are reported for motorized boating.

The river is also used for recreational fishing and hunting. Game fish include rainbow trout, cutthroat trout, brown trout, sturgeon, mountain whitefish, catfish, smallmouth and largemouth bass, yellow perch, and crappie (IDFG, written communication). Waterfowl are hunted in the fall. The SR^3 program identifies maximum, minimum, and preferred flows for sport fishing at specific river reaches.

Viewing is another recreational use of the river. Bird-watchers visit the Henrys Fork to view trumpeter swans, which require winter flows to prevent total icing of the river. Visitors come to Shoshone Falls, Twin Falls, and other waterfalls throughout the year.

It appears that diversions for managed recharge have the potential to affect two recreational uses of the river. Sport fishing, which occurs throughout the year, would be affected by any impacts to fish habitat that decrease fish populations. If diversions for managed recharge are limited to maintain the river flows recommended by the Department of Fish and Game, however, fishing should not be affected. Float boating in rafts and kayaks, which occurs during spring and summer, depends on high stream velocities that may be reduced if the diversions are made during those seasons.

J. STATE WATER PLAN

The Idaho State water plan, prepared by IWRB in 1996 and adopted by the legislature in 1997, presents Idaho water management policies relating to issues of public interest, economic development, environmental quality, and public safety.

State water policies are directed toward optimum management and utilization of the States water resources, and are concerned with improvement in practices, procedures, and laws that relate to existing water use. Among other things, the policies provide a framework within which private enterprise and government entities can develop new water resource projects, and propose new water management scenarios.

The State water plan contains many Water Use Policies that would potentially affect large-scale managed recharge activity. Among the most important are those policies that prescribe conjunctive management of water resources, and those that require balancing of ground water recharge and withdrawals.

It is the policy of Idaho that where evidence of hydrologic connection exists between ground and surface water, Policy 1-F, the waters are to be managed conjunctively (IWRB, 1996). Nearly all aquifers in the state discharge to, or are recharged by surface water. Precipitation and seepage from streambeds are significant sources of ESPA recharge water. Springs along the Snake River are the largest component of ESPA discharge.

It is also state policy (Policy 1H) that average withdrawals from an aquifer should not exceed the reasonably anticipated rate of future recharge to the aquifer. The Director of IDWR may designate critical ground water management areas where ground water withdrawal/ recharge imbalances exist. The Director may also prohibit or limit withdrawal of ground water if the withdrawal exceeds the reasonably anticipated future natural recharge rate. Withdrawals may be allowed to exceed natural recharge if a program exists to either increase recharge or decrease withdrawals, thereby protecting senior water rights. The present moratorium on new ground-water development in the Snake Plain aquifer was intended as a temporary suspension of the issuance of any new ground-water rights, while issues of declining ground-water levels and reduced spring flows are addressed in a conjunctive management plan.

Pursuant to state law, it is state policy to encourage managed recharge (Policy 1J) of the ESPA (IWRB, 1996). In support of this policy, the 1995 Idaho Legislature funded the IWRB to implement an artificial recharge program. The IWRB, in a resolution dated April 1995, required the Water District 01 Watermaster to administer the program and required the watermaster to submit recharge plans on an annual basis, and to report the results of the annual programs accordingly. The IWRB agreed to pay a conveyance fee of $0.25 per acre-foot to those entities participating in the program. Most canal companies and irrigation districts participating used the available canal capacity above irrigation requirements during the irrigation season and some percentage of full canal capacity during the non-irrigation season to divert water under this program. Canals on the ESPA diverted over 180,000 acre-feet in 1995, about 169,000 acre-feet in 1996, about 230,000 acre-feet in 1997, and about 200,687 acre-feet in 1998.

Managed recharge and a continued moratorium on new ground-water development are mechanisms for balancing ESPA recharge and discharge rates and will be alternatives to include in future conjunctive management plans.

IV. HYDROLOGIC FEASIBILITY

A. GOAL OF MANAGED RECHARGE HYDROLOGIC FEASIBILITY STUDY

The goal of the managed recharge hydrologic feasibility study is to determine the requirements, limitations, and expected outcomes of large-scale managed aquifer recharge in the ESPA, and then to prioritize recharge locations based on their potential to meet key hydrologic objectives for managed recharge.

The project workplans identify five actions that are necessary in order to make a determination of the hydrologic feasibility of large-scale managed recharge.

1. Quantify the key hydrologic objectives for managed recharge projects in the ESPA.

2. Estimate recharge water availability subject to present day institutional and environmental constraints on river diversions.

3. Evaluate potential recharge scenarios to determine their effectiveness in meeting key hydrologic objectives for ESPA managed recharge.

4. Prioritize recharge locations based on effectiveness in meeting key objectives.

5. Assess the net impact of large-scale managed recharge on flows in the Snake River.

B. INVESTIGATIVE APPROACH

Previous investigations and demonstration projects have contributed important information regarding the hydrologic feasibility of managed recharge including estimates of surplus Snake River flows, available diversion capacity of canals, understanding of ground water and river responses to managed recharge, and estimates of aquifer infiltration capacity at different locations on the plain. In spite of this, relatively little information has been generated in these studies regarding basin-wide hydrologic effectiveness or feasibility of managed recharge.

In part, the absence of information on basin-wide effectiveness is due to lack of data. Once outside the immediate area of a small-scale recharge demonstration project, it has proven extremely difficult to isolate the effects of recharge on ground-water levels or spring discharges. The difficulty in isolating individual components of ESPA hydrology which affect spring discharge has been pointed out by both Moreland (1976) and Thomas (1968).

In addition, there has been a notable absence in many previous studies, of clearly defined hydrologic objectives for managed recharge projects. A study by the Idaho Water Resource Board (IWRB, 1981) notes that previous investigations by USBR and by IWRB have not sufficiently quantified the benefits to be derived from individual recharge projects, and this has prevented individual project criteria from being developed. Specific, quantifiable hydrologic objectives for recharge projects are essential for assessing hydrologic feasibility of managed recharge, and for comparing and prioritizing projects as part of a basin-wide conjunctive water management plan.

The methods used in this study to assess hydrologic effectiveness and feasibility are primarily statistical and mathematical in nature. They involve the use of statistical spreadsheets and various hydrologic and water budgeting models. The principal hydrologic model used in this investigation is referred to as the IDWR/UI ground-water model. The IDWR/UI model was the first digital numerical model of the ESPA, developed for the IDWR and the USBR by the University of Idaho (deSonneville, 1974). The model has been in regular use by IDWR and other agencies since 1974, and has been revised and updated several times since then (Johnson, Brockway et al., 1985). An in-depth discussion of the IDWR/UI model is beyond the scope of this report, however a brief description of those elements that pertain directly to managed recharge modeling is included. A more detailed description of the model can be found in a report by Johnson and Brockway (1983).

1. The IDWR/UI Ground-Water Model

The IDWR/UI model represents the ESPA as a heterogeneous, unconfined, single layer aquifer. Eleven hundred, 25 square kilometer (km^2) grid cells are used to approximate the distribution of aquifer properties, (hydraulic conductivity, thickness, and storativity). In the extended basin version of the model, the grid cell representation incorporates the Henry's Fork tributary basin and the South Fork of the Snake River. For each 25-km^2 cell, recharge and discharge conditions are specified which represent precipitation, ground-water pumpage, canal leakage, river losses, tributary basin underflow, as well as incidental and managed aquifer recharge. Model cells representing portions of the aquifer that discharge directly to the Snake River do not have a specified discharge condition. Rather, the river response to ESPA recharge and discharge conditions is calculated by the model, after specifying a river head condition for these cells. 0These (fixed head) river cells are the only cells in the IDWR/UI model where a river response to managed recharge can be simulated. For every cell, the IDWR/UI model generates just one computation of ground-water level and one of ground water flux, representing the average condition in each cell.

Recent upgrades to the IDWR/UI model were made by IWRRI as part of the Bureau of Reclamation's Snake River Resources Review (SR3). The conversion of the IDWR/UI model to a USGS Modflow format (McDonald, Harbaugh, 1988) and extension of the model domain to include the Henrys Fork tributary basin and the South Fork of the Snake

River, are described in reports by Johnson and Cosgrove (1999). The IDWR/UI model can also be run using a Groundwater Modeling System® graphical user interface for Modflow based models.

While the IDWR/UI model is a transient model, it differs conceptually from other transient models that have been developed for the ESPA, such as the USGS (RASA) model (Garabedian, 1992). While the USGS model aimed at describing the historical development of basin hydrology over the last century using five-year time steps, the IDWR/UI model describes transient hydrologic conditions of the basin during a single year that is broken down into biweekly time steps. Multi-year simulations are made up of time-dependent repetitions of the one-year model, in which the ending conditions from the first year become the starting conditions for the second year, ending conditions from the second year become the starting conditions for the third year, etc.

The IDWR/UI model has been calibrated using the 1980 mass measurement of ESPA ground-water levels and aquifer discharges. The calibration is performed at steady-state, and a least squares procedure is used to minimize total model error. Recharge and discharge conditions representative of the early 1990's (i.e., irrigation, ground-water pumping, evapotranspiration, etc.) are then imposed on the calibrated model. The calibrated one-year model with 1990's recharge and discharge conditions is termed the base case model. A multi-year base case simulation that is run until equilibrium conditions are reached (approximately 60 years) is termed the base case equilibrium model. The ESPA ground-water gradient that results from the base case equilibrium model (figure 4-1) is representative of aquifer conditions during the early 1990's (compare figure 2-1).

The progression toward equilibrium during 58 repetitions of the base case model is demonstrated in a plot which shows the monthly discharge rate for model cells that make up two fixed-head reaches of the river, the Kimberly to Bliss reach and the Blackfoot to Minidoka reach (figure 4-2). The total annual discharge rate to the river is unchanged once equilibrium is achieved (after 58 years), however, monthly discharge rates continue to fluctuate in response to seasonal changes in aquifer stresses that are part of the base case data set. In the base case equilibrium model, the average annual discharge rate for model cells which make up the Kimberly to Bliss reach is a close match to the annual discharge rate from Thousand Springs during the early 1990's (compare figure 2-4).

The IDWR/UI model therefore assumes that present day hydrologic conditions in the ESPA are the result of an equilibrium process. Aquifer recharge scenarios are individually superimposed on the base-case equilibrium model. Multi-year recharge simulations are run to show the time-dependent aquifer and river response to imposition of recharge stresses. The responses are the difference between recharge model results, and base-case equilibrium model results, which represent a continuation of present day ESPA conditions.

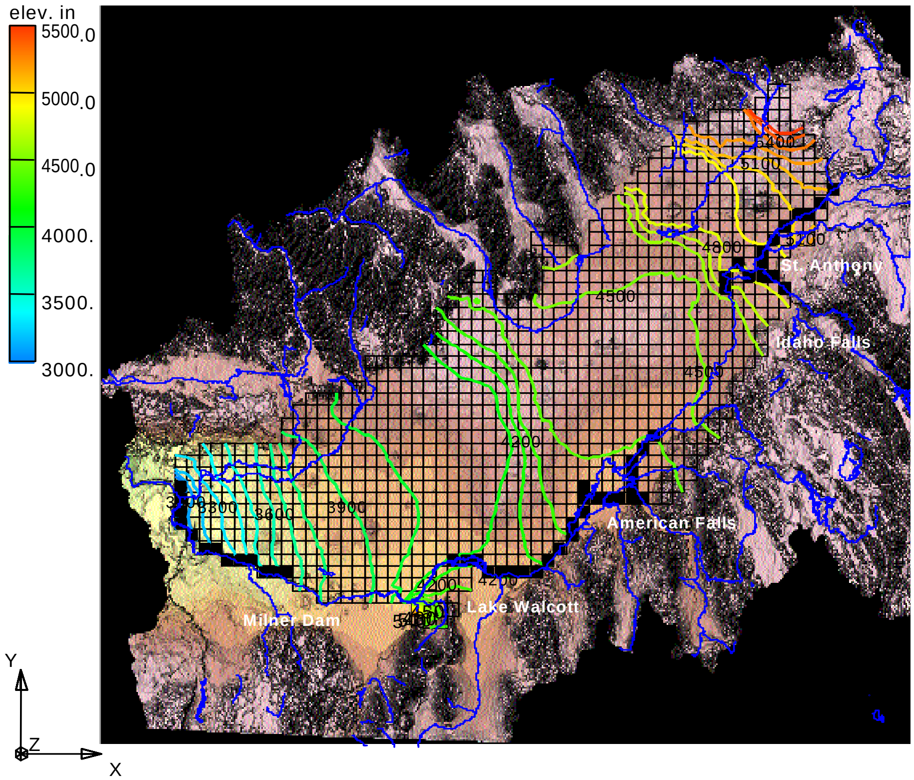


Figure 4-1. Base Case Equilibrium Model, Ground-Water Elevations

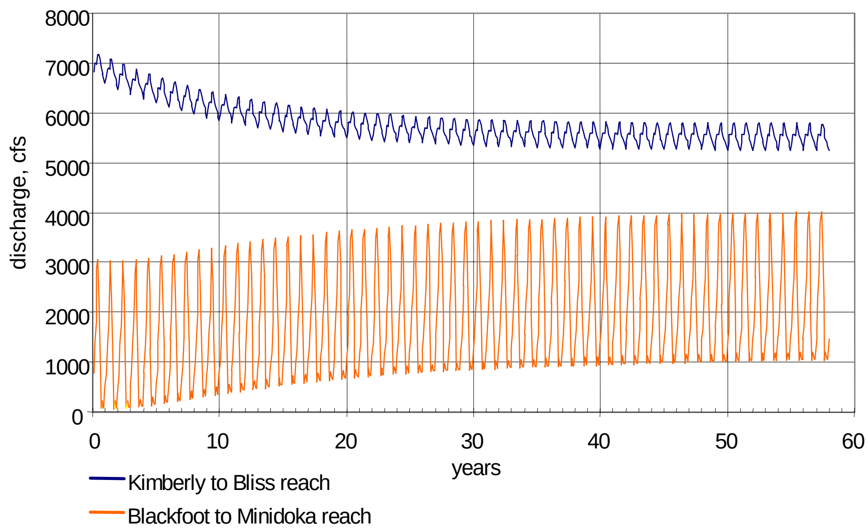


Figure 4-2. Multi-Year Base Case Model, Discharge to the Snake River

The main advantage of the IDWR/UI modeling approach is its simplicity, and the ease with which scenario data sets can be developed from just one year of base-case data. The biweekly time steps also provide an opportunity to examine seasonal variations in flow and head conditions that result from recharge. Aquifer and river response to recharge stress is approximately proportional to the magnitude of recharge stress imposed. (Responses are not exactly proportional, due to unconfined nature of the aquifer, and the dependence of aquifer transmissivity on saturated aquifer thickness.)

Collectively, the recent enhancements of the IDWR/UI model have overcome some of the difficulties faced by previous investigators of managed aquifer recharge. The extended basin model makes it possible to evaluate a broader range of recharge alternatives. The new (GMS) user interface makes it possible to generate alternative models, and to perform comparative analyses of model results far more quickly and efficiently than has been the case in the past.

2. The Recharge Water Availability Program

The Recharge Water Availability (RWA) program developed at IDWR (Sutter, 1998) is used to determine the rate at which aquifer recharge water is expected to be available at potential diversion points. The determination is made subject to specification of a minimum instream flow below the diversion point, and to specification of a maximum rate of diversion at each diversion point. The minimum instream flow requirements that are specified can be used to represent any appropriated or unappropriated instream use of water, including hydropower rights, fisheries needs, FERC required minimum flows, habitat maintenance, etc. The constraints on rate of diversion can also be arbitrarily specified, and can reflect canal capacity, total aquifer infiltration rate, or any other aspect of recharge operations which limits the rate at which water actually recharges the aquifer.

3. The Scenario Approach to Modeling Managed Recharge

Previous investigators have identified over one hundred potential sites on the Eastern Snake River plain for managed aquifer recharge projects (USBR, 1962; Norvitch et al., 1969; Anderson, 1975; IWRB, 1978; LePard, 1981; Corless, 1998). Their locations on the plain are indicated on figure 4-3. Most sites that rely on diversion of Snake River water are clustered together in four areas, where they are accessible to existing canals and diversion facilities. On the western end of the plain near the Thousand Springs river reach, a cluster of sites is associated with the North Side and the Milner-Gooding main canals. In the central part of the plain there is a small cluster of sites adjacent to Lake Walcott and the Minidoka Canal. There is also a larger cluster between Idaho Falls and Blackfoot, adjacent to the Aberdeen-Springfield and Peoples canals. At the northeastern end of the plain there is a cluster of sites near the Egin Lakes that can be serviced by the Fremont-Madison Irrigation District canals.

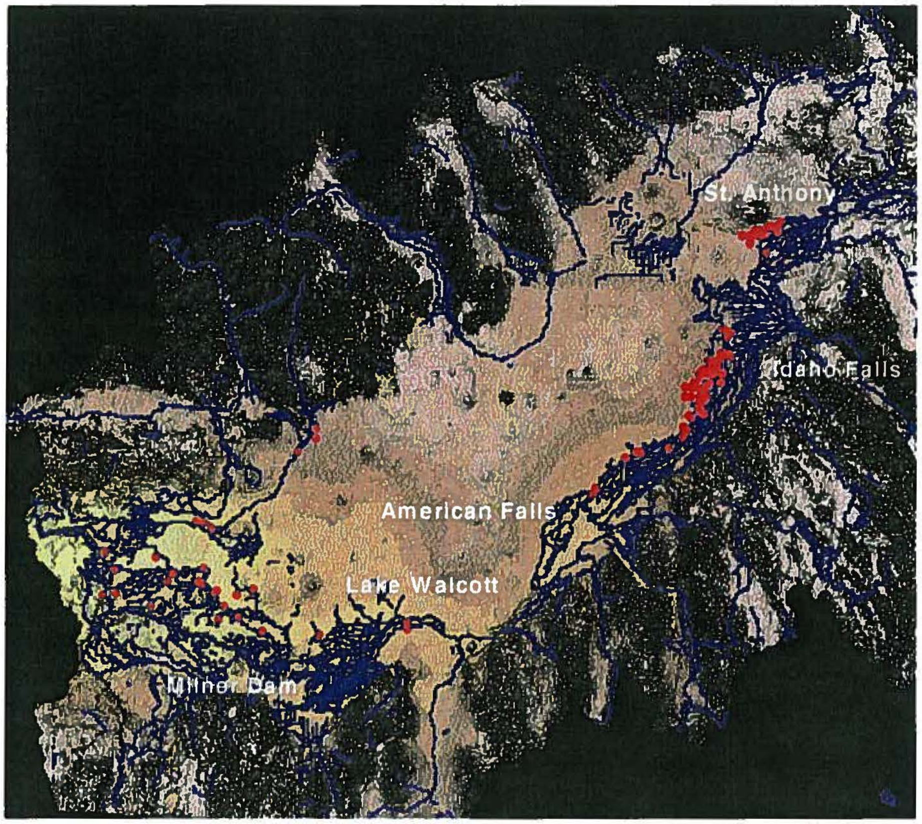


Figure 4-3. Potential Recharge Sites on the Eastern Snake River Plain.

An IDWR/UI model recharge scenario is developed to represent each of the four clusters of recharge sites (figure 4-4). Each recharge scenario is modeled independently of the others (although it is possible to model combined scenarios). Recharge is assumed to be uniformly distributed over the cells that encompass each cluster of sites. In addition, the scenarios each have at least two variations, representing different sets of constraints on recharge water availability. Simulations are run for 58 years duration to approximate equilibrium conditions in the aquifer. However, intermediate time-dependent results are produced for each scenario.

From left to right in figure 4-4, the "Thousand Springs" recharge scenario is comprised of twelve grid cells adjacent to the Thousand Springs river reach. The diversion point for this scenario is at Milner Dam. The "Lake Walcott" scenario encompasses just two cells located just to the north of Lake Walcott. The scenario requires pumping of recharge water from the river at Minidoka Dam. The "Hells Half Acre" scenario encompasses seven cells and is located northeast of American Falls. River diversions occur below Idaho Falls. The "Egin Lakes" scenario is made up of two cells located northeast of Idaho Falls. Diversion from the Henrys Fork for the "Egin Lakes" scenario occurs above St. Anthony.

The scenario approach to modeling managed recharge, assumes simultaneous operation of multiple sites that are clustered together in a particular area of the plain. The approach

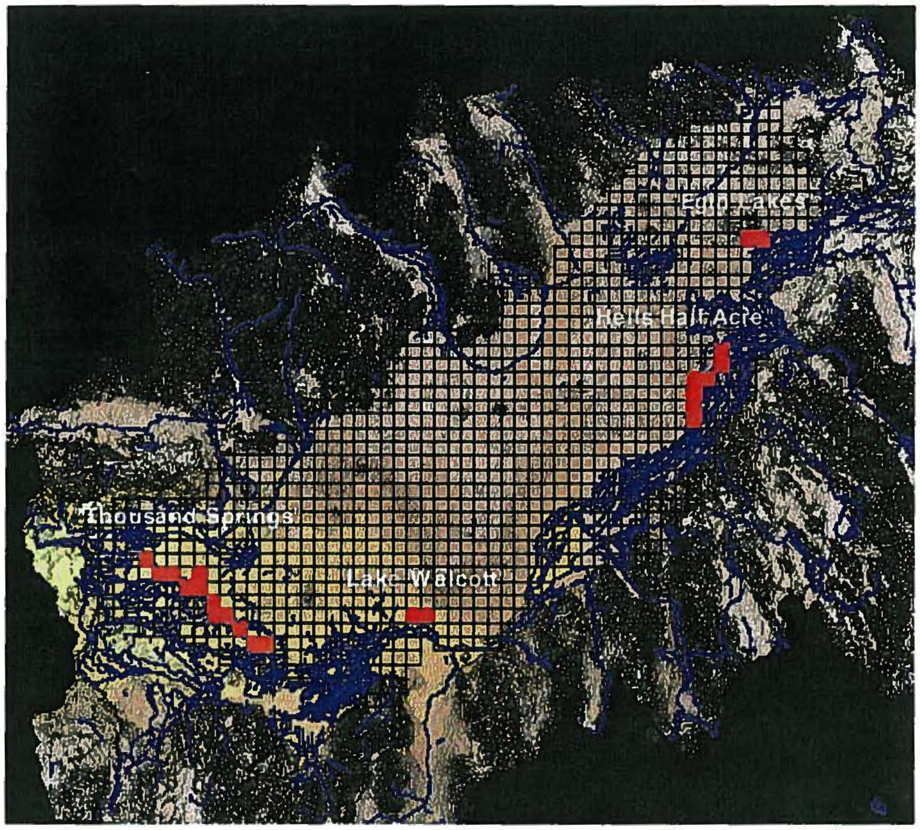


Figure 4-4. Locations of Four Managed Recharge Model Scenarios

is consistent with the main goal of this investigation; to evaluate large-scale managed recharge projects, and to prioritize recharge locations based on their potential to meet key hydrologic objectives. The scenario approach is also made necessary by the limited numerical resolution of the IDWR/UI model.

C. Quantifying The Key Hydrologic Objectives of Managed Recharge

The key hydrologic objectives for managed recharge in the ESPA emanate from conditions that have developed in the Kimberly to Bliss reach of the Snake River and the central part of the Eastern Snake River plain, where prolonged and widespread declines in spring flows and ground-water levels are evident. Restoring spring flows between Kimberly to Bliss to early 1980's levels would require an increase in aquifer discharge in this 50-mile river reach of 700-800 cfs. Restoring ground-water levels in the central part of the plain to levels of the early 1980s would require raising the water table in this area by 10 to 15 feet over present levels. These two objectives are hydrologically linked to aquifer conditions basin-wide. Therefore modeling results are developed to show the basin-wide impacts of managed recharge on ground-water levels, aquifer storage, and spring discharges. Each of the four recharge scenarios is evaluated, based on its effectiveness in meeting one or both of these key hydrologic objectives.

D. RECHARGE WATER AVAILABILITY

Surplus flow is a term used to describe Snake River flows that are surplus to irrigation demands for natural flow and surface storage above Milner Dam and could potentially be used for managed aquifer recharge projects. Estimates of water availability for managed recharge are based on historical records of surplus flows subject to certain institutional, environmental, and economic constraints.

1. Conditioning of Historical Flow Data

Management of the Snake River system has undergone significant change during the period of available hydrologic record (for this study 1928-1992). More than one hundred canals divert water from the Snake River and Henrys Fork, and some did not exist for the entire 1928-1992 period of record. Others have changed in timing and quantity of diversion. As new reservoirs and structural controls were built, management criteria for reservoir operations have also changed. Meaningful use of historical flow data requires the removal of time-dependent trends in the hydrograph that result from the almost continuous changes in system management and use.

"Conditioning" of Snake River flow data is the process of removing these historical trends in diversions and reach gains, from the 65-year hydrologic record (Robertson and Sutter, 1989). The conditioning process begins with an application of the IDWR Snake River System Planning Model (SRPM) (Sutter 1998), which is used to develop control criteria for representing historical trends in the Snake River hydrograph. Control criteria that satisfactorily reproduce changes in river and reservoir hydrographs during a ten-year period from 1982 to 1991 are used in the SRPM model to "condition" the 65-year record of historical flows at the locations of the four managed recharge diversions. Regardless of where the diversion occurs, only the conditioned flows that pass Milner Dam are considered surplus to upstream irrigation demands, and potentially available for managed recharge.

2. Measures of Central Tendency and Recurrence

A probabilistic approach to data analysis underlies the flow recurrence and exceedance curves that are typically used to describe historical stream flow data. While the arithmetic mean value (the average) is the single best estimate of surplus flow over the long term, the median flow value (flow that is expected to be equaled or exceeded 50 percent of the time) is a measure that conveys useful information about both the magnitude and the likelihood of future surplus flows.

Tables 4-1, 4-2, and 4-3 show monthly mean and median values for conditioned surplus flows at the St. Anthony, Blackfoot, and Milner Dam gaging stations, during the 1928-1992 period of record (1928-1995 for the Milner Dam location). Not surprisingly, the tables reveal most surplus flow to be available during the six-month non-irrigation season (November through April). On average at Milner Dam, surplus flow during December, January, and February, account for 42 percent of the total annual surplus at this location. Surplus flows at the Blackfoot and St. Anthony gages are more uniformly distributed during winter and spring months. Still, surplus flow during the three winter months accounts for 34 percent of the annual total at Blackfoot, and 31 percent of the annual total at St. Anthony. Also, it is not surprising that more surplus water is available at downstream locations than at upstream locations. Less than 30 percent of the total Snake River surplus flow above Milner Dam is available at St. Anthony, while about 85 percent of the total is available at Blackfoot.

In general, comparable values for median and mean monthly flow rate in tables 4-1, 4-2, and 4-3 are an indicator that flows approximating the mean are likely to occur during most years. Large differences between these two statistics, during June for instance, indicate that averages may be the result of extraordinarily high surplus flows during a small number of years, combined with little or no surplus flow during most other years.

While on average, there is some surplus flow available every month of the year at all three locations, less than 20 percent of the total surplus is available during what is mainly the irrigation season; i.e., the five month period from June through October. In addition, the median surplus flow at all locations during these five months is zero, indicating that in at least one out of every two years there has been no surplus available during these months.

Flow rate recurrence relationships describe the likelihood of surplus flow of a given magnitude occurring during a given month. Recurrence interval plots (figures 4-5, 4-6, and 4-7) show the number of years between each recurrence of surplus flow equaling or exceeding a given value. Each diversion location is represented by two recurrence interval plots, showing monthly recurrence of surplus flow during the irrigation season (April-September) and the non-irrigation season (October-March). The median monthly surplus flows in tables 4-1, 4-2, and 4-3, are the flows that are equaled or exceeded in one out of every two years, and would therefore have a two year recurrence interval.

The recurrence interval plots show that during most months and at most diversion locations, as the magnitude of surplus flow increases, the frequency of occurrence decreases. For instance at Milner Dam in January, (figure 4-5) one would expect average flows exceeding 6,400 cfs to occur in one out of every two years. During the same month one could expect average flows exceeding 12,000 cfs to occur once in fifteen years, and average flows exceeding 16,000 cfs to occur only once in every fifty years. The high negative correlation between flow frequency and flow magnitude (high coefficient of variation) is evident at all three locations during eight months of the year (November-June). The high correlation is not apparent during four summer months (July-October) when river flows above Milner Dam are most highly regulated.

Surplus flows occur most frequently during winter months. During December, January, and February, surplus flows that exceed 1,000 cfs, on average, at Milner Dam could be expected to occur nearly every year and flows that exceed 2,600 cfs, on average, could be expected in at least one out of every two years. During these same months surplus flows at the St Anthony gage that exceed 250 cfs could be expected almost every year.

Table 4-1. Surplus Flow at St. Anthony gage

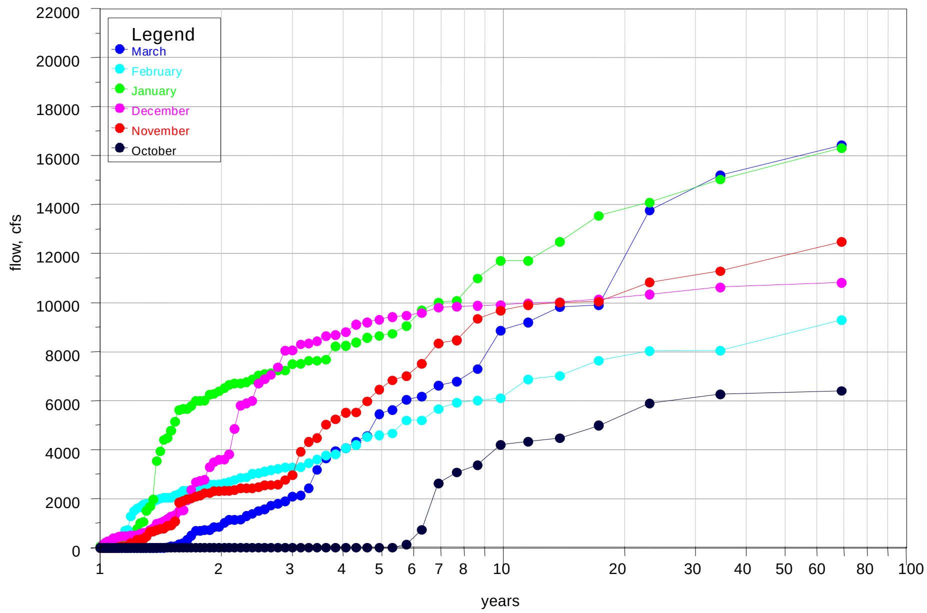
Month	Flow, cfs, n=65	
	Median (50th)	arithmetic mean
October	0	268
November	1213	1016
December	925	943
January	1003	953
February	1122	1086
March	771	673
April	1118	1077
May	2160	2021
June	0	1206
July	0	100
August	0	85
September	0	56

Table 4-2. Surplus Flow at Blackfoot gage

Month	Flow, cfs, n=65	
	median (50th)	arithmetic mean
October	0	686
November	2335	2773
December	3251	3133
January	3067	3325
February	2499	2930
March	865	2427
April	2575	5492
May	2800	3925
June	0	2382
July	0	135
August	0	114
September	0	71

Table 4-3. Surplus Flow at Milner Dam gage

Month	Flow, cfs, n=69	
	median (50th)	arithmetic mean
October	0	673
November	2313	3310
December	3594	4697
January	6404	5904
February	2601	3043
March	865	2596
April	2511	5385
May	2800	3868
June	0	2511
July	0	128
August	0	108
September	0	67



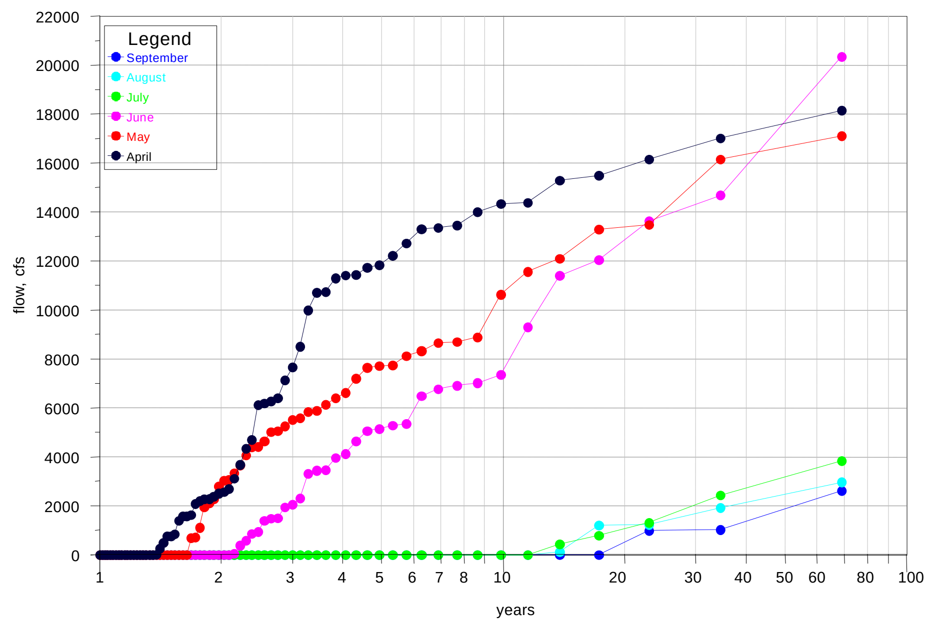


Figure 4-5. Surplus Flow Recurrence for Milner Dam Diversions

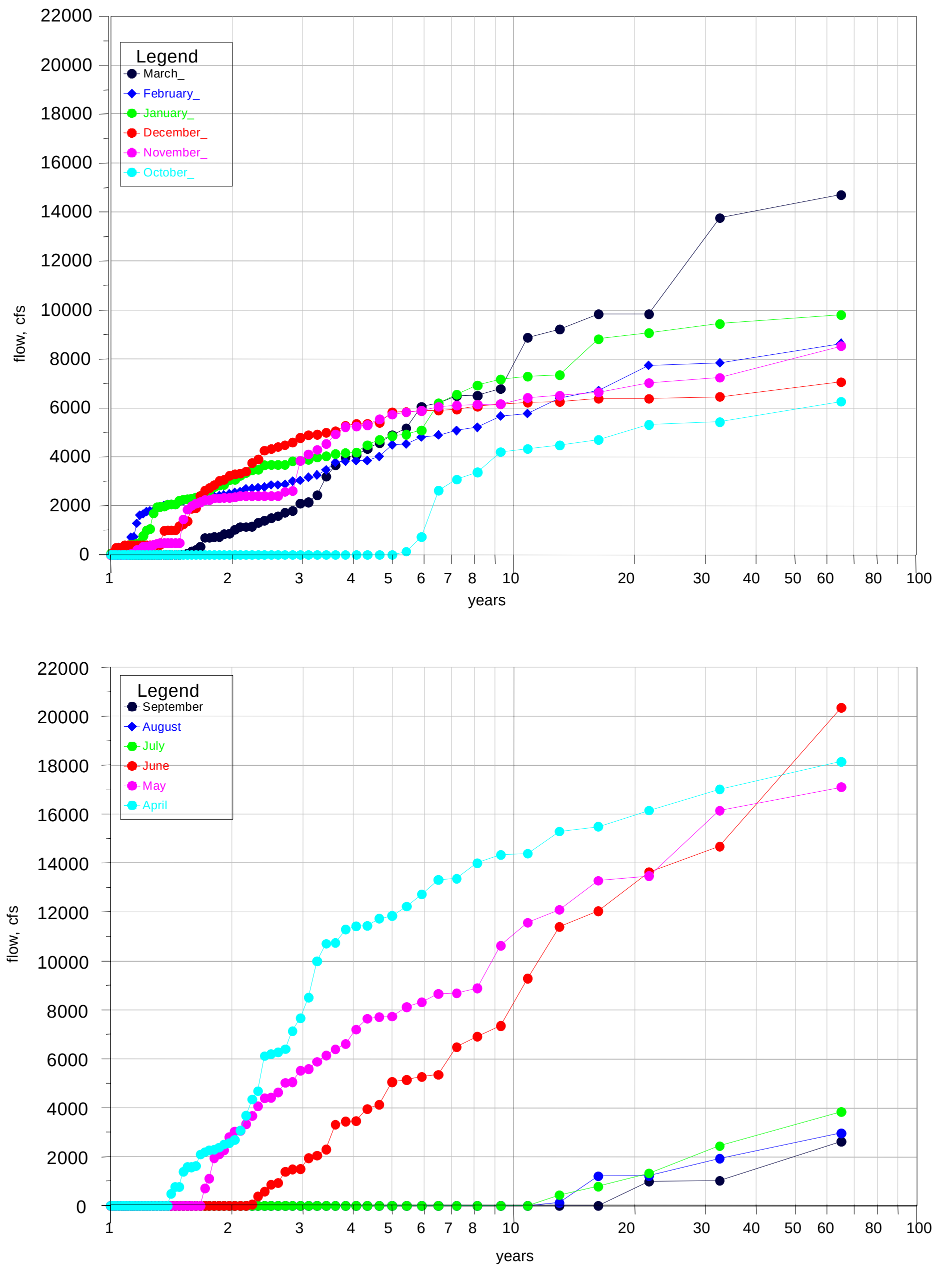


Figure 4-6. Surplus Flow Recurrence for Blackfoot Diversions

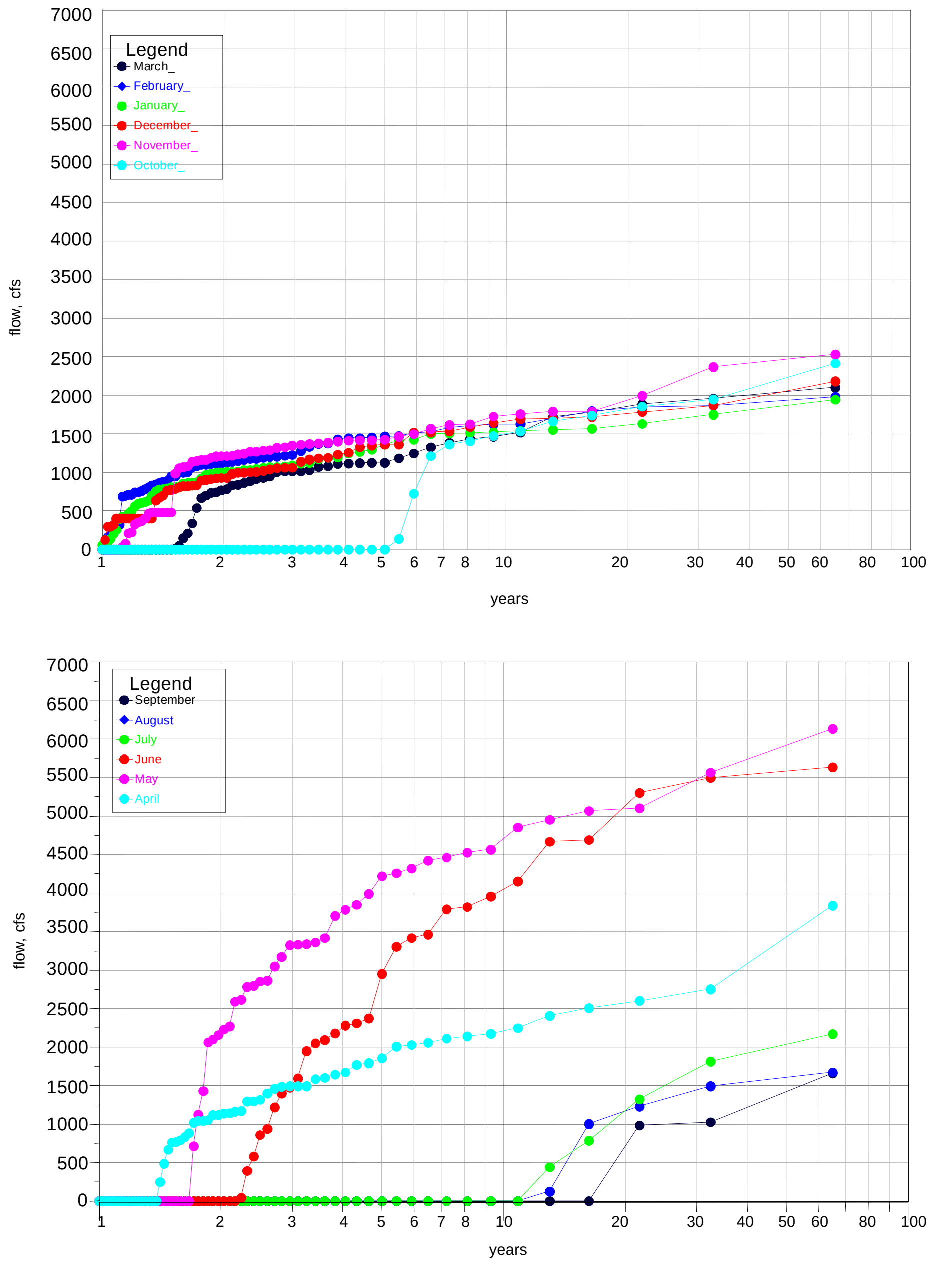


Figure 4-7. Surplus Flow Recurrence for St. Anthony Diversions

The shorter recurrence interval for surplus flows during winter months is due mainly to the increasing frequency of reservoir flood control releases at this time of the year. This is apparent in histograms (figure 4-8), which show a bimodal distribution of surplus flow at Milner Dam during December, January, and February. The bimodal distribution is the result of combining data from wet years when flood control releases are commonly made from upper basin reservoirs, with data from dry years when flood releases are not made. The gap between the two modal peaks in these histograms is greatest during December (over 10,000 cfs) and January (over 7,000 cfs) and is reduced somewhat in February (about 2,000 cfs). The bimodal distribution is an indicator that flows commonly occur during these months that are excess to the system, above Milner Dam. The bimodal distribution would not be revealed in historical flow data that has not first been "conditioned" to reflect more recent trends in reservoir and river system management.

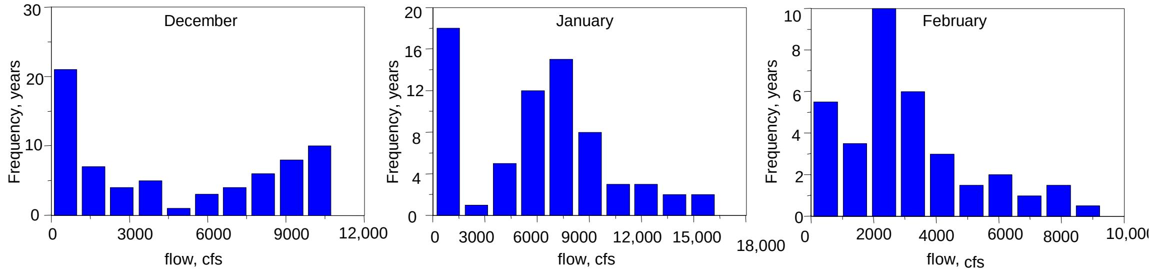


Figure 4-8. Surplus Flow Histograms at Milner Dam over 65-Year Period of Record

3. Constraints on Use of Conditioned Surplus Flows

Flows that pass Milner Dam are considered surplus to upstream irrigation demands. However, they are not necessarily surplus to other instream demands. The Recharge Water Availability (RWA) program is used to determine the rate at which aquifer recharge is expected to occur, given the record of conditioned surplus flow and given some additional constraints on use of these flows for aquifer recharge.

Constraints that are imposed on the use of surplus flows relate both to the instream flows below a recharge diversion point that must be met before water is diverted for aquifer recharge, and to the maximum recharge capacity which cannot be exceeded regardless of how much surplus water is available. In this study, three sets of constraints, each consisting of 12 monthly averages, are imposed on the use of conditioned surplus flows. The three constraints that limit water availability for recharge are:

- Planned releases of storage water for Federal Energy Regulatory Commission (FERC) bypass flows, hydropower, salmon flow augmentation, and system maintenance, but not including flood control releases.
- Stream maintenance flows needed to sustain resident fisheries populations and/or ESA listed snails.
- Excess diversion capacity of canals or maximum infiltration capacity of recharge basins.

Constraints representing existing hydropower rights are not imposed on conditioned flows in this application of the RWA program. Recent investigations (IDWR 1997) have demonstrated that if managed recharge were completely subordinated to existing hydropower rights, annual divertable recharge would be reduced on average by about 90 percent, to about 43,000 acre-feet per year, making a study of the feasibility of large-scale managed recharge unnecessary. In the absence of any information that would indicate how much (if any) of the existing hydropower rights (e.g. 17,250 cfs held by

Idaho Power Co. at Lower Salmon Falls) might be subordinated to managed recharge, the alternative is to develop recharge scenarios that assume hydropower rights are completely subordinated to managed recharge. As indicated previously, aquifer and river responses to recharge are generally proportional to expected recharge rates, hence model results are useful even if some future subordination agreement reduces expected recharge rates. In the interim, model results provide estimates of the net impact of managed aquifer recharge on Snake River flows and, therefore, the likely effect of managed recharge scenarios on hydropower production.

The RWA program can apportion divertable instream flow among multiple diversion points according to a specified priority of use. Typically, this means either an upstream (high in the basin) or downstream (low in the basin) prioritization of aquifer recharge water. However, in this study, in order to isolate and better understand the basin-wide hydrologic impacts of managed recharge activity, water is apportioned to only one diversion point (recharge scenario) at a time.

4. Storage Water Releases Passing Milner Dam

The first potential constraint that is imposed on use of conditioned surplus flows for managed recharge relates to reservoir storage water passing Milner Dam. Estimates of planned monthly reservoir releases passing Milner Dam (table 4-4) are based on historical records (Sutter, 1998).

Historically, planned releases of storage water for hydropower, system maintenance, salmon flow augmentation, or fisheries maintenance have resulted in flows that exceed the FERC bypass minimum at Milner Dam during all but three months of the year. Planned releases are generally at the minimum (225 cfs) during March, April, and May. Reservoir releases are generally highest (1,000-1,800 cfs) during July, August, and September, due to a combination of Salmon flow augmentation and hydropower demand. Maintenance activity and flood control releases made during the period October through February account for an average release of about 420 cfs during these months.

Table 4-4. Estimated Planned Releases Passing Milner Dam

	flow, cfs	flow, ac.ft.
October	400	24,598
November	300	17,854
December	400	24,598
January	500	30,748
February	500	27,772
March	225	13,529
April	225	13, 093
May	225	13,529
June	300	17,854
July	1,000	61,496
August	1,000	61,496
September	1,800	107,120
Annual	573	36,418

5. Stream Maintenance Flow Recommendations for Fisheries

The second potential constraint on the use of conditioned surplus flow for managed recharge relates to flow recommendations for resident fisheries. Stream maintenance flow recommendations provided by the Idaho Fish and Game Department (IDFG, 1999) are represented as a range of flows within which fish and aquatic organisms in selected river reaches of the Henrys Fork and Upper Snake River are maintained or protected in the long term. The maintenance flows recommendations are simply recommendations. There exist no instream water rights based on these recommendations, however, fisheries needs are recognized as a part of the public interest criteria that must be considered in permitting of large-scale managed recharge.

Stream maintenance flow recommendations for river reaches (both above and below Milner Dam) are expressed as “trigger” flows, which are the flows needed at the four recharge diversion locations: i.e., Milner Dam, Minidoka Dam, Idaho Falls, and St. Anthony (table 4-5), in order to satisfy fisheries flow recommendations downstream. The trigger flows at Milner Dam and Minidoka Dam reflect needs of fisheries in the Milner to Brownlee Reservoir reach of the river. Flows exceeding the trigger flows at these locations could potentially be diverted for managed recharge. At Blackfoot and St. Anthony there is an additional IDFG flow recommendation which would limit recharge diversion to one half of the flow exceeding the stream maintenance recommendation in table 4-5.

Table 4-5. Trigger Flows to Satisfy Stream Flow Maintenance Recommendations Downstream (IDFG, 1999)

	Trigger at Milner Dam (Milner to Lower Salmon Falls) cfs	Trigger at Minidoka Dam (Milner to Lower Salmon Falls) cfs	Trigger at Idaho Falls* (Blackfoot to Neeley) cfs	Trigger at St Anthony* (Lower Henrys Fork reach) cfs
October	4850	5050	2070	1450
November	4075	4380	3750	2100
December	3800	4140	3750	2100
January	3800	4140	3750	2100
February	3800	4140	3750	2100
March	6700	6650	5100	2100
April	7227	7110	7030	2300
May	12300	11510	10450	4400
June	13525	12580	9040	3370
July	8400	8130	not specified	1680
August	5600	5700	not specified	1470
September	5050	5220	not specified	1360

*Plus ½ of flow exceeding the trigger flow.

The seasonal differences in flow recommendations reflect the specific biological requirements of resident fish with respect to water quality, food, escape cover, passage, and reproduction. At Milner Dam the mean annual stream-maintenance flow recommendation is about 6,600 cfs, but ranges from 3,800 cfs to 13,525 cfs. Recommended flows at Milner Dam are generally lowest (about 57 percent of the annual mean) during winter months (December, January, and February) and highest (157 percent of the annual mean) during spring and summer months (April, May, June, and July).

At Blackfoot the mean annual stream-maintenance flow recommendation is about 5,400 cfs, but ranges from 2,070 cfs to 10,450 cfs. Maintenance flows at Blackfoot are also generally lowest (about 63 percent of the annual mean) during autumn and winter months (October through February) and highest (163 percent of the annual mean) during spring and early summer months (April, May, and June). Maintenance flows at Blackfoot for July, August, and September were not specified by IDFG, since storage water releases made to meet irrigation demand downstream from Blackfoot typically provide adequate stream maintenance flows during these months.

At St. Anthony the mean annual stream maintenance flow recommendation is 2,200 cfs, but ranges from 1,450 cfs to 4,440 cfs. Maintenance flows at St. Anthony are also generally lowest (about 65 percent of the annual mean) during summer months (August, September, and October) and highest (150 percent of the annual mean) during spring months (April, May, and June).

The U.S. Fish and Wildlife Service (USFWS) strategy for recovery of five listed snails species is basically described as conserving and restoring mainstem Snake River and cold-water spring tributary habitats. It recommends flow augmentation to maintain year round flows below Milner Dam, protection of cold water springs, and stabilization of ground-water levels to insure reliable spring discharges from the ESPA (USFWS, 1995). As part of the Snake River Resources Review (SR3), the USBR compiled estimates of flow requirements for aquatic snails (USBR, 1998). The critical time period for meeting flow water quality needs of snails is between June and September. Acceptable flow consistency during these months is judged to be between 5,000 and 8,000 cfs. Since the fisheries maintenance flows specified by IDFG exceed 5,000 cfs in all four months, it is assumed in this study that the IDFG fisheries maintenance flows for Milner Dam would satisfy the instream flow needs of ESA listed snails as well.

The monthly IDFG stream maintenance flow recommendations are entered in the RWA program as an instream flow requirement at the four potential diversion locations, to be met prior to any diversion of water for managed recharge.

6. Maximum Diversion and Recharge Capacity

The third constraint imposed on the use of surplus flow for aquifer recharge is expressed as a maximum recharge rate at each diversion location. In most cases, aquifer recharge rates are limited by the excess diversion capacity of existing canal systems that supply water to recharge basins. Estimates of excess canal capacity were obtained from a recent IWRRI report on this subject (Sullivan, Johnson et al., 1996). However, in a departure from the IWRRI report, which assumed that most canals would not be used to supply recharge water during winter months, the present study assumes that in most cases canals could be used during winter months to supply water to recharge sites.

Twelve potential canal diversions have been grouped together based on their proximity to three main aquifer recharge locations (table 4-6). Five major canal diversions are located in the vicinity of St. Anthony (Last Chance, St. Anthony, Egin, St. Anthony Union, and Independent). Five diversions are upstream from the Blackfoot (Great Western, Porter, New Lavaside, Peoples, and Aberdeen-Springfield). Two diversions are located just upstream from the Milner Dam (Milner-Gooding and North Side (at Twin Falls)). Minidoka canal diversion capacity is not considered a limiting factor for recharge diversions at Minidoka Dam.

Table 4-6. Excess Diversion Capacity of Canals (based on IWRRI, 1996)

Excess capacity, cfs	North Side (at Twin Falls)	Milner-Gooding	Great Western Porter New Lavaside Peoples Aberdeen-Springfield	Last Chance St. Anthony Egin St Anthony Union Independent
October	917	1,281	863	617
November	967	1,519	1,184	475
December	3,500*	1,653*	1,130**	326
January	3,500*	1,659*	1,110**	310
February	3,500*	1,659*	1,110**	457
March	558	1,659	1,130	705
April	767	1,138	1,047	664
May	572	491	361	550
June	222	324	84	432
July	134	211	44	441
August	147	303	314	514
September	567	541	447	695

* assumes entire canal capacity is available during these months.
** assumes partial canal capacity is available during these months.

As indicated in table 4-6, the assumption that canals could be used during three winter months for managed recharge significantly increases potential capacity for recharge diversion. About 68 percent of the total annual excess diversion capacity of the North Side Canal is available during December, January, and February and about 39 percent of the excess Milner-Gooding capacity is available during these three months. The combined capacity of these two canals during winter months is 5,159 cfs. Similarly, at least 37 percent of the total excess capacity of canals located near Blackfoot is available during these months. By contrast, due to irrigation demand, only about 7 percent of excess canal capacity is available during the three summer months. Spring and autumn months offer diversion opportunities that are in the intermediate range.

The assumption of wintertime recharge has not been tested with respect to either the North Side or Milner-Gooding canals, and it is understood that there are significant operational difficulties and costs associated with winter time use of canals for aquifer recharge. Nevertheless, a workable wintertime canal diversion and aquifer recharge program has been in operation in the Fremont-Madison Irrigation District for many years.

Within the RWA program, maximum canal capacity constraints are imposed on conditioned flows as a simple cap on diversion. The instream flow constraints are imposed first, and then the capacity constraint is imposed on the remaining surplus flow. Surplus flows that are less than instream requirements or greater than the capacity of managed recharge facilities cannot be diverted, and so remain in the river. For recharge diversions that would require pumping of recharge water, the capacity constraint is based on an estimate of the total capacity of recharge basins.

7. Expected Aquifer Recharge Rates

The rate at which aquifer recharge is expected to occur over the long term is referred to as the expected aquifer recharge rate. While expected aquifer recharge is mainly a function of the magnitude and frequency of conditioned surplus flows, it is limited by the capacity of managed recharge/diversion facilities and by instream flow requirements. The IDWR/UI model requires an expected value for aquifer recharge for each month of the base case year at each potential diversion location.

The RWA program is used to generate expected aquifer recharge rates for subsequent modeling of managed recharge scenarios. A recurrence plot which shows the constraints imposed on flow passing Milner Dam, during January (figure 4-9) demonstrates the method used in the RWA program to calculate the expected aquifer recharge rate for this particular month. Conditioned surplus flow during January (also in figure 4-5) is indicated by the blue recurrence curve in this figure. Three additional recurrence curves show the effect of imposing three different constraints on the use of surplus flows for managed recharge. Conditioned surplus is first reduced by 500 cfs (table 4-1) to account for planned releases of storage water during January (yellow curve). An additional 3,800 cfs reduction (table 4-5) is made to meet IDFG recommendations for stream maintenance below Milner Dam during this month (red curve). Finally a 5,158 cfs cap (table 4-6) is imposed on recharge at Milner Dam to represent the fact that diversions are also limited by the excess capacity of the North Side and Milner-Gooding canals (green curve). Flows during January that exceed the combined capacity of the North Side and Milner-Gooding canals cannot be diverted, and so remain in the river. For any given flow-rate recurrence interval in figure 4-9, the difference between the blue and green curves is the portion of conditioned surplus flow that is expected to remain in the river during January, while recharge is ongoing.

The arithmetic mean value of flows represented by this last (green) recurrence curve (2,592 cfs) is one of the twelve expected aquifer recharge rates used in the IDWR/UI model for the "Thousand Springs" recharge scenario. The expected recharge rate describes the rate at which aquifer recharge could be expected to occur over the long term, during January, for a recharge scenario that diverts surplus flows at Milner Dam and is subject to these three types of constraints. While it is probably not necessary to reduce surplus flows by both planned releases and instream flows in order to meet the IDFG recommendations, the effect of doing so is small. On average, expected recharge diversions at Milner Dam are reduced by less than 50 cfs as a result.

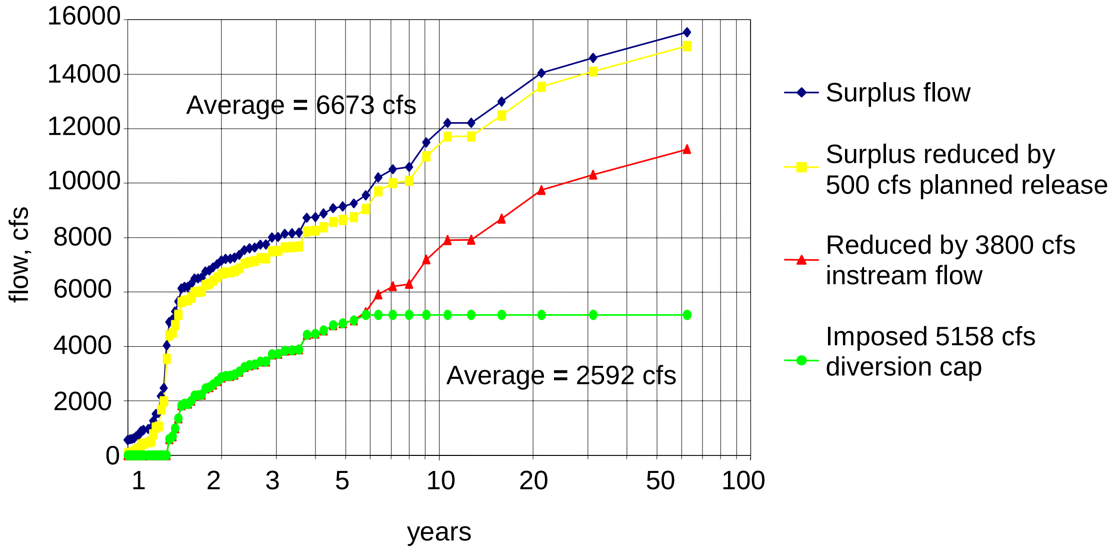


Figure 4-9. Expected Aquifer Recharge Rate at Milner Dam during January

Since both the historical record of flow and the constraints on use of flow for managed recharge vary from location to location and month to month, expected aquifer recharge rates will also vary accordingly. The expected aquifer recharge rates for each month of the year and each diversion location are presented in the following sections, which describe the application of the IDWR/UI model, in evaluating four large-scale managed recharge scenarios for the Eastern Snake River Plain.

E. THE "THOUSAND SPRINGS" RECHARGE SCENARIO

The seasonal response of springs in the Kimberly to Bliss reach of the river to the onset of the irrigation season has been well documented (Thomas, 1968), and over the years a large number of potential recharge sites located in close proximity to the North Side and Milner-Gooding canals have been identified. Twenty-eight potential recharge sites along Milner-Gooding Canal range in size from 10 to 700 acres and total more than 4,500 acres. Seventeen potential sites along the North Side Canal have a total area exceeding 1,000 acres.

The proximity of these canal systems to Thousand Springs and the demonstrated ability of irrigation diversions and canal leakage to affect discharge from springs in the Kimberly and Bliss reach makes this area of the plain an important potential candidate for large-scale managed recharge.

The Lower Snake River Aquifer Recharge District has operated an aquifer recharge project two miles north of Shoshone since 1984. Surplus water is delivered to the site through the Milner-Gooding Canal and released into a 200-acre basin. Typically, recharge at the Shoshone site occurs in April through mid-June and in September through

November. The average recharge rate during diversion is approximately 250 cfs (EHM Engineers, 1997).

In the past, the capacity of canals to convey recharge water during the irrigation season has limited the scope of recharge activity. The "Thousand Springs" recharge scenario is developed assuming that managed recharge could be conducted year round using the combined excess capacity of both the North Side and the Milner-Gooding canals.

Diversion for the "Thousand Springs" scenario occurs just above Milner Dam. Expected recharge is superimposed on the base-case equilibrium model, and uniformly distributed over eighteen model cells which encompass the location of potential recharge basins adjacent to the North Side and Milner-Gooding main canals (figure 4-10).

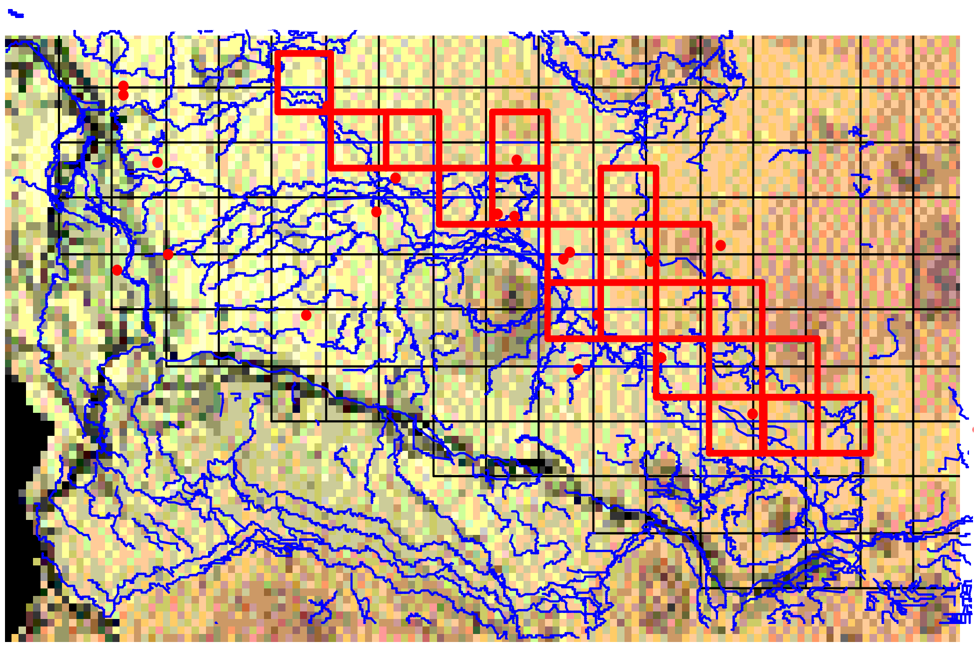


Figure 4-10. IDWR/UI Model Representation of "Thousand Springs" Recharge Scenario

<u>1. Expected Recharge Rate, "Thousand Springs" Scenario</u>

Expected aquifer recharge is a function of the magnitude and frequency of surplus flows, and it is limited by instream flows and by the capacity of managed recharge/diversion facilities. In order to show the relative influence of these constraints on large-scale managed recharge, expected recharge rates for the Thousand Springs Scenario are determined subject to three possible sets of constraints on use of surplus flows for managed recharge (figure 4-11). In the first set, recharge is constrained only by the excess diversion capacity of the North Side Canal. In the second, the recharge is constrained by IDFG stream maintenance flow recommendations and by the North Side canal capacity. In the third, recharge is constrained by IDFG stream flow recommendations and capped by the combined excess diversion capacity of the North Side Canal and the Milner-Gooding Canals.

Depending on the set of constraints imposed on use of surplus flow at Milner Dam, between 76 and 85 percent of the annual aquifer recharge could be expected to occur during just three winter months (December, January, and February). Between 14 and 23 percent of expected recharge could be expected during the spring or autumn (March-June, October, and November); however, less than 1 percent of total recharge is expected during the summer months (July, August, and September).

The high potential for wintertime recharge in the "Thousand Springs" scenario is due to a combination of factors. Surplus flows during these months (between 3,600 cfs and 6,700 cfs on average) are among the highest of the year, mainly because of flood control releases. Also, the entire capacity of the North Side and the Milner-Gooding canals (5,159 cfs) is potentially available for diversion during these months. The planned releases of storage water that are made during winter months are mainly for hydropower, and these are low (500 cfs), compared to those made during summer months. Finally, IDFG stream maintenance flow recommendations (3,800 cfs) are at their lowest during winter months.

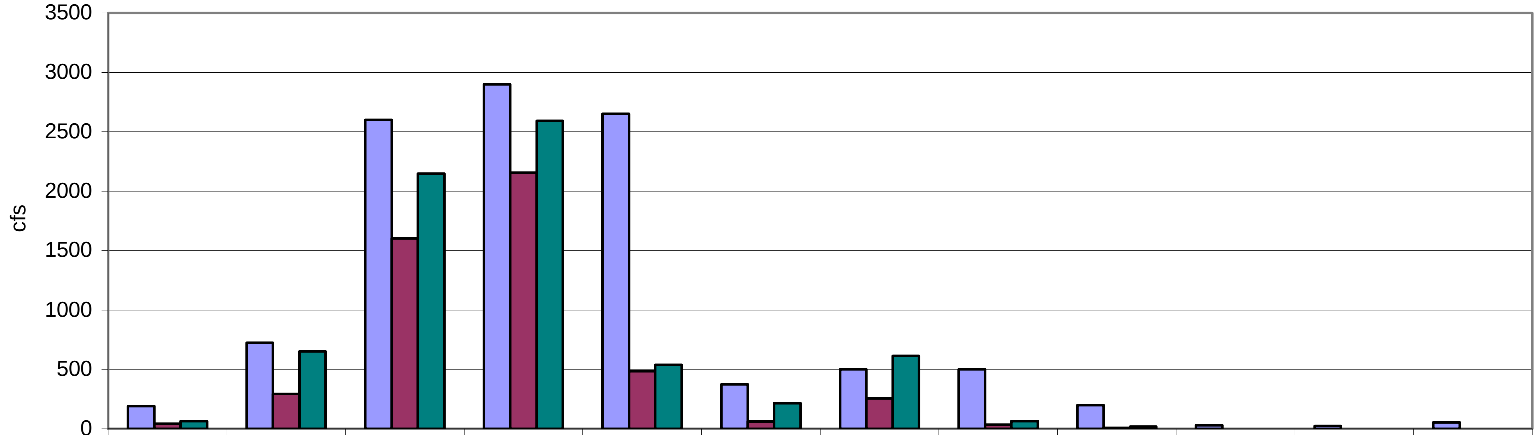
On an annual basis, the average expected recharge rate is approximately 895 cfs (648,000 acre-feet per year) if just the North Side Canal is used for diversion. The introduction of a prior stream-maintenance flow requirement cuts the annual rate by more than half to 412 cfs (298,000 acre-feet per year). However, the use of two canals (Milner-Gooding and North Side) instead of one for recharge diversion allows managed recharge operations to take advantage of higher flows that occur less frequently and to offset the effects of meeting stream maintenance flow recommendations. With the additional capacity of the Milner-Gooding Canal, the average annual recharge rate is increased to 575 cfs, (416,000 acre-feet per year) or about two-thirds of the original rate.

The "Thousand Springs" recharge scenario is modeled subject to this third set of constraints on expected recharge rates. The expected recharge rate for this simulation is constrained by the IDFG flow maintenance recommendations for fisheries (table 4-5) and by the combined excess capacity of both the North Side Canal and Milner-Gooding Canal (table 4-6).

The "Thousand Springs" scenario assumes that sufficient opportunities for recharge exist in sites adjacent to the two main canals to accommodate the expected monthly recharge rates in figure 4-11. With over 5,500 acres of potential recharge basin identified adjacent to the North Side and Milner-Gooding canals, thus far, and expected infiltration rates of between 1 and 1.5 cfs per acre of recharge basin (based on results from the Shoshone site), this is almost certain to be the case.

2. Aquifer Response to "Thousand Springs" Recharge Scenario

The aquifer response to the "Thousand Springs" recharge scenario is represented by five color coded contour maps showing the change in ground-water level that could be expected to occur in the ESPA after 1 year, 3 years, 10 years, 20 years, and 58 years of continuous recharge (58 years is the minimum time required for the system to reach a new equilibrium after recharge begins).



	October	November	December	January	February	March	April	May	June	July	August	September
canal cap only*	190	725	2600	2900	2650	375	500	500	200	30	25	55
canal cap and fisheries**	44	293	1602	2155	486	61	255	35	9	0	0	0
canal cap and fisheries***	64	651	2147	2592	540	215	613	64	19	0	0	0

* Northside canal (annual ave. = 895 cfs)
** Northside canal (annual ave. = 412 cfs)
*** Northside & Milner Gooding canals (annual ave. = 575 cfs)

Figure 4-11. Expected Aquifer Recharge Rates for the "Thousand Springs" Scenario

The change maps are developed by differencing ground-water level estimates from the "Thousand Springs" scenario recharge model from those of the base case equilibrium model. The minimum contour displayed on these ground-water level change maps is three feet. While the model is capable of predicting very small changes in ground-water levels that occur virtually everywhere within the aquifer, the conceptual representation of the aquifer in this model and the calibration experience do not support this level of confidence in the models predictive capability. The change maps are intended to show the aquifer area that is most likely to be influenced by managed recharge. The three-foot minimum contour in the ground-water level change maps represents the expectation that a measurable response to recharge would be observed in the aquifer at these locations.

The portion of the ESPA that could be expected to be measurably influenced by recharge after just one year is indicated in figure 4-12a. The dark blue area denotes a three-foot rise in ground-water level and marks the extent of recharge influence on ground-water levels. For the most part, this recharge mound coincides with the eighteen grid cells over which recharge is uniformly distributed, although the mound area extends to the east about 3 to 5 miles beyond the recharge area. (Recall that each grid cell is about a three-mile square.) Simulated ground-water levels directly beneath the recharge sites rose less than ten feet as a result of recharge.

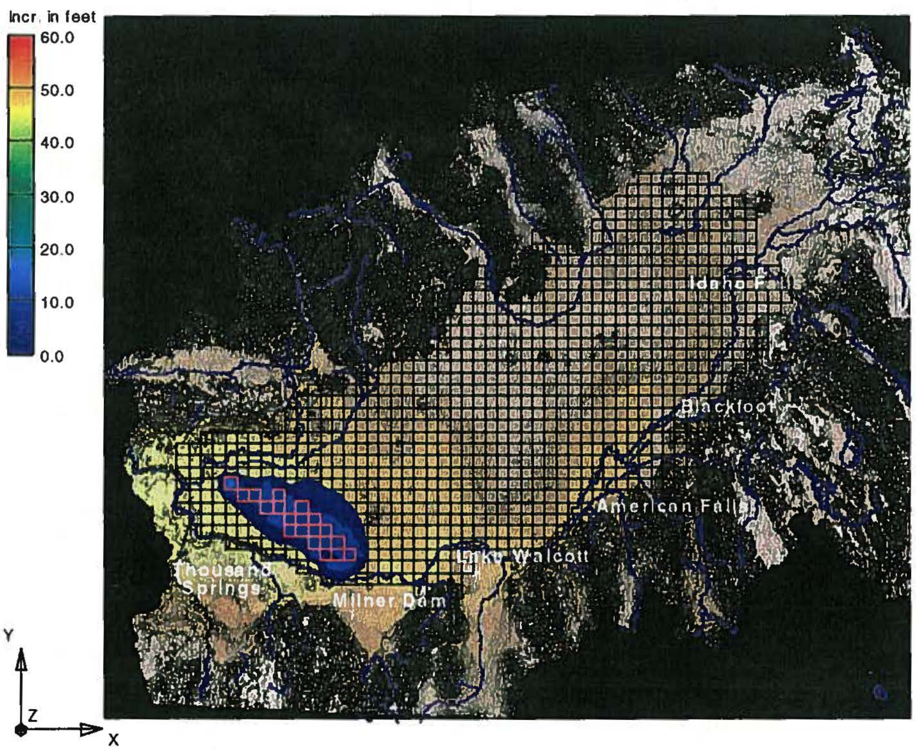


Figure 4-12a. Ground-Water Level Change After One Year of Recharge

After three years of continuous recharge, the ground-water mound has expanded an additional 6 to 8 miles northeast of the recharge cells (figure 4-12b). The expansion of the recharge mound to the south and west is, of course, prevented by the Snake River. In general, changes in ground-water level close to the river would be expected to be small, due to the fixed elevation of springs that discharge ground water into the river. Simulated ground-water levels directly beneath the recharge sites have risen between 15 and 20 feet in places. However, for the most part, the ground-water level rise is ten feet or less.

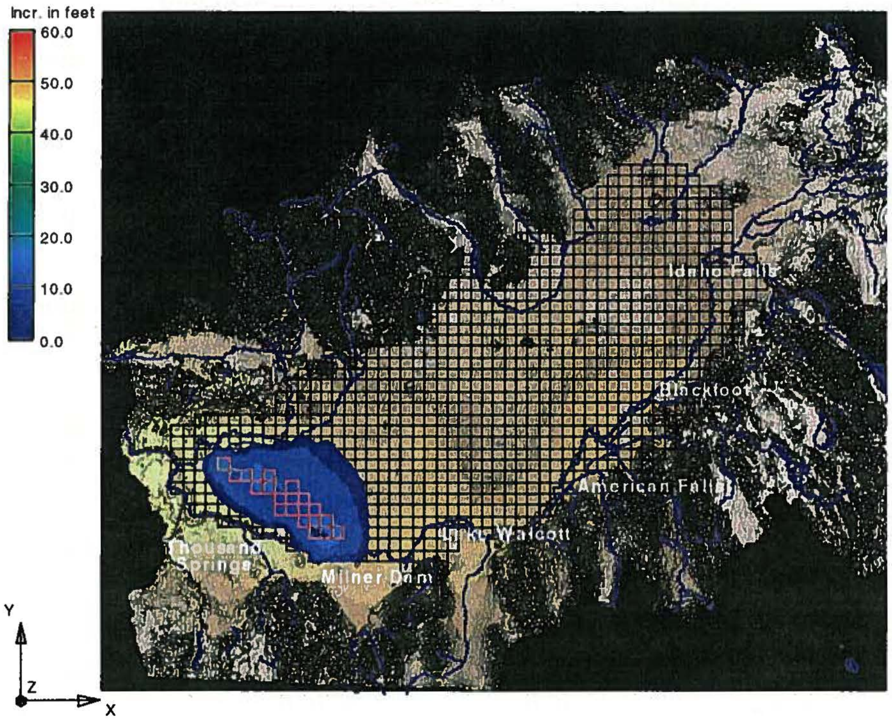


Figure 4-12b. Ground-Water Level Change after Three Years of Continuous Recharge

After ten years of continuous recharge, the area of aquifer that has been measurably affected has extended an additional 30 to 35 miles, mainly to the northeast into Lincoln County (figure 4-12c). Increases in simulated ground-water levels of about 5 feet are also observed in the central part of the plain. However, the ground-water level beneath the recharge sites has changed little and remains about 20 feet higher than base case levels. The relatively close proximity of the North Side and Milner-Gooding recharge sites to the fixed head boundary of the river prevents water levels from rising further in Gooding County, to the west of the recharge sites.

After twenty years of continuous recharge, the aquifer area influenced by recharge has expanded past Lake Walcott into Minidoka and Blaine counties (figure 4-12d). The ground-water level rise in much of the central part of the plain is about 10 feet. Ground-water levels directly beneath the recharge sites remain between 15 and 20 feet higher than base case levels.

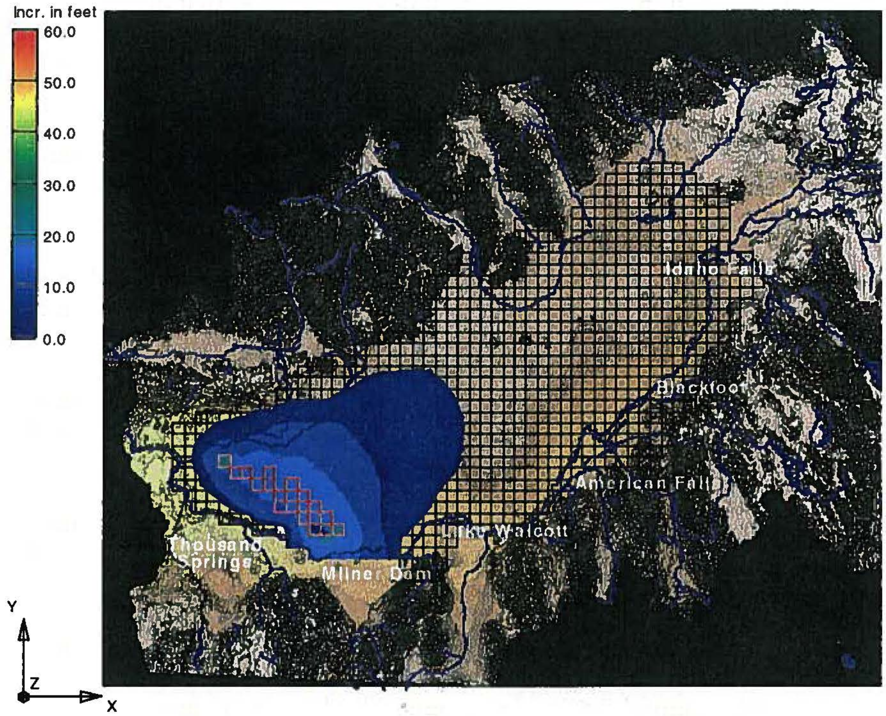


Figure 4-12c. Ground-Water Level Change after Ten Years of Continuous Recharge

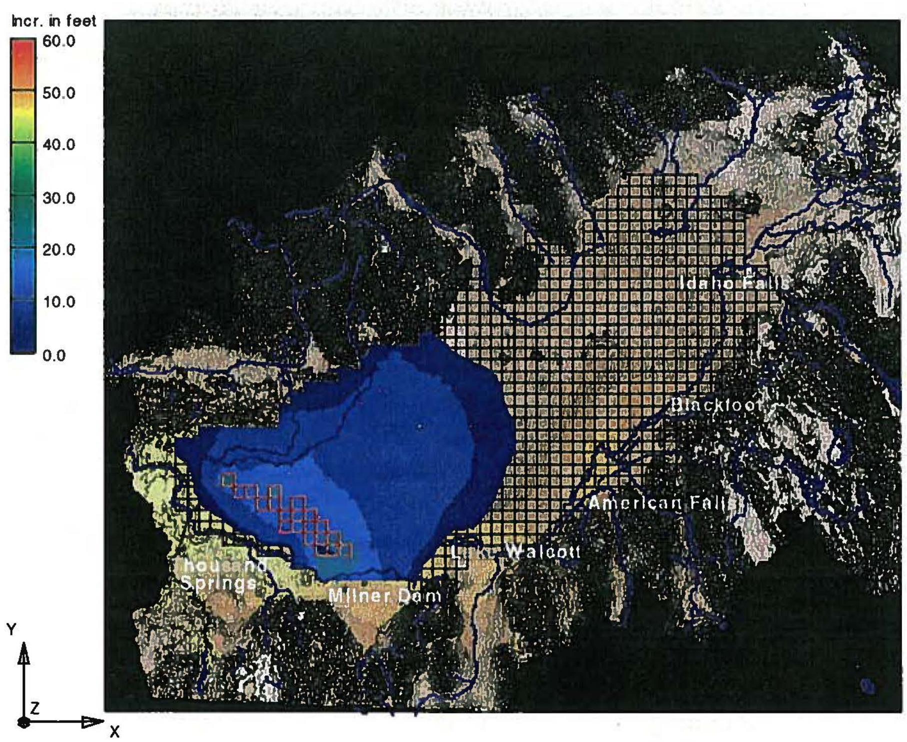


Figure 4-12d. Ground-Water Level Change after Twenty Years of Continuous Recharge

After fifty-eight years of continuous recharge, the aquifer area that has been influenced by the “Thousand Springs” recharge scenario has extended to the east into Power County, but is only slightly larger overall, which is evidence of near equilibrium conditions (figure 4-12e). Ground-water levels within the area of influence have increased somewhat. In the central part of the plain, simulated ground-water levels are 10 to 15 feet higher. Directly beneath the recharge sites, ground-water elevations are 20 to 25 feet higher than base case levels.

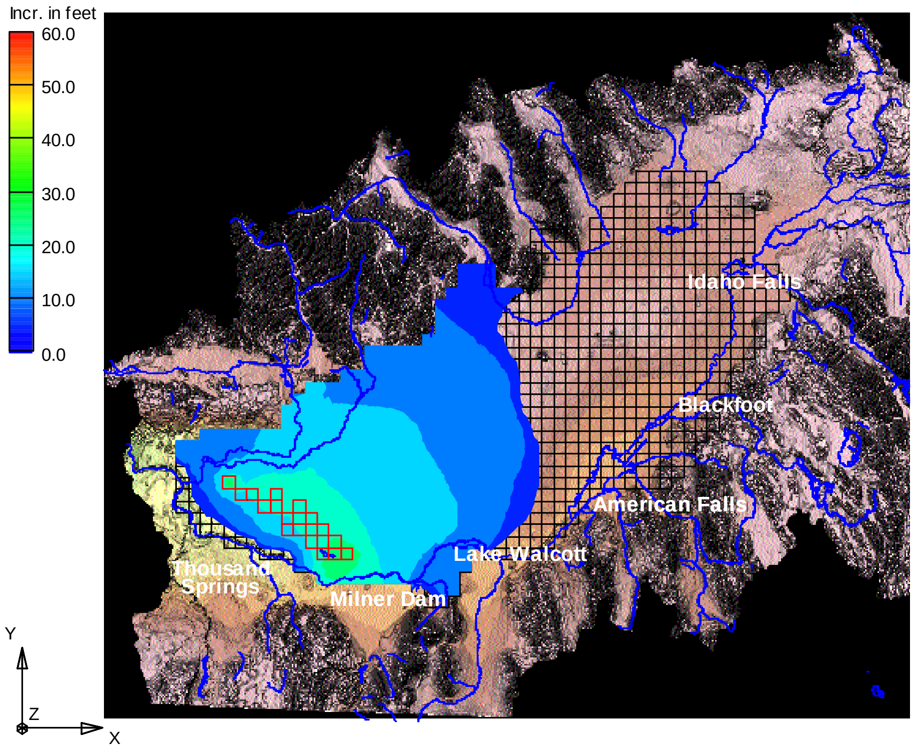


Figure 4-12e. Ground-Water Level Change at Equilibrium (after 58 years of Recharge)

It is important to note in these model results that the recharge mound that results from the “Thousand Springs” recharge scenario is not entirely a plume of recharge water. Without doubt, the recharged water flows to the west, down gradient, exiting the aquifer in the Kimberly to Bliss reach. The expansion of the recharge mound up gradient from the North Side and Milner-Gooding recharge sites is a reflection of the growing influence of recharge on the regional hydraulic gradient since this increase in ground-water level reduces slightly the regional northeast to southwest ground-water gradient. Ground water that would otherwise be discharged in the Kimberly to Bliss reach is in a sense backed up behind a “hydraulic barrier” that is created by the “Thousand Springs” recharge mound.

The relatively rapid expansion of the ground-water mound in the up gradient direction into the central part of the plain is due to the high transmissivity of basalt flows in this area and to the relatively flat water-table conditions associated with them (figure 2-1). The main factor limiting this up gradient expansion of the recharge mound appears to be the low transmissivity and steep hydraulic gradient associated with the Great Rift Fault Zone (figure 2-2).

At equilibrium, the "Thousand Springs" recharge scenario could be expected to induce a ground-water level rise of about 25 feet, directly beneath the recharge sites. In most of the area influenced by recharge, which happens to be east of the recharge sites, the increase in ground-water level is less than 10 feet.

3. Snake River Response to the "Thousand Springs" Recharge Scenario

The Snake River response to managed recharge is also represented by the difference between base case equilibrium model results with managed recharge stresses imposed and base case equilibrium model results without managed recharge stresses imposed.

With the exception of that portion of recharge water that remains in aquifer storage, virtually all of the "Thousand Springs" recharge water exits the aquifer below Milner Dam in the Kimberly to Bliss river reach. In the IDWR/UI model, this river reach is represented by twelve fixed head river-cells (figure 4-10). While river-cell head conditions remain fixed through time, discharge from the aquifer to the river varies over time in response to recharge stresses that are imposed on the aquifer.

In order to isolate the effects of recharge on specific resident fisheries and hydropower plants in the river reach between Kimberly and Bliss, the twelve cells that represent this reach of the river in the model are split into three sub-reaches, each represented by four river-cells. The sub-reaches are identified as the Kimberly to Rock Creek sub-reach, the Rock Creek to Salmon Creek sub-reach, and the Salmon Creek to Bliss sub-reach.

The sub-reach breakdown is justified in the IDWR/UI model provided that modeled discharge to individual sub-reaches conforms to actual measurements of spring discharge within each sub-reach. The base case equilibrium model places approximately 44 percent of the total spring discharge to the river below Milner Dam within the Rock Creek to Salmon Creek sub-reach. The Salmon Creek to Bliss sub-reach accounts for 32 percent of the total and the Kimberly to Rock Creek sub-reach accounts for 24 percent. This distribution of aquifer discharge is comparable to indexed measurements of spring flow on the north side of the river between Milner and King Hill. (Kjelstrom, 1992).

The river response to the "Thousand Springs" recharge scenario during the first ten years of recharge is shown in figure 4-13. The four curves in this figure shows the time-varying river response to recharge in the three sub-reaches of the river below Milner Dam, along with the repeating annual pattern of the expected aquifer recharge rate. Recharge rates during winter months peak at just over 2,500 cfs but drop to near zero during summer months.

While the aquifer recharge rate remains fixed during the ten years of this simulation, the discharge from springs steadily increases over time. Approximately 74 percent of the recharged water reenters the river in springs located in the the Rock Creek to Salmon Creek sub-reach. About 24 percent of the total recharge reenters in the Kimberly to Rock Creek sub-reach and less than 1 percent enters in the Salmon Creek to Bliss sub-reach.

Compared to the large seasonal variablity in expected recharge rates of the “Thousand Springs” scenario, there is very little seasonal fluctuation in the river response to aquifer recharge in the Kimberly to Bliss reach. While recharge rates vary between zero and 2,600 cfs in the course of a year, river response to recharge is remarkably uniform, ranging between 400 and 500 cfs (figure 4-14a and 4-14b). Discharge from springs is just slightly higher in the period April through June and slightly lower in the period December through February. The uniformity of discharge from springs illustrates the overall effect that managed rechrge has on instream flows. The baseflow rate of the river is increased, while the frequency and magnitude of high-flow events is reduced.

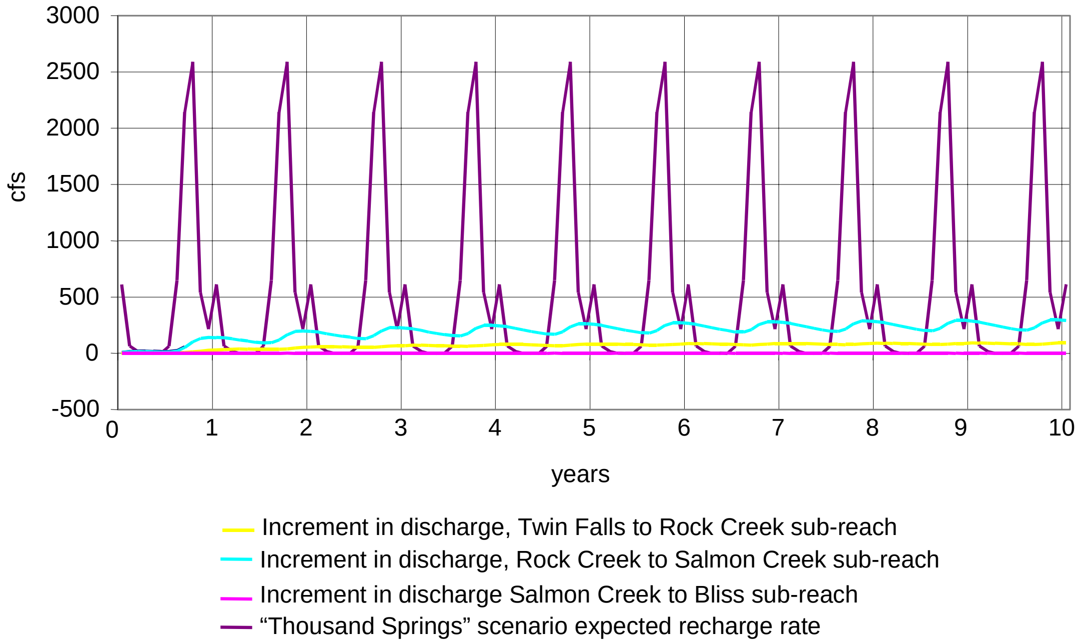


Figure 4-13. River Response and in Sub-Reaches and Expected Recharge Rate

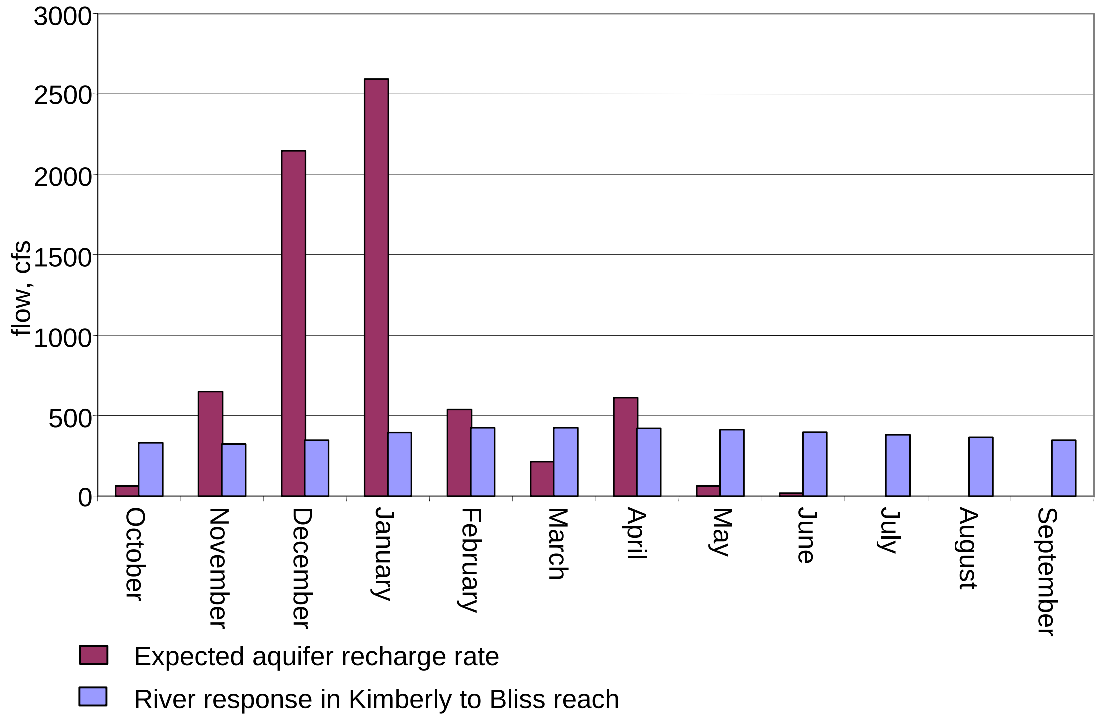


Figure 4-14a. Expected Recharge Rates and River Response after 20 Consecutive Years

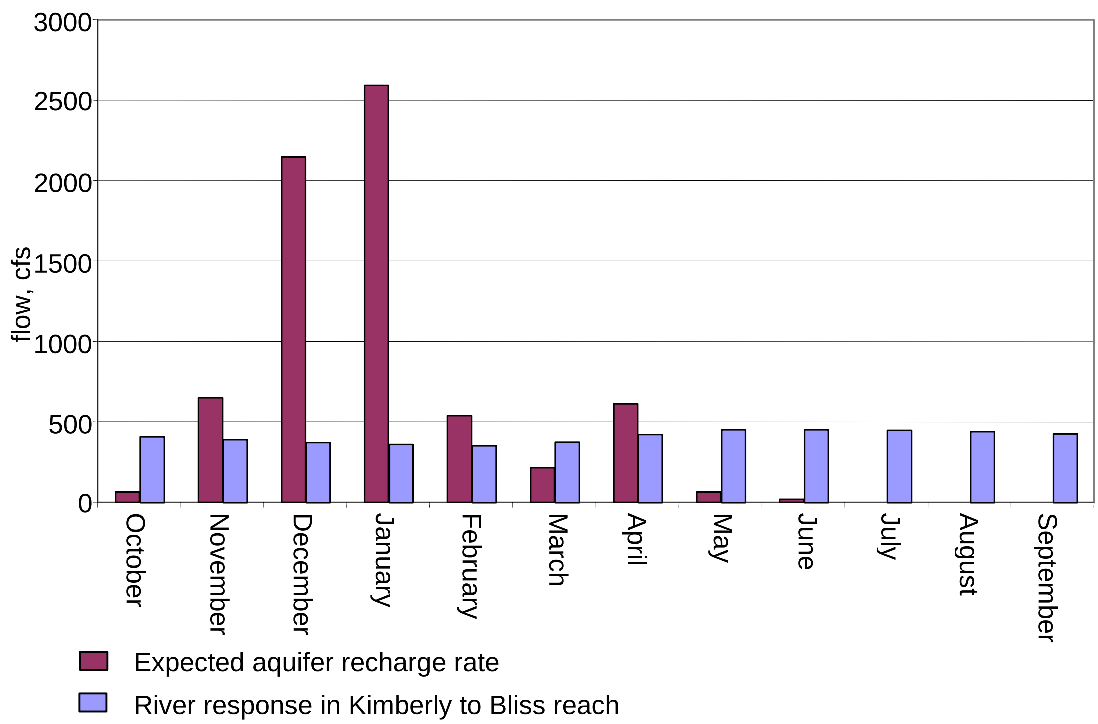


Figure 4-14b. Expected Recharge Rates and Monthly River Response at Equilibrium

4. Cumulative Aquifer and River Response to "Thousand Springs" Recharge Scenario

River response to aquifer recharge is not instantaneous, in part because some of the water that is recharged is stored (temporarily at least) in the aquifer. As the water table beneath the recharge sites rises, some of the recharged water is used to fill previously unsaturated pore spaces. The proportion of recharge water that goes into aquifer storage depends on the porosity (or specific yield) of the aquifer, on the amount of increase in the water table, and on the size of the area that is influenced by recharge. At any point in time, the amount of water put in storage plus the amount returned to the river is equal to the amount of water recharged. Initially, all recharge water goes into aquifer storage. Over time, as the water table approaches a new equilibrium, the rate at which water goes into aquifer storage diminishes to near zero, and the annual river response to recharge becomes nearly equivalent to the annual aquifer recharge rate.

A cumulative river response plot is used to show the time-dependent relationship between these two hydrologic responses to managed recharge (figure 4-15). The cumulative increase in aquifer storage and the cumulative river response are shown relative to cumulative recharge for the "Thousand Springs" Scenario, which is simply the sum of these two variables.

Initially, all of the "Thousand Springs" recharge water goes into aquifer storage. A small response in the Kimberly to Bliss reach of the river is evident after about a year of recharge. Over the next few years the proportion of total recharge that has returned to the river increases rapidly, while the proportion of total recharge that is in aquifer storage increases much more slowly. After 10 years about 7 million acre-feet of water have recharged the aquifer, and it is expected that about 62 percent of the total volume of recharged water (approximately 4.3 million acre-feet) would have returned to the river in the Kimberly to Bliss reach, while 38 percent of the volume would be in aquifer storage.

While the vast majority of the river response to the "Thousand Springs" scenario occurs down gradient from the recharge sites in the Kimberly to Bliss reach, a small response also occurs up gradient from the recharge sites in the Blackfoot to Minidoka Dam reach, which is represented in the model by 25 fixed-head river cells (figure 4-1). The up gradient response is evident after about 30 years of recharge. Without pumping, it is physically impossible for gravity diverted recharge water to reenter the river at an elevation above its diversion point. Rather, the "hydraulic barrier" effect, which produces an aquifer response to recharge up gradient of the recharge sites, also produces this up gradient river response to recharge.

The cumulative response plot indicates that after 58 years, total recharge and total river response are increasing at almost the same rate, indicating that the system is near equilibrium and that little additional water will be stored in the aquifer. At this point, 37 million acre-feet of water have recharged the aquifer and approximately 88 percent of the recharged water (32.5 million acre-feet) has returned to the river, only 12 percent of this volume (4.4 million acre-feet) is in aquifer storage.

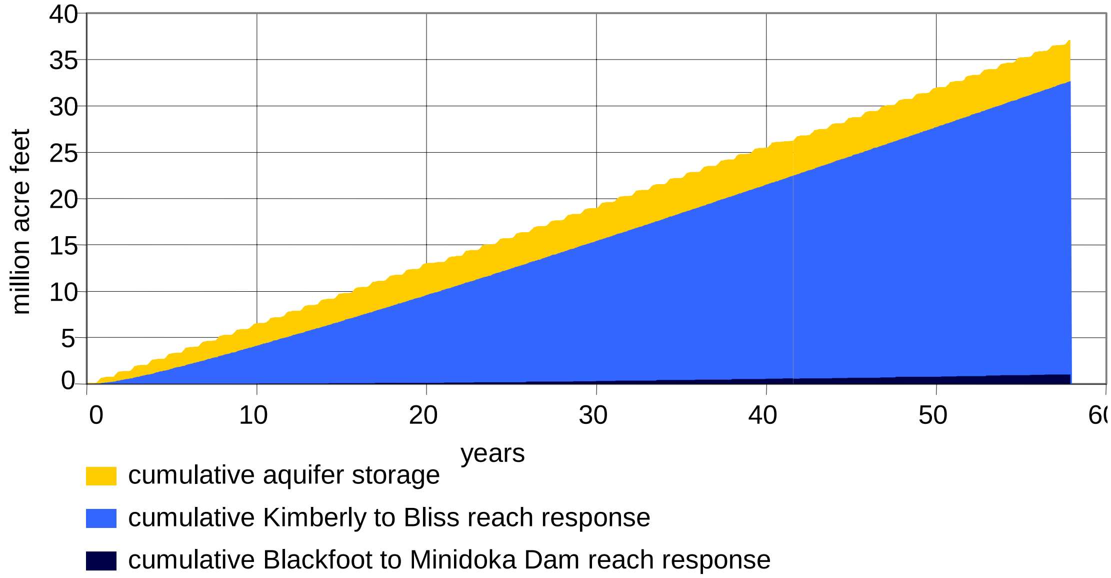


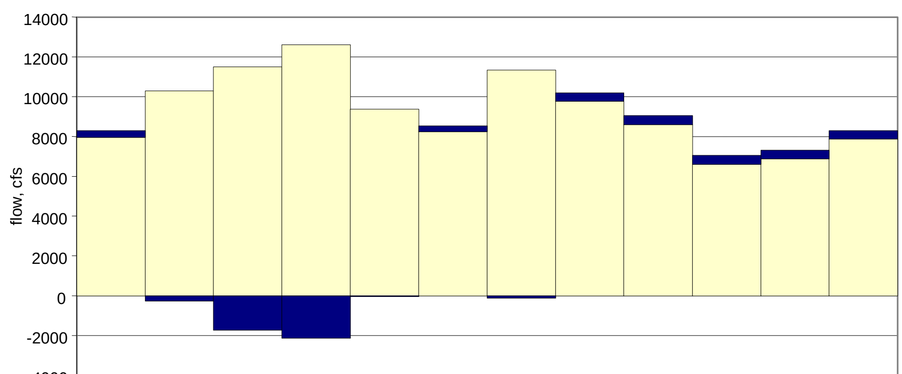
Figure 4-15. Cumulative River/Aquifer Response to the "Thousand Springs" Recharge Scenario

5. Net Effect of "Thousand Springs" Recharge on the Flows in the River

Estimating the net effect of recharge on flows in the river is essential for understanding the impact of recharge on resident fisheries and hydropower production. Net effect on flow in a selected reach of the river and a particular month of the year is determined by adding together two managed recharge model parameters. The first is the expected recharge diversion from the river upstream from the selected reach. This is the monthly recharge rate that is input to the model, and is always a negative number, since relative to flow in the river it has negative impact. The second parameter is the increase in discharge from the aquifer to the river that is expected to occur both upstream and downstream from the diversion point. This is the river response to recharge stress that results from modeling and it is always a positive number, since relative to flow in the river it has a positive impact.

The net managed recharge effect on river flows are negative only at locations downstream from the diversion point. However, positive effects on river flow can be observed both upstream and downstream. On a month-by-month basis, positive effects on river flows that occur downstream from the diversion point generally mean that water that has previously been diverted from the river for aquifer recharge is subsequently returning to the river. Positive effects upstream are due to the "hydraulic barrier" effect. During any given month, the net effect on the river downstream from a diversion point may be positive or negative depending on whether or not aquifer response exceeds the recharge diversion rate. Even when the net downstream effect is negative, the negative effects diminish over time (successive years of recharge) and distance (a longer gaining reach). On an annual basis, the net downstream effects of recharge approach zero.

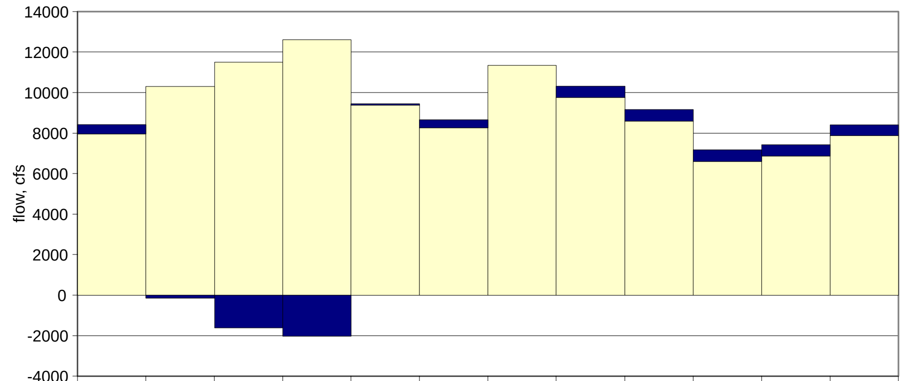
The net impact of the "Thousand Springs" scenario on flows at the Bliss gaging station after ten consecutive years of recharge is represented in figure 4-16. The seasonal nature of recharge activity means that the net impact on flow is expected to be negative during five months of the year (mainly winter months) and positive the other seven months. Average (conditioned) monthly flow in the Snake River near Bliss is also shown, along with the percentage increase or decrease that results from managed recharge. The net impact on flows at the Bliss gage ranges from a 17 percent reduction below the average flow during January to a 7 percent increase above the average during July. The negative impacts are notable during three winter months (November, December, and January) when most recharge occurs. During the remainder of the year, due to increased spring discharge both upstream and downstream from the diversion point, the net impact of recharge on flows is generally positive.



	October	November	December	January	February	March	April	May	June	July	August	September
percentage impact	4%	-3%	-15%	-17%	-1%	3%	-1%	4%	5%	7%	6%	5%
Net impact of managed recharge, cfs	329	-267	-1741	-2135	-48	283	-117	420	452	453	439	419
Average flow (conditioned), cfs	7960	10294	11489	12604	9379	8257	11346	9774	8592	6605	6873	7876

Figure 4-16. Net Impact at Bliss after Ten Years of "Thousand Springs" Recharge

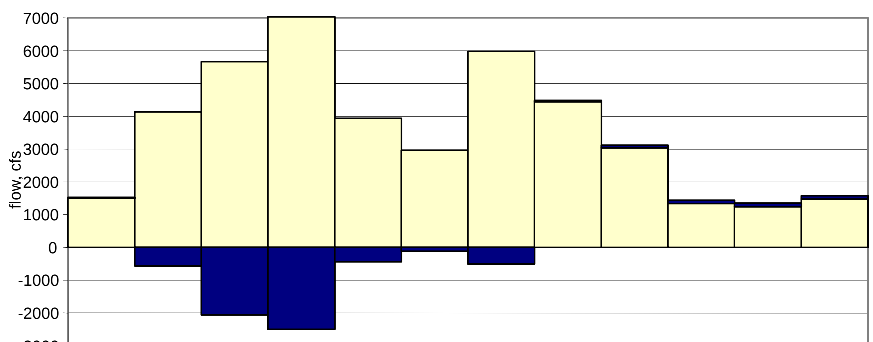
The net effect of recharge on flow at Bliss, over time, is illustrated by comparing 10-year impacts at Bliss (figure 4-16) to equilibrium impacts at Bliss (figure 4-17). At equilibrium (after 58 consecutive years of recharge), only two months, December and January, display a net reduction in flow. During the remaining ten months of the year, flows at Bliss could be expected to be at or above the monthly averages as a result of the "Thousand Springs" scenario. Over the course of year 58, the average reduction in flow at Bliss is expected to be only about 10 cfs.



	October	November	December	January	February	March	April	May	June	July	August	September
percentage impact	6%	-1%	-14%	-16%	1%	5%	0%	6%	7%	9%	8%	7%
Net impact of managed recharge, cfs	448	-146	-1624	-2018	66	396	-3	538	564	567	547	528
Average flow (conditioned), cfs	7960	10294	11489	12604	9379	8257	11346	9774	8592	6605	6873	7876

Figure 4-17. Net Effect at Bliss after 58 Years of "Thousand Springs" Recharge

The net effect of recharge on flow over distance is illustrated by comparing 10-year impacts at Bliss (figure 4-16) to the 10-year impacts at Kimberly (figure 4-18). The net effect on flow at Kimberly is negative during six months of the year, especially so in December and January where it is reduced on average by about 36 percent. Nevertheless, during summer months flow would be expected to be above average, this despite the fact that Kimberly is at the upper end of this reach of springs.



	October	November	December	January	February	March	April	May	June	July	August	September
percentage impact	2%	-14%	-36%	-36%	-11%	-4%	-8%	1%	3%	8%	8%	7%
net impact Twin Falls (Kimberly), cfs	31	-559	-2054	-2496	-439	-109	-507	40	86	103	105	101
ave flow near Kimberly (Twin Falls), cfs	1494	4133	5665	7027	3930	2965	5972	4442	3035	1340	1249	1478

Figure 4-18. Net Effect at Kimberly after 10 Years of "Thousand Springs" Recharge

As shown, the net annual effect of recharge on flows diminishes to near zero with time and distance. However, the seasonal distribution of these impacts may be positive or negative, depending on the timing of recharge activities. The net effect of managed recharge on flows at Bliss is of particular interest during summer months (from mid April through September) when augmentation of flows from the Upper Snake River are sought to enhance Salmon recovery.

The net effect of "Thousand Springs" recharge on flows at Bliss during this five and one-half month period (figure 4-19) is expected to be negative, at least part of the time, during the first year of recharge. However, expected recharge rates are low during summer months, and after the first year the net impact of managed recharge during this period is positive. After five years of recharge, one could expect an additional 100,000 acre-feet of water to pass Bliss during this five and one-half month period and at equilibrium about 165,000 acre-feet of additional water. The net impact on flows shown in these figures is achieved with an annual recharge rate of 416,000 acre-feet per year (575 cfs).

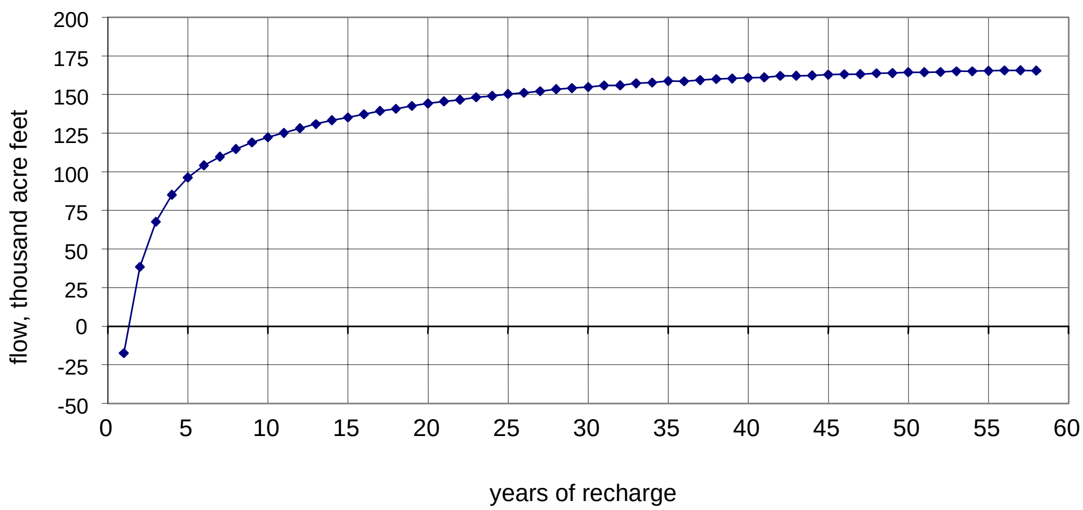


Figure 4-19. Net Impact of Recharge on Flows at Bliss, from Mid-April through September

As indicated earlier, the hydrologic response of the ESPA is generally proportional to the magnitude of the stress that is applied. Reductions in the expected recharge rate for the "Thousand Springs" scenario could be expected to alter system responses proportionally to the change in expected recharge rate.

F. THE "LAKE WALCOTT" RECHARGE SCENARIO

Ground-water contour maps and other historical sources of data indicate that filling of Lake Walcott reservoir in 1908 contributed to a localized increase in ground-water levels for several miles to the north and west of the reservoir. During the 1920s, and 1930's lake losses were estimated to be over 100,000 acre-feet per year (Stearns, et al., 1938). Over the years, the build up of sediment at the bottom of Lake Walcott has significantly reduced the rate of infiltration into the underlying aquifer. It has been estimated that current lake losses are about 35,000 acre-feet per year (Kjelstrom, 1992). As a result of the build up of these sediments impeding infiltration, it is estimated that the water table beneath the western half of the lake is currently between 60 and 100 feet below the lake bottom.

The decline in Lake Walcott losses has undoubtedly contributed, to some degree, to the decline in ground-water level that has occurred over the last twenty years immediately to the north and west of Lake Walcott (figure 4-20). However, it is almost certain that the major factor contributing to these declines has been increased ground-water pumping in the area.

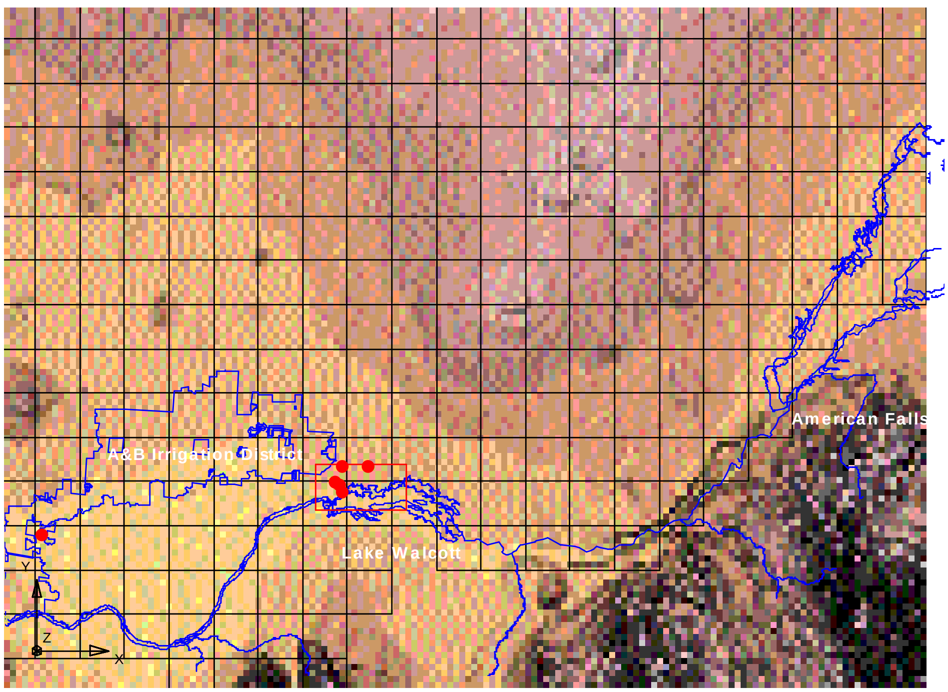


Figure 4-20. Location of "Lake Walcott" Recharge Scenario North of Lake Walcott

Because of the effects that lake losses have historically had on ground-water levels north and west of Lake Walcott, this area has long been considered to have potential as a managed recharge site. Managed aquifer recharge conducted near the northern boundary of Lake Walcott could potentially have an affect on ground-water levels similar to that of the reservoir after it was initially filled.

A recharge planning guide (Corless, 1998) has identified three comparatively large depressions on the north side of Lake Walcott that could function as recharge basins. The basins were estimated to have combined recharge capacity of about 150 cfs. All three sites are within two miles of the reservoir. Further inspections of the area north of Lake Walcott have revealed that there are more than 50 other (large and small) depressions that have potential for use as recharge basins.

Managed recharge north of Lake Walcott would require pumping from Lake Walcott or from the Minidoka Canal to recharge basins at an elevation approximately 60 feet above average lake level. Subsequently, water could be gravity diverted to a network of interconnected recharge basins, all located within two miles of the lake. At present, however, there are no pumping or pipeline facilities or other structures for diverting water to these basins.

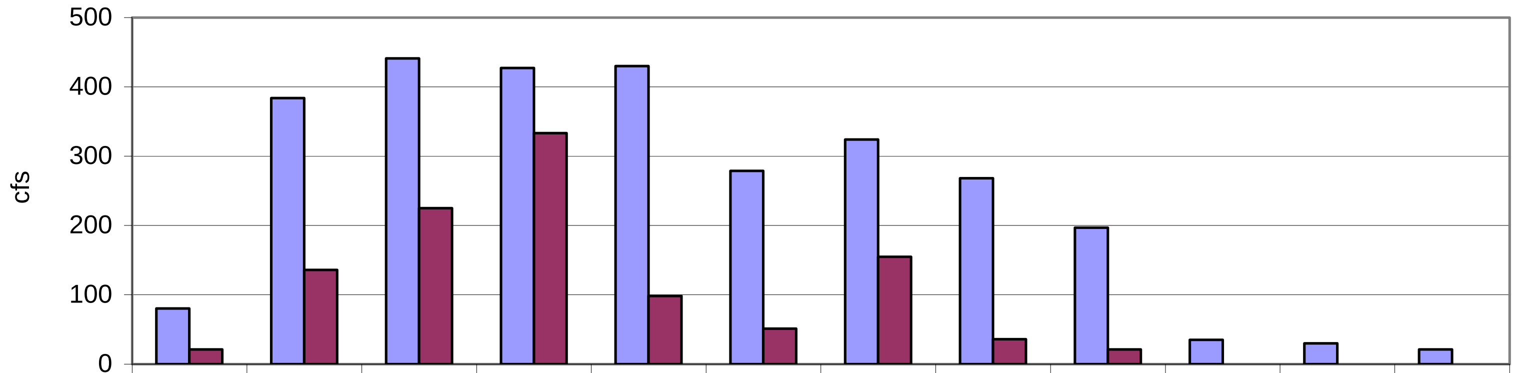
The "Lake Walcott" scenario is modeled by imposing recharge on two grid cells on the northern boundary of Lake Walcott (figure 4-20). The scenario is aimed primarily at affecting ground-water levels in the central part of the plain, including the B unit of the A & B Irrigation District, and in the Magic Valley Ground Water District, an area of approximately 650 square miles.

1. Expected Aquifer Recharge Rate, "Lake Walcott" Scenario

As with the "Thousand Springs" scenario, the "Lake Walcott " recharge scenario is developed in order to show the maximum potential impact that managed recharge conducted in the area north of Lake Walcott could have on ground-water levels and discharge from springs. Therefore, in determining the expected aquifer recharge rates for this scenario, the assumption is made that recharge rates would not be directly limited by pumping capacity, but rather by infiltration capacity of natural basins that are located within two miles of the northern boundary of Lake Walcott. Within this two-mile range, the area of natural basins over which recharge water could be spread is estimated to be from 800 to 1,000 acres.

The total infiltration capacity of this area is extrapolated from historical records. Stearns, Crandall et al., (1938) estimated that during the first filling of Lake Walcott, in May 1906, lake losses were 178,000 acre-feet. Assuming a lake area of 6,000 acres at the time, (about one-half the current area) the infiltration rate during this period of initial filling would have been approximately 2,900 cfs, or a little less than 0.5 cfs per acre of lake bed. Using this estimate of infiltration rate as a rough guide, an upper bound on recharge capacity of all of the natural basins located within two miles of the northern boundary of Lake Walcott is somewhere between 400-500 cfs.

The expected aquifer recharge rates for the "Lake Walcott" scenario are determined by the RWA program, subject to two possible sets of constraints (figure 4-21). In the first



	October	November	December	January	February	March	April	May	June	July	August	September
recharge cap only *	80	384	441	427	430	279	324	268	197	35	30	21
recharge cap and fisheries **	21	136	225	333	98	51	155	36	21	0	0	0

* annual average = 243 cfs
** annual average = 90 cfs

Figure 4-21. Expected Aquifer Recharge Rate for the “Lake Walcott” Recharge Scenario set, expected recharge rate is constrained only by the maximum infiltration capacity of recharge, estimated to be 450 cfs. In the second, the recharge rates are also constrained by IDFG stream maintenance flow recommendations (table 4-6).

If “Lake Walcott” recharge is limited only by the 450 cfs recharge cap, then the average recharge rate at Minidoka Dam is expected to be 243 cfs (176,000 acre-feet per year). Approximately 45 percent of total recharge could be expected to occur in December, January, and February. About 37 percent is expected to occur in March, April, May, and June. Very little recharge could be expected during the remaining summer months. Since the infiltration capacity of recharge basins doesn’t change, the monthly variation in expected recharge rate is due simply to monthly variation in surplus flow.

The introduction of IDFG stream maintenance flow recommendations reduces expected recharge rates for the “Lake Walcott” scenario by more than half, to an average rate of about 90 cfs (65,000 acre-feet per year). Recall that at locations above Milner Dam, IDFG recommends that only one half of flows, which exceed the minimum maintenance level, be diverted for recharge.

2. Aquifer Response to “Lake Walcott” Recharge Scenario

The “Lake Walcott” recharge scenario is modeled using expected recharge rates that are subject to the first set of constraints. The average annual recharge rate is therefore 243 cfs (176,000 acre-feet per year). The less restrictive of the two sets of constraints is chosen for modeling, in order to show the maximum potential impact of the “Lake Walcott” recharge scenario on aquifer and river conditions.

The modeling results of greatest interest for this scenario are those which show the impacts of recharge on ground-water levels in the central part of the plain. However the model also provides information about the localized impact of recharge on ground-water elevations at the recharge site, and the impact of recharge on current losses from Lake Walcott.

Once again, five color-coded contour maps of ground-water level change are used to show the development of the recharge area of influence over a period of 58 years. The minimum contour displayed (the dark blue) represents a three-foot increase in ground-water level, above the base case equilibrium level. For reference, the A & B Irrigation District is also displayed on each map.

After one year of the “Lake Walcott” recharge scenario (figure 4-22a), a rise in ground-water level of three feet or more could be expected to occur in an area that extends about five miles north and west from the recharge sites. The area of influence extends to the easternmost portion of the B-unit in the A & B Irrigation District. Because recharge is imposed on the model at just two points (at the centers of two grid cells), the color contours in the very center of the plume are not necessarily realistic representations of ground-water level rise that could be expected directly beneath the recharge basins. The light blue contour surrounding the two cells is probably more representative of conditions beneath the sites, indicating a simulated ground-water level rise of between 20 and 30 feet at these locations.

After three consecutive years of recharge (figure 4-22b) the "Lake Walcott" scenario area of influence extends about 10 miles to the west and about 15 miles to the north of the Lake Walcott recharge sites. About a third of the B-unit is within the three foot contour. The expansion of the recharge mound occurs independently of the regional ground-water gradient, however it is aided by the comparatively high transmissivity of the aquifer in the central part of the plain, and hindered by comparatively low transmissivity conditions along the margins of the plain.

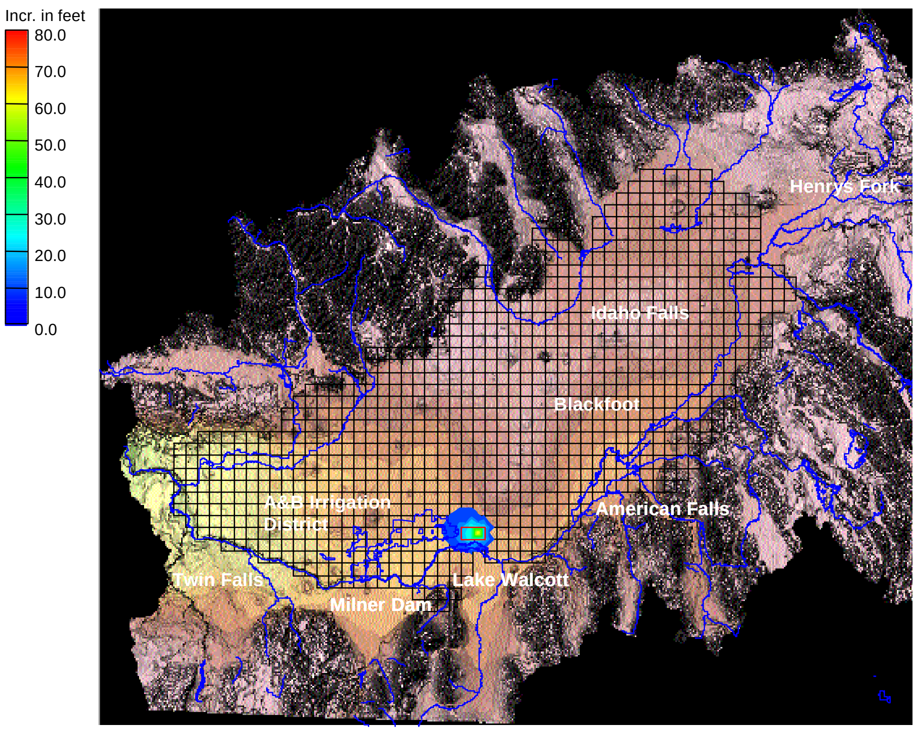


Figure 4-22a. Ground-Water Level Change After One Year of Recharge

After ten consecutive years of recharge (figure 4-22c), the area of influence has extended an additional twelve miles to the west and more than 30 miles to the north of Lake Walcott. Ground-water levels within ten miles of the recharge site have risen about 10 feet. The predominant expansion of the recharge mound to the north into the Magic Valley area is due, once again, to the high transmissivity conditions associated with thick basalt layers and numerous interflow zones in the central part of the plain (figure 4-2) and the relatively flat water table in this area (figure 4-1). There is also some additional expansion of the mound to the west of Lake Walcott. Nearly all of the B unit is now within the "Lake Walcott" scenario area of influence. Directly beneath the recharge sites the simulated ground-water level rise is between 30 and 40 feet.

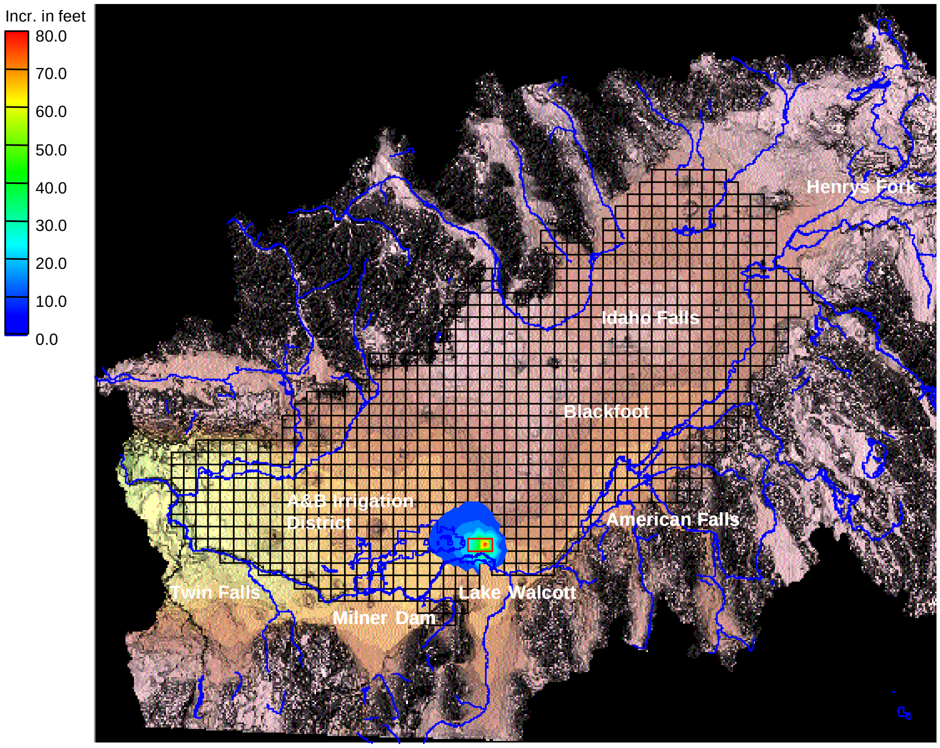


Figure 4-22b. Ground-Water Level Change After Three Consecutive Years of Recharge

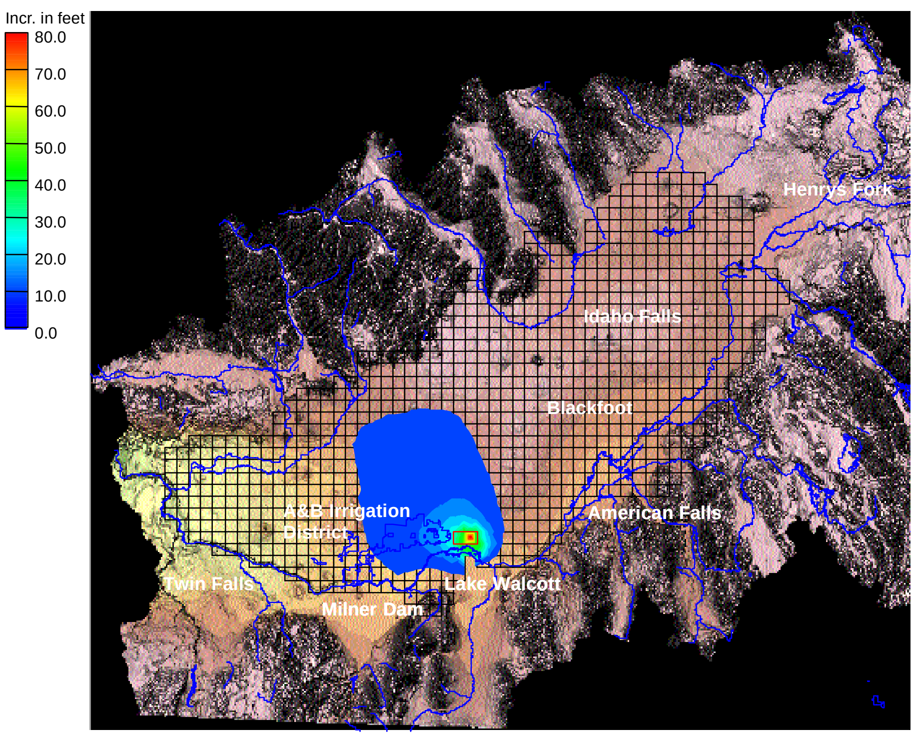


Figure 4-22c. Ground-Water Level Change After Ten Consecutive Years of Recharge

After twenty consecutive years of recharge (figure 4-22d) the area influenced by the "Lake Walcott" recharge scenario extends all the way to the northern boundary of the plain. At the same time, the recharge mound has spread out east and west along the axis of the plain. Expansion of the mound to the east is limited by the low transmissivity and steep hydraulic gradient associated with the Great Rift Fault Zone. Within an area eighteen to twenty miles west, thirty miles north, and six miles east of Lake Walcott, ground-water levels have risen 15 feet or more, as a result of recharge. Directly beneath the recharge sites ground-water levels are about 40 feet higher.

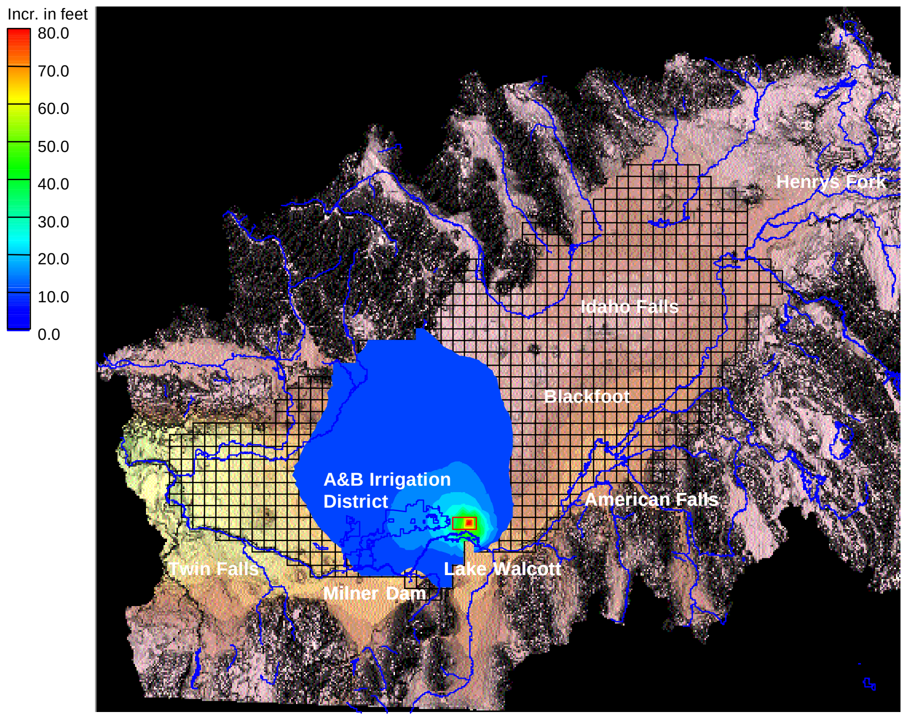


Figure 4-22d. Change in Ground-Water Levels after Twenty Consecutive Years of Recharge

After fifty-eight consecutive years of recharge (near equilibrium) (figure 4-22e) the area of influence has spread out more along northern boundary of the plain, and extends to the west into Jerome County about as far as Twin Falls. Simulated ground-water levels have risen fifteen feet or more in the central part of the plain. In about three quarters of the A & B Irrigation District, ground-water levels have risen 20 feet or more. The recharge area of influence extends only a short distance to the east of Lake Walcott due to the influence of the Great Rift Fault Zone (and to the influence of gaining reaches of the river just to the east of the fault zone). Directly beneath the "Lake Walcott" recharge sites, simulated ground-water levels rise between 40 and 50 feet.

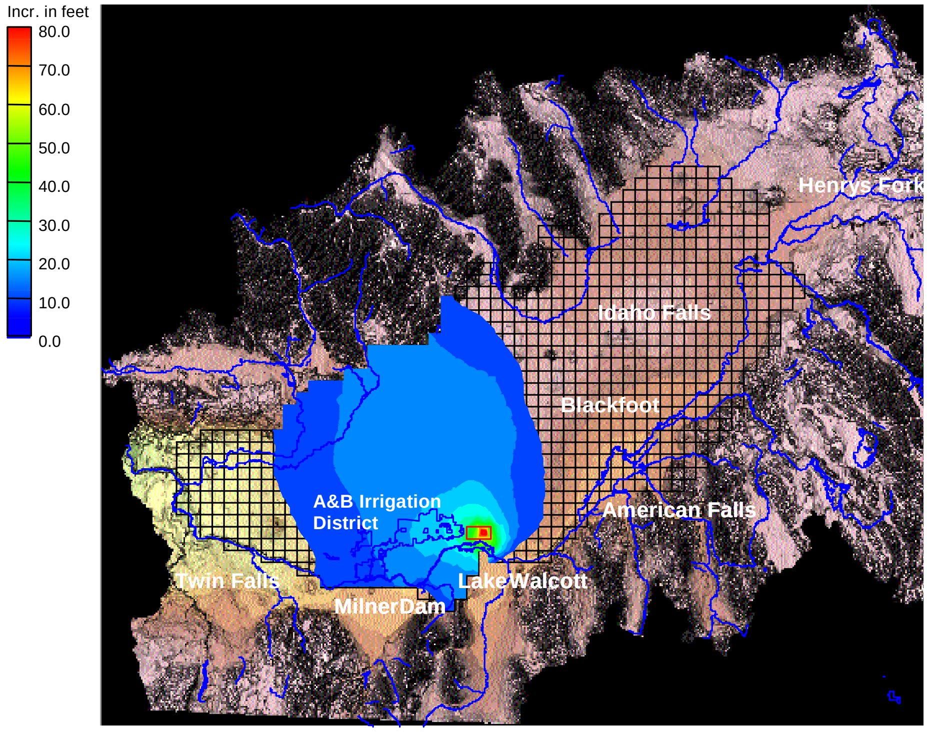


Figure 4-22e. Ground-Water Level Change at Equilibrium (after 58 years of recharge)

The increase in ground-water level that is expected to occur in the immediate vicinity of Lake Walcott recharge sites is an important modeling consideration, since ground-water mounding that occurs locally could limit the infiltration rate of recharge water over the long term. The depth to ground water up to two miles north of Lake Walcott is between 100 and 110 feet below the surface. The model assumes that recharge rate is not limited by vertical conductance of materials located immediately beneath recharge basins. However, the two recharge cells (figure 4-20) have assigned hydraulic conductivities that differ by nearly two orders of magnitude. Additional testing is needed to determine if transmissivity conditions would in fact limit recharge north of Lake Walcott.

The impact that recharge has on the natural infiltration rate from Lake Walcott depends how high the ground-water level beneath the reservoir rises, as a result of recharge activity. The elevation of the lake bottom is about 4,160 feet mse. After 58 years of "Lake Walcott" recharge, ground-water level below the reservoir is expected to rise 55 to 60 feet, to approximately 4,100 feet mse, still well below the lake bottom elevation. Thus natural infiltration from the western half of the reservoir (40-60 cfs) would be unaffected by recharge. For the same reason, subsurface return of recharge water to the reservoir is not anticipated.

In contrast to the "Thousand Springs" scenario, the recharge mound that develops in the "Lake Walcott" scenario is indicative of the actual subsurface distribution of recharge water. Due to the fact that recharge water is pumped initially to a elevation over 100 feet above the water table before being distributed to recharge basins, some water would return to the river up gradient from the recharge sites between Lake Walcott and American Falls.

3. River Response to "Lake Walcott" Recharge Scenario

After 20 consecutive years of recharge, the river response to the "Lake Walcott" scenario appears exceptionally uniform, due to the longer aquifer residence time of "Lake Walcott" recharge water (figure 4-23). An increase in flow of about 100 cfs in the Kimberly to Bliss reach, and an increase of about 35 cfs in the Blackfoot to Minidoka reach appears equally distributed throughout all twelve months of the year.

In contrast to the Thousand Springs recharge scenario, where much of the recharge water exits the aquifer within a short time via springs in the Kimberly to Bliss reach, a much higher percentage of the "Lake Walcott" recharge water remains in the aquifer for an extended period of time (figure 4-24). After 10 years, about 2 million acre-feet of water has been recharged. Of this, 87 percent is still in storage, in the aquifer. As expected, an increasing percentage of the recharge water returns to the river over time. After ten years about 13 percent of the recharge water has returned to the river, either in the Kimberly to Bliss reach or in the Blackfoot to Lake Walcott reach. Because water is pumped to a higher elevation before it is recharged, it is possible that some of this water will return to the river up gradient from where it was withdrawn, although the majority of water returns to the river west of the recharge sites, in the Kimberly to Bliss reach.

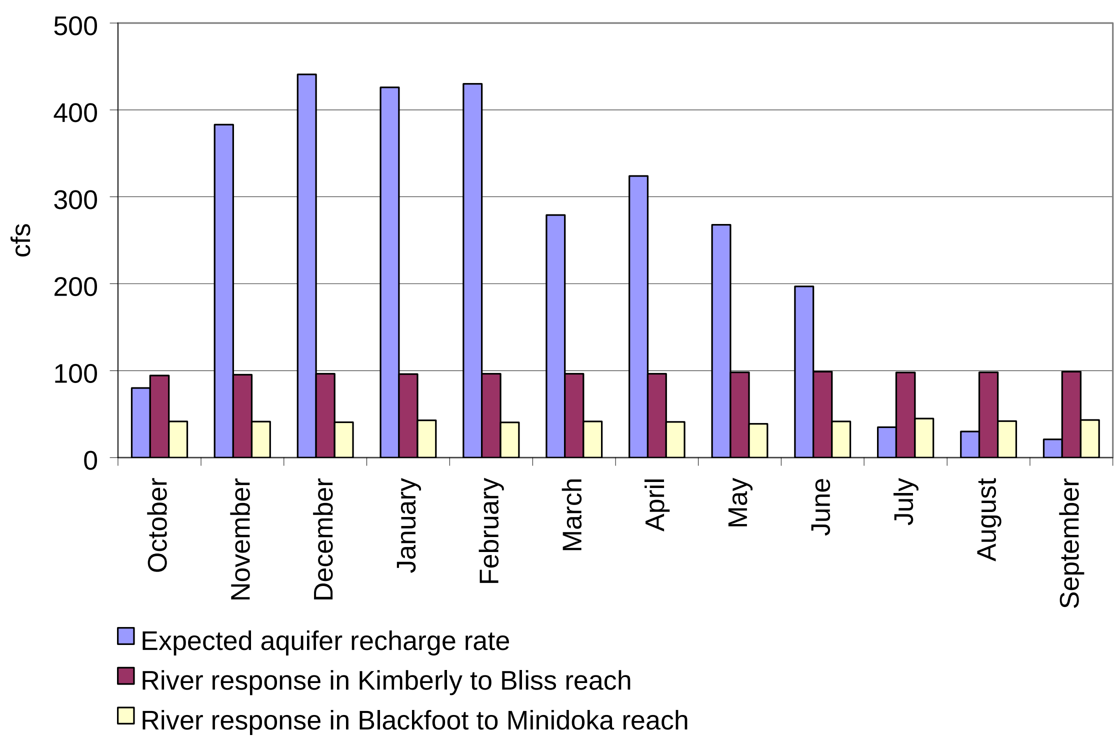


Figure 4-23. Expected Recharge Rates and Monthly River Response after 20 Years

The proportion of recharged water returning to this reach of the river increases steadily over time. Near equilibrium (after 58 consecutive years of recharge) approximately 11 million acre-feet of water has recharged the aquifer, about 39 percent of this water (4.3 million acre-feet) is still in the aquifer, and about 42 percent (4.6 million acre-feet) is expected to have returned to the river in the Kimberly to Bliss reach. Less than 19 percent (2 million acre-feet) would have returned to river via springs that are up gradient from Lake Walcott, although without further analysis it is difficult to determine exactly how much of this is recharge water, and how much is due to a "hydraulic barrier" effect.

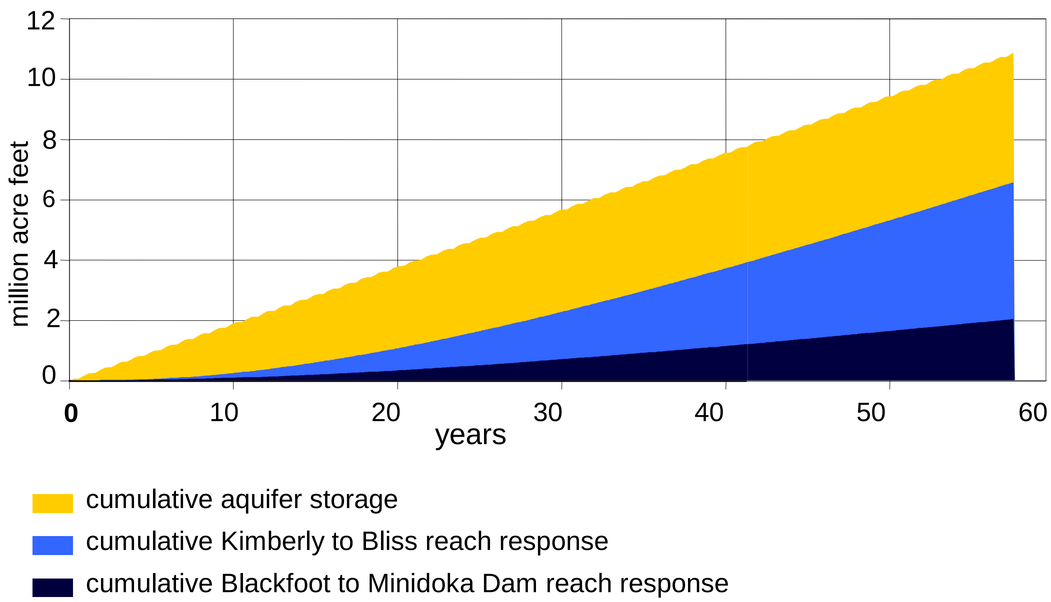


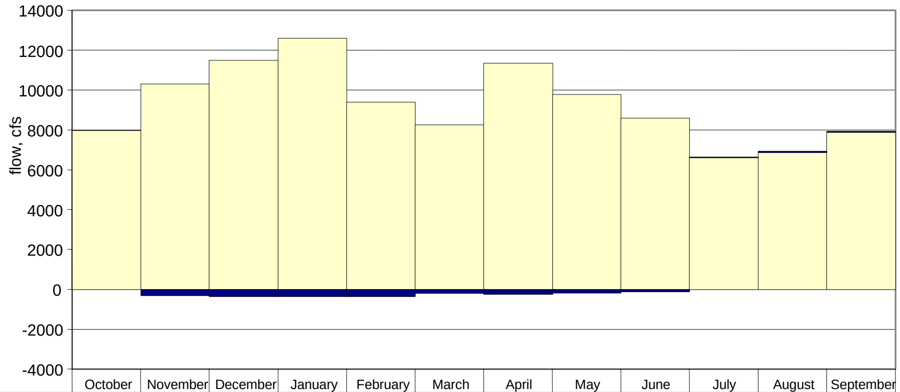
Figure 4-24. Cumulative River/Aquifer Response to the "Lake Walcott" Recharge Scenario

4. Net Impact of Managed Recharge on the Flows in the River

After ten consecutive years of recharge, the net impact of the "Lake Walcott" scenario on flows at the Bliss gage is expected to be negative during all but three months of the year (figure 4-25). It is expected to be positive only during the period July through September when almost no recharge occurs. The negative responses are expected, given the high percentage of recharge water remaining in aquifer storage after ten years, but they are also comparatively small, between 2 and 4 percent of average (conditioned) flows during these months.

During critical summer months between mid April and September, the net impact of managed recharge on flows at Bliss is positive only after about 20 consecutive years of recharge (figure 4-26). After 58 years of recharge, one could expect a little more than

25 thousand additional acre-feet of additional flow at Bliss during these months, as a result of the “Lake Walcott” recharge scenario.



	October	November	December	January	February	March	April	May	June	July	August	September
percentage impact	0%	-3%	-3%	-3%	-4%	-2%	-2%	-2%	-1%	1%	1%	1%
Net impact of managed recharge, cfs	-4	-307	-364	-348	-354	-200	-245	-186	-116	46	53	61
Average flow (conditioned), cfs	7960	10294	11489	12604	9379	8257	11346	9774	8592	6605	6873	7876

Figure 4-25. Net Impact at Bliss after 10 Years of “Lake Walcott” Recharge

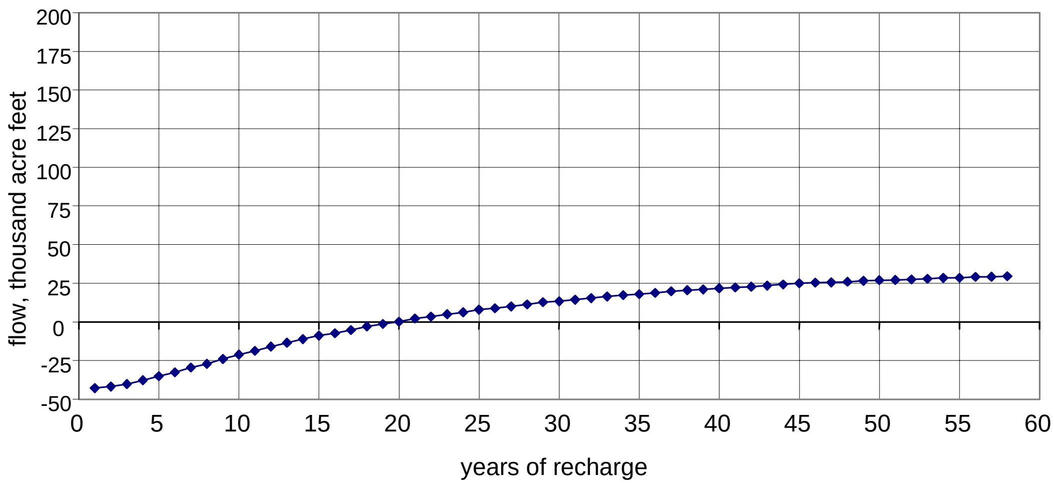


Figure 4-26. Net Impact of Recharge on Flows at Bliss, Mid-April through September

The 20-year lag is a reflection of the time required for the influence of recharge at Lake Walcott to be expressed as increased discharge from springs in the Kimberly to Bliss reach. The net impact on flows at Bliss is achieved with an average annual recharge rate of 176,000 acre-feet per year (243 cfs).

G. The "Hells Half Acre" Recharge Scenario

River gains in the Blackfoot to Neeley reach of the Snake provide an important part of the surface water diversions appropriated by Magic Valley area irrigators. Maintaining these reach gains has been the implied objective for a number of recent small-scale recharge projects at over fifty sites located in Bingham and Bonneville counties.

The "Hells Half Acre" scenario includes the area between Idaho Falls and Blackfoot (figure 4-27) and uses the excess capacity of several canal systems, including portions of Peoples Canal, Aberdeen Springfield Canal, New Lavaside Ditch, and New Sweden Canal. Recharge is not actually expected to occur on the "Hells Half Acre" basalts, but rather through gravity diversion to gravel pits, basins and ditches located adjacent to these canals.

The Burgess Canal, Harrison Canal, Farmers Friend Canal and the Progressive Irrigation District recharged 42,000 acre-feet of water, prior to the start of the irrigation season in 1995. Recharge occurred in abandoned gravel pits and through canals and ditches where percolation losses were known to be high. The total capacity of the recharge sites was demonstrated to be about 575 cfs. During the same year, the New Sweden Irrigation District, using the Great Western and Porter canals, recharged about 9,900 acre-feet of water in a cluster of twenty small sites, including gravel pits, and leaky canals located between Idaho Falls and Shelley, just to the east of the Hells Half Acre Lava Beds. The project demonstrated a recharge capacity of 107 cfs in the cluster of sites.

The Aberdeen Springfield Canal is the largest diverter from the Snake River east of Burley and has estimated that over 50 percent of its normal annual diversion of 330,000 acre-feet percolates down to the water table (Carlson, 1995). Ten potential Aberdeen Springfield sites totaling more than 300 acres have been identified. An additional four sites are located along the Peoples Canal, including an abandoned gravel pit that has an area of about 160 acres.

The "Hells Half Acre" scenario is represented in the IDWR/UI model by recharge that is uniformly distributed over seven model cells. All of the cells are located in the non-trust area established as part of the Swan Falls Agreement. By definition, ground water in the non-trust area is considered to be non-tributary to the Snake River below Milner Dam. However the trust/non-trust line (figure 4-27), simply marks the location of a historical ground-water divide. It should not be interpreted as meaning that changes in ground-water conditions within the non-trust area will not influence ground-water levels and spring discharges in the trust area of the aquifer. This was demonstrated in an earlier application of the IDWR/UI model (Johnson, Bishop et al., 1993).

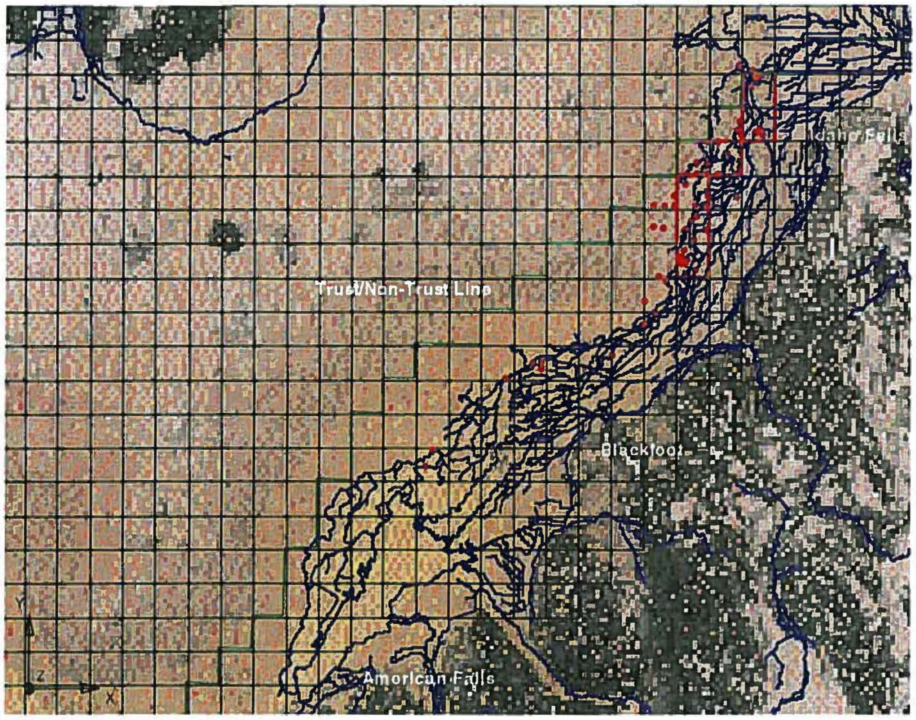


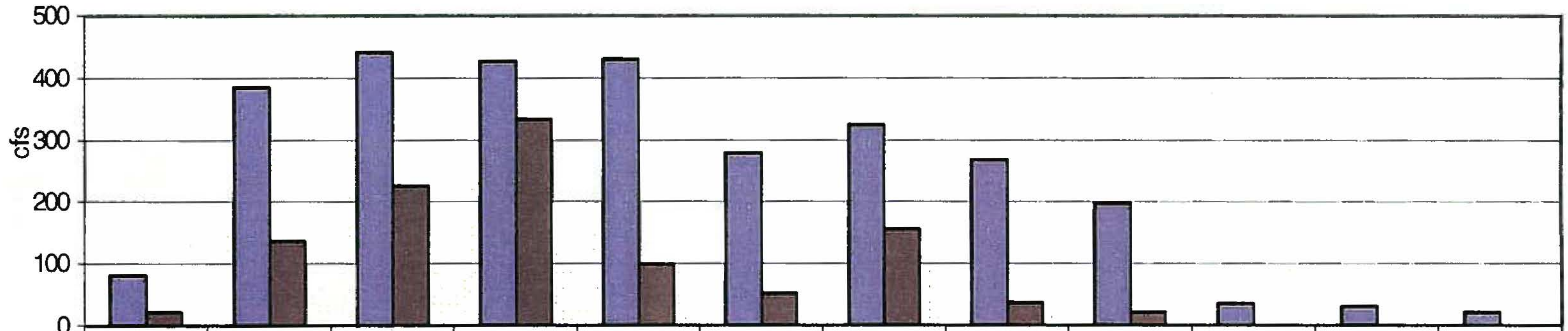
Figure 4-27. "Hells Half Acre" Recharge Scenario

1. Expected Recharge Rate, "Hells Half Acre" Scenario

Expected recharge rates for the "Hells Half Acre" scenario (figure 4-28) are calculated by the RWA program in a manner similar to that of the "Thousand Springs" scenario, in the sense that surplus flows are constrained by excess diversion capacity of canals rather than by the infiltration capacity of recharge basins. Given the fact that over fifty individual sites have been identified, and that the combined capacity of the few sites that have been investigated exceeds 800 cfs, it is anticipated that recharge would be limited by diversion capacity of canals rather than by the infiltration capacity.

Expected recharge rates for the "Hells Half Acre" scenario are subject to two possible sets of constraints. In the first set, expected recharge rates are constrained only by the excess diversion capacity of the five canal systems (table 4-6). In the second set, rates are further constrained by IDFG stream-maintenance flow recommendations at Blackfoot (table 4-5). In either case, about 51 percent of total recharge is expected to occur during just three winter months, December, January, and February. As before, to be truly surplus to irrigation demands, surplus flows at Blackfoot must pass Milner Dam. This is a consideration higher in the basin, when storage water releases upstream from Blackfoot are being made during summer months in order to satisfy downstream irrigation demands. As a result little if any surplus flow is expected during summer months.

The high expected rate of wintertime recharge is due, once again, to greater surplus flow and greater excess canal capacity during these months. On an annual basis, the average



	October	November	December	January	February	March	April	May	June	July	August	September
recharge cap only*	80	384	441	427	430	279	324	268	197	35	30	21
recharge cap and fisheries**	21	136	225	333	98	51	155	36	21	0	0	0

* annual average = 462 cfs
** annual average = 77 cfs

Figure 4-28. Expected Aquifer Recharge Rate for the "Hells Half Acre" Recharge Scenario recharge rate for the "Hells Half Acre" scenario is expected to be 462 cfs (334,000 acre-feet per year) if recharge is constrained only by canal capacity. Imposing the additional constraint of IDFG stream maintenance flow recommendations reduces expected recharge rates for the "Hells Half Acre" scenario by more than eighty percent, to an annual average of 77 cfs (56,000 acre-feet per year). As before, only one half of the surplus flows that exceed the IDFG stream maintenance flow recommendation are used for recharge.

2. Aquifer Response to "Hells Half Acre" Recharge Scenario

The "Hells Half Acre" recharge scenario is modeled using expected recharge rates subject to just the first set of constraints on surplus flows. The average annual recharge rate is therefore 462 cfs (334,000 acre-feet per year). As with the "Lake Walcott" scenario, the less restrictive set of constraints is chosen for modeling, in order to show the maximum potential impact of the "Hells Half Acre" scenario.

Once again, five color-coded contour maps of ground-water level change show the gradual development of the recharge area of influence over a period of 58 years. The minimum contour displayed (the dark blue) again represents a three-foot increase in ground-water level, above that of the base case equilibrium level.

After one year of the "Hells Half Acre" recharge scenario an increase in ground-water level of three feet or more could be expected to occur in an area that extends from 3 to 5 miles around the recharge sites (figure 4-29a). Directly beneath the area of recharge, simulated ground-water levels rise 10 to 15 feet.

After three consecutive years of recharge the aquifer area influenced by recharge has expanded about 12 or 13 miles, mainly to the northwest, (figure 4-29b). As with the "Lake Walcott" scenario, preferential expansion of the recharge mound into the central part of the plain is due the higher transmissivity of basalt layers in this area, and to the comparatively flat water table in this part of the aquifer (figure 4-1). The simulated ground-water level beneath the recharge sites rises 20 and 25 feet after three consecutive years of recharge activity.

After ten consecutive years of recharge, the area of influence has expanded significantly further in the central part of the basin, (figure 4-29c). The area extends more than 20 miles to the northwest almost to the Big Lost River. The area also extends to the northeast to the edge of Mud Lake. Mainly, however, the area of influence extends down to the southwest, more than 40 miles along the axis of the plain. Ground-water levels within this central part of the plain could be expected to rise between 3 and 10 feet. The southwestward expansion of the recharge mound continues to be aided by the high transmissivity conditions. Directly beneath the sites, ground-water levels have risen about 30 feet above base case equilibrium levels. After ten years, one could expect that the effects of "Hells Half Acre" recharge, which is conducted in the non-trust area of the aquifer, would be observable in both the trust and non-trust areas.

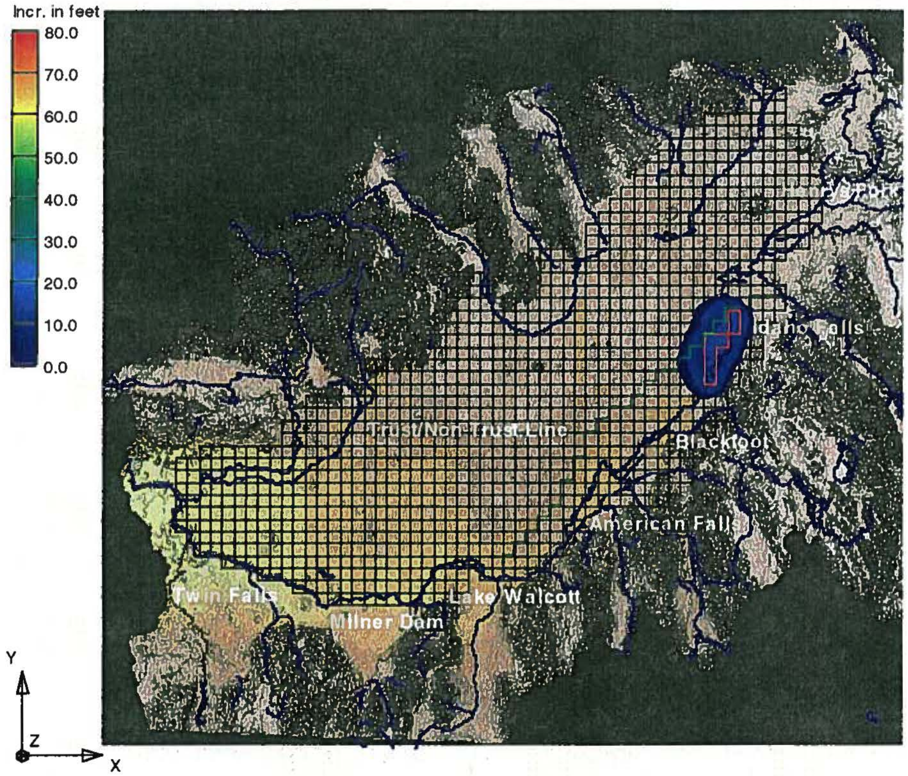


Figure 4-29a. Ground-Water Level Change after One Year of Recharge

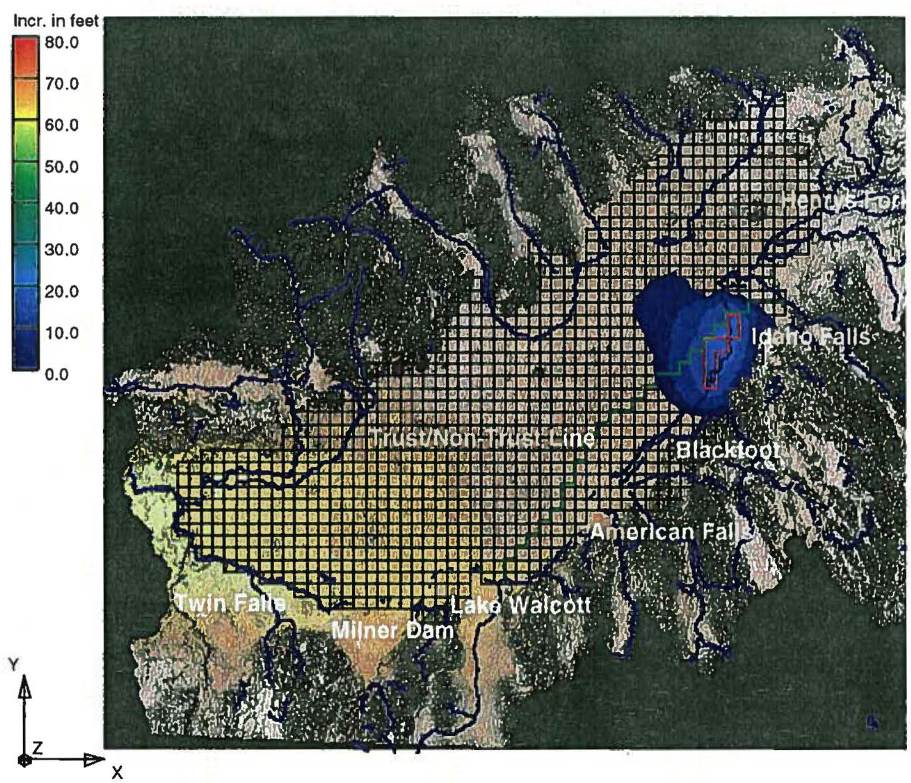


Figure 4-29b. Ground-Water Level Change After Three Consecutive Years of Recharge

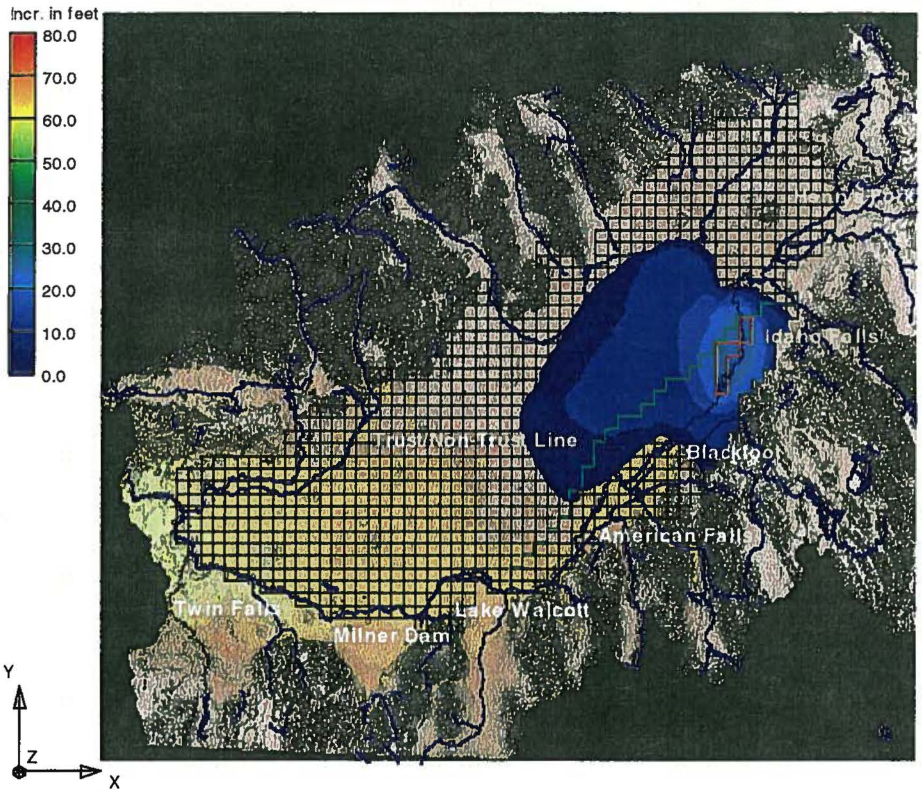


Figure 4-29c. Ground-Water Level Change After Ten Consecutive Years of Recharge

After twenty consecutive years of recharge (figure 4-29d), the area influenced by the "Hells Half Acre" scenario has expanded slightly further to the northwest, reaching the northern boundary of the plain. However, it has not expanded much further to the southwest along the axis of the plain. It is apparent, however, that within this area of influence, ground-water levels have risen substantially. In much of the recharge mound ground-water levels are between 10 and 20 feet higher than base case equilibrium levels. Beneath the recharge sites themselves, ground-water levels remain about 30 feet above base case level.

After 58 consecutive years of recharge (near equilibrium), the area of influence has spread out more along the northern boundary of the plain (figure 4-29e). It has also spread up gradient past Mud Lake about 18 to 20 miles, and down gradient a few additional miles into Butte and Power counties, just to the east of Lake Walcott. Within this area ground-water levels are mostly 10 to 20 feet higher. Water levels directly beneath the recharge sites remain mostly unchanged from the earlier map, although the 30-foot contour has now expanded somewhat further around the recharge sites.

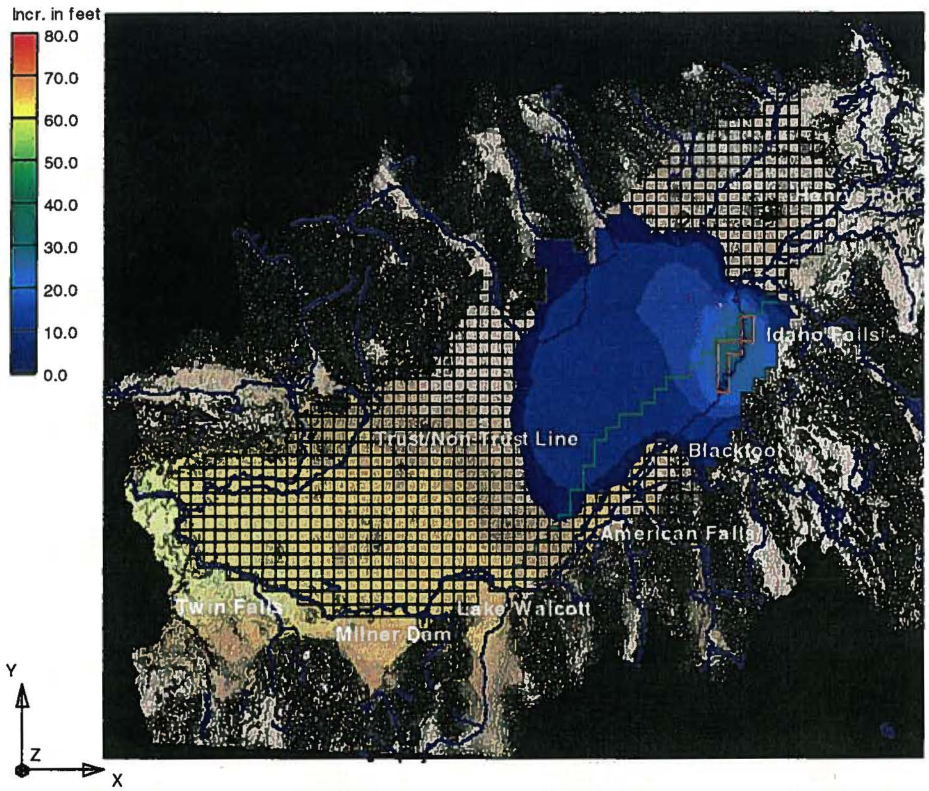


Figure 4-29d. Ground-Water Level Change after Twenty Consecutive Years of Recharge

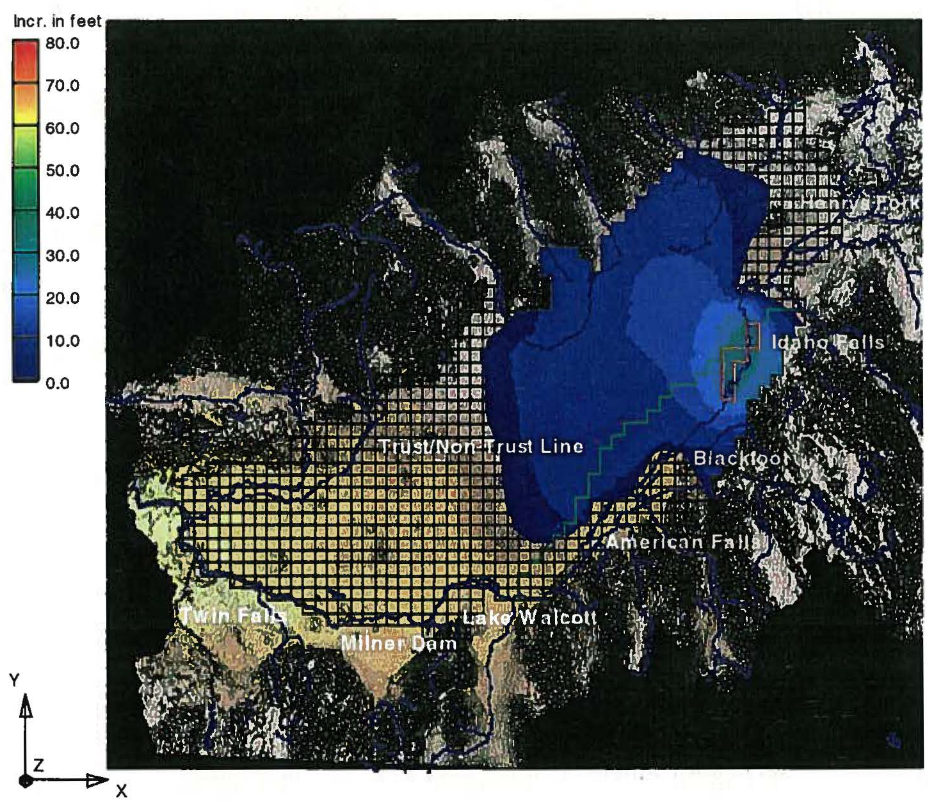


Figure 4-29e. Ground-Water Level Change at Equilibrium (after 58 years of recharge)

Once again the hydrologic influence exerted by the Great Rift Fault Zone is evident, since it appears to mark the limit of down gradient expansion of the “Hells Half Acre” recharge mound. Up gradient from the “Hells Half Acre” sites expansion is slowed by the lower transmissivity conditions and steeper hydraulic gradient associated with the Mud Lake deposits (figure 2-3). Increasing river response by the Henrys Fork below St. Anthony, is also a factor limiting expansion of the recharge mound.

The expansion of the “Hells Half Acre” area of influence into the central part of the plain diminishes slightly, the regional ground-water gradient. To the extent that the influence of this scenario is observed up gradient from the recharge sites in the Egin Bench, it is once again attributed to the “hydraulic barrier” effect. The down gradient portion of the recharge mound is representative of the actual distribution of recharge water. Although, without further analysis, it is difficult to know the exact path of the “Hells Half Acre” recharge water as it moves generally to the southwest.

3. River Response to “Hells Half Acre” Scenario

The river response to the “Hells Half Acre” recharge scenario is once again presented in the form of monthly reach responses after 20 years of recharge (figure 4-30) and as a cumulative river/aquifer response plot (figure 4-31). The extended basin model, which is used for the “Hells Half Acre” scenario, includes a third fixed head river reach boundary representing the Henrys Fork and the South Fork of the Snake River.

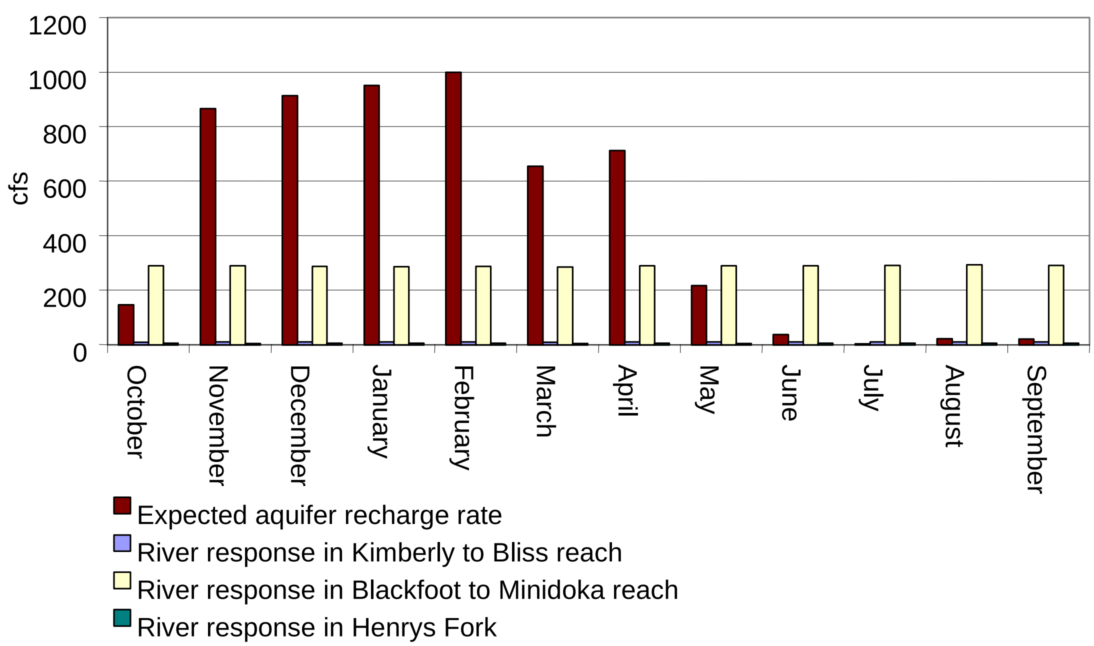


Figure 4-30. Expected Recharge Rates and Monthly River Response after 20 Years

The monthly reach response plot (figure 4-30) shows that the only significant river response to the “Hells Half Acre” scenario occurs in the Blackfoot to Minidoka Dam reach, and that once again the 300 cfs increase in spring discharge in this reach is very uniformly distributed throughout the year.

The cumulative distribution plot (figure 4-31) shows that after ten years of the “Hells Half Acre” scenario, about 3 million acre-feet of water have recharged the aquifer. A substantial portion of this, about 66 percent, remains in aquifer storage after ten years. About 26 percent of the recharge water has returned to the river down gradient from the recharge site in the Blackfoot to Minidoka Dam reach. The “Hells Half Acre” recharge scenario has also induced a small increase in discharge from the aquifer in the Henrys Fork reach, (over the first ten years, approximately 300,000 acre-feet). Over time a rapidly growing percentage of the “Hells Half Acre” recharge returns to the river in the Blackfoot to Minidoka Dam reach, and the scenario continues to induce greater aquifer discharge into the Henrys Fork. However, there is little evidence that the “Hells Half Acre” recharge scenario affects spring discharges in the Kimberly to Bliss reach. Only after forty consecutive years of recharge is there an indication that this scenario has measurable influence on discharge from Kimberly to Bliss springs.

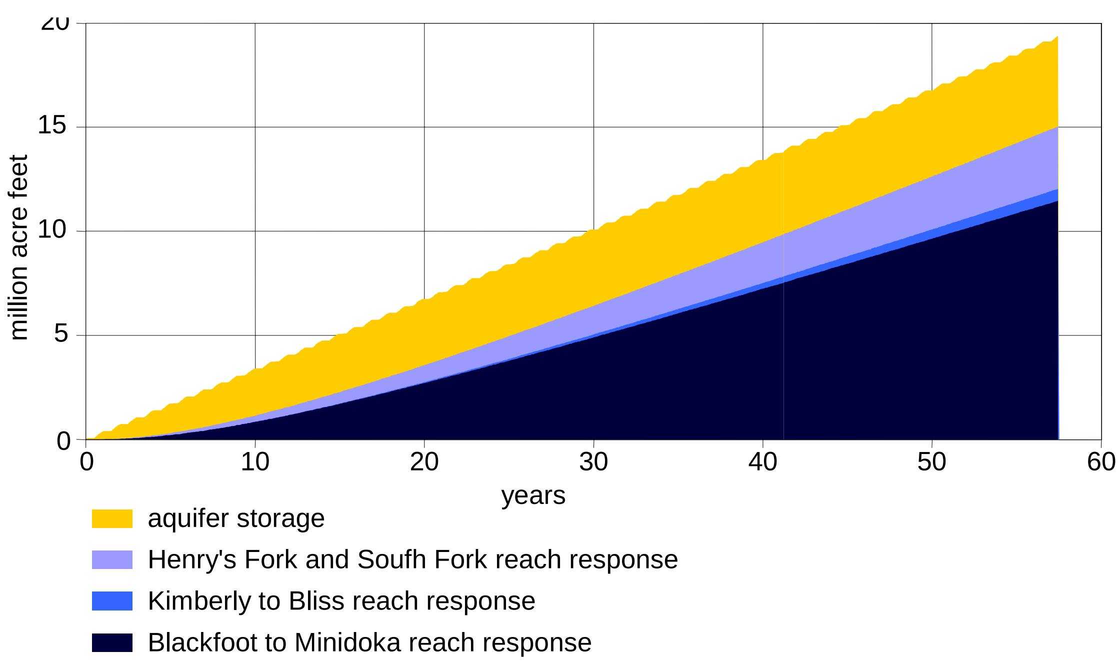


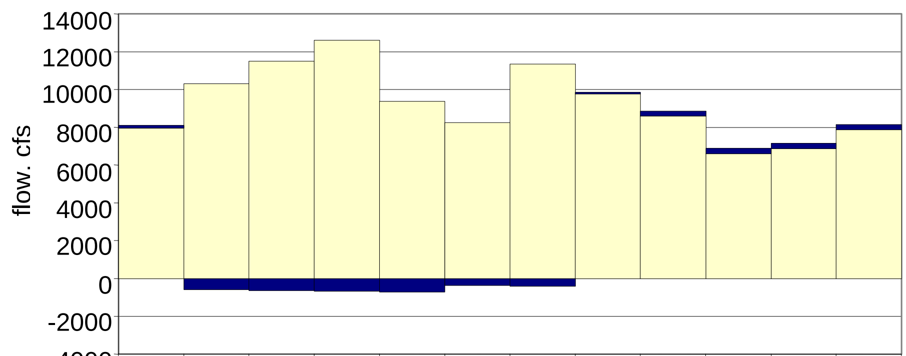
Figure 4-31. Cumulative Aquifer and River Response to “Hells Half Acre” Recharge Scenario

After 58 consecutive years of the “Hells Half Acre” scenario, about 19 million acre-feet of water have recharged the aquifer, and about 24 percent of this water (4.6 million acre-feet) remains stored in the aquifer. Approximately 59 percent of the water (11.2 million acre-feet) has returned to the river in the Blackfoot to Minidoka Dam reach. The “Hells

Half Acre" scenario has induced an additional 2.9 million acre-feet of discharge to the Henrys Fork and South Fork reaches. Only about 2 percent of the recharged water (380,000 acre-feet) was discharged to springs in the Kimberly to Bliss reach.

4. Net Effect of "Hells Half Acre" Recharge on the Flows in the River

After ten consecutive years of recharge, the net effect of the "Hells Half Acre" scenario on flows at the Bliss gage is expected to be negative six months of the year, between November and March, and positive the other six months of the year, between April and October (figure 4-32). The reduction in flow during winter months ranges from 4 to 8 percent of the average flows during these months. The increases in flow during summer months range from 1 to 4 percent of the average flows. Since the "Hells Half Acre" scenario contributes almost nothing to spring flows in the Kimberly to Bliss reach, most of the increased flow during summer months comes from increased discharge in the Blackfoot to Minidoka Dam reach.



	October	November	December	January	February	March	April	May	June	July	August	September
percentage impact	2%	-6%	-5%	-5%	-8%	-4%	-4%	1%	3%	4%	4%	4%
Net impact of managed recharge, cfs	137	-582	-629	-668	-715	-368	-420	77	261	292	276	278
Average flow (conditioned), cfs	7960	10294	11489	12604	9379	8257	11346	9774	8592	6605	6873	7876

Figure 4-32. Net Effect at Bliss after 10 Years of "Hells Half Acre" Recharge

The net effect of "Hells Half Acre" recharge on flows at Bliss between mid April and September is positive after about four consecutive years of recharge (figure 4-33). Initially, the net increase in flow is due exclusively to increased discharge in the Blackfoot to Minidoka Dam reach and the Henrys Fork. A very slight increment in flow at Bliss that appears after about 45 years can be attributed to the Kimberly to Bliss reach. At equilibrium, one could expect about 110,000 additional acre-feet of flow at Bliss during this five and one-half month period, as a result of the "Hells Half Acre" recharge scenario.

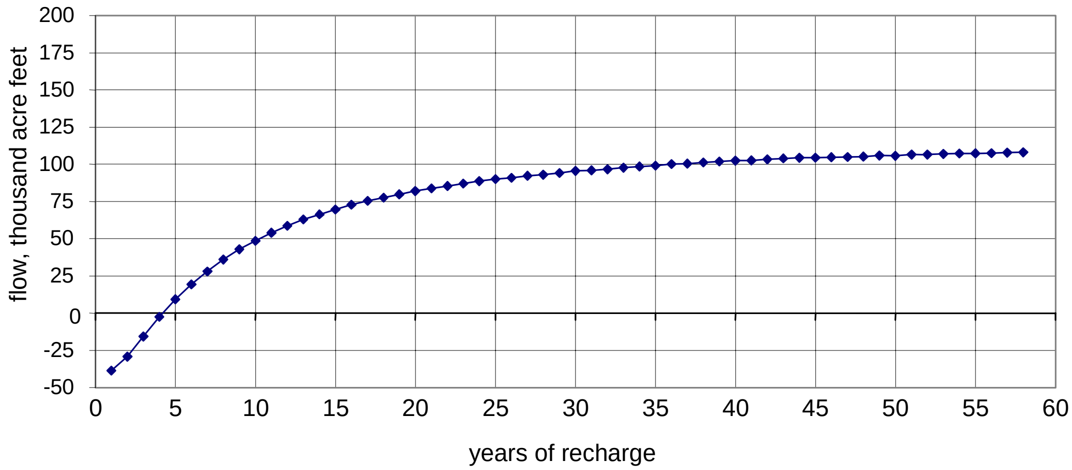


Figure 4-33. Net Effect of Recharge on Flows at Bliss, from Mid April through September

The net effect on flows at Bliss is achieved with an average annual recharge rate of 334,000 acre-feet per year (462 cfs).

H. THE "EGIN LAKES" RECHARGE SCENARIO

The Egin Bench area has long been considered an important area to consider for managed aquifer recharge. Fremont-Madison Irrigation District has a long history of involvement with managed recharge in both experimental and practical applications. For many years, water was diverted into the Egin Lakes during winter months, using the Last Chance and St. Anthony canals, in order to aid in sub-irrigation of the district. The Egin Lakes consist of a series of three shallow basins separated by dikes and levees. The basins are located between seven and thirteen miles east of St. Anthony and have a combined area of about 3,000 acres.

In the early 1960's the Snake Plain Recharge Reconnaissance Investigation (USBR, 1962) focused much of its attention on the Egin Bench, in the belief that recharge conducted as far up gradient in the aquifer as possible would have the greatest overall benefit for ESPA ground-water storage. In 1972, the St. Anthony Pilot Recharge Project was initiated by the Idaho Water Resource Board in cooperation with the BOR, USGS, and the St Anthony Union Canal Company (Anderson, 1975).

The goals of early "Egin Lakes" recharge projects were described as recharge testing to maintain ground-water levels for sub-irrigation, flood control, and recreational development. Since the mid 1970's, however, most of the Egin Bench irrigators have converted to more efficient sprinkler irrigation and the earlier arguments for recharge no longer apply. However, irrigation diversions on the Egin Bench remain high, typically about eleven acre-feet per acre of land. It is surmised that most of this water is simply passed through the Fremont-Madison Canal system and returned to the river (Carlson, 1995). Conversion from sub-irrigation to sprinkler irrigation on the Egin Bench is expected to result in 95,000 acre-feet less incidental aquifer recharge (King, 1987).

The recent conversion to sprinkler irrigation, along with increased ground-water pumping in the Mud Lake area, has prompted concern for maintenance of ground-water levels in the area. A recent modeling study projected that ground-water levels in the Mud Lake area would eventually decline by one to four feet, and net discharge to streams (mostly Henrys Fork) would be reduced by 34,000 acre-feet, as a result of sprinkler conversion and ground-water pumping. Annual tributary underflow from the Henrys Fork basin (into the main part of the ESPA) would also be reduced, by about 17,000 acre-feet (Spinazola, 1994).

The "Egin Lakes" recharge scenario provides an opportunity to assesses the potential of managed recharge to offset anticipated declines in ground-water levels in the Mud Lake area. It also provides an opportunity to assess the validity of early assumptions of aquifer recharge investigators, that recharge conducted as far as up gradient as possible in the aquifer would have the most beneficial effect on down gradient ESPA storage.

Water is diverted to the Egin Lakes and to a few other potential sites in the immediate area, using the Last Chance, St Anthony, Egin, St Anthony Union, and Independent Canals. The "Egin Lakes" recharge is uniformly distributed over two IDWR/UI model cells, which encompass the Egin Lakes and most of the other sites (figure 4-34).

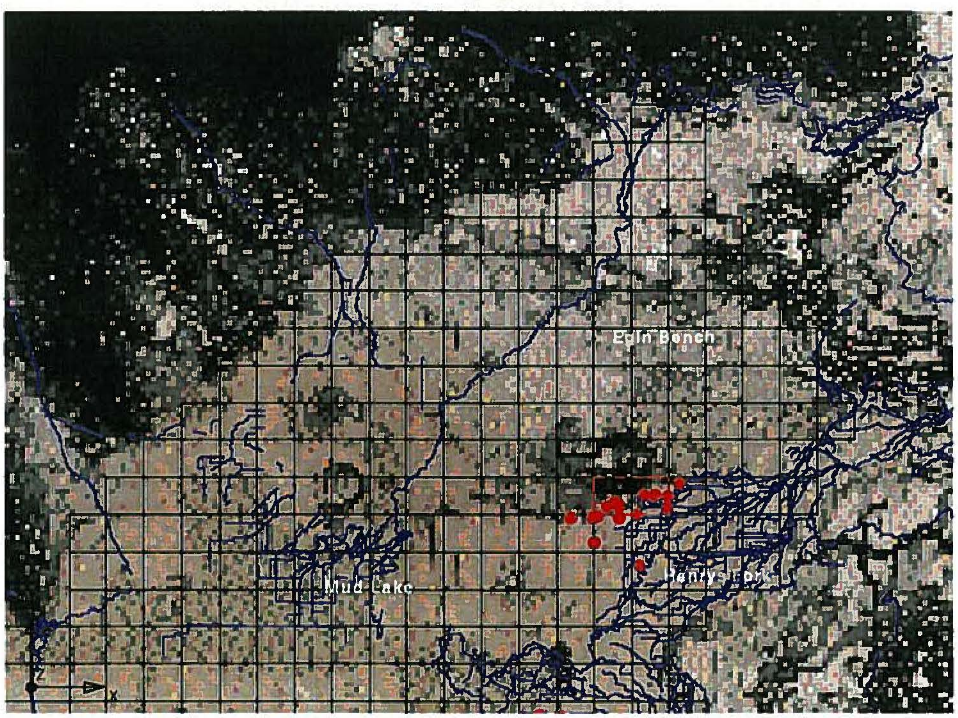


Figure 4-34. The "Egin Lakes" Recharge Scenario

1. Expected Recharge Rate “Egin Lakes” Scenario

Because of the historical practice of year round diversion to maintain ground-water levels for sub-irrigation, the Egin Bench Canal Co. is able to make a distinction between maximum diversion capacity of canals and the maximum capacity to divert water for recharge during winter months. The diversion capacity constraint for the “Egin Lakes” scenario is therefore the current and anticipated capacity of the Egin Bench Canal Co. for winter time recharge diversion (Sullivan, Johnson et al., 1996). This includes recharge capability from supplemental canal seepage plus the potential recharge from an enlarged Beaver Dick Ditch that was proposed by the Independent Canal Co.

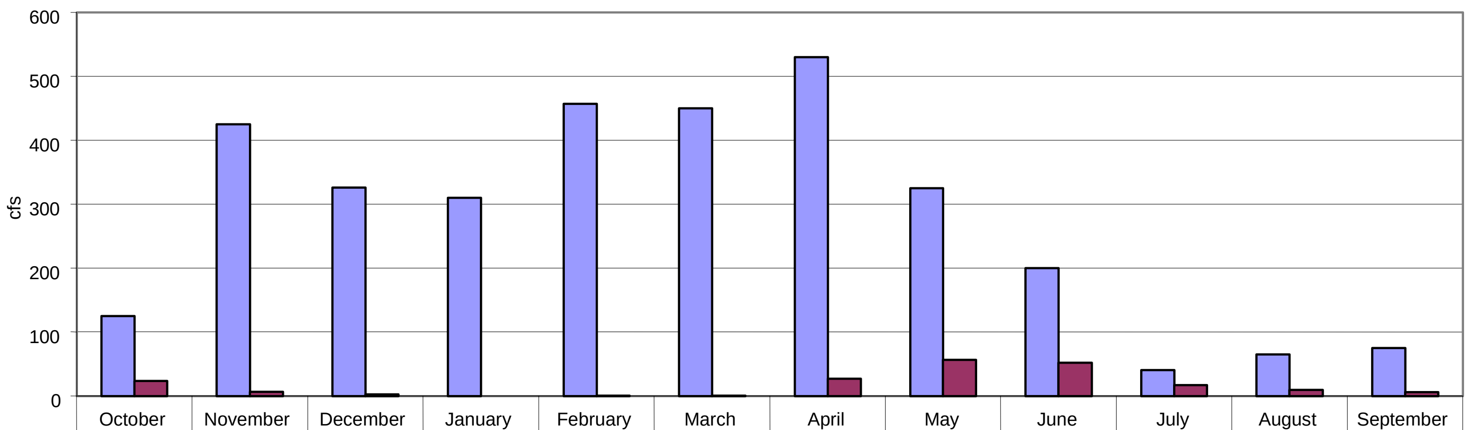
Once again, two sets of constraints are imposed on use of surplus flows for recharge in the “Egin Lakes” scenario. For the first set, expected recharge rates are constrained by only the current and anticipated capacity of the five canals that make up the Egin Bench Canal Co. (table 4-6). In the second set, expected recharge rates are also constrained by IDFG stream maintenance flow recommendations for the Henrys Fork below St. Anthony (table 4-5).

In contrast to the other recharge scenarios in which recharge occurs mainly during a few winter months, “Egin Lakes” recharge would be distributed over nine months of the year (figure 4-35). Only during July, August, and September is little recharge likely to occur. About 43 percent of annual recharge is expected during February, March, and April. Constrained only by canal capacity, the average annual recharge rate for the “Egin Lakes” scenario is 277 cfs, (201,000 acre-feet per year). The imposition of IDFG stream maintenance flow recommendations erases nearly all the expected aquifer recharge for the “Egin Lakes” scenario, reducing the annual average to just 17 cfs.

LePard (1981) estimated the average seepage rate of “Egin Lakes” ponds to be .51 ft/day. Given a combined basin area of more than 3,000 acres, this seepage rate would enable a total recharge capacity of more than 1,500 cfs, far exceeding the maximum recharge rate expected during winter months. Therefore, for the “Egin Lakes” scenario, recharge could be expected to be limited by water availability rather than by the recharge capacity of the Egin Lakes basins.

2. Aquifer Response to “Egin Lakes” Recharge Scenario

Once again, the “Egin Lakes” scenario is modeled, based on a planning premise that allows maximum recharge subject to availability of surplus flow and diversion capacities of canals, but does not provide for minimum stream flow maintenance for fisheries. As before, the intent of modeling is to show the maximum potential impact of recharge scenarios.



	October	November	December	January	February	March	April	May	June	July	August	September
canal cap only*	125	425	326	310	457	450	530	325	200	40	65	75
canal cap and fisheries**	23.5	6.5	2.5	0	0.5	0.5	27	56.5	51.5	17	9.5	6

* annual average = 277 cfs
** annual average = 17 cfs

Figure 4-35. Expected Aquifer Recharge Rate for the “Egin Lakes” Recharge Scenario.

Again, five color-coded contour maps of ground-water level change show the gradual development of the recharge area of influence in the ESPA during 58 consecutive years of recharge of the "Egin Lakes" scenario. The minimum contour displayed (the dark blue), again, represents a three-foot increase in ground-water level above the base case equilibrium level.

After one year of the "Egin Lakes" recharge scenario (figure 4-36a), an increase in ground-water level of three feet or more could be expected to occur in an area that extends from 3 to 4 miles from the recharge sites. Directly beneath the area of recharge simulated ground-water levels rise 20 feet. Once again, because only two cells are used to represent the recharge area, the ground-water levels on the periphery of these cells is a better indicator of ground-water level change that would occur directly beneath the recharge sites, than is the ground-water level change inside these cells.

After three consecutive years of recharge (figure 4-36b), the area of influence extends about 6 miles to the west and about 10 or 11 miles to the north of the sites. The recharge mound also extends some distance to the south and east, beneath the Henry Fork. Directly beneath the "Egin Lakes" recharge sites simulated ground-water level rise is about 30 feet above the base case equilibrium level.

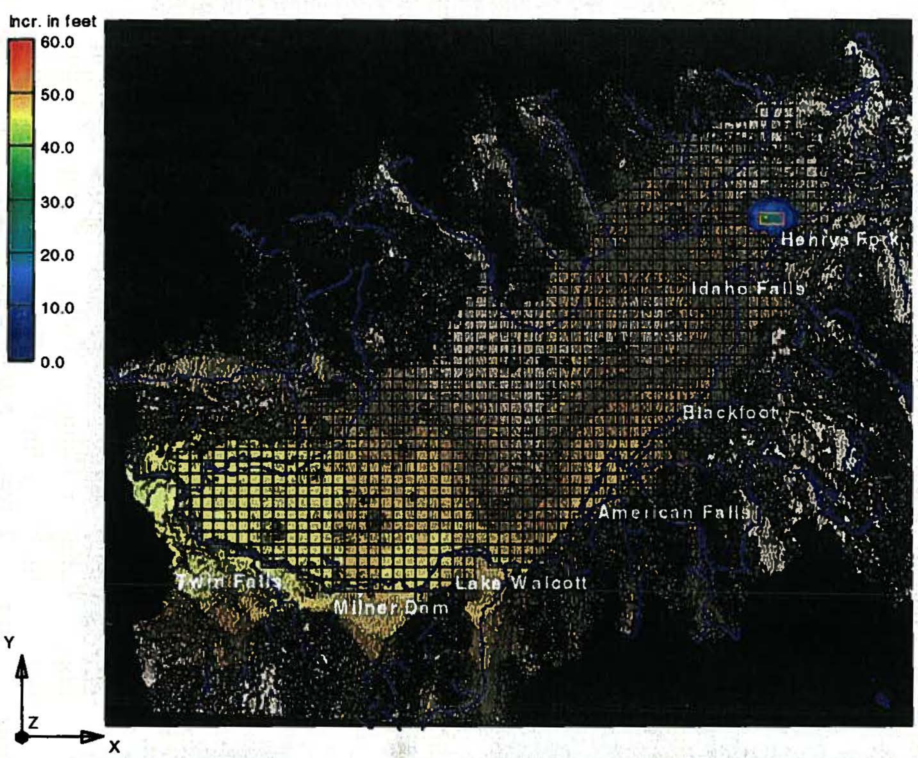


Figure 4-36a. Ground-Water Level Change after One Year of Recharge

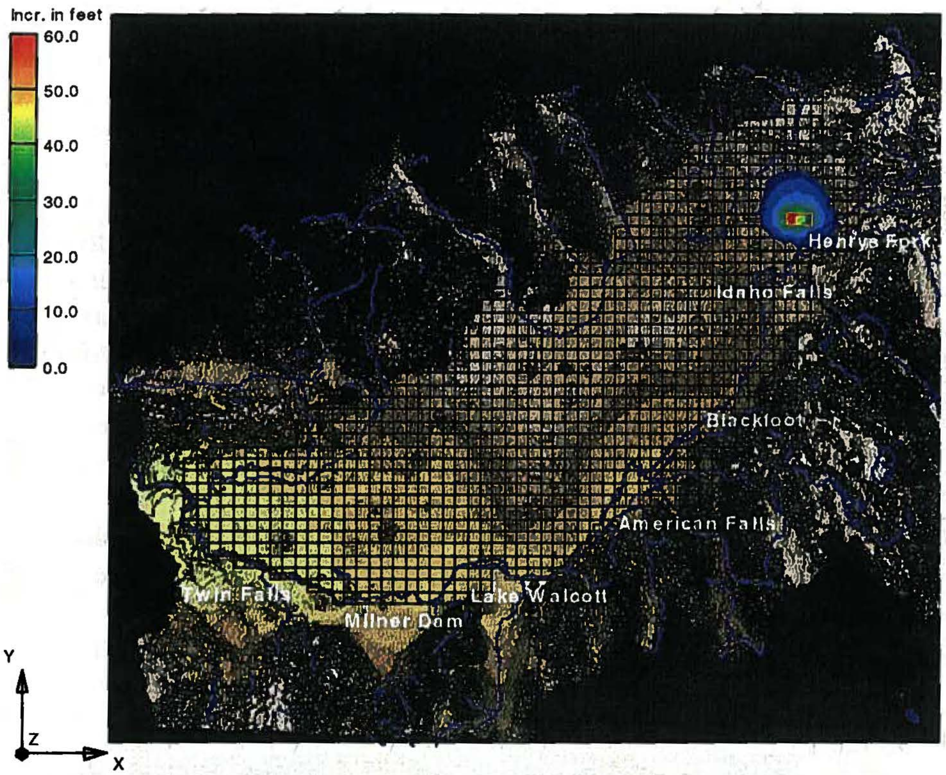


Figure 4-36b. Ground-Water Level Change after Three Consecutive Years of Recharge

After ten consecutive years of recharge (figure4-36c) the area of influence has expanded significantly into a portion of the Egin Bench surrounding Mud Lake. The extension occurs in an area of the plain where the water table is comparatively flat and aquifer transmissivity is comparatively high. Surrounding this area of the plain, aquifer transmissivity is about an order of magnitude lower and for the time being, this limits further expansion of the recharge mound. Directly beneath the "Egin Lakes" recharge sites ground-water levels have risen, more than 40 feet.

After twenty consecutive years of recharge (figure 4-36d), the area influenced by the "Egin Lakes" scenario has expanded slightly to the northeast. Simulated ground-water levels in the Mud Lake area have risen about 15 feet, and beneath the Egin Lakes the groundwater rise is 50 to 60 feet above base case levels.

After fifty-eight consecutive years (near equilibrium), the recharge mound has spread out only slightly more (figure4-36e). On the east, west, and north sides of the "Egin Lakes" it extends to the boundary of the plain. To the south the recharge mound extends to about Mud Lake. Expansion of the recharge mound further down gradient in the aquifer is impeded by the low transmissivity of the Mud Lake deposits (figure 2-3). Within the Henrys Fork tributary basin, ground-water levels have risen in many areas by as much as 30 feet. Near Mud Lake the increase in ground-water level is expected to be about 15 feet. In the area directly beneath the recharge sites, ground-water levels have risen 60 feet or more.

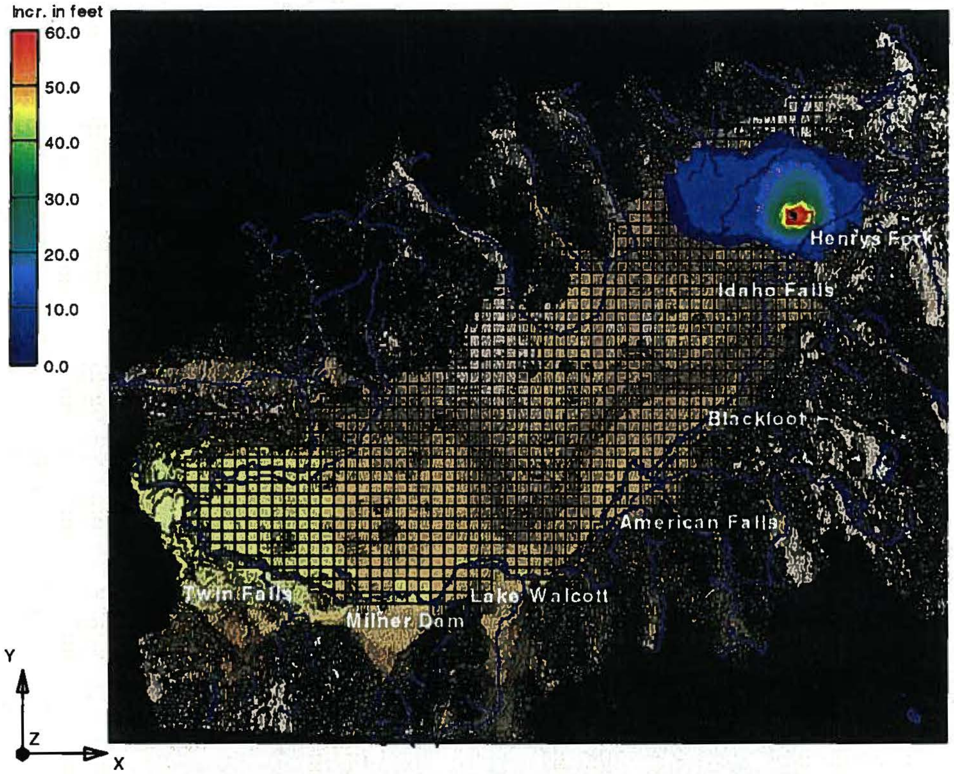


Figure 4-36c. Ground-Water Level Change after Ten Consecutive Years of Recharge

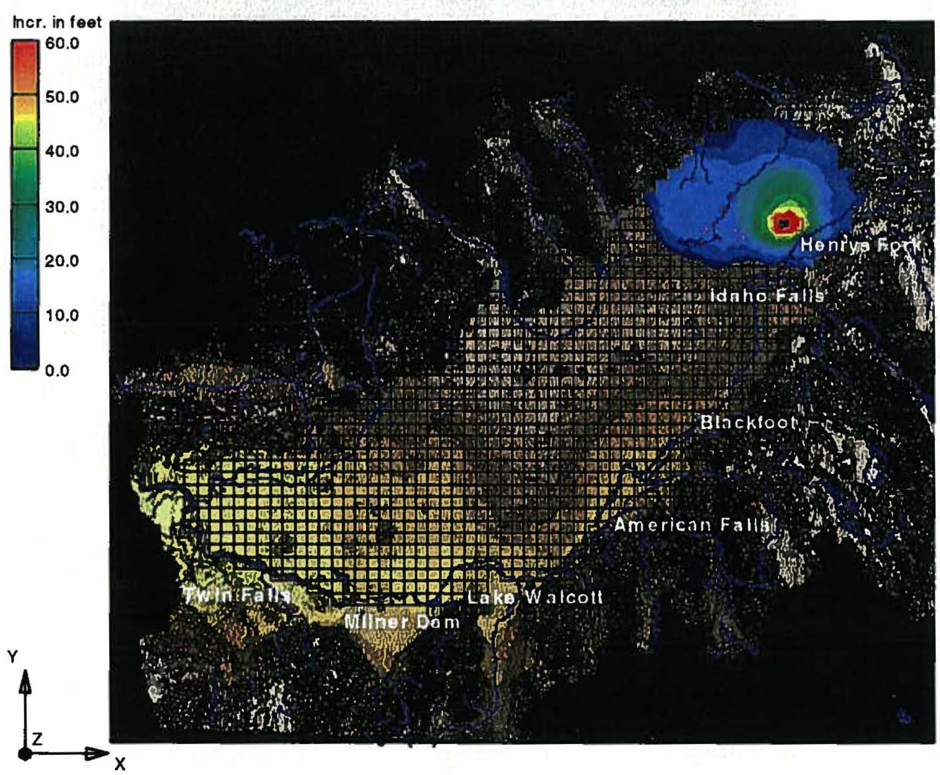


Figure 4-36d. Ground-Water Level Change after Twenty Consecutive Years of Recharge

The water table at the "Egin Lakes" is generally about 80 feet below the surface (Anderson, 1975), although, in previous experiments there has been evidence that a perched water table condition develops in the surficial sand layer directly beneath the recharge ponds. The perched water table could be a limiting factor in the "Egin Lakes" recharge rate, although, the experimental data from two different recharge tests supports the assumption that the combined capacity of the three recharge basins exceeds the expected recharge rates imposed in the "Egin Lakes" scenario.

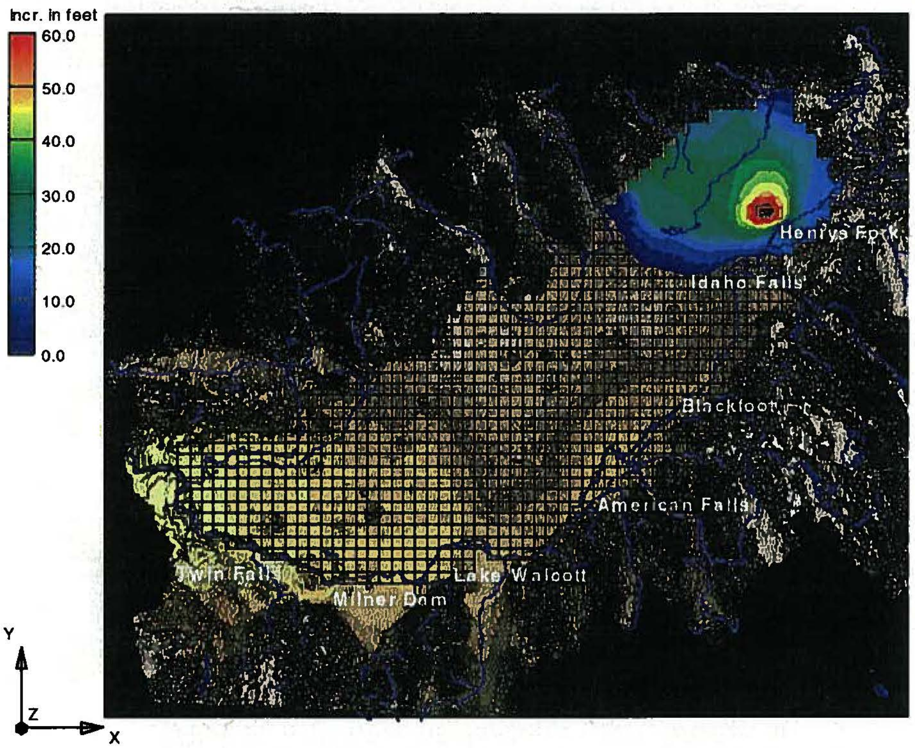


Figure 4-36e. Ground-Water Level Change after 58 Consecutive Years of Recharge

Large-scale recharge in the "Egin Lakes" has a substantially greater influence on ground-water levels in the immediate area than does recharge conducted in other parts of the plain. The reason has mainly to do with the close proximity of ESPA boundaries to the Egin Lakes, which limits the expansion of the recharge mound on three sides and with the low transmissivity of the Mud Lake deposits that impede the flow of recharge water to the southwest.

<u>3. River Response to "Egin Lakes" Scenario</u>

The river response to the "Egin Lakes" recharge scenario is once again presented in the form of a monthly river reach response plot after 20 years of recharge, and as a cumulative river/aquifer response plot. The monthly response plot (figure 4-37) shows that the only notable river response to the "Egin Lakes" scenario occurs in the Henrys Fork reach. The increase in discharge in this reach (which does not include the South

Fork of the Snake River) is about 175 cfs and the increase is uniformly distributed throughout the year.

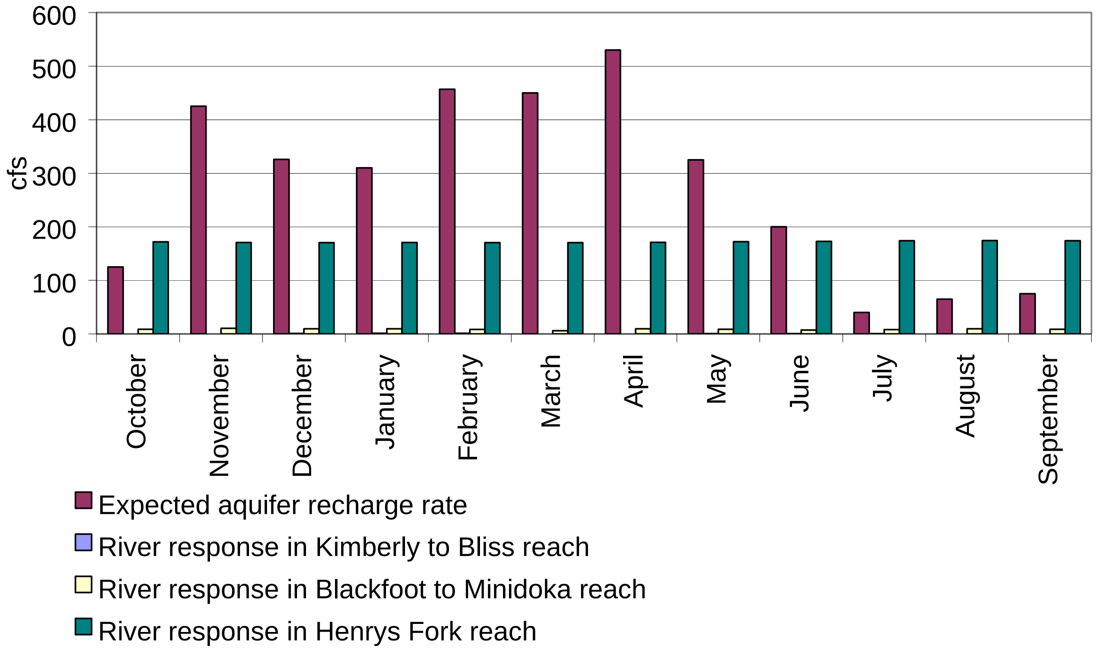


Figure 4-37. Expected Recharge Rates and Monthly River Response after 20 Years

The cumulative river/aquifer response plot (figure 4-38) shows that after ten years of the "Egin Lakes" scenario, about 2 million acre-feet of water have recharged the aquifer. A substantial portion of this, about 68 percent, is in aquifer storage in the Henrys Fork tributary basin aquifer and the remaining 32 percent has returned to the Henrys Fork or to the South Fork reach of the Snake River. After ten years, there is no measurable influence on spring discharges in either the Kimberly to Bliss reach or the Blackfoot to Minidoka reach.

After 58 consecutive years of recharge, almost 12 million acre-feet of water have been recharged in the "Egin Lakes", about 32 percent of this (3.8 million acre-feet) is stored in the aquifer, mostly in the Henrys Fork tributary basin. Approximately 63 percent of the recharged water (7.6 million acre-feet) has returned to the river, mainly in the Henrys Fork and South Fork reaches. Only about 5 percent of the recharged water has returned in the Blackfoot to Minidoka reach. There is no measurable influence on spring discharge in the Kimberly to Bliss reach of the river.

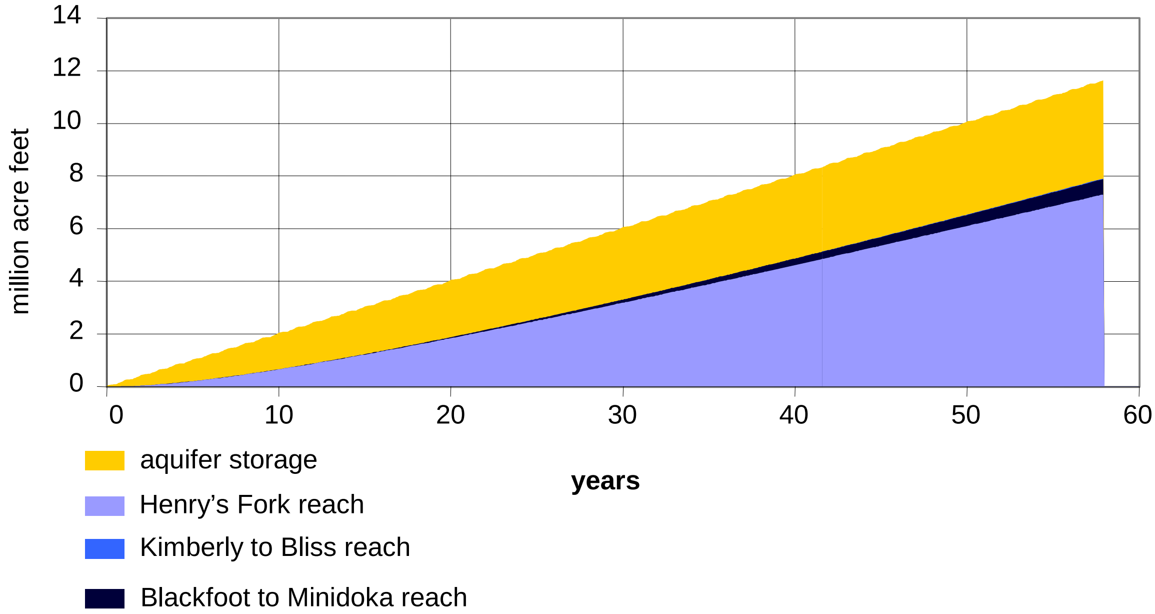
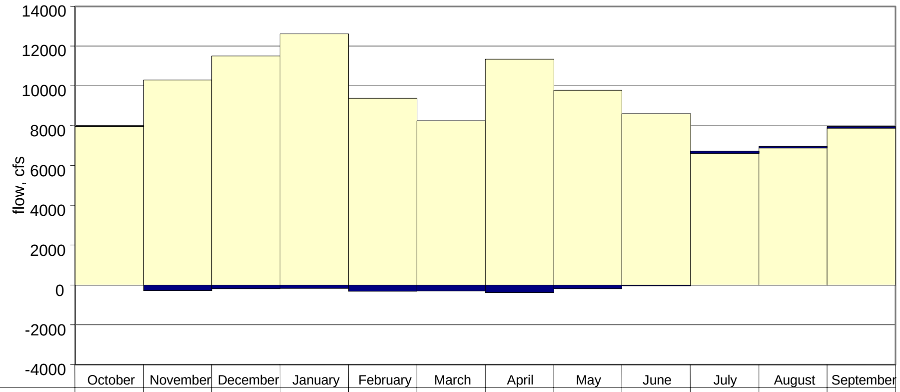


Figure 4-38. Cumulative Aquifer and River Response to "Egin Lakes" Recharge Scenario

4. Net Impact of Managed Recharge on the Flows in the River

After ten consecutive years of recharge, the net impact of the "Egin Lakes" scenario on flows at the Bliss gage (figure 4-39) is expected to be negative during eight months of the year, November through June, and positive four months of the year, July through October. The reduction in flow during winter months ranges from 163 cfs in January, to 379 cfs in April, representing, respectively, 1 and 4 percent of the average flow during these months. The increases in flow during summer months ranges from 23 cfs in October, to 115 cfs in July, representing less than 2 percent of the average during these months.

The net impact of "Egin Lakes" managed recharge on flows at Bliss during the period mid-April through September, is expected to become positive after about eighteen consecutive years of recharge (figure 4-40). The net increase in flow is due almost entirely to increased spring discharge that occurs in the Henrys Fork reach. At equilibrium, one could expect about 24 thousand additional acre-feet of flow at Bliss during this five and one-half month period as a result of the "Egin Lakes" recharge scenario.



	October	November	December	January	February	March	April	May	June	July	August	September
percentage impact	0%	-3%	-2%	-1%	-3%	-4%	-3%	-2%	-1%	2%	1%	1%
Net impact of managed recharge, cfs	23	-280	-177	-163	-308	-300	-379	-175	-46	115	89	81
Average flow (conditioned), cfs	7960	10294	11489	12604	9379	8257	11346	9774	8592	6605	6873	7876

Figure 4-39. Net River Response at Bliss to "Egin Lakes" Recharge Scenario

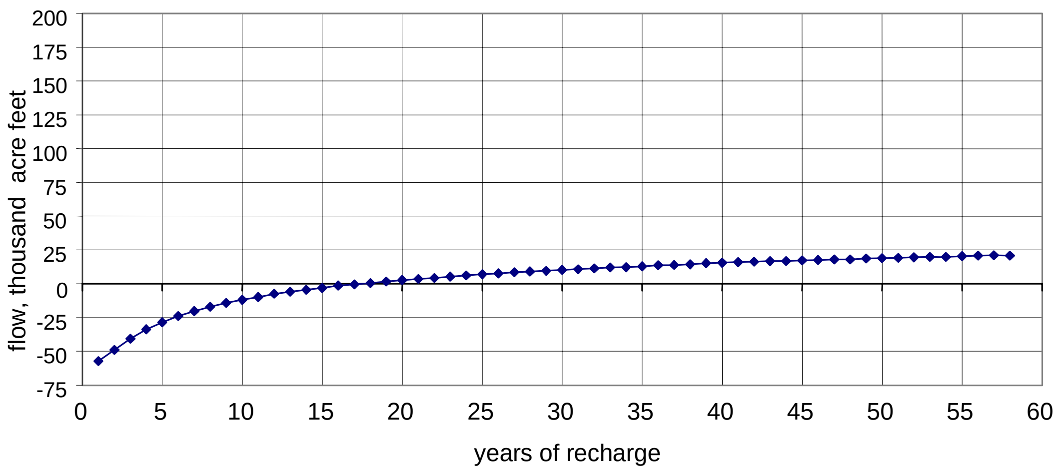


Figure 4-40. Net Impact of Recharge on Flows at Bliss, from Mid April through September

This net impact on flows at Bliss is achieved with an average annual recharge rate of 201,000 acre-feet per year (277 cfs).

I. DISCUSSION

In planning for large-scale managed recharge it is necessary to understand the hydrologic outcomes that could ultimately be expected from proposed recharge projects. The four modeling scenarios of this report show the hydrologic impact of managed aquifer recharge conducted on a very large scale and over a very long term, using surplus natural flows and excess capacity of existing canal facilities to the maximum extent possible. As indicated earlier, model results are most often scalable. A reduction in expected recharge rates in any of the scenarios would produce a proportional reduction in river and aquifer response, therefore there is little to be gained at this point from modeling small-scale recharge projects.

To a large extent, the hydrogeology of the Eastern Snake River Plain dictates what can and cannot be achieved with managed aquifer recharge. The four scenarios reveal the influence of hydrogeologic features that are important in determining the basin-wide hydrologic response to recharge activity. The influence of these features would not generally be revealed unless recharge stresses were relatively large and relatively long duration.

In previous studies, which did not have the benefit of a well-developed hydrologic model, it was widely assumed that aquifer recharge conducted high up in the basin would have the greatest overall benefit for the ESPA, because it would impact the entire aquifer down gradient. For this reason, the most desirable recharge sites were thought to be at the eastern end of the plain. Recharge in these areas, it was widely believed, would raise water levels throughout the aquifer, whereas recharge near the discharge areas (e.g. the Kimberly to Bliss reach) would raise ground-water levels only locally.

The modeling results from this study provide a new perspective on this longstanding assumption. While there clearly exists a regional south-westward ground-water flow gradient that influences the movement of recharge water, there is also a substantial degree of aquifer “compartmentalization” with respect to the influence of managed recharge activity. The “compartmentalization” of recharge effects is mainly a function of the distribution of aquifer transmissivity, combined with the necessity to develop recharge scenarios that take advantage of existing diversion facilities.

A color-coded distribution of ESPA transmissivity, as it is represented in the IDWR/UI model, is shown in figure 4-41. Transmissivity color contours are displayed in powers of ten. The red areas of the plain have the highest transmissivity, about 100 million square-feet per day. The orange areas denote transmissivity of about 10 million square feet/day, the yellow-green areas denote 1 million square feet/day, and so forth. The blue areas have the lowest transmissivity about 100 square feet/day. As indicated earlier, there is an enormous range of transmissivity conditions across the plain.

The Great Rift Fault Zone and the Mud Lake deposits are low transmissivity features that cut across the plain (figure 2-2). They appear in figure 4-41 as two bands of low transmissivity separating areas of much higher aquifer transmissivity. The internal boundaries of three aquifer “compartments” or areas of influence, coincide with these two prominent ESPA hydrogeologic features, and are indicated as Areas I, II, and III on this figure.

The presence of springs discharging ground water to the Snake River at the upper end of Lake Walcott (on the up gradient side of the Great Rift fault Zone) and in the Market Lake area (on the up gradient side of the Mud Lake deposits) demonstrate the influence that these two hydrogeologic features exert on aquifer/river interactions. The low transmissivity of these two features restricts the regional south-westward flow of ground water at these locations on the plain. Near the river and on the up gradient side of these features, ground-water levels rise nearly to land surface, and some regional ground-water flow is diverted via spring discharge, to the river.

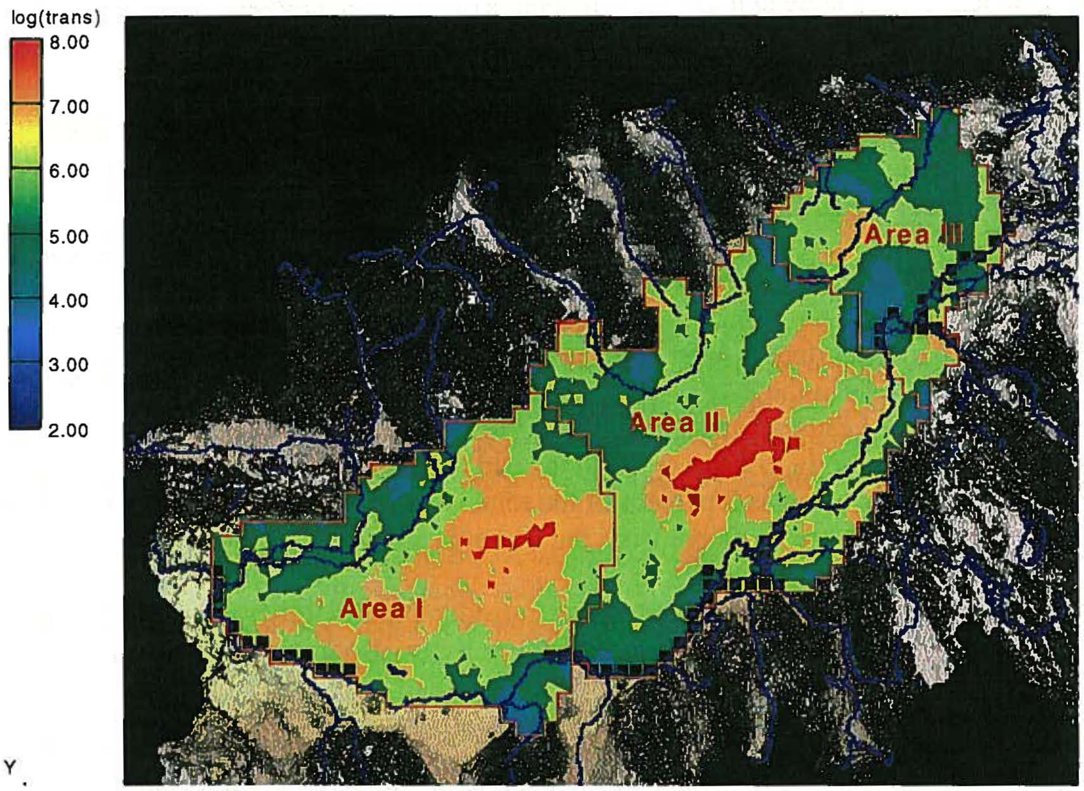


Figure 4-41. Transmissivity Distribution and Areas of Influence

The basic nature of river/aquifer interaction within these three areas of influence, combined with the prerequisite that recharge scenarios use existing facilities, limits the basin-wide influence of any particular scenario. The majority of recharge water exits the aquifer in the same area that the recharge occurs, regardless of whether the recharge occurs up gradient or down gradient from the other two areas.

The compartmentalization of recharge effects is apparent in all four of the previous modeling scenarios. Aquifer and river responses to the "Thousand Springs" and "Lake Walcott" scenarios demonstrates that managed recharge conducted in Area I affects ground-water level in an area of the aquifer mainly to the west of the Great Rift Fault zone, and spring discharge mainly in the Kimberly to Bliss reach of the river. Although there is a small up-gradient influence in the Blackfoot to Minidoka reach due to the "hydraulic barrier" effect, virtually all of the water that is recharged in Area I exits the aquifer in the Kimberly to Bliss reach of the river.

Aquifer and river responses to the "Hells Half Acre" scenario demonstrate that managed recharge conducted in Area II affects ground-water levels in the aquifer, mainly to the west of the Mud Lake deposits and to the east of the Great Rift Fault Zone, and spring flows mainly in the Blackfoot to Minidoka river reach. Only a very small portion of the Area II recharge water (about 2 percent) crosses the Great Rift Fault Zone and enters Area I.

Response to the "Egin Lakes" scenario demonstrates that recharge in Area III affects ground-water levels mainly to the east of the Mud Lake deposits. Recharge water that enters the aquifer in Area III is discharged from the aquifer mainly in the Snake River reach between Market Lake and the confluence with the Henrys Fork. A very small portion of the recharge water (about 5 percent) crosses the Mud Lake boundary (to the west) and enters Area II of the aquifer.

As indicated previously, long-term managed recharge can result in a small increase in aquifer discharge in river reaches that are up gradient from the diversion point. The "hydraulic barrier" effect is most noticeable for managed recharge diversions that occur low in the basin, as in the case of the "Thousand Springs" scenario, in Area I. Long-term recharge in Area I causes some ground water in Area II, which would otherwise exit the aquifer in the Kimberly to Bliss reach to instead exit in the Blackfoot to Minidoka reach. At equilibrium, as much as 3 percent of the total river response to "Thousand Springs" recharge could occur up-gradient from the recharge sites.

The four scenarios have demonstrated that considerable flexibility exists with respect to choosing the timing and location for recharge activity. Both variables can be manipulated in ways that could support several different aquifer and river management objectives. The use of existing canals during winter months for diversion of recharge water is one example of this. Overall, there is a strong motivation to conduct managed aquifer recharge mainly during winter months (December through February). The motivation stems from a combination of factors, including greater availability of surplus flows, greater excess canal capacity during these months, and lower instream flow requirements of resident fisheries. Equally important, winter time recharge affords the opportunity to demonstrate a net positive impact on Snake River flows during critical summer months (May through September). Timing of recharge activity to provide for increased net river response from the upper Snake during late summer months could make a significant contribution (as much as 150,000 acre feet) toward meeting endangered species and water quality targets.

V. ECONOMIC COSTS

Evaluation of the feasibility of managed recharge includes two levels of cost analysis, where cost is defined by direct expenditures needed to construct, improve, or operate recharge facilities. The first level, presented here, considers the costs associated with the general conceptual design of a large-scale managed recharge program. The second level, to be discussed in Section VII of this report, considers costs associated with the structural design of specific recharge ponds, canal improvements, and associated costs at priority sites. The general, first-level cost analysis described below comprises one of the screening criteria used in Section VIII to develop the list of priority sites.

A managed recharge program may be designed to use existing canals or to construct new canals for conveying water from surface-water sources to recharge sites. In terms of engineering costs, the canal component represents the most fundamental design alternative for a regional program. The cost analysis begins, therefore, by evaluating the economic feasibility of new canal construction. The estimate of construction costs for new canals establishes that new canals are not economically feasible at this time.

The economic and engineering feasibility of using existing canals is then addressed. Facility improvements to existing canals, such as control structures, will be needed for managed recharge operations. These can be constructed for a reasonable cost. The primary feasibility question regarding the use of existing canals is whether recharge water can be conveyed during the winter, when the canals are not being used for irrigation. In addition to offering unused canal capacity, the winter months are characterized by surplus flows available for diversion, as described in Section IV of this report, and by relatively low environmental impacts, as described in Section III. The use of canals in the winter may be constrained, however, by freezing conditions. The companies that own and operate the larger canal systems have indicated that operations under freezing conditions may be feasible and have further expressed a willingness to participate in a managed recharge program operated during the winter months.

In addition to costs associated with conveying recharge water, costs will be incurred with the construction and operation of recharge ponds and with establishment and maintenance of a water quality monitoring program. Some costs are relatively modest; others may require additional expense depending upon site conditions and proximity to population centers and public water supplies.

A. New Conveyance Facilities

The preliminary cost estimates described here cover the construction of two large canals to convey water from the Snake River to recharge areas. The two recharge areas were chosen in accordance with previous suggestions by the Idaho Water Resource Board. The two areas are the Egin Bench and Milner-Gooding canal areas. The possible project configuration was established for each location to determine the construction necessary to convey approximately 500,000 acre-feet of recharge water per year. The following subsections describe the two cost estimates.

1. Egin Bench Area

The assumed Egin Bench recharge canal would include the construction of a new river diversion and a conveyance canal with a capacity of 3,700 cfs. The diversion would be located approximately 3.5 miles northeast of St. Anthony on the Henry's Fork of the Snake River. The construction would include a low weir across the river and headgate to the conveyance canal.

The conveyance canal would include three sections to reach the recharge sites. The first section would carry the water from the diversion to the first recharge pond at the Egin Lakes Recreation Area. The canal would travel approximately ten miles through range and farm land. The second canal reach would travel from the west end of the Egin Lakes recharge site to the Nine Mile Knoll site, approximately two miles west. The third canal section would extend from the Nine Mile Knoll site one mile south to the rangeland west of Quayles Lake.

The total recharge area includes three separate sites that would be connected with three canal sections. The first site would be at the Egin Lakes Recreation Area approximately seven miles west of St. Anthony. This site is currently used for recharge using the existing Egin Bench Canal facilities. The increased flow with the dedicated conveyance system could more thoroughly utilize the Egin Lake site. The second pond site would be near the Nine Mile Knoll, approximately 10 miles west of St. Anthony. This site is desert rangeland with an irregular surface with many pockets. The third site is west of Quayles Lake, which is 12 miles west and 1 mile south of St. Anthony. It also is sagebrush steppe rangeland with an irregular surface. All three sites have sandy surface soils that have good permeability.

The primary items required for full facility development include excavating, embankments, control structure construction, and bridges. The quantities of construction items were developed using quad maps from the USGS, existing soils data, past experience of canal company or district personnel, and field observation. Unit costs were derived from the USBR, experienced contractors, and records of previous similar projects. The items were combined to develop an overall preliminary cost estimate to determine the economic costs that would be required for such an undertaking.

A conveyance canal cross section was developed to carry the necessary capacity of 3,700 cfs. The typical canal cross section used for the cost estimate has a bottom width of 110 feet with 1:1 side slopes and a water depth of 10.25 feet. The estimated canal slope along the channel is 0.02 percent to maintain a minimum velocity of 3 feet per second. The canal section included excavation to 8 feet below the existing ground and embankment to 5.25 feet above the existing ground for a total of 13.25 feet from top of embankment to invert of canal.

Structures required include the diversion weir, two control gates, and nine bridges. The diversion would include a low weir structure across the Henry's Fork of the Snake River and the headgates into the conveyance canal. Control structures would be located at the outlet of the Sand Dunes and Nine Mile Knoll recharge sites. Bridges would be provided wherever existing roads cross the proposed canal. The average bridge size is estimated to be 24 feet wide and 140 feet long.

The USBR unit costs were obtained from Dan Wilson at the Boise, Idaho office and included soil and rock excavation and embankment. Structure costs were estimated based on similar structures built for hydroelectric projects. Bridge construction costs were estimated based on contractor input and previous highway project structures. The estimated unit costs used for the proposed recharge projects reflect costs on similar large-scale, federally funded construction.

The estimated project quantities and unit prices were combined to develop an estimate of the total cost of the dedicated recharge canals. The estimated cost to construct a new Egin Bench recharge canal is summarized in Table 5-1. No costs were included for any necessary improvement of the recharge sites. Those costs might include diking, grading, surface infiltration enhancement (such as scarification), and other items that will be site-specific.

Table 5-1. Preliminary Construction Cost Estimate for New Recharge Canal in Egin Beach Area

Assumptions

Unit Costs			Canal Sizing		
Rock Excavation	$30.00	per cubic yard [1]	Canal Length	13	miles
Soil Excavation	$7.00	per cubic yard [1]	Total Excavation	2,402,400	cubic yards
Embankment	$3.00	per cubic yard [1]	soil excavation = 80%		
Right-of-Way			rock excavation = 20%		
agricultural land	$3,000	per acre	Total Embankment	337,000	cubic yards
range land	$1,000	per acre	Right-of-Way		
			agricultural land	255.0	acres
			range land	76.4	acres

Estimated Costs [2]

Soil Excavation	$13,453,000
Rock Excavation	14,414,000
Embankment	1,011,000
Right-of-Way	
agricultural land	765,000
range land	76,000
Structures (Diversion, 9 Bridges, & 2 Control Structures)	2,766,000
Sub-Total	32,486,000
Contingencies (25%)	8,122,000
Engineering (12%)	3,898,000
TOTAL ESTIMATED PROJECT COST	$44,506,000

[1] Unit costs provided by U.S. Bureau of Reclamation.

[2] Rounded to the nearest thousands.

The total estimated cost to construct a new canal with a capacity of 3,700 cfs in the Egin Bench area is $44.5 million.

2. The Milner-Gooding Area

The assumed Milner-Gooding recharge canal would include the construction of a new river diversion and a conveyance canal with a capacity of 7,000 cfs. The new canal would parallel the existing Milner-Gooding Canal, which travels through a long stretch of rocky desert rangeland. The diversion would be located upstream from the existing Milner-Gooding diversion above Milner Dam. The diversion would be similar to the existing Milner-Gooding facilities, which include radial gates, operators, screens, and a measurement device, and would utilize the existing Milner Dam pool.

The conveyance canal would run nearly parallel to and east of the existing Milner-Gooding Canal. The canal would run through a deep rock cut for the first four miles, then through a deep cut through soil for another four miles to the desert rangeland north of Interstate 84. The canal would meander through the rocky desert rangeland 30 miles to a diversion structure that would split off approximately 40 percent of the flow. The split flow canal would cross the Milner-Gooding Canal and run southwest across desert rangeland to a recharge site adjacent to the North Side Canal north of the city of Eden. A canal would run out of the Eden recharge site and flow along the east side of the North Side Canal to a recharge site approximately 12 miles east of Jerome. This canal would run through desert rangeland and irrigated farm land.

The main recharge canal would continue paralleling the Milner-Gooding Canal to a recharge site north of the Hunt Project area. A smaller canal would exit that recharge site and continue northwest to a recharge site south of Dietrich. The estimated total canal length is 49 miles.

The excavation and embankment quantities for the assumed Milner-Gooding recharge canal were developed using USGS quad maps, irrigation district input, and actual site observation. The new canal would be placed east and north of the Milner-Gooding Canal and have similar depth and slope. The canal cross sections were determined for stretches whose elevations and depths could be determined from existing bench marks. The initial canal stretch was from the river diversion 33,700 feet to the first bridge north of Interstate 84. The bottom slope of the existing Milner-Gooding Canal was estimated to be 0.0113 percent, which was used for the proposed recharge canal. The cross section required to achieve a 7,000 cfs capacity at that slope is a bottom width of 148 feet with 1:1 side slopes and a flow depth of 15 feet.

The second and third canal stretches that reach to the point of diversion north of Eden, have a slope of 0.032 percent, which results in an 87-foot bottom width and 15-foot flow depth. Forty percent of the flow is diverted to cross the Milner-Gooding Canal and flow to the recharge sites along the North Side Canal. The canal to the recharge site north of Eden will have a bottom width of 21 feet and flow depth of 8 feet. A similar canal configuration will continue from that recharge site to the Red Bridge recharge site. The canal from the diversion to the North Hunt Project recharge site would have a 37-foot bottom width and 15-foot flow depth. The canal from the North Hunt site to the site south of Dietrich would have a 42-foot wide bottom and 8-foot flow depth.

The actual canal depth below the existing topography would vary with location from 6 to 40 feet for all the stretches of the canal. Excavation quantities were determined by comparing the estimated surface elevation with the canal bottom elevation at 1,000-foot intervals.

The largest cost factor included in the estimated cost of construction is rock excavation. Most of the existing Milner-Gooding Canal is constructed into the basalt bedrock through both farm land and rangeland. The rock excavation quantities used for cost estimation were derived through observation of the terrain and existing canal. Rock excavation factors were applied to the estimated total excavation on 1,000-foot sections throughout the canal. The rock excavation factors vary from 20 to 100 percent of the total excavation.

The structures required for the new canal include two diversions, two control structures, and 18 bridges. The diversion from the Snake River would be at Milner Dam pool and would not require any further damming of the river channel. The structure would be comprised of headgates and controls leading to the conveyance canal. The second diversion would be at the point where the flow would be split to follow along the Milner-Gooding and North Side canals. The control structures would be located at the outlets of the recharge sites north of Eden and north of the Hunt Project. These would be check structures with control gates to maintain the water level in the recharge sites and to control outflow to the other recharge sites. The bridges required for this project are located at the same locations as the existing Milner-Gooding Canal. Two large bridges would be required at the crossing of Interstate 84.

The estimated project quantities and unit prices were combined to develop an estimate of the total cost of the dedicated recharge canal. Unit costs for excavation and embankment, structure costs, and bridge costs were estimated in the same manner as for the assumed new Egin Bench recharge canal. The estimated cost to construct a new Milner-Gooding recharge canal is summarized in Table 5-2. No costs were included for improvements to the recharge sites that may be necessary.

The total estimated cost to construct a new canal with capacity of 7,000 cfs located in the Milner-Gooding area is $510 million.

3. Feasibility of New Canals

The clear conclusion from the above cost estimates is that construction of new canals is not economically feasible for a managed recharge program. Even if some of the design assumptions made above were to be modified within reasonable limits, the final cost estimate would not be reduced sufficiently to make new canals feasible.

Table 5-2. Preliminary Construction Cost Estimates for New Recharge Canal in Milner-Gooding Area

Assumptions

Unit Costs			Canal Sizing		
Rock Excavation	$30.00	per cubic yard [1]	Canal Length	49	miles
Soil Excavation	$7.00	per cubic yard [1]	Total Excavation	15.480.038	cubic yards
Embankment	$3.00	per cubic yard [1]	soil excavation = 29%		
Right-of-Way			rock excavation = 71%		
agricultural land	$3.000	per acre	Total Embankment	1.511.900	cubic yards
range land	$1.000	per acre	Right-of-Way		
			agricultural land	299	acres
			range land	644	acres

Estimated Costs [2]

Soil Excavation	$31.708.000
Rock Excavation	328.511.000
Embankment	4.536.000
Right-of-Way	
agricultural land	898.000
range land	644.000
Structures	6.351.000
(2 Diversions. 2 Control Structures & 18 Bridges)	
Sub-Total	372.648.000
Contingencies (25%)	93.162.000
Engineering (12%)	44.718.000
TOTAL ESTIMATED PROJECT COST	$510.527.000

[1] Unit costs provided by U.S. Bureau of Reclamation.

[2] Rounded to the nearest thousands.

B. USE OF EXISTING CANAL SYSTEMS

The economics of new canal construction dictate the use of existing canal facilities, with possible improvements, to convey water to recharge sites. The use of existing facilities will be feasible only if the owners of the canal systems consent to their use. Members of the consulting team responsible for this report arranged meetings with the canal companies and irrigation districts involved to determine their willingness to participate in a managed recharge program. Meetings with the parties listed in Table 5-3 were held in February 1998.

Table 5-3. Canal Company Contacts

Canal Company	Contact
A & B Irrigation District P.O. Box 675 Rupert, ID 83350	Dan Temple, Manager 208-436-3152
Aberdeen-Springfield Canal Company P.O. Box Y Aberdeen, ID 83210	Steve Howser, Manager 208-397-4192
American Falls Reservoir District 2 P.O. Box C Shoshone, ID 83252	Lynn Harmon, Manager 208-886-2331
Burgess Canal Company P.O. Box 536 Rugby, ID 83442	Lloyd Hicks, President 208-754-4302 (residence)
Fremont Madison Irrigation District P.O. Box 15 St. Anthony, ID 83445	Dale Swenson, Manager 208-624-3381
Minidoka Irrigation District 50 South 10 West Rupert, ID 83350	Billy R. Thompson, Manager 208-436-3188
North Side Irrigation District 921 North Lincoln Jerome, ID 83338	Ted Diehl, Manager 208-324-2319
Peoples Canal Company 1050 West Highway 39 Blackfoot, Idaho 83221	Cliff Merrill, President 208-684-4951 (residence)
New Sweden Irrigation District 2350 West 17 Street Idaho Falls, ID 83404-6540	Paul Bergren, Manager 208-523-0175

1. Participation by Canal Companies and Irrigation Districts

At the meetings with the canal companies and irrigation districts, the following questions were asked to initiate points for discussion:

- Would your organization be willing to participate in partnerships that would allow expansion of some parts of your canal system to carry water to sites where significant recharge could take place? Such expansions would take place at no cost to your organization. Annual assistance in operation and maintenance costs on expanded portions of your delivery system could be expected. Participation would require coordination of information and cooperation on your part.

- Does your organization have current plans to develop recharge sites other than the incidental recharge that is already occurring?
- What is, or will be, your anticipated source of recharge water: excess river flows or storage?
- Who would be the appropriate person or committee to use as a point of contact?

All the canal companies and irrigation districts were willing to participate in partnerships to transport water to recharge areas. They each were conducting recharge activities in cooperation with the Idaho Water Resource Board (IWRB) current program to some extent, using existing facilities and natural recharge areas. The source water for existing recharge efforts has been flows from their regular water rights that exceed demand at certain times during the year.

The representatives of the canal companies and irrigation districts had a number of concerns regarding existing and future recharge efforts in regard to cost, water rights, existing contracts and liability issues. The companies and districts were concerned with the economics of the recharge efforts. They are willing to participate, but need reimbursement for the cost of operation, particularly when no flows are found in the systems. They also want protection from the following sources of potential liability they perceive:

- Ground-water contamination resulting from managed recharge;
- Surface water safety associated with ponds and canals;
- High ground-water levels resulting from managed recharge;
- Adverse impacts on wildlife, including lost habitat;
- Additional human-animal interaction; and
- Increased animal and plant nuisances.

Company representatives also expressed concerns about the effect that recharge diversions may have on their existing water rights, particularly for the entities that are under the Palisades Winter Water Savings Contract, which requires no diversions for 150 days during the winter. They had concerns regarding the effect that recharge diversions may have on their normal maintenance period. They also raised questions regarding operational control and asked whether "strings would be attached" in regard to normal operations for the participating entities. Another area of concern is control of the recharge sites to limit access, vandalism and associated liabilities.

Notwithstanding the concerns raised, all the canal companies and irrigation districts involved in the meetings expressed a willingness to participate in a managed recharge program that uses their canals. Many questions must be answered, however, before they will be willing to commit their facilities for diversion and conveyance.

2. Physical Improvements

A large-scale managed recharge program will require that existing canals be improved with new headgate control structures at entry locations to laterals that connect to recharge ponds. A control structure will be needed at every location along a canal at which water is shunted into a new lateral. Each control structure consists of a headwall, a slide gate, a culvert through the canal bank, and a measuring device.

The cost of a control structure will depend upon the surface geology at the site and the flow capacity of the structure. Table 5-4 contains cost estimates for six classes of control structures: built into soil or rock, with a small, medium, or large capacity. A "small" structure is defined by a capacity of up to 10 cfs, a "medium" structure is defined by a capacity from 10 cfs to 70 cfs, and a "large" structure is defined by a capacity above 70 cfs.

The estimated cost to install a small headgate control structure through a soil canal bank is $1,700. The estimated cost to install in a canal bank with 50 percent solid rock is $2,100. This estimated cost is based on the use of a submerged orifice for measurement, a 15-inch slide gate with wheel lift, and a 15-inch corrugated metal pipe culvert 30 feet in length.

The estimated cost to install a medium headgate control structure through a soil canal bank is $5,400 and through a bank with 50 percent solid rock is $6,600. This estimated cost includes a 36-inch slide gate with wheel control, a 36-inch corrugated metal pipe culvert 30 feet in length, and an 8-foot-wide cipolletti weir.

The large headgate control structures could be constructed in a variety of ways. Corrugated metal pipe culverts are available in standard corrugated steel in sizes up to 8 feet in diameter. Wheel controlled slide gates are available in sizes up to 60 inches. Specific site topography and head conditions will determine if regular headgate and culvert construction is acceptable or if a concrete structure with radial gates should be used. The estimated cost to install a 60-inch headgate control structure through a soil bank using the hand-operated wheel-controlled slide gate is $18,000. The estimated cost to install the 60-inch headgate control structure through a canal bank with 50 percent solid rock is $22,200. Where concrete construction is required, those costs could range from two to ten times higher, depending on the site conditions.

Table 5-4. Preliminary Construction Cost Estimate for Headgate Control Structures

Flow Capacity	Geologic Material in Canal Bank	
	100 % soil	50% soil, 50% hard rock
Up to 10 cfs	$ 1,700	$ 2,100
10 cfs – 70 cfs	5,400	6,600
Above 70 cfs	18,000	22,200

In addition to new control structures, existing canals may be improved by capacity expansion. While control structures will be required, capacity expansion is an optional improvement. The need for expanded capacity depends on the amount of recharge water that can be delivered with existing capacity, given the availability of surplus flow in the Snake River, the environmental and institutional constraints, and the resulting hydrologic benefits. Additional analyses will be needed subsequent to this report to quantify any needs for expanded capacity. Therefore, we did not attempt to quantify the cost of capacity expansion, which will be sensitive to the magnitude of expansion for each canal.

Canal expansion may require all features of an existing canal system to be enlarged. The diversion structure at the Snake River may require widening and the construction of additional gates to provide sufficient capacity. The conveyance canals may require widening and/or deepening, particularly the laterals that lead to the recharge sites. Existing bridges, checks, and control structures may also require expansion.

C. Recharge Ponds

Costs associated with recharge ponds include land acquisition, facility improvements, and operation and maintenance costs. Land acquisition costs will depend in part on current ownership. The largest tracts of land available for recharge ponds are desert rangeland owned by the BLM. These lands may be acquired or leased at a very low direct cost. Before agreeing to provide these lands to a recharge program, however, BLM will require environmental studies to satisfy federal regulations. While most of the candidate sites are located on rangeland owned by BLM, some sites are owned by the State of Idaho or private individuals. These are primarily gravel pits and marginal farm land. The cost of purchasing or leasing private property for recharge projects is likely to be modest.

All the candidate recharge sites are in natural depressions that require minimal work to construct recharge facilities. Construction may be necessary to increase the capacity and performance of the ponds. Possible construction includes building perimeter dikes to allow use of more surface area, excavation to connect to nearby depressions, and grading and leveling to increase the useable area within each pond. In addition, small canals may be necessary to connect recharge sites. The scope of improvements will vary widely, depending on individual site characteristics.

Table 5-5 shows the unit costs of dikes and excavation. The cost of dike construction is shown per linear foot. Final cost would depend upon topography and size of the site. For example, a 50-acre pond may have a total perimeter length of about 6,000 feet. If 20 percent of the perimeter required a 10-foot dike to increase pond capacity, the cost of diking would be $33,600 (1,200 feet at $28/foot). If 5 percent of the pond required soil excavation to a depth of 3 feet, the cost of excavation would be $84,700.

Table 5-5. Unit Costs of Dike Construction and Excavation

Dike Height (feet)	**Quantity of Embankment Material (cubic yards/linear foot)**	**Estimated Dike Construction Cost[1] ($/linear foot)**
5	3.3	$10
10	9.3	28
15	19.2	58

Excavation Material	**Unit Cost[2] ($/cubic yard)**
Soil	$ 7
Rock	30

[1]Estimated dike construction cost based on materials for the embankment being located on site and does not include engineering and permits required for larger dikes.
[2]Unit costs provided by USBR and are based on disposal of excavated materials on site with a minimal haul distance.

The operation and maintenance of the recharge ponds will also vary with each site. While one of the site characteristics that is most desirable is permeability of the soil surface, that characteristic needs to be tempered by the desire to achieve some filtration of the recharge water through suitable soil material, whether natural or constructed. The soil surface may require care during off-season months to maintain permeability. Undesirable plants and insects will have to be controlled. To the extent that the ponds will be operating in normal slack times of year for the companies and districts, personnel normally laid off may have to be retained to manage the ponds. Operations that occur during freeze/thaw cycles in the winter will require additional maintenance and supervision. The detailed economic analysis of the priority sites that will occur subsequent to this report will evaluate site-specific operation and maintenance costs.

D. WATER-QUALITY MONITORING

Water quality monitoring of both surface water as the source and ground-water in the vicinity and downgradient of a recharge facility can incur considerable costs in addition to the costs associated with the actual construction and operation of a recharge facility. No cost estimates are provided as part of this analysis, since the costs are so site- and facility-specific. Instead, factors to consider in estimating costs are as follows:

- Hydrogeologic site characterization – the character and hydraulic properties of geologic materials underlying and extending some distance from the recharge site. An assessment needs to be made of the suitability of surface soils to act as a filtration medium as well as any subsurface sedimentary interbeds. May require test drilling and/or geophysics.

- The cost of providing a suitable filtration medium, if one does not naturally occur at the recharge site, needs to be considered.

- Determine the number and cost of drilling and equipping new wells or retrofitting existing monitoring wells that will provide adequate information on water level and water-quality changes occurring in the vadose zone and in the regional aquifer in the vicinity of and downgradient from the recharge site.

- Availability of existing data on water quality parameters of interest for the surface water used as a source for recharge. The cost of monitoring will be contingent upon the parameters to be monitored, at what frequency, and using what methods, needs to be determined.

- A means of real-time monitoring key water-quality parameters needs to be included in any cost estimate, to allow recharge to be halted before polluted water could enter the recharge facility. An automated system that would close the diversion works in the event of parameter monitoring exceedance would be the preferred alternative.

- Cost of a site survey to characterize land use and cover. If the recharge site accepts surface runoff from grazed land or has existing dump sites, for instance, plans could be made to either divert runoff or restrict access to the runoff contribution area.

- Cost of developing and maintaining a contingency plan to protect ground-water users in the area of influence of the recharge facility has to be considered should pathogenic contaminants be introduced into the aquifer.

- Public drinking water systems that are determined to be under the direct influence of surface water under the federal Safe Drinking Water Act may be required to perform additional expensive monitoring and disinfection.

Most of the costs are site- and scale-specific. Someone proposing a recharge project should contact the appropriate regulatory agency, e.g. Idaho Division of Environmental Quality (if the recharge site is a pit, pond, or lagoon), early in the project-planning process to cooperatively develop an acceptable water-quality monitoring plan from which realistic cost estimates associated with monitoring can be made. IDEQ has indicated that a well-designed water-quality monitoring plan could be of material help in greatly reducing potential liability of the project sponsor for ground-water contamination. A recharge facility contemplating the use of injection wells should follow the same course of action with the Idaho Department of Water Resources.

VI. CANDIDATE SITES FOR MANAGED RECHARGE

Numerous potential recharge sites have been identified throughout the Eastern Snake Plain, based on previous studies, interviews with canal company and irrigation district personnel, and through field observation. The following is a brief description of the location and features of the potential sites categorized by the irrigation entity that is located nearest to the site. Although other potential sites that are not described here have been proposed, the following discussion accounts for the larger and most promising candidate sites for a regional-scale managed recharge program. The candidate sites are summarized in Table 6-1. Site locations are shown on Figure 6-1.

A. FREMONT-MADISON IRRIGATION DISTRICT

Five sites have been identified within the Fremont-Madison Irrigation District Service area. The sites are:

- Recharge Canal,
- Egin Lakes Recreation Area,
- Nine Mile Knoll,
- Quayles Lake, and
- Beaver Dick State Park.

The Recharge Canal is the existing irrigation lateral traveling from the St. Anthony Canal to the Egin Lakes Recreation Area. It is located north and west of St. Anthony in Section 31, Township 8 North, Range 39 East and Sections 1, 2, and 3 of Township 7 North, Range 39 East. The soil along the five-mile canal length has a high permeability and the Irrigation District estimates that the canal contributes up to 40 cfs to the ground water.

The Egin Lakes Recreation Area site is located in Sections 3, 4, and 5 of Township 7 North, Range 39 East, eight miles west of St. Anthony. The recharge site features a natural depression bordered on the north by sand dunes and on the east, south, and west by higher farm and range ground. This site is currently used for recharge with water delivered through existing canals. Additional recharge capacity is available; however, the capacity of the supply canal will have to be increased. The recharge site occupies approximately 70 acres on publicly owned property administered by the BLM.

Table 6-1. Summary of Potential Recharge Sites

Figure 7-1 Reference		Recharge Site	Capacity Characteristics: Recharge Rate	Pond Area [1]	Perme-ability [2]	Property Owner	New Construction Requirements [3]
A		Fremont - Madison Irr. Dist.					
	1	Recharge Canal	40 cfs			District	none
	2	Egin Lakes Recreation Area		70 ac	H	Private	increase canal capacity
	3	Nine Mile Knoll		250 ac	H	BLM	control structure
	4	Quayles Lake		70 ac	M/H	BLM & Private	control structure & 1,000-ft dike
	5	Beaver Dick State Park		480 ac	M/H	BLM	increase canal capacity
B		Burgess Canal Company					
	1	Gravel Pits	500 cfs			Private	none
C		Harrison Canal Company					
	1	Sink Holes	15 cfs			Unknown	none
D		New Sweden Irrigation District					
	1	New Sweden Reservoir	50 cfs			District	none
	2	State Highway Gravel Pit		15 ac	H	State	headgate control structure
	3	Gravel Pit New Swed Sch Rd		60 ac	H	Private	headgate control structure
	4	Martin Canal Sinkholes		6 ac	H	Private	headgate control structure
	5	Sinkhole Canal		Med.	M/H	District	headgate control structure
	6	Lava Flows West Of Dist		Lg.	H	BLM	pump stations
E		Butte Market Lake Canals					
	1	Lava Flows West of Canals		Lg.	H	Private & BLM	pump stations
	2	Depressions Robinson Canal		460 ac	L/M	Private	headgate control structure
F		People's Canal Company					
	1	Gravelly Farm		160 ac	M/H	Private	headgate control structure
	2	Sink Holes along Lavas		Med.	H	Private	headgate control structures
	3	People's Canal Spillway Pond	6 cfs			Canal Co.	none
	4	Moreland Gravel Pit [4]		10 ac	H	Private	expand canal & control structure
G		Aberdeen Springfield Canal Co.					
	1	Upper Reaches Main Canal		Lg.	H	Canal Co.	none
	2	Rose Spill		Med.	H	Canal Co.	none
	3	Gravel Pits at Mile 12.5		60 ac	H	Private	headgate control structure
	4	Gravel Pits at Mile 13.5 [4]		10 ac	H	Private	headgate control structure
	5	Hilton Spill	150 cfs			Canal Co.	none
	6	Depression at Mile 29.0		20 ac	H	Private	headgate control structure
	7	Depression at Mile 31.0		10 ac	H	BLM	headgate control structure
	8	Depression at Mile 31.5		80 ac	H	BLM	headgate control structure
	9	Depression at Mile 32.5		60 ac	H	BLM	headgate control structure
	10	Big Fill Reservoir		60 ac	M	Canal Co.	small dike

Table 6-1. Summary of Potential Recharge Sites (continued)

Figure 7-1 Reference		Recharge Site	Capacity Characteristics: Recharge Rate	Pond Area [1]	Perme-ability [2]	Property Owner	New Construction Requirements [3]
H		A & B Irrigation District					
	1	Lava's North of Lake Walcott	150 cfs			BLM	pump stations
	2	Well 33B922	8 cfs			District	overflow pipes
	3	Well 33C922	8 cfs			District	overflow pipes
	4	D-D Drain		70 ac	H	Private	standpipe
	5	A Drain [5]		80 ac	M/H	State of Idaho	none
	6	C Drain Pond [6]		40 ac	M/H	BLM	pump station & pipeline
	7	Well 20A922	7 cfs			District	connecting pipe
	8	F Drain	25 cfs			BLM	pump station (under const.)
	9	Well 22A922	3 cfs			District	connecting pipe
	10	Well 26A922	15 cfs			District	pump station & pipeline
	11	Well 02A1021	10 cfs			District	connecting pipe
I		Minidoka Irrigation District					
	1	Near Minidoka Dam [5]		80 ac	M/H	State of Idaho	none
	2	Camp Holley Lake		60 ac	M/H	BLM	none
	3	Goyne Sump		40 ac	M/H	BLM	none
	4	C Drain [6]		40 ac	M/H	BLM	pump station & pipeline
J		American Falls Res. Dist. No. 2 Upper Recharge Area					
	1	Mile 7.8		100 ac	H	Private & BLM	headgate control structure
	2	Mile 10.3		12 ac	H	BLM	headgate control structure
	3	Mile 12.2		20 ac	H	BLM	headgate & 80-ft dike
	4	Mile 12.7		40 ac	H	Private & BLM	40-ft dike
	5	(Combined Mile 12.2 & 12.7)		200 ac	H	Private & BLM	280-ft dike
	6	Mile 19.0		30 ac	H	BLM	headgate control structure
	7	Mile 22.6		100 ac	H	BLM	headgate control structure
K		American Falls Res. Dist. No. 2 Middle Recharge Area					
	1	Mile 24.9		40 ac	H	Private & BLM	170-ft dike, 20-ft high
	2	Mile 25.5		40 ac	H	Private & BLM	100-ft dike
	3	Mile 26.5		120 ac	H	BLM	1,400-ft dike
	4	Mile 28.1		10 ac	H	BLM	none
	5	Mile 31.0		600 ac	H	BLM	headgate control structure
	6	Star Lake		600 ac	M/H	State of Idaho	3.2-mile canal, 40-ft deep [7]
	7	Mile 32.0, north of canal		160 ac	H	BLM	headgate control structure
	8	Mile 32.0, south of canal		700 ac	H	BLM	headgate control structure
	9	Mile 33.0 to Mile 34.0		500 ac	H	BLM	headgate control structure
	10	Mile 34.5, east of canal		200 ac	H	BLM	headgate control structure
	11	Mile 34.5, west of canal		80 ac	H	BLM	headgate control structure

Table 6-1. Summary of Potential Recharge Sites (continued)

Figure 7-1 Reference	Recharge Site	Capacity Characteristic: Recharge Rate	Pond Area [1]	Perme-ability [2]	Property Owner	New Construction Requirements [3]
	American Falls Res. Dist. No. 2					
L	Lower Recharge Area					
1	State Highway 75		100 ac	H	BLM	headgate control structure
2	Lower Snake River Aquifer	300 cfs			BLM	none
3	Lower Snake River Aquifer	600 cfs			BLM	excavation
4	Dahar Flume		River Chan.	M/H	State of Idaho	none
5	Gooding Little Wood Bypass		Med.	M/H	Private	none
	North Side Canal Company					
M	Upper Recharge Area					
1	Pump Station #1		5 ac	L/M	Private	none
2	Wilson Lake Reservoir	200 cfs			BLM & Private	none
3	Wilson Canyon		30 ac	H	BLM	headgate & 200-ft canal
4	Near Wilson Lake		200 ac	H	BLM	headgate & 1-mi. canal
5	Eden Butte Site		100 ac	M/H	Private & BLM	none
	North Side Canal Company					
N	Middle Recharge Area					
1	Near F Canal Diversion		200 ac	M/H	Private	none
2	Sugarloaf Reservoir	400 cfs			Private	none
3	Near K Canal Diversion		160 ac	M/H	BLM	headgate control structure
4	1/2 Mile Upstream of Red Bridge		10 ac	M/H	BLM	headgate control structure
5	Red Bridge Site	22 cfs			Private	none
6	Prescott Pond	3 cfs			Private	none
	North Side Canal Company					
O	Lower Recharge Area					
1	Thousand Springs Wetland	10 cfs			Canal Co.	none
2	Section 8 T 8 S, R 14 E		Med.	M	Canal Co.	none
3	End W Canal		Med.	H	BLM	none
4	J-3 Lateral		Med.	H	BLM	none
5	X Canal		370 ac	M/H	Private & BLM	11-headgate control structures
6	X-4 Canal		100 ac	M/H	BLM	headgate control structure

[1] Med. = 35 to 100 acres, Lg. = 100+ acres.

[2] L = .06 to 0.2, M = 0.6 to 2, and H = 6 to 20 inches per hour.

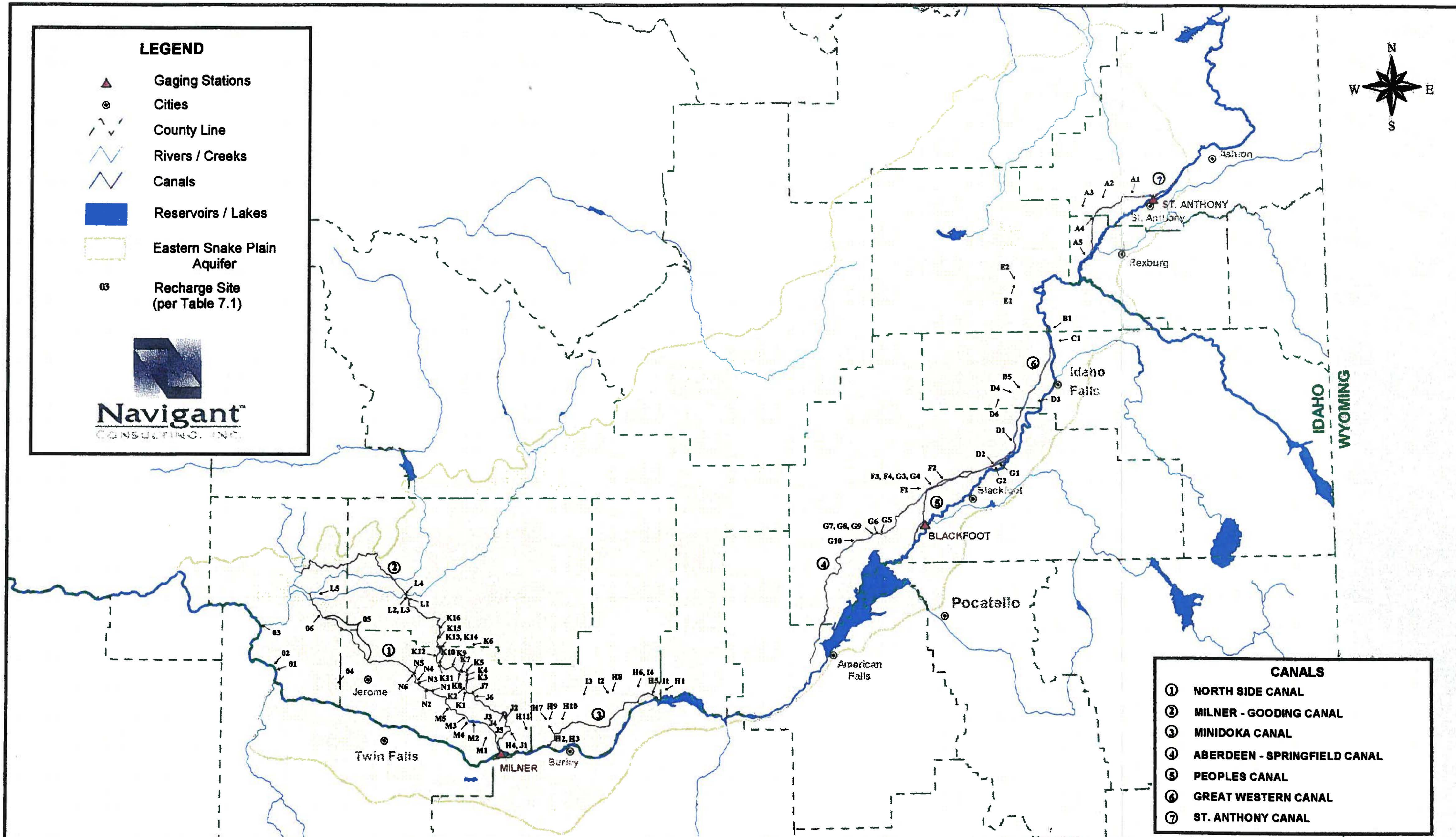
[3] Unless otherwise noted, dikes are approximately 10-feet in height.

[4] Water from the People's Canal and Aberdeen-Springfield Canal can both be delivered to Moreland Gravel Pit.

[5] The A Drain of the A & B District and the Near Minidoka Dam of the MID are the same site.

[6] Water from the A & B District and MID can be delivered to the C Drain Pond.

[7] Alternative construction at Star Lake is a 500-ft pipline with a pumping plant.



SCALE

10 0 10 20 Miles

EASTERN SNAKE PLAIN AQUIFER MANAGED RECHARGE PROJECT

CANDIDATE RECHARGE SITES

IDAHO DEPARTMENT OF WATER RESOURCES

FIGURE 6-1

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The proposed Nine Mile Knoll recharge site is located in Sections 6 and 7, Township 7 North, Range 39 East and Sections 11, 12, 13, and 14, Township 7 North, Range 38 East. The water supply for the site would flow from the Egin Lakes Recreation Area, one mile to the east. The site is desert rangeland with numerous pockets and a sandy soil surface that could have a recharge area of 250 acres. This site has historically been used for overflow from the Fremont-Madison Irrigation District system and has shown good permeability characteristics. The recharge site and surrounding property is public property administered by the BLM. A control structure would be required at the Egin Lakes Recreation Area Site to maintain water levels in the recharge pond.

The Quayles Lake site is located in Sections 18 and 19 of Township 7 North, Range 39 East, approximately 10 miles west and two miles south of St. Anthony. The site was formerly a lake that has been partially drained for use as farmland under private ownership. The existing lake covers 25 to 30 acres. An additional pond area to the south on public property administered by the BLM could increase the size by 40 acres. The abandoned regulating structure would have to be reactivated and a 1,000-linear-foot dike constructed to prevent runoff onto adjacent farmland. Additional potential recharge sites are located on public property located west of the Quayles Lake Site in Sections 13 and 24 of Township 7 North, Range 37 East. Water is transported to the site through existing canals and the existing lake is used for overflow and canal regulation. The soil at the site is finer-grained than that at the Egin Lakes Recreation Area or Nine Mile Knoll, but still exhibits good permeability. Minor diking may be required to fully utilize the capacity of the site.

The Beaver Dick State Park site is located in Sections 18 and 19 of Township 6 North, Range 39 East and Section 24, Township 6 North, Range 38 East. The recharge site is west of the state park and north of State Highway 33. The useable area of the recharge site is approximately 480 acres on public property administered by the BLM. The surrounding topography is desert rangeland. The canals serving this site would have to be expanded to realize the full recharge potential. The site is located within one mile of the Henry's Fork of the Snake River.

B. BURGESS CANAL

The Burgess Canal supplies irrigation water to the Rigby Fan area south of the Snake River in Jefferson County. The canal contributes to the ground water in the area through normal operations. Additional ground-water recharge can be accomplished by diverting water at the west end of the canal into existing gravel pits in Section 36, Township 4 North, Range 37 East. The porous gravel soils have rapid permeability. The recharge site is located only one mile east of the Snake River.

C. HARRISON CANAL COMPANY

The Harrison Canal Company provides irrigation water to the area south of the Burgess Canal Company. The potential recharge site is located at the end of the Harrison Canal in Sections 8 and 17 of Township 3 North, Range 38 East. The site has numerous sinkholes that currently accept up to 15 cfs of excess water. The recharge capacity may be enhanced with only minor work. This site is located one mile east of the Snake River.

D. New Sweden Irrigation District

The New Sweden Irrigation District provides irrigation water to the area west and south of Idaho Falls through the Great Western Canal. The service area contains six potential recharge sites:

- New Sweden Reservoir,
- Idaho Transportation Department (ITD) gravel pit,
- Gravel pits on New Sweden School Road,
- Martin Canal Sinkholes,
- Sinkhole Canal, and
- Lava flows west of the district.

The New Sweden Reservoir is located in Section 11, Township 1 South, Range 36 East, four miles west and two miles south of Shelley. The site is a sinkhole area of 8 to 10 acres that has been previously used for aquifer recharge of up to 50 cfs. The water is delivered to the site through the Basalt Canal. The surrounding topography is farmland with numerous residences.

The ITD gravel pit is located in the southeast quarter of Section 32, Township 1 South, Range 36 East at the end of the New Sweden System. The pit has a surface area of 10 to 15 acres and is approximately 20 feet deep. The canal leading to the site has a capacity of 20 cfs and may require enlarging to utilize the full potential of the recharge site. A headgate control structure would be required to divert the recharge water from the lateral that passes west of the pit.

The gravel pits on New Sweden School Road are located in Section 3, Township 2 North, Range 37 East, north of U.S. Highway Business 15. The site is privately owned and no intentional recharge has been conducted. The gravel pits occupy approximately 60 acres in the farm and residential neighborhood. The site is bordered on the east by the Snake River.

The Martin Canal Sinkholes site is located in Section 25 and 36, Township 2 North, Range 36 East. The site has a natural depression of 5 to 6 acres beside the canal that contains several sinkholes. Also water flow at the end of the canal is injected into the aquifer through a well located in Section 25. A headgate control structure would be required to supply water to the depression. The surrounding topography is irrigated farmland with an increasing number of residences.

The Sinkhole Canal site is located in Section 20, Township 2 North, Range 37 East. The site is located in the bottom of the canal and opens up annually to divert water into the ground. The site could be used for recharge by diverting the canal around it and utilizing the sinkhole for recharge. The surrounding topography is rapidly changing to residential use.

The West Side of the New Sweden Irrigation District is bordered by lava flows that are elevated above the adjacent farmland. The site provides a large area with an irregular rocky surface that could hold water for recharge. The water would have to be pumped from the existing laterals to the recharge sites.

E. BUTTE-MARKET LAKE CANALS

The Butte-Market Lake Canals provide irrigation water to the areas northwest and southwest of Roberts. There are two types of candidate sites. First, the area west of the farmland is characterized by irregular lava flows. Numerous potential recharge sites can be found throughout the lava flows; however, water from the existing laterals would require pumping to reach the sites.

Second, existing depressions that are under cultivation in Sections 9, 10, and 15, Township 5 North, Range 36 East, could be utilized for recharge with water from the Robinson Canal. The recharge ponds would occupy approximately 460 acres. The sites are located two miles west of the Market Lake Slough.

F. PEOPLES CANAL COMPANY

The People's Canal supplies irrigation water to the area west and southeast of Blackfoot. Four potential recharge sites were identified in the People's Canal service area:

- Gravelly farm land near the last crossing with the Aberdeen-Springfield Canal,
- Sinkholes along the lava flows,
- People's Canal Spillway Pond, and
- Moreland gravel pit.

The gravelly farmland near the last crossing of the Aberdeen-Springfield Canal is located in Section 29 of Township 2 South, Range 34 East, two miles west of Moreland. The site is currently farmed, but the high soil permeability may make the property more valuable for recharge. Two large natural depressions of nearly 160 acres in the northern half of Section 29 may provide a good recharge site. A headgate control structure would be required to divert recharge water from the canal. The surrounding topography is farmland.

The sinkholes along the lava flows are west of the People's Canal. Several potential recharge sites are found here in Sections 4, 5, 7, and 8, Township 2 South, Range 35 East and Sections 13, 14, and 15, Township 2 South, Range 34 East. The sites are typically low areas against the elevated lava flows. The sinkholes will include many sites that may have separate turnouts from the Main canal. The property is privately owned farmland with a number of residences north of Moreland.

The People's Canal Spillway Pond site is located in Section 16 and 23, Township 2 South, Range 34 East, just west of state Highway 26. The pond has an area of 15 acres and belongs to the People's Canal Company. The Intermountain NLP Institute (1996) indicates the pond will recharge at a continuous rate of 6 cfs. No construction would be required to use this site.

The Moreland Gravel Pit is located in Section 23, Township 2 South, Range 34 East. The site occupies 10 acres with an irrigation lateral running beside the pit. The Intermountain NLP Institute (1996) estimates the infiltration capacity of the site to be 10 cfs continuously. The irrigation lateral would have to be expanded for approximately three-quarters of a mile to supply that amount of water. The site would also require construction of a control structure. The People's Canal Company Board Members were concerned about shallow wells and ground water in the area and the potential for contamination. The site is at the north edge of the City of Moreland with many new residences in the surrounding area. There are small ponds in the bottom of the pit resulting from seepage from the nearby lateral.

G. ABERDEEN-SPRINGFIELD CANAL COMPANY

The Aberdeen -Springfield Canal Company provides irrigation water for the area west of Blackfoot and north of the American Falls Reservoir. Water is diverted near Firth and travels west and south along the same route as the People's Canal, but continues on farther west. Ten potential recharge sites have been identified along the Aberdeen-Springfield System:

- Upper reaches of the Main Canal
- Rose Spill
- Gravel pits at Mile 12.5
- Gravel pits at Mile 13.5
- Hilton Spill
- Depressions at Mile 29.0
- Depressions at Mile 31.0
- Depressions at Mile 31.5
- Depressions at Mile 32.5
- Big Fill Reservoir

The upper reaches of the Main Canal from the river diversion to the gravel pit at Mile 13.5 have a gravelly porous channel. An undetermined amount of recharge occurs here during normal operations. The recharge could be enhanced by maintaining water flows for a longer period of time. No new construction would be required to recharge at this site.

The Rose Spill is located in Section 4, Township 2 South, Range 36 East. The spill is controlled by a radial gate structure and leads south returning to the Snake River, three-quarter mile to the south. The soil is very gravelly and infiltration is expected to be high. The Board of Directors of the Aberdeen-Springfield Canal Company has agreed to run water through the spill year-round for recharge. No new construction would be necessary for this site.

The gravel pits at Mile 12.5 are located in Sections 13 and 24, Township 2 South, Range 34 East, northeast of the City of Moreland. There are two gravel pits at this location on either side of the canal. The gravel pit on the north covers approximately 20 acres and would require a headgate control structure for recharge activities. The gravel pit to the south occupies approximately 40 acres and would require a headgate control structure and 400 to 500 feet of canal. Both gravel pits are still operating and the surrounding land is developing into a residential neighborhood.

The gravel pit at Mile 13.5 is located in Section 23, Township 2 South, Range 34 East at the northern edge of the City of Moreland. The site is approximately 10 acres with a depth of 15 to 20 feet. The construction required to develop this as a recharge site includes a headgate control structure and 50 feet of pipe to place the water at the bottom of the pit to prevent erosion. The surrounding land use is residential and commercial. This site is the same as the Moreland Gravel Pit described in the People's Canal section.

The Hilton Spill at Mile 28 is located in Section 31, Township 3 South, Range 33 East. The site is used for regulation by the canal company with up to 120 acres under water. The canal company reports that the site will accept 150 cfs on a continuous basis. No construction would be necessary to use the site. The surrounding land use is farming to the south and rangeland to the north.

The depression at Mile 29.0 is located north of the canal just west of Judge Road in Section 1, Township 4 South, Range 32 East. The site is privately owned desert rangeland and approximately 20 acres in size. A headgate control structure would be required to use this site. The surrounding land use is rangeland to the north and farmland to the south.

The depression at Mile 31.0 is located in Section 2, Township 4 South, Range 32 East, north of the canal and west of a county road. The site is approximately 10 acres in size and is publicly owned desert rangeland administered by the BLM. This site was formerly used as a landfill that was closed approximately five years ago.

The depression at Mile 31.5 is located in Sections 2 and 3, Township 4 South, Range 32 East along the north edge of the canal. The site has several depression areas that could be fed through a new headgate control structure. The total size of the affected rangeland is estimated to be 80 acres. The site and surrounding land use are publicly owned rangeland administered by the BLM north of the canal and farmland on the south side.

The site at Mile 32.5 consists of depressions in the desert range area that could be reached through an unused excavated canal channel. Some blasting and rock excavation may be required to increase flow to the required amount. A headgate control structure would be required in Section 3, Township 4 South, Range 32 East. The recharge site is located in Section 4, Township 4 South, Range 32 East. The recharge pond would cover approximately 60 acres of public property administered by the BLM. The surrounding land use is desert rangeland.

The Big Fill Reservoir is located north of the Main Canal at the diversion where the High Line and Low Line canals split. It is located in Section 7, Township 4 South, Range 32 East in desert rangeland. The reservoir is used by the canal company as a regulating pond and is approximately 40 acres in size. Little infiltration occurs here because of the soil type and the sealing effects of continuous inundation. The water level could be raised to increase the size of the pond to 60-acres and increase recharge. No new construction would be necessary to divert more water; however, a small amount of diking may be required to prevent runoff onto adjacent property.

H. A & B Irrigation District

The A & B Irrigation District is a project developed by the USBR to provide irrigation water to Minidoka and Jerome counties, north and west of Rupert and Paul. Water is provided to the A portion from a lift station on the Snake River located in Section 25, Township 10 South, Range 21 East. The B portion of the project is supplied with ground water from a number of wells across the area with conveyance canals to individual takeouts. Excess irrigation and sub-water is removed from the area through drain laterals and injection wells. Eleven potential recharge sites have been identified in the A & B Irrigation District area:

- Lava flows north of Lake Walcott
- Well 33B922
- Well 33C922
- D-D Main Drain
- A Drain
- C Drain Pond
- Well 20A922
- F Drain
- Well 22A922,
- Well 26AD922
- Well 02A1021

The A & B Irrigation District has reviewed these sites in its Recharge Action Planning Guide and the following is a summary of their findings.

The A & B Irrigation District Action Planning Guide identifies three recharge sites in the lava flows north of Lake Walcott. These sites are located in desert rangeland in Sections 22, 23, 26, 29, and 30 of Township 8 South, Range 26 East and Section 36, Township 8 South, Range 25 East. These sites would require pumping plants to move recharge water from Lake Walcott to the sites at which it would pond in natural depressions. The capacities of the sites are estimated to range from 125 to 150 cfs. The property is publicly owned and administered by the BLM.

Wells 33B922 and 33C922 are located in Section 33, Township 9 South, Range 22 East. In the past, the wells were used to supply irrigation water, but have been abandoned because of declining water levels. The site would require overflow pipes from the nearby irrigation lateral to the wells. The estimated recharge capacity of wells is 16 cfs. The surrounding land use is farmland.

The recharge site on the D-D Main Drain is located in Section 33, Township 9 South, Range 21 East, adjacent to the east side of the Milner-Gooding Canal. The site could be constructed by installing a standpipe on the culvert that crosses under the Milner-Gooding Canal and redirecting the drain back to its original location. The estimated size of the recharge pond is 80 to 100 acres. The surrounding land use is desert rangeland and farmland.

The A Drain site is located in Sections 34 and 35 of Township 8 South, Range 25 East near the outlet of Lake Walcott. The A Drain ponds up against the embankment of the Minidoka Irrigation District's Main North Side Canal on state-owned property. An existing headgate structure could release water from the canal to the site. The recharge pond could be enlarged with little effort to a size of approximately 80 acres. The surrounding land use is desert rangeland.

The C Drain Pond is located in Section 29, Township 8 South, Range 25 East. Water can be delivered to this area through the Minidoka Irrigation District system and could be pumped to the recharge site. Work has begun to build facilities to transfer water from injection wells at this site to Section 30, where drainage from the D-D Drain is already being relocated. The recharge sites in Section 30 are in desert rangeland with sandy soils and have a surface area of approximately 40 acres. Section 30 is public property administered by the BLM.

Well 20A922 is located in Section 20, Township 9 South, Range 22 East. A pumping plant moves water from the "Kerr Grain Pond" to the site of this former production well, now abandoned, to provide irrigation water. This same system could be used for recharge through the well. The estimated capacity of the well for recharge is 7.1 cfs.
The F Drain site is located in Section 33, Township 8 South, Range 24 East, on publicly owned desert rangeland administered by the BLM. The A & B District is currently constructing pumping facilities to divert irrigation runoff from the F Drain in Section 32 to the recharge pond. The F Drain currently ends at Camp Holley Lake, where the excess water is injected into wells. The depression that can be used for a recharge pond occupies 50 to 60 acres and has a sandy soil surface.

Well 22A922 is located in Section 22, Township 9 South, Range 22 East. The district has constructed a pumping plant from the lateral downstream of the "Kerr Grain Pond" to provide irrigation water to the vicinity. Recharge could be accomplished by operating the system during the non-irrigation season and injecting the pumped flow into the well. The expected recharge capacity is 3 cfs.

Well 26AD922, located in Section 23, Township 9 South, Range 22 East, is a former injection well that was closed a number of years ago. The site would require a pumping plant and pipeline to utilize the full capacity of the well, which is estimated to be 10 to 15 cfs. There are a number of domestic wells within the vicinity of this site.

Well 02A1021 is located in Section 2, Township 10 South, Range 21 East. Water could be delivered from the "D" lateral by installing a connecting pipe from the lateral to the well. The estimated recharge capacity of the well is 7 to 10 cfs. The surrounding land use is farmland.

I. MINIDOKA IRRIGATION DISTRICT

The Minidoka Irrigation District (MID) diverts water from the Snake River at Lake Walcott to irrigate the farmland around Rupert and Paul. Four potential recharge sites have been identified in the MID service area:

- Near Minidoka Dam,
- Camp Holley Lake
- Goyne Sump
- Terminus of the C Drain

The potential recharge site near the Minidoka Dam is located in Sections 34 and 35 of Township 8 South, Range 25 East. This is the same location as the A Drain site of the A & B Irrigation District. The site has a headgate turnout to the lower elevation state-owned rangeland on the north side of the Main North Side Canal. The size of the potential recharge pond is approximately 80 acres.

Camp Holley Lake is a wetland of approximately 60 acres on publicly owned property managed by the BLM. It is located in Section 6, Township 9 South, Range 24 East at the end of the A & B Irrigation District F Main Drain and near the MID B-1 Canal. Excess drainage is injected through injection wells. The site could be used for recharge in the non-irrigation part of the year with no additional construction.

The Goyne Sump is located in Section 10 of Township 9 South, Range 23 East at the end of the D-9 Drain. The site is a low area that receives runoff from the north into a 40-acre wetland. Excess drainage is injected through a 6-foot-diameter well that opens into a lava tube. Three MID laterals also end at this site. The capacity of the injection well is large, although not specifically known. Additional recharge could be accomplished through operations during the non-irrigation season with no new construction. The property is publicly owned and administered by the BLM.

The potential recharge site at the end of the C Drain is located in Section 29, Township 8 South, Range 25 East. This is the same location as the C Drain described in the A & B

Irrigation District recharge sites. Recharge water could be delivered here through MID laterals.

J. AMERICAN FALLS RESERVOIR DISTRICT #2

The American Falls Reservoir District #2 supplies irrigation water to eastern Jerome County and Gooding County through the Milner-Gooding Canal. The canal diversion is at Milner Dam on the Snake River south of Hazelton. The canal runs through many miles of lava rock and desert rangeland and contains numerous potential recharge sites of varying size. The sites can be divided into three areas that will have different zones of influence on the ground water. These areas are the upper Milner-Gooding, middle Milner-Gooding and lower Milner-Gooding. Additional potential recharge sites in the lower area may involve water from the Little and Big Wood Rivers or involve the channels of those rivers. There are seven potential recharge sites along the upper Milner-Gooding Canal:

- Mile 7.8
- Mile 10.3
- Mile 12.2
- Mile 12.7
- Combined Mile 12.2 & 12.7
- Mile 19.0
- Mile 22.6

The first potential recharge site along the upper Milner-Gooding Canal is at Mile 7.8, the same location as the D-D Main Drain of the A & B Irrigation District. This site is a desert rangeland depression east of the canal that could have recharge water diverted to it with the installation of a headgate control structure and a culvert standpipe extension on the D-D Main Drain. The recharge pond could cover 80 to 100 acres. The site is located in Section 33, Township 9 South, Range 21 East on private property and public land administered by the BLM.

The potential recharge site at Mile 10.3 is in the desert rangeland east of the canal in Section 29, Township 9 South, Range 21 East. The site has a potential recharge pond size of 10 to 12 acres that could be utilized with the construction of a headgate control structure. The topography of the surrounding property is desert rangeland with numerous lava outcroppings. The site is located on public lands administered by the BLM.

The potential site located at Mile 12.2 is a narrow draw west of the canal that could be used by constructing a 80-linear-foot dike at the west end. A headgate control structure would have to be constructed to divert water to the site. The recharge pond is estimated to occupy 20 acres. The surrounding topography is extremely rocky desert rangeland. The site is on public lands administered by the BLM.

At Mile 12.7, the Milner-Gooding Canal crosses the EE Main Drain of the A & B Irrigation District in a concrete flume. The flume is equipped with outlet gates for emergency spillage of the canal. The site southwest of the crossing is a rough desert sloping slightly to the southwest. A recharge site could be developed with the construction of a 40-linear-foot dike to retain water from the gates, creating a pond of approximately 40 acres. The recharge sites at Mile 12.2 and 12.7 could be combined with the construction of a larger 280-linear-foot dike up to 10 feet tall that would create a pond of 200 acres or more. Part of the Mile 12.7 site and the combined site is on private property, but the majority is on public property administered by the BLM.

The site located at Mile 19.0 is in Section 11, Township 9 South, Range 20 East. This site is located one-quarter mile southwest of Cinder Butte and is desert rangeland. A headgate control structure would be required in the north bank of the canal to feed a recharge pond of about 30 acres. The site is on public lands administered by the BLM. The site located at Mile 22.6 is in Section 32, Township 8 South, Range 20 East. A headgate control structure would be required through the north bank of the canal. The recharge pond would be located in desert rangeland covering from 80 to 100 acres. The site is on public property administered by the BLM. The surrounding land use is desert rangeland.

The middle Milner-Gooding recharge area stretches from the northern edge of the Hunt Project to Dietrich. There are 16 potential recharge sites in this area:

- Mile 24.9
- Mile 25.5
- Mile 36.5
- Mile 28.1
- Mile 31.0
- Star Lake
- Mile 32.0, north of canal
- Mile 32.0, south of canal
- Mile 33.0 to Mile 34.0
- Mile 34.5, east of canal
- Mile 34.5, west of canal
- Mile 36.0
- Mile 37.5
- Mile 38.0
- Mile 39.0 to Mile 41.0
- Mile 41.5

The first site is located at Mile 24.9 in Section 30, Township 8 South, Range 20 East. There is a headgate and culvert through the south bank and a channel flowing west through a Cipolletti weir. The channel flows out into Section 25, Township 8 South, Range 19 East across desert rangeland owned by public and private entities. Since no large depressions are noted on the USGS 1:24000 quadrangle map, a pond area would have to be created. A 100-linear-foot dike with a maximum height of 10 feet would create a pond of approximately 20 acres and a 20-foot-high, 170-linear-foot dike would result in a pond of 40 acres. The surrounding land use is desert rangeland.

At Mile 25.5, there is an existing headgate and channel to the west in Section 19, Township 8 South, Range 20 East. A 100-linear-foot dike would have to be constructed to create a recharge pond that would be located on public and private property. A dike with a maximum height of 10 feet could create a pond of approximately 40 acres.
The potential recharge site at Mile 26.5 is also located in Section 19, Township 8 South, Range 20 East. Here there is an old headgate and lateral heading to the west into the desert rangeland. No large natural depressions are shown on the USGS map; therefore, a dike will have to be constructed to create a recharge pond. A 1,400-linear-foot dike with a maximum height of 10 feet would create a pond with a surface area of approximately 120 acres. The site facilities would be located on public land administered by the BLM. The surrounding land use is desert rangeland.

At Mile 28.1, a set of existing outlet gates through the west bank could divert water to the potential recharge site in Section 7, Township 8 South, Range 20 East and Section 12, Township 8 South, Range 19 East. This site has a depression that could be utilized as a recharge pond of 10 acres; however, the construction of a dike could increase the size. The site is located in rough, potholed, desert rangeland that is public property administered by the BLM.

The potential recharge site at Mile 31.0 is a large depression on the northeast side of the canal. The north canal bank will act as a dike for the recharge pond that could cover up to 600 acres. The site is located in Section 36, Township 7 South, Range 19 East and Section 1, 2, 11, and 12 of Township 8 South, Range 19 East on rough, rocky desert rangeland that is public property administered by the BLM. A headgate control structure would have to be constructed to divert water to the site.

The Star Lake recharge site could be developed by constructing a conveyance canal from the Mile 31.0 site to the Star Lake area located in Sections 11 and 12, Township 7 South, Range 19 East. Star Lake is a wildlife management area that is owned by the State of Idaho. A recharge pond that would cover 500 to 600 acres could be developed. The conveyance canal would be 3.2 miles long with cut depths up to 40 feet. An alternative would be to construct a pumping plant, a 500-foot pipeline, and a conveyance canal without the deep cut. Another alternative to delivering water to the site would be to construct a conveyance canal from near Mile 41.0 east across desert rangeland to the site.

Two large potential recharge sites, one on each side of the canal, are found at Mile 32.0. The site to the north is in desert rangeland in Sections 3 and 4 of Township 8 South, Range 19 East. A new headgate control structure would divert water to a recharge pond that could be 140 to 160 acres in size. The site to the south of the canal would utilize a natural depression with some additional dike construction to create a recharge pond with a surface area of 600 to 700 acres. The property is publicly owned and administered by the BLM.

Several depressions north of the canal between Mile 33.0 and 34.0 could be used for recharge ponds with the construction of a headgate control structure. The overall site is located in Sections 3, 4, and 5 of Township 8 South, Range 19 East. The recharge ponds would occupy up to 500 acres of desert rangeland that is on public property administered by the BLM. The surrounding area is publicly held desert rangeland.

At Mile 34.5, a large depression east of the canal could be used for a recharge pond of up to 200 acres in size. The site would require the construction of a headgate control structure. The site is located in Section 5, Township 8 South, Range 19 East and Sections 31 and 32, Township 7 South, Range 19 East. Two depressions approximately 80 acres in size and found west of the canal would also require the construction of a headgate control structure. These sites are all located on public property administered by the BLM and are used for desert rangeland, as is the surrounding area.

The next potential recharge site is west of the canal at Mile 36.0, where there are several depressions in the desert rangeland to the west. A headgate control structure would have to be constructed to divert water to the recharge sites located in Sections 25 and 36, Township 7 South, Range 18 East. Construction of dikes totaling 300 linear feet would enlarge the recharge pond to 250 to 300 acres. The site is located on public property administered by the BLM. The surrounding land use is desert rangeland.

Two small potential recharge sites are located at Mile 37.5 in Section 20, Township 7 South, Range 19 East. A headgate control structure will be required on each side of the canal to supply recharge ponds with a total area of approximately 40 acres. The site and surrounding area is desert rangeland on public property administered by the BLM.

The next recharge site along the middle Milner-Gooding area is located at Mile 38.0 in Section 20, Township 7 South, Range 19 East. A depression east of the canal is desert rangeland that is publicly owned and administered by the BLM. The only construction required would be a headgate control structure to divert water to a recharge pond that could be 50 to 60 acres in size.

Three depressions east of the canal between Miles 39.0 and 41.0 could be used as recharge sites by constructing headgate control structures to each. The sites are located in Sections 7, 8, 17, and 18 of Township 7 South and Range 19 East. The total recharge pond area for these sites would be approximately 140 acres located on publicly owned desert rangeland administered by the BLM.

The last site in the middle Milner-Gooding recharge area is located at Mile 41.5 in Section 5, Township 7 South, Range 19 East. The recharge pond could be located in a natural depression east of the canal with a possible surface area of 160 to 200 acres. The site is located on publicly owned desert rangeland administered by the BLM. A headgate control structure would be required through the east bank of the canal. A dike could be constructed along the northern edge to protect adjacent farmland and allow expansion of the pond. The surrounding land use is desert rangeland except to the north, where the land use is farmland.

There are four potential recharge sites along the lower Milner-Gooding Canal:

- Main canal site
- Lower Snake River Aquifer Recharge District site
- Dahar Flume
- Little Wood Bypass

The first site is on the Main Canal east of State Highway 75. The site is located in Sections 25 and 26, Township 5 South, Range 17 East on public property administered by the BLM. The recharge pond would be located north of the canal in lava rock depressions. The depressions could be connected with some excavation to form a pond of nearly 100 acres in size. A headgate control structure would be required through the concrete flume wall that runs through the area. A number of residential lots are being developed on property southwest of the site.

The Lower Snake River Aquifer Recharge District site is located north of Shoshone in Section 22, Township 5 South, Range 17 East. The site is used for recharge by diverting the canal flow into the adjacent lava rock formations at a rate of 300 cfs. With additional excavation, the estimated usage could be doubled. The site is located on publicly owned property administered by the BLM.

The last site on the Main Canal is at the Dahar Flume, located at the crossing over the Big Wood River in Section 15, Township 5 South, Range 17 East on state-owned land. Recharge water can be diverted into the Big Wood River channel, which has a high infiltration water loss. No new construction would be required for this project.

The fourth potential recharge site using Milner-Gooding water is the City of Gooding's Little Wood Bypass located in Section 36, Township 5 South, Range 15 East. Water from the Milner-Gooding Canal can be diverted to the Little Wood River east of Shoshone to run to the bypass east of Gooding. The bypass runs water through privately owned desert rangeland to the Big Wood River to decrease flooding in the City of Gooding. The recharge site would be located in Sections 26, 27, and 28 of Township 5 South, Range 17 East. The site's recharge capacity requires further study. The surrounding land use is farmland with increasing residential development to the south, the City of Gooding to the southwest, and farmland in the other directions.

K. North Side Canal Company

The North Side Canal Company supplies irrigation water to southern Jerome and Gooding Counties and western Gooding County. Irrigation water is diverted at Milner Dam and flows to the northwest along the North Side Main Canal to Wilson Lake Reservoir and beyond to irrigated farmland. The Main Canal runs through several areas of desert rangeland that includes potential recharge sites. The North Side Canal Company is currently conducting recharge in several locations; however, there are many other candidate sites. The North Side Canal service area can be divided into three recharge areas having different zones of influence on the ground-water system. These areas are the upper North Side, middle North Side, and lower North Side. The upper area stretches from the diversion at Milner Dam to the Hunt project, the middle area includes the Hunt project to Highway 93, and the lower area extends west of Highway 93. There are five potential sites along the upper North Side Canal:

- Pump Station #1
- Wilson Lake Reservoir
- Wilson Canyon
- Near Wilson Lake
- Eden Butte

The first potential recharge site is near the Pump Station #1 on the C Canal in Section 3, Township 10 South, Range 20 East. The canal company built an overflow pond inside the canal curve at the pump station. The site could be used for recharge by diverting water through the headgate into the pond, which covers approximately 5 acres. The pond is located on privately owned property in a farming area.

The site at Wilson Lake Reservoir is located north of Hazelton in Sections 19, 28, 29, and 30 of Township 9 South, Range 20 East. Most of the site is public property administered by the BLM, but small portions of the site are privately owned. Recharge of up to 200 cfs can be realized by holding the reservoir level at a higher elevation than normal. No new construction will be required to achieve these recharge goals.

The site at Wilson Canyon, located in Section 29, Township 9 South, Range 19 East, is a closed contour lava rock canyon that has historically received irrigation water leaking from the Main Canal. Construction to utilize this site would include a headgate control structure and 150 to 200 linear feet of conveyance canal. The recharge pond size would be approximately 25 to 30 acres on publicly owned desert rangeland administered by the BLM.

Another potential site is located near Wilson Lake in Section 25, Township 10 South, Range 19 East. The site includes several lava rock depressions in rough desert rangeland under public ownership. The recharge pond would occupy an area of 160 to 200 acres of varying depths. A headgate control structure and conveyance canal would be required from Wilson Lake one mile west to the recharge site. The canal would cross one section of private property one-quarter mile wide. The topography of the area is rough-surfaced basalt flows to the north and west and farmland to the east and south. The City of Eden lies slightly over one-quarter mile southwest of the site.

The Eden Butte site is located in Sections 15, 16 and 17 of Township 9 South, Range 19 East. The canal is equipped with an unused radial gate structure near the northern boundary of Section 15. Recharge water released here would travel west into depressions in the desert rangeland. Sections 15 and 17 are public property administered by the BLM and Section 16 is private property. The recharge pond would include several small areas that could add up to 80 to 100 acres. The site would require careful management to prevent runoff onto adjacent property.

There are six potential recharges sites located along the middle area of the North Side canal:

- Near the F Canal diversion
- Sugarloaf Reservoir
- Natural depression east of the canal, upstream of K Canal diversion
- Natural depression east of the canal, ½ mile upstream of Red Bridge site
- Red Bridge site
- Prescott Pond site

The potential site near the "F" Canal diversion is located in Sections 25 and 36, Township 8 South, Range 18 East. Several small depressions in the desert rangeland north of the canal have elevations below the canal level. One headgate that could supply water to the ponds is found along this stretch. The total area of the recharge pond could cover up to 200 acres on privately held property. The land use of the surrounding property is desert rangeland north of the canal and farmland to the south.

The potential site known as the Sugarloaf Reservoir is located in Sections 26, 27, 34, and 35 of Township 8 South, Range 18 East. The site has an extremely rough surface of lava rock with numerous holes and pockets. The canal has a check structure and radial gate known as the F spill leading to this area that was originally built for storage and emergency spillage. The recharge ponds would be located on privately owned desert rangeland. A flow of 40 cfs has been released to this area without overflow. There is farmland to the east and west of the site. No additional construction would be required.

The third potential recharge site is a natural depression east of the canal on public property in Section 22, Township 8 South, Range 18 East. A headgate control structure would be required to deliver recharge water to the pond, which would occupy 140 to 160 acres. This site is approximately one-half mile upstream of the "K" Canal diversion on publicly owned desert rangeland administered by the BLM.

The next potential recharge site is located one-half mile upstream of the existing Red Bridge recharge site in Section 15, Township 8 South, Range 18 East. The recharge site is a natural depression east of the canal on publicly held desert rangeland administered by the BLM. The site would require a headgate control structure to deliver water to a recharge pond approximately 10 acres in size. The surrounding land use is desert rangeland.

The next site is the existing Red Bridge recharge site in Section 9, Township 8 South, Range 18 East. The North Side Canal Company has been recharging at this location with a continuous flow of 22 cfs. The property is privately owned, but the owner is cooperating with the canal company efforts. Raising the water level could expand the recharge pond.

The last potential site in the middle North Side recharge area is the Prescott Pond site, where recharge has been taking place. The pond is located on private property in Section 9, Township 8 South, Range 18 East. The three-acre site can handle a continuous flow of 3 cfs. The surrounding land use is desert rangeland to the north and east and farmland to the west and south.

There are six potential sites located along the lower area of the North Side Canal:

- Thousand Springs Wetlands Project
- North Side Canal Company return flow ponds
- W Canal site
- Terminus of the J-3 lateral
- X canal
- X-4 canal

The potential sites are spread over a large area. The first four sites are currently used by the North Side Canal Company for recharge efforts in conjunction with elimination of irrigation return flows to the Snake River.

The Thousand Springs Wetlands Project is located in Section 17, Township 8 South, Range 14 East. The site covers 40 acres with multiple ponds for sedimentation, infiltration, and evaporation. The site can accept at least 10 cfs on a continuous basis with no outflow.

The North Side Canal Company has also constructed return flow ponds in Section 8, Township 8 South, Range 14 East to treat and dispose of irrigation return flows. This project was under construction during the winter of 1998; no capacity had been established at that time.

Another retention pond has been constructed at the end of the W Canal in Section 36, Township 6 South, Range 13 East near the Malad Gorge State Park. This pond was also constructed to treat and dispose of irrigation return flows, but could be used for recharge. All these treatment ponds are within one mile of the Snake River Canyon and spring areas.

The North Side Canal Company has also conducted recharge at a site at the end of the J-3 lateral in Sections 24 and 25, Township 8 South, Range 15 East and Sections 19 and 30, Township 8 South, Range 16 East. The site is on public lands administered by the BLM and is hilly with sandy soil and rock outcroppings. The recharge is accomplished through a series of ponds that occur in natural depressions. The recharge at the site is limited by the size of the J-3 lateral.

Additional potential recharge sites are found along the "X" Canal as it travels through the desert rangeland north of Jerome to Gooding. At least 11 depressions north of the canal could be used for recharge with the construction of headgate control structures. If all 11 depressions were used, total pond area would be approximately 370 acres. The first site of approximately 10 acres is found in Section 15, Township 7 South, Range 16 East. The second site is of approximately 10 acres is found in Section 10, Township 7 South, Range 16 East, as is part of the third site, which contains approximately 80 acres in Sections 3 and 10; the fourth site contains 40 acres in Section 3. The fifth site could have a recharge pond of nearly 60 acres located in Section 4, Township 7 South, Range 16 East. The sixth and seventh sites are adjacent to each other in Section 5, Township 7 South, Range 16 East and Section 31, Township 6 South, Range 11 East. The recharge pond area could be 10 and 60 acres, respectively. The eighth site, the only one found on private property, is located in Section 36, Township 6 South, Range 15 East. The potential recharge pond would have an area of 20 acres. The ninth potential recharge area is located in Section 25, Township 6 South, Range 15 East and would occupy an area of 20 acres. The tenth site, which would include a recharge pond area of 40 acres, is located along the "X" Canal in Section 27, Township 6 South, Range 15 East. The last depression along the "X" Canal, also located in Section 27, Township 6 South, Range 15 East, would produce a potential recharge pond covering 16 to 20 acres.

A potential site is located on the "X-4" Canal a mile downstream from the diversion from the "X" Canal. Known as the Robinson Site, this site is located in Sections 20 and 29, Township 5 South, Range 15 East just east of State Highway 46. This site is a depression north of the canal that could hold a recharge pond of over 100 acres. A headgate control structure would be needed. The site and surrounding area is publicly owned desert rangeland administered by the BLM.

VII. ENGINEERING COSTS FOR SPECIFIC SITES

This section presents cost estimates for construction of the five specific recharge sites. For each site, an engineering design has been developed in sufficient detail to provide a basis for estimating capital improvement costs. Improvements required to utilize each site were identified through site reconnaissance and preliminary surveying. The five specific sites are:

- Egin Lakes/Nine Mile Knoll
- New Sweden Reservoir
- Lava Flows North of Lake Walcott
- Mile 31 on the Milner-Gooding Canal
- K-Canal diversion on the North Side Canal Company Main Canal

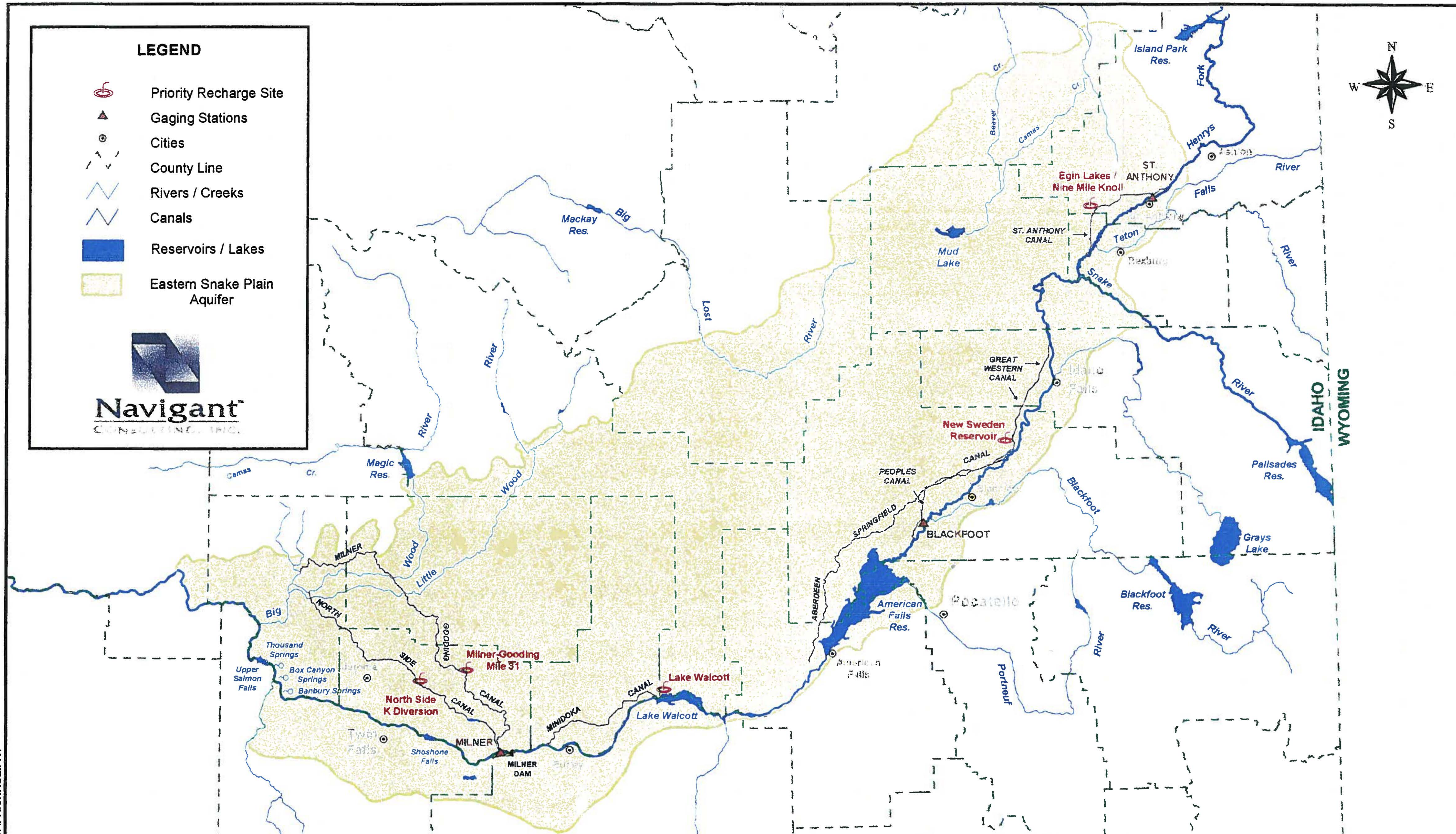
The locations of these sites are shown in Figure 7-1.

A. EGIN LAKES/NINE MILE KNOLL RECHARGE SITE

The Egin Lakes/Nine Mile Knoll recharge site is located in Sections 3, 4, and 7 in Township 7 North, Range 39 East and Section 12 in Township 7 North, Range 38 East. The area is currently used for recharge operations, but the recharge capacity is limited by the size of the recharge canal. The existing canal that feeds the area has a maximum capacity of approximately 40 cfs. The recharge canal is diverted from the St. Anthony Canal in Section 31, Township 8 North, Range 40 East. The St. Anthony Canal and the upstream bridge and check structures have a capacity of approximately 500 cfs.

A recharge area of 103 acres can be accessed in the Egin Lakes/Nine Mile Knoll area. The sandy soil in the area should have a high infiltration capacity of 6 inches per hour or more, providing an infiltration capacity of up to 600 cfs. To more fully utilize the recharge capacity of the site, the recharge canal would have to be enlarged, as would all the structures crossing it. A drawing identifying the recharge canal, recharge ponds, and capital improvements is included as Figure 7-2.

The capital improvements required to increase the capacity of the recharge canal to 500 cfs include a new outlet at the diversion from the St. Anthony Canal, three bridges, 13 check structures, and widening of the recharge and overflow canals. The recharge canal would be widened to 30 feet at bottom with 2:1 side slopes and a total depth of five feet. Bridges will be required at all current road crossing locations and check structures provided to minimize bank erosion typical to the sandy soil. The overflow canal will be reconstructed to a bottom width of 20 feet, 2:1 side slopes and a total depth of four feet. Figure 7-3 illustrates the proposed new outlet structure. Figures 7-4 and 7-5 show a typical bridge structure and a typical check structure.



SCALE	EASTERN SNAKE PLAIN AQUIFER MANAGED RECHARGE PROJECT	FIGURE 7-1
10 0 10 20 Miles	PRIORITY RECHARGE SITES IDAHO DEPARTMENT OF WATER RESOURCES	

D:\SNAKE\755\11x17\PRICHRGE.PRT

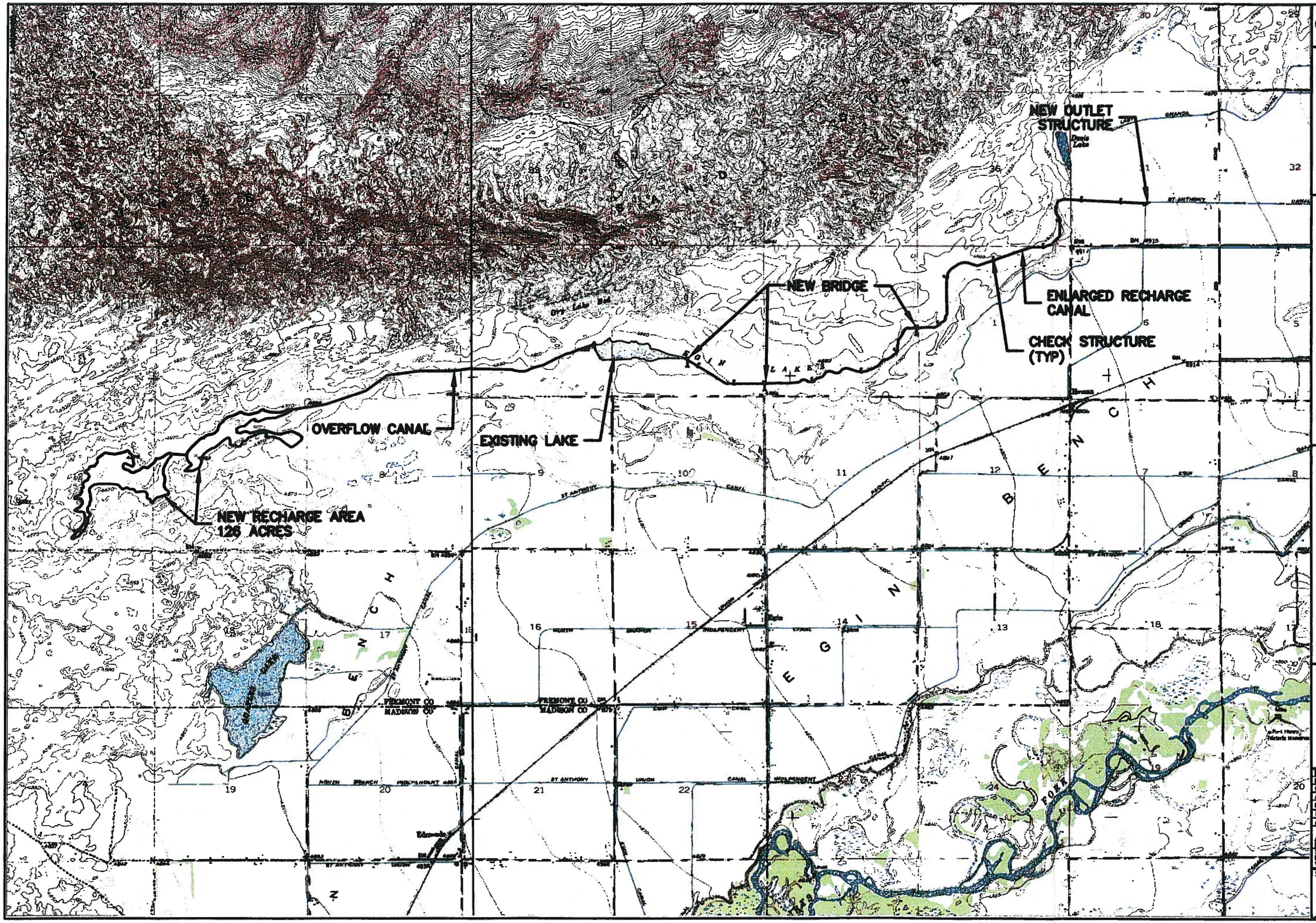


FIGURE 7-2
EGIN LAKES RECHARGE SITE

ESTIMATED CONSTRUCTION

J-U-B ENGINEERS, Inc.
250 FALLS AVENUE
TWIN FALLS, IDAHO 83301-3300
PHONE: 208-733-2414
FAX: 208-733-0455

REUSE OF DRAWINGS

REVISION

DRAWN BY: RLH
DESIGN BY: RLH
CHECKED BY: -
ARCHIVE LOCALE:
PROJECT NO. 61207-080
DRAWING NO. EGIN
ACAD PLOT SCALE (1=300)
ONE INCH
AT FULL SIZE, IF NOT ONE INCH, SCALE ACCORDINGLY
HOR SCALE: 3000
VER SCALE: NONE
SHEET
1

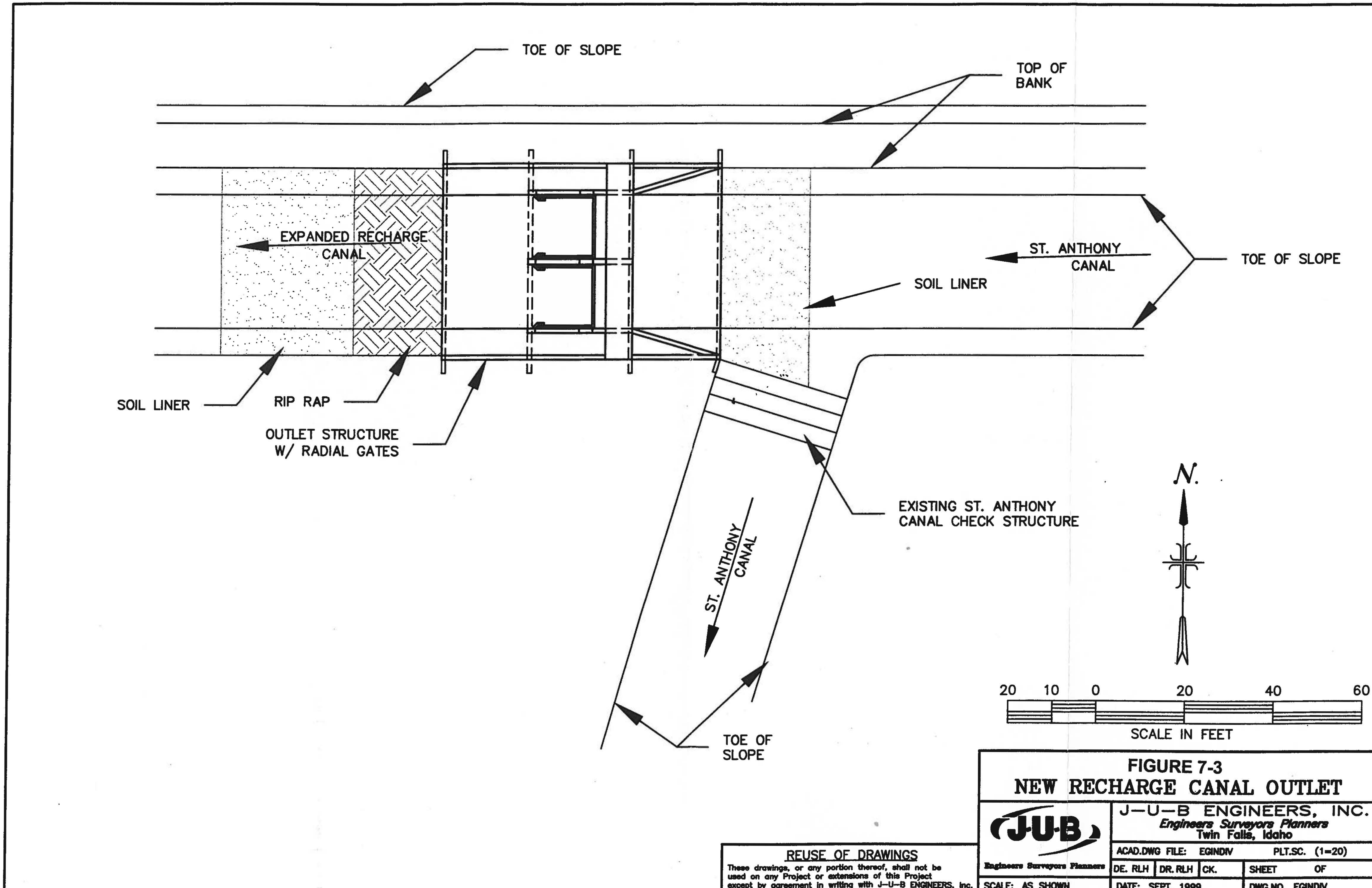


FIGURE 7-3
NEW RECHARGE CANAL OUTLET

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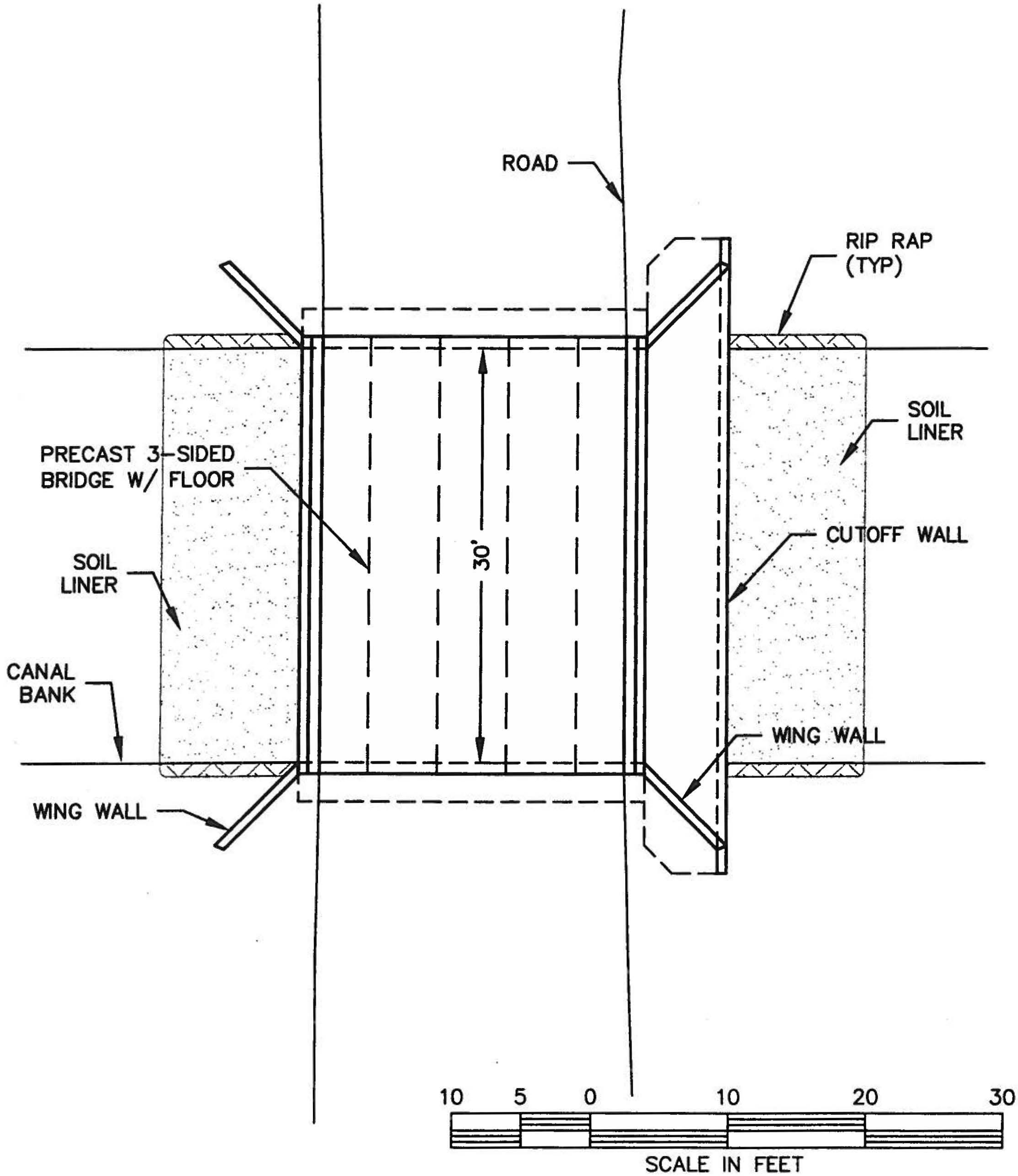


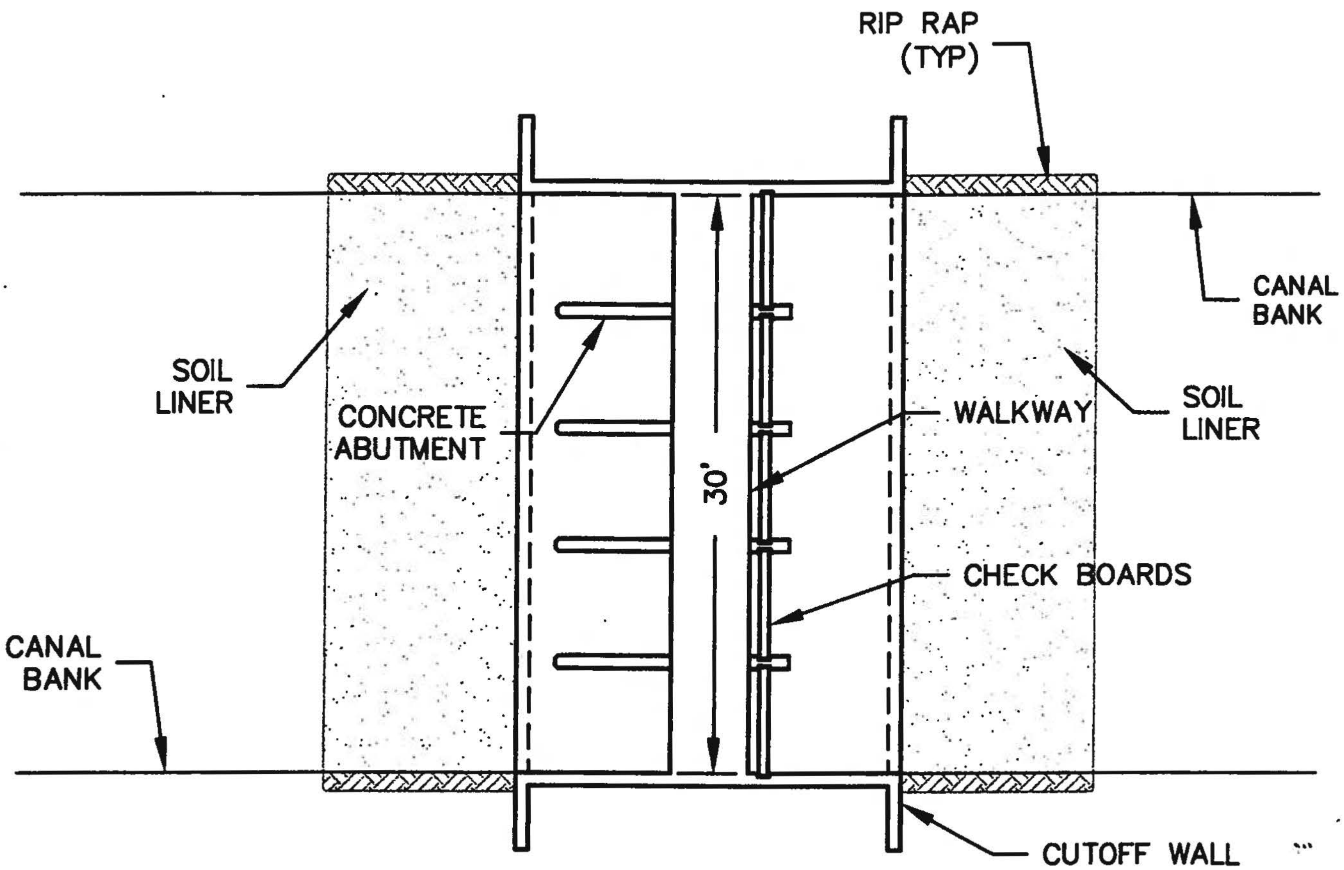
FIGURE 7-4

EGIN LAKES CANAL BRIDGE

J-U-B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho

Engineers Surveyors Planners

ACAD.DWG FILE: EGINBRID			PLT.SC. (1=510
DE. RLH	DR. RLH	CK.	SHEET
SCALE: (1"=10')	DATE: SEPT. 1999		DWG.NO.



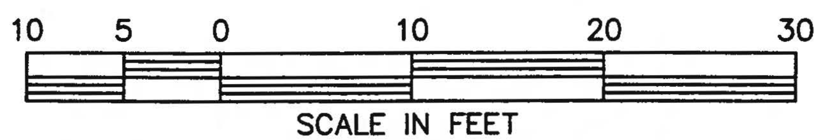


FIGURE 7-5

EGIN LAKES CHECK STRUCTURE

J-U-B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho

Engineers Surveyors Planners

ACAD.DWG FILE: EGINCHCK			PLT.SC. (1=10)
DE. RLH	DR. RLH	CK.	SHEET
SCALE: (1"=10')	DATE: SEPT. 1999		DWG.NO.

The estimated cost to construct the capital improvements is $1.2 million. Cost components are shown in Table 7-1. Note that 70 percent of the total cost is incurred by expansion of the recharge canal to accommodate flows of 500 cfs.

Table 7-1. ESPA Managed Recharge - Egin Lakes Recharge Area Estimated Cost of Construction

ESTIMATED DIVERSION CAPACITY 500 CFS
SIZE OF RECHARGE AREA 126 ACRES

ITEM		QUANTITY	UNITS	COST/UNIT	TOTAL COST
OUTLET STRUCTURE:					
STRUCTURE EXCAVATION	SOIL	614	Cu. Yd.	$8	$4,912
COMPACTED BACKFILL		200	Cu. Yd.	$15	$3,000
SOIL LINER		301	Cu. Yd.	$28	$8,428
RIP RAP		165	Cu. Yd.	$20	$3,300
REINFORCED CONCRETE		172	Cu. Yd.	$380	$65,360
14' X 5' RADIAL GATE W/ CONTROLLER		2	Each	$40,000	$80,000
HANDRAILS AND MISC. METAL		1	L.S.	$1,200	$1,200
		SUB TOTAL OUTLET STRUCTURE			*$166,200*
ADDITIONS:	MOBILIZATION AND DEMOBILIZATION				$16,620
	CONTINGENCIES				$33,240
	ENGINEERING AND CONSTRUCTION SERVICES				33,240
	TOTAL ESTIMATED COST OUTLET STRUCTURE				***$249,300***
CHECK STRUCTURE:					
STRUCTURE EXCAVATION	SOIL	82	Cu. Yd.	$8	$656
COMPACTED BACKFILL		30	Cu. Yd.	$15	$450
SOIL LINER		44	Cu. Yd.	$28	$1,232
RIP RAP		7	Cu. Yd.	$20	$140
REINFORCED CONCRETE		41	Cu. Yd.	$380	$15,580
CHECK BOARDS (5.65' X 8" X 4")		8	Each	$45	$360
HANDRAILS AND MISC. METAL		1	L.S.	$1,200	$1,200
		SUB TOTAL EACH CHECK STRUCTURE			*$19,618*
ADDITIONS:	MOBILIZATION AND DEMOBILIZATION				$1,962
	CONTINGENCIES				$3,924
	ENGINEERING AND CONSTRUCTION SERVICES				3,924
	TOTAL ESTIMATED COST EACH CHECK STRUCTURE				***$29,427***
BRIDGE:					
STRUCTURE EXCAVATION	***SOIL***	108	Cu. Yd.	$8	$864
COMPACTED BACKFILL		64	Cu. Yd.	$15	$960
SOIL LINER		44	Cu. Yd.	$28	$1,232
RIP RAP		7	Cu. Yd.	$20	$140
REINFORCED CONCRETE		89	Cu. Yd.	$380	$33,820
GRAVEL ROAD SURFACE		23	Cu. Yd.	$22	$506
		SUB TOTAL EACH BRIDGE			*$37,522*
ADDITIONS:	MOBILIZATION AND DEMOBILIZATION				3,752
	CONTINGENCIES				7,504
	ENGINEERING AND CONSTRUCTION SERVICES				7,504
	TOTAL ESTIMATED COST OF EACH BRIDGE STRUCTURE				***$56,283***

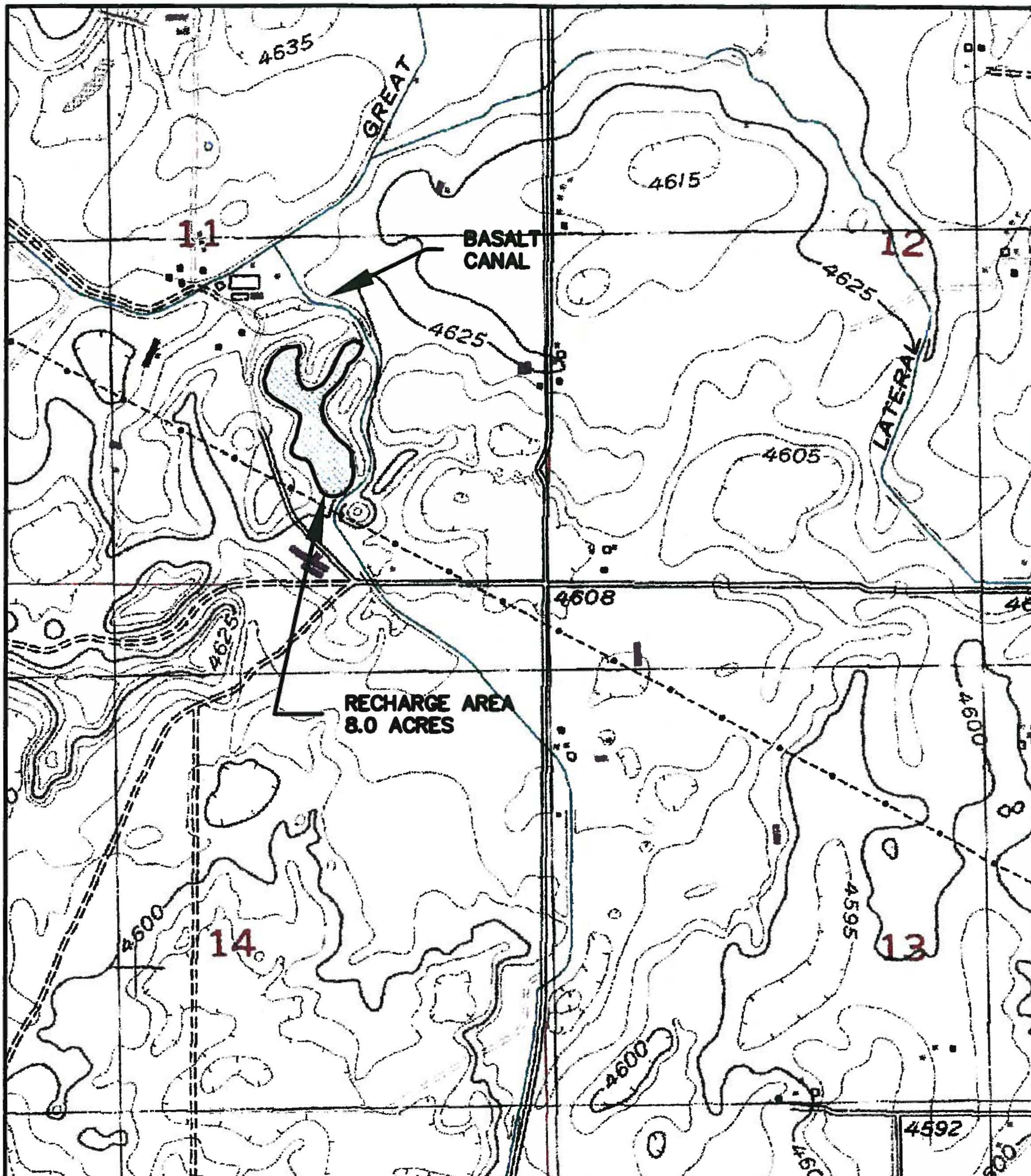
Table 7-1. (continued)

ITEM		QUANTITY	UNITS	COST/UNIT	TOTAL COST
RECHARGE CANAL EXPANSION: 3.92 MILES					
CANAL EXCAVATION	SOIL	57,439	Cu. Yd.	$7	$402,073
CANAL EMBANKMENT		45,951	Cu. Yd.	$3	$137,853
RIGHT-OF-WAY	30' ADD.	14.2	Acres	$3,000	$42,600
		SUB TOTAL RECHARGE CANAL EXPANSION			$582,526
ADDITIONS:	MOBILIZATION AND DEMOBILIZATION				58,253
	CONTINGENCIES				116,505
	ENGINEERING AND CONSTRUCTION SERVICES				116,505
		TOTAL ESTIMATED COST OF RECHARGE CANAL EXPANSION			***$873,789***
OVERFLOW CANAL RECONSTRUCTION: 2.08 MILES					
CANAL EXCAVATION	SOIL	25,417	Cu. Yd.	$7	$177,919
CANAL EMBANKMENT		22,773	Cu. Yd.	$3	$68,319
		SUB TOTAL OVERFLOW CANAL RECONSTRUCTION			*$246,238*
ADDITIONS:	MOBILIZATION AND DEMOBILIZATION				24,624
	CONTINGENCIES				49,248
	ENGINEERING AND CONSTRUCTION SERVICES				49,248
		TOTAL ESTIMATED COST OF OVERFLOW CANAL RECONSTRUCTION			***$369,357***

TOTAL COST OF CONSTRUCTION FOR EGIN LAKES RECHARGE AREA				
OUTLET STRUCTURE				$249,300
CHECK STRUCTURE	13	EACH	$29,427	$382,551
BRIDGE	3	EACH	$56,283	$168,849
RECHARGE CANAL EXPANSION				$873,789
OVERFLOW CANAL RECONSTRUCTION				$369,357
TOTAL ESTIMATED COST FOR EGIN LAKES CONSTRUCTION				***$1,243,146***

B. New Sweden Reservoir Recharge Site

The New Sweden Reservoir recharge area is located in Section 11, Township 1 South, Range 36 East at the end of the Great Western Canal. Figure 7-6 shows the recharge area and the surrounding topography. The recharge pond has a surface area of approximately 8 acres and is fed from the Basalt Canal. The site is currently utilized for recharge with a capacity of 50 cfs. The pond could not be expanded without major construction because of its location on the edge of the bench overlooking the Snake River floodplain. No new construction would be necessary to continue to realize the full recharge capacity of the site. Extending the time period the site is used to include the months when the canal system is not in operation could increase the total annual recharge.



DESIGN PARAMETERS:

RECHARGE BASIN AREA = 8.0 ACRES

EST. INFILTRATION RATE = 6.0 IN./HR.

FACILITY DESIGN CAPACITY = 50 CFS

FIGURE 7-6

NEW SWEDEN RESERVOIR SITE

J—U—B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho

Engineers Surveyors Planners

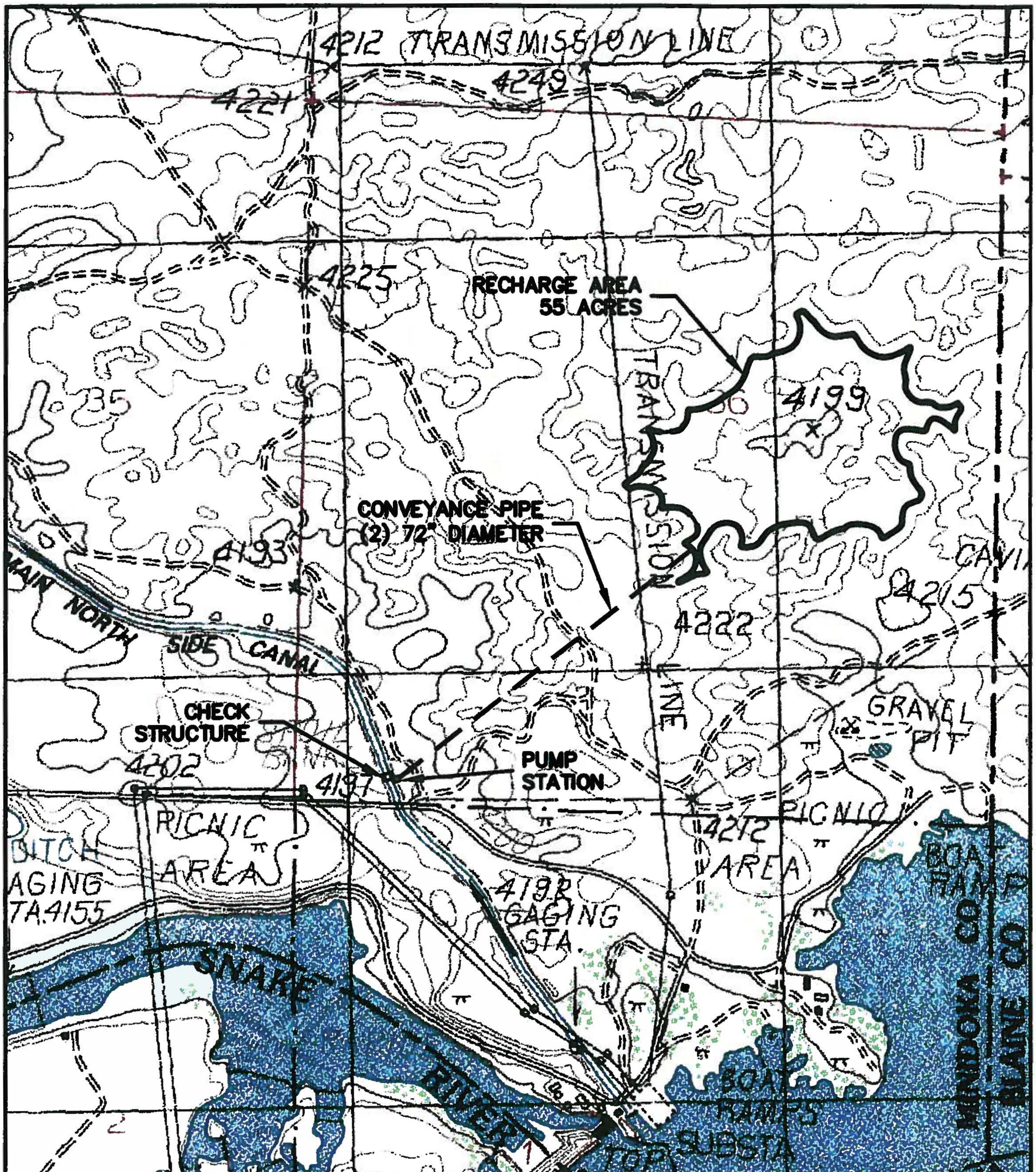
ACAD.DWG FILE: 61207NS			PLT.SC. (1=1000)
DE. RLH	DR. RLH	CK. KCK	SHEET
SCALE: 1"=1000'	DATE: SEPT. 1999		DWG.NO.

C. LAVA FLOWS SITES NORTH OF OF LAKE WALCOTT

Numerous natural surface depressions exist in the lava rock lands north of Lake Walcott. The depression nearest an existing water conveyance structure is located in Section 36, Township 8 South, Range 25 East and is owned by the State of Idaho. Water could be pumped from the Minidoka Irrigation District (MID) Main North Side Canal to the depression that lies approximately 45 feet higher in elevation than the canal diversion point. A pump station and pipeline would be required to use this site. The recharge area occupies 55 acres of rough lava rock and sagebrush desert. The soil between the rock outcroppings is sandy and should have an infiltration capacity of 6 inches per hour or more. To utilize infiltration at this rate over the 55 acres would require a conveyance capacity of 330 cfs.

The site location is shown in Figure 7-7. The capital improvements that will be necessary to utilize the recharge area include a check structure in the MID Main North Side Canal, a pump station, and a pipeline to the depression. A drawing of the check structure and pump station is included as Figure 7-8. A check structure bottom width of 30 feet would be necessary at the proposed location. The existing canal sides are lined with rock and slope at 0.5:1. The check structure would be anchored into the lava rock along the bottom and sides. The pump station would be built into the bank at the location of a depression outside the bank. The structure excavation would be through both soil and rock.

The necessary pump station capacity is 148,000 gallons per minute. For the purpose of cost estimates, a reasonable configuration of the pump station is six pumps, each with a capacity of approximately 25,000 gpm and each equipped with a 500 horsepower motor. The recharge water would be conveyed to the depression through two buried 72-inch-diameter steel pipes, each fed by three pumps. The pipe excavation will be through lava rock throughout the entire stretch. Additional electrical capacity will be required to provide energy to the motors.



DESIGN PARAMETERS:

RECHARGE BASIN AREA = 55 ACRES

EST. INFILTRATION RATE = 6.0 IN./HR.

FACILITY DESIGN CAPACITY = 330 CFS

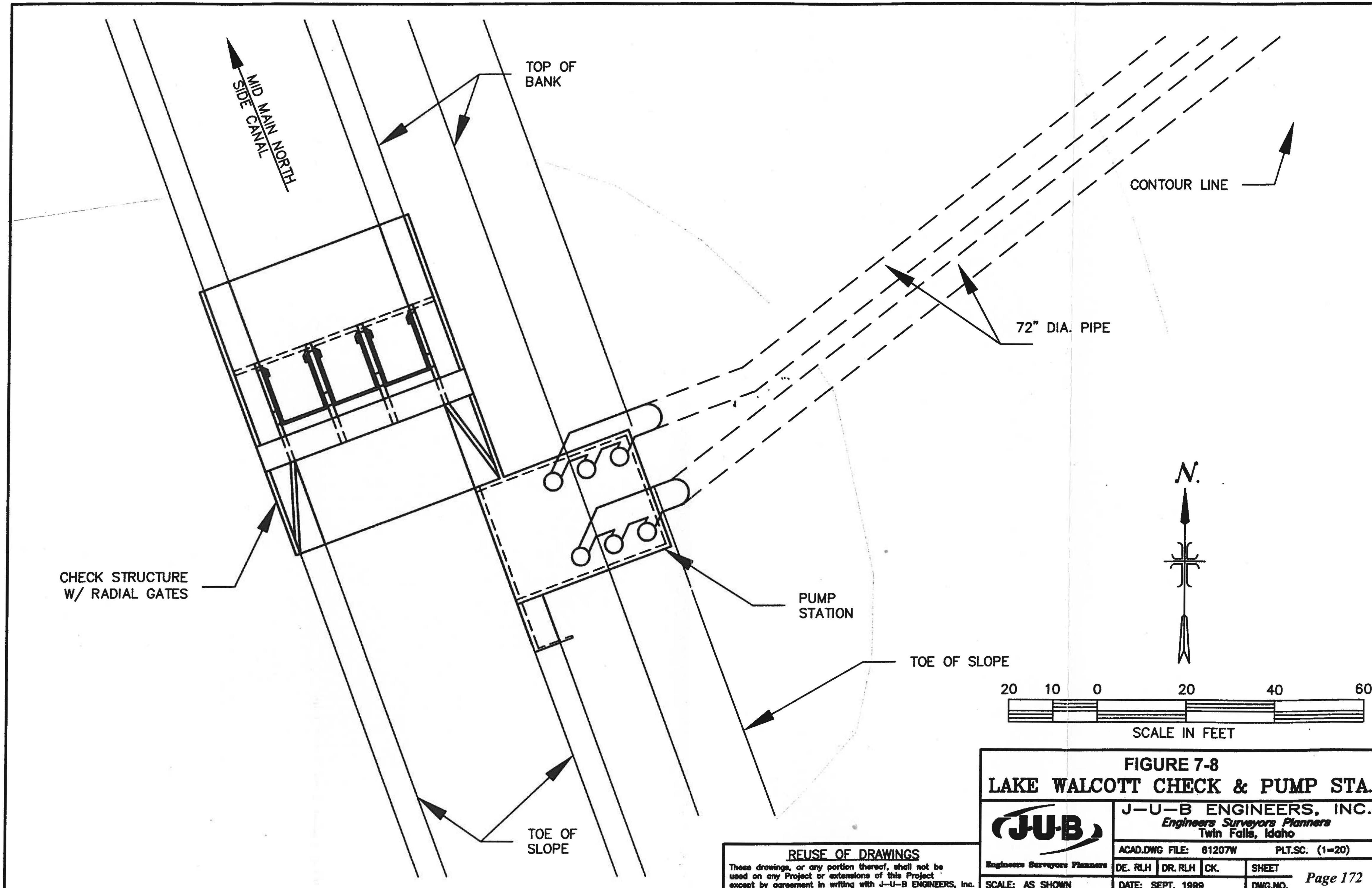
FIGURE 7-7

LAKE WALCOTT SITE

J-U-B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho

J-U-B Engineers Surveyors Planners

ACAD.DWG FILE: WALCOTT		PLT.SC. (1=1000)	
DE. RLH	DR. RLH	CK. KCK	SHEET
SCALE: 1"=100'	DATE: SEPT. 1999		DWG.NO.


MID MAIN NORTH SIDE CANAL
TOP OF BANK
CONTOUR LINE
72" DIA. PIPE
N.
CHECK STRUCTURE W/ RADIAL GATES
PUMP STATION
TOE OF SLOPE
20 10 0 20 40 60
SCALE IN FEET
TOE OF SLOPE
FIGURE 7-8
LAKE WALCOTT CHECK & PUMP STA.
J-U-B
Engineers Surveyors Planners
J–U–B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho
ACAD.DWG FILE: 61207W
PLT.SC. (1=20)
REUSE OF DRAWINGS
These drawings, or any portion thereof, shall not be used on any Project or extensions of this Project except by agreement in writing with J–U–B ENGINEERS, Inc.
SCALE: AS SHOWN
DE. RLH
DR. RLH
CK.
SHEET
DATE: SEPT. 1999
DWG.NO.

The estimated cost of the capital improvements for this recharge site is $5.0 million, as shown in Table 7.2. The need for a buried pipeline and pumping station make this a costly site to improve for managed recharge.

Table 7.2. ESPA Managed Recharge Lava's North of Lake Walcott Site Estimated Cost of Construction

ESTIMATED DIVERSION CAPACITY — 330 CFS

SIZE OF RECHARGE AREA — 55 ACRES

ITEM		QUANTITY	UNITS	COST/UNIT	TOTAL COST
CHECK STRUCTURE					
STRUCTURE EXCAVATION	ROCK	451	Cu. Yd.	$30	$13,530
COMPACTED BACKFILL		200	Cu. Yd.	$15	$3,000
SOIL LINER		191	Cu. Yd.	$28	$5,348
RIP RAP		114	Cu. Yd.	$20	$2,280
REINFORCED CONCRETE		165	Cu. Yd.	$380	$62,700
11' WIDE X 8' HIGH RADIAL GATE W/ CONTR.		3	Each	$38,000	$114,000
HANDRAILS AND MISC. METAL		1	L.S.	$5,000	$5,000
				SUB TOTAL CHECK STRUCTURE	*$205,858*
PUMP STATION AND PIPELINE					
STRUCTURE EXCAVATION	ROCK	389	Cu. Yd.	$30	$11,670
	SOIL	292	Cu. Yd.	$8	$2,336
COMPACTED BACKFILL		120	Cu. Yd.	$15	$1,800
PIPE EXCAVATION	ROCK	16,360	Cu. Yd.	$30	$490,800
PIPE BACKFILL		10,575	Cu. Yd.	$24	$253,800
REINFORCED CONCRETE		126	Cu. Yd.	$380	$47,880
TRASH SCREEN		240	Sq.Ft.	$4	$960
PUMPS		6	Each	$95,000	$570,000
MANIFOLD PIPING		1	L.S.	$10,000	$10,000
72" DIA. DELIVERY PIPE		5,520	L.F.	$280	$1,545,600
ELECTRICAL EQUIPMENT		1	L.S.	$120,000	$120,000
ELECTRIC UTILITY EXTENSION		1	L.S.	$80,000	$80,000
				SUB TOTAL PUMP STATION	*$3,134,846*

TOTAL COST OF CONSTRUCTION FOR LAVAS NORTH OF LAKE WALCOTT SITE

CHECK STRUCTURE	1	EACH	$205,858	$205,858
PUMP STATION AND PIPELINE	1	EACH	$3,134,846	$3,134,846
SUBTOTAL CONSTRUCTION COST FOR CHECK STRUCTURE AND PUMPSTATION				*$3,340,704*

ADDITIONS:	**MOBILIZATION AND DEMOBILIZATION**	$334,070
	CONTINGENCIES	$668,141
	ENGINEERING AND CONSTRUCTION SERVICES	668,141
	TOTAL ESTIMATED COST OF LAKE WALCOTT STRUCTURE	***$5,011,056***

D. MILE 31 ON THE MILNER -GOODING CANAL

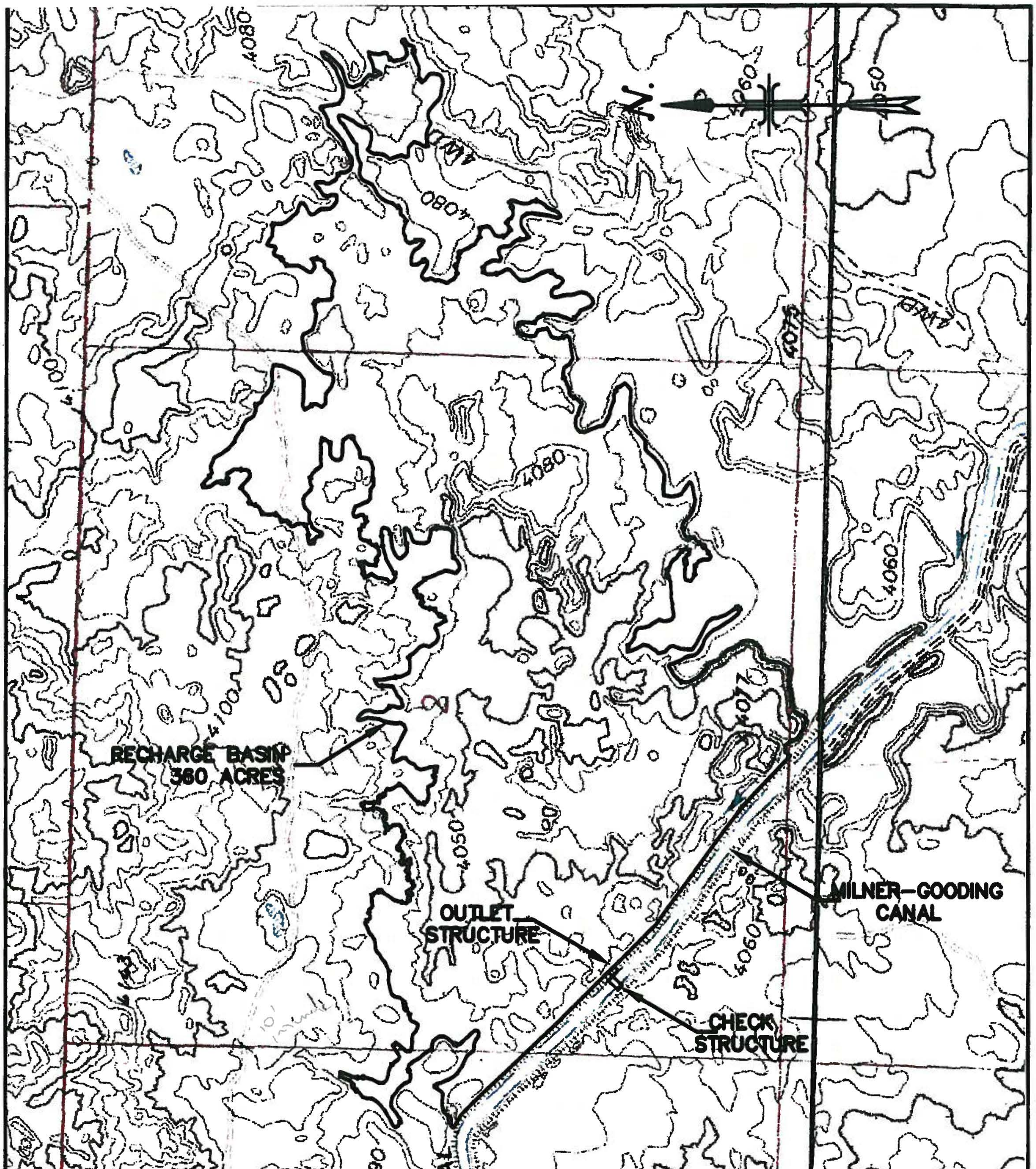
The Mile 31 recharge site is a depression east of the Milner-Gooding Canal in Sections 1 and 2 of Township 8 South, Range 19 East on public property managed by the U.S. Bureau of Land Management. The depression was created when the canal was constructed across the natural drainage basin. The size of the recharge area could vary greatly, depending on the actual elevation to which the basin is filled. The basin size used for cost estimation is 360 acres. With the expected infiltration rate of 6 inches per hour, the basin could recharge at a rate of 1,500 cfs, equal to the capacity of the Milner-Gooding Canal. If actual infiltration rates are less than expected, the recharge basin size could be expanded to 1,170 acres by raising the water level 10 feet. Figure 9-9 shows the recharge area and proposed improvements.

The capital improvements required to develop the site include a check and outlet structure, which are illustrated in Figure 7-10. The check structure would have a bottom width of 60 feet, matching the existing canal. It will be equipped with four manually operated radial gates to control bypass flow. The outlet structure will divert water to the recharge basin east of the canal bank through six 60-inch-diameter pipes. The diverted flow will be controlled with six slide gates, each gate measuring 4 feet by 4 feet.
The estimated cost to construct the proposed capital improvements is $790,000, as shown in Table 7-3. Excavation costs are low, and no new conveyance structures are needed to transmit water from the canal to the recharge basin. The total capital cost for this site is small relative to the potential recharge capacity the site provides.

Table 7-3. ESPA Managed Recharge Milner-Gooding Canal Mile 31 Site Estimated Cost of Construction

ESTIMATED DIVERSION CAPACITY 1500 CFS
SIZE OF RECHARGE AREA 360 ACRES

ITEM		QUANTITY	UNITS	COST/UNIT	TOTAL COST
STRUCTURE EXCAVATION	SOIL	1,142	Cu. Yd.	$8	$9,136
	ROCK	1,073	Cu. Yd.	$30	$32,190
COMPACTED BACKFILL		297	Cu. Yd.	$15	$4,455
SOIL LINER		580	Cu. Yd.	$28	$16,240
RIP RAP		345	Cu. Yd.	$20	$6,900
PIPE BACKFILL		671	Cu. Yd.	$24	$16,104
REINFORCED CONCRETE		327	Cu. Yd.	$380	$124,260
15' WIDE X 6' HIGH RADIAL GATE W/ CONTR.		4	Each	$43,000	$172,000
4' X 4' SLIDE GATE W/ HAND WHEEL		6	Each	$6,000	$36,000
60" DIAMETER CONCRETE PIPE		300	L. F.	$340	$102,000
COVER GRATE		165	Sq. Ft.	$20	$3,300
HANDRAILS AND MISC. METAL		1	L.S.	$5,000	$5,000
				SUB TOTAL	$527,585
ADDITIONS:	MOBILIZATION AND DEMOBILIZATION				$52,759
	CONTINGENCIES				$105,517
	ENGINEERING AND CONSTRUCTION SERVICES				$105,517
				TOTAL ESTIMATED COST OF MILE 31 STRUCTURE	***$791,378***



DESIGN PARAMETERS:

RECHARGE BASIN AREA = 360 ACRES

EST. INFILTRATION RATE = 6.0 IN./HR.

FACILITY DESIGN CAPACITY = 1500 CFS

FIGURE 7-9

MILNER—GOODING MILE 31 SITE

J-U-B

Engineers Surveyors Planners

J—U—B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho

ACAD.DWG FILE: MILE31			PLT.SC. (1=1000)
DE. RLH	DR. RLH	CK. KCK	SHEET
SCALE: 1"=100'	DATE: SEPT. 1999		DWG.NO.

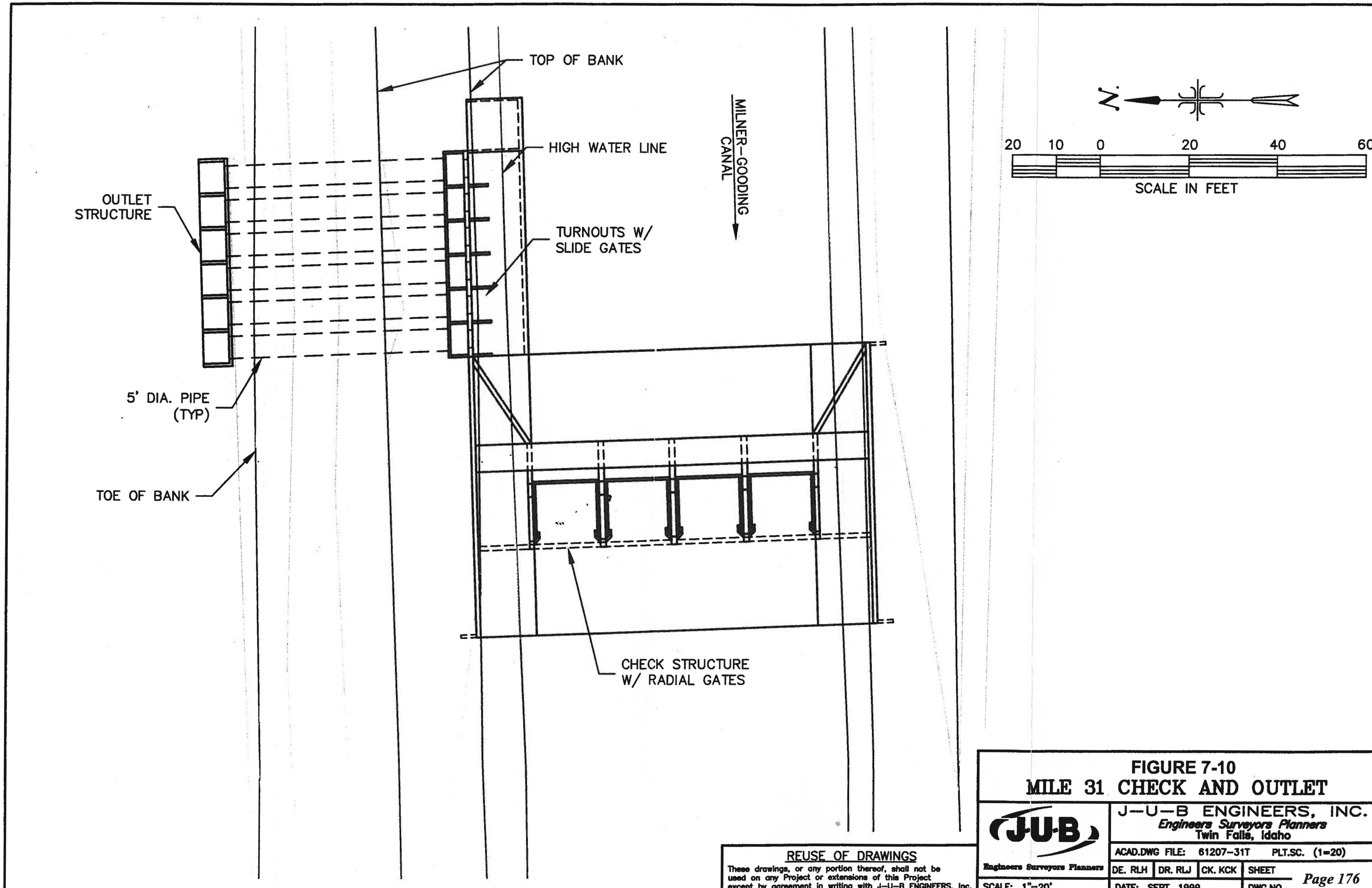


FIGURE 7-10

MILE 31 CHECK AND OUTLET

J–U–B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho

ACAD.DWG FILE: 61207-31T		PLT.SC. (1=20)	
DE. RLH	DR. RLJ	CK. KCK	SHEET
SCALE: 1"=20'	DATE: SEPT. 1999		DWG.NO.

REUSE OF DRAWINGS

These drawings, or any portion thereof, shall not be used on any Project or extensions of this Project except by agreement in writing with J–U–B ENGINEERS, Inc.

E. NORTH SIDE MAIN CANAL NEAR THE K-CANAL DIVERSION

The recharge area near the K-Canal diversion.is located in Section 22. Township 8 South. Range 18 East on federal property managed by the U.S. Bureau of Land Management. The area is a natural depression of desert rangeland interspersed with lava rock outcroppings that was enhanced by the construction of the canal. The size of the potential recharge area is 76 acres. With an estimated infiltration rate of 6 inches per hour. the recharge capacity of the basin is 500 cfs. The location of the recharge area and proposed improvements are shown on Figure 7-11.

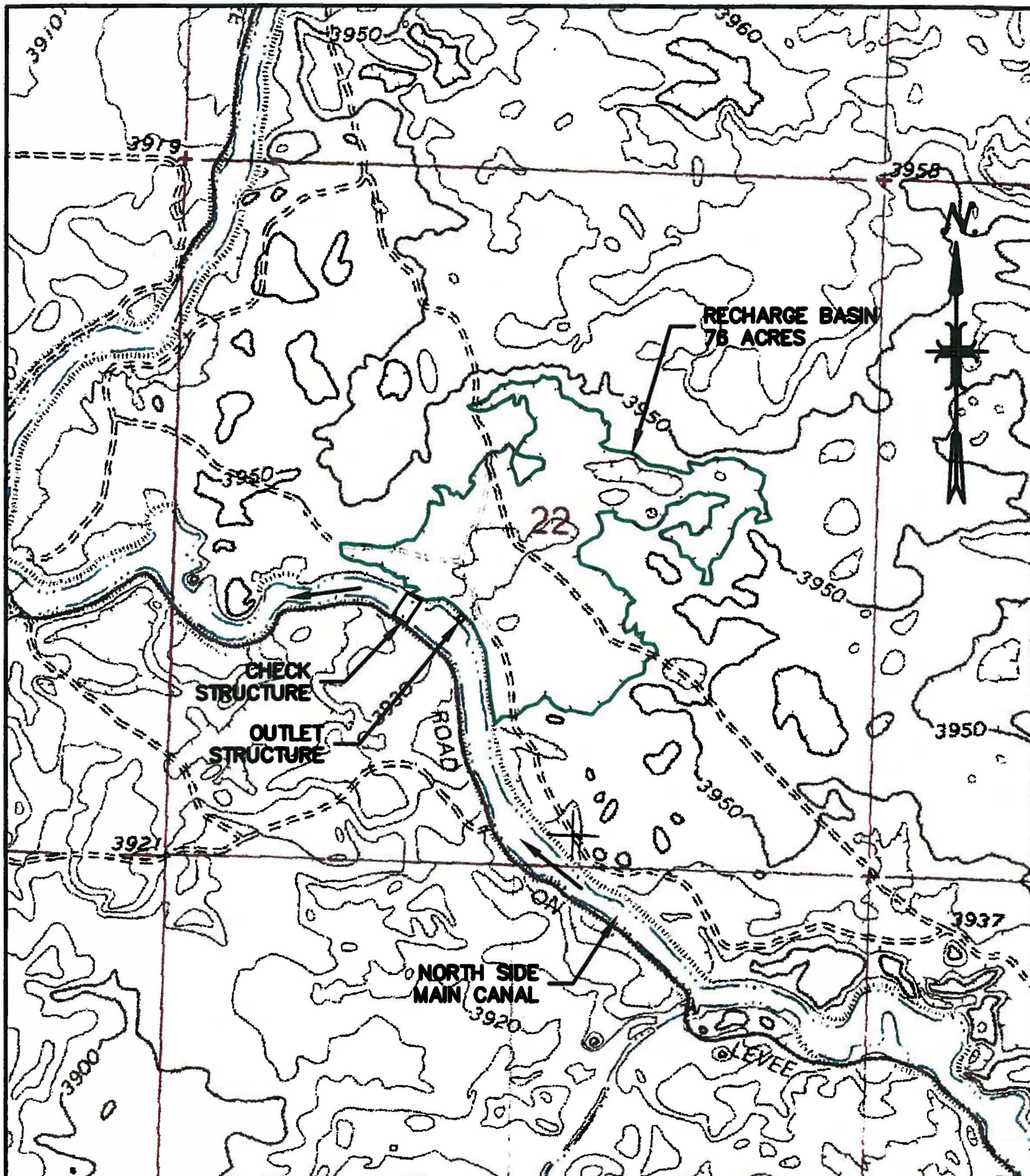
A check structure and outlet will also be required to utilize this recharge site. as illustrated in Figure 7-12. The check structure would have a bottom width of approximately 130 feet and a height of 8 feet. Eight 15-foot-wide manually operated radial gates would control the bypass flow. The outlet structure will release water northeast of the canal bank through four 60-inch-diameter pipes. Four slide gates. each sized 4 feet by 4 feet. will control the recharge flow.

The estimated cost to construct the proposed capital improvements is $950.000. as shown in Table 7-4. Similar to the Mile 31 Milner-Gooding site. no new conveyance structures are needed and small amounts of excavation are required.

Table 7-4. ESPA Managed Recharge North Side Canal Co. – Near K-Canal Diversion Estimated Cost of Construction

ESTIMATED DIVERSION CAPACITY 500 CFS
SIZE OF RECHARGE AREA 76.2 ACRES

ITEM		QUANTITY	UNITS	COST/UNIT	TOTAL COST
STRUCTURE EXCAVATION	SOIL	1293	Cu. Yd.	$8	$10,344
	ROCK	322	Cu. Yd.	$30	$9,660
COMPACTED BACKFILL		320	Cu. Yd.	$15	$4,800
SOIL LINER		492	Cu. Yd.	$28	$13,776
RIP RAP		269	Cu. Yd.	$20	$5,380
PIPE BACKFILL		289	Cu. Yd.	$24	$6,936
REINFORCED CONCRETE		454	Cu. Yd.	$380	$172,520
15' WIDE X 5' HIGH RADIAL GATE W/ CONTR.		8	Each	$40,000	$320,000
4' X 4' SLIDE GATE W/ HAND WHEEL		4	Each	$6,000	$24,000
60" DIAMETER CONCRETE PIPE		160	L. F.	$340	$54,400
COVER GRATE		110	Sq. Ft.	$20	$2,200
HANDRAILS AND MISC. METAL		1	L.S.	$7,000	$7,000
				SUB TOTAL	*$631,016*
ADDITIONS:	MOBILIZATION AND DEMOBILIZATION				$63,102
	CONTINGENCIES				$126,203
	ENGINEERING AND CONSTRUCTION SERVICES				$126,203
	TOTAL ESTIMATED COST OF K-CANAL STRUCTURES				*$946,524*



DESIGN PARAMETERS:

RECHARGE BASIN AREA = 76 ACRES

EST. INFILTRATION RATE = 6.0 IN./HR.

FACILITY DESIGN CAPACITY = 500 CFS

FIGURE 7-11

NSCC K-CANAL SITE

J-U-B ENGINEERS, INC.
Engineers Surveyors Planners
Twin Falls, Idaho

ACAD.DWG FILE: KCANAL			PLT.SC. (1=1000)
DE. RLH	DR. RLH	CK. KCK	SHEET
DATE: SEPT. 1999			DWG.NO.

SCALE: 1"=100'

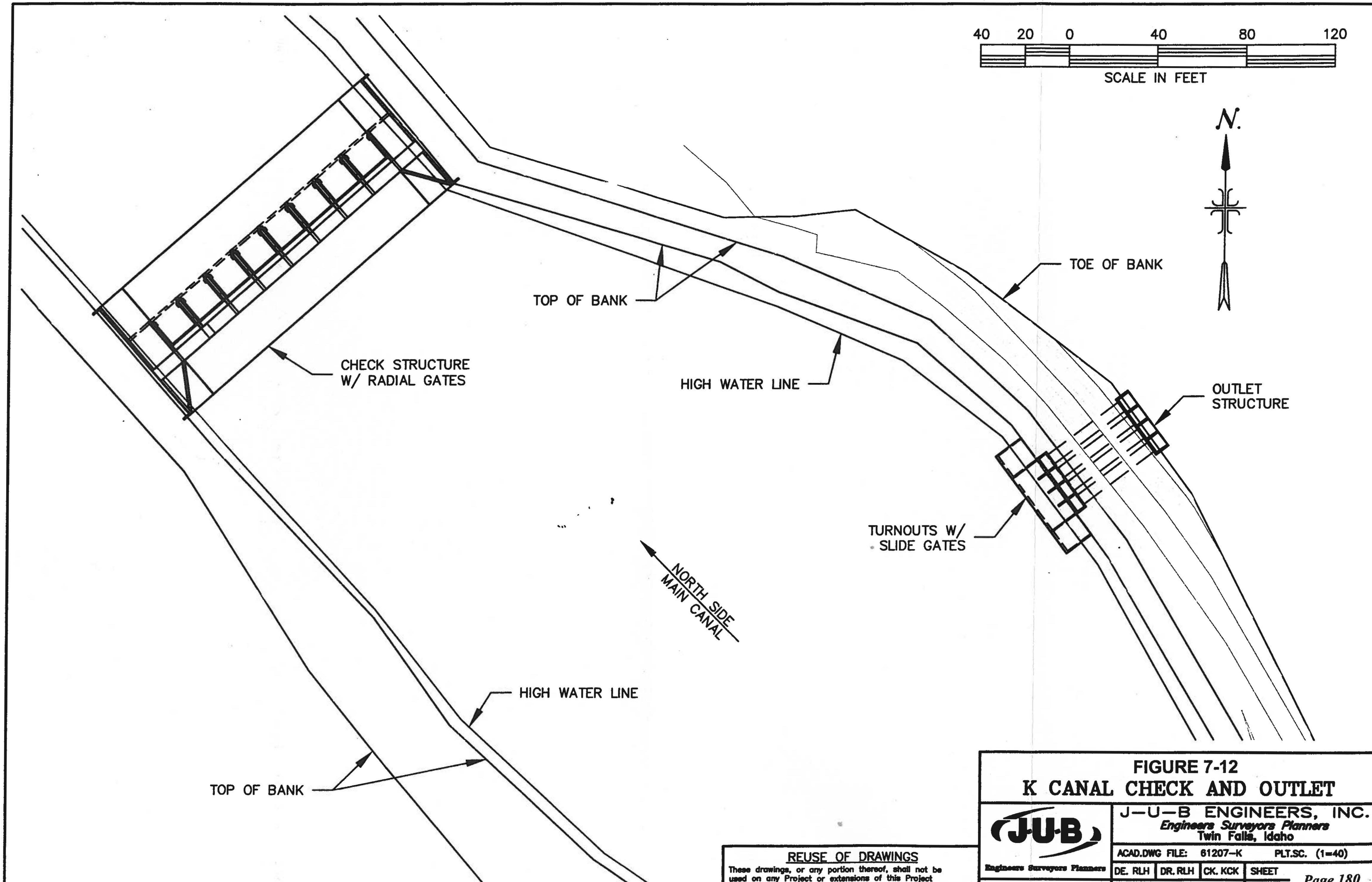


FIGURE 7-12

K CANAL CHECK AND OUTLET

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ACAD.DWG FILE: 61207–K			PLT.SC. (1=40)
DE. RLH	DR. RLH	CK. KCK	SHEET
SCALE: (1"=40')	DATE: SEPT. 1999		DWG.NO.

REUSE OF DRAWINGS
These drawings, or any portion thereof, shall not be used on any Project or extensions of this Project except by agreement in writing with J–U–B ENGINEERS, Inc.

VIII. SUMMARY/CONCLUSIONS

This report presents an evaluation of large-scale managed recharge for the Eastern Snake Plain Aquifer in terms of four broad screening criteria. *Recharge water availability* refers to the volumes, timing, and location of water available to be diverted from the Snake River and conveyed to recharge sites. *Hydrologic impacts* are the simulated response of the ground-water system to managed recharge, measured as changes in ground-water levels and changes in spring discharge to the river. *Institutional controls and environmental constraints* define the legal, regulatory, and environmental requirements that a managed recharge program must satisfy to be implemented. *Economic costs* are the expenditures that will be needed to construct recharge sites and associated conveyance structures required for conducting large-scale managed recharge.

A. Recharge Water Availability

Recharge water availability has been estimated by statistical analysis of conditioned historical flows at four main diversion locations on the Upper Snake River. Expected annual recharge rates must of necessity be determined subject to many different assumptions. For this study, there were four main assumptions. Only surplus natural flows (flows passing Milner Dam) are used for recharge, diversion of surplus flows are not limited by hydropower rights. Excess capacity of existing canal facilities limit recharge, although modification of USBR winter water savings agreements would allow the use of most canals during winter months. Stream maintenance flow recommendations developed by IDFG may limit water availability. Finally, recharge is not limited by availability of suitable recharge sites.

The assumption that canals may be used during winter months to convey recharge water is based on results of previous studies which concluded that managed recharge activity on a scale much larger than what has been attempted in the past would be needed, in order to meet basin-wide hydrologic objectives. At the same time, an economic analysis has revealed that construction of entirely new diversion facilities specifically for managed recharge would be cost-prohibitive. This leads to the conclusion that the use of existing facilities in new or different ways must be considered as part of any large-scale managed recharge plan.

The rate at which large-scale aquifer recharge could be expected to occur over the long term, is referred to as the expected aquifer recharge rate. Expected aquifer recharge is mainly a function of the magnitude and frequency of surplus flows, however it is also constrained by instream flow requirements and by availability of existing canal capacity.

A range of expected aquifer recharge rates was generated for each of the four recharge scenarios presented in this report. At the high end of the range are those rates that are constrained only by canal capacity and not by IDFG flow recommendations. At the low end are those that are constrained by both canal capacity and the IDFG recommendations. For each scenario, the estimate of expected recharge was determined independently of other scenarios.

The high-end estimate of expected recharge for the "Egin Lakes" scenario that diverts above St Anthony is 201,000 acre-feet per year, and the low-end estimate is 12,000 acre-feet per year. For the "Hells Half Acre" scenario that diverts below Idaho Falls, the high-end estimate is 334,000 acre-feet per year, and the low-end estimate is 56,000 acre-feet per year. The high-end estimate for the "Lake Walcott" scenario, which diverts above Minidoka Dam, is 176,000 acre-feet per year, and the low-end estimate is 65,000 acre-feet per year. For the "Thousand Springs" scenario, which diverts water at Milner Dam, the high-end estimate of expected recharge is 648,000 acre-feet per year, and the low-end estimate is 416,000 acre-feet per year.

From the standpoint of expected recharge rate, the "Thousand Springs" scenario has the greatest potential for large-scale managed recharge development, especially if IDFG recommendations for stream maintenance flows are imposed. As this scenario also demonstrated, expected recharge rates are greatly influenced by availability of excess canal diversion capacity. The additional diversion capacity that results from using both the North Side and Milner Gooding canals during winter months, allows the "Thousand Springs" scenario to take advantage of much higher flows that recur less frequently. Over the long term, the increase in expected recharge that this extra capacity affords, offsets significantly, the effect of meeting IDFG stream maintenance flow recommendations.

B. Hydrologic Impacts

Restoring and sustaining ground-water levels in the central part of plain and spring discharges in the Kimberly to Bliss reach of the Snake River, are key hydrologic objectives of large-scale managed recharge in the ESPA. The notion of "recharge efficiency" conveys the idea that managed recharge which achieves these key objectives in the most hydrologically efficient manner will incur the least overall cost, and will have the least impact on other water use priorities. Therefore, conclusions regarding relative efficiency of recharge scenarios are useful for prioritizing recharge projects in different areas of the plain. The following conclusions are based on results of modeling the four managed recharge scenarios that were presented in this report.

The "Thousand Springs" recharge scenario is highly efficient in meeting the two key objectives. After 20 consecutive years of recharge at the expected rate of 416,000 acre-feet per year, spring flows in the Kimberly to Bliss reach could be expected to increase between 350 and 450 cfs. Ground-water levels in the central part of the plain could be expected to increase between 10 and 15 feet. Nearly 100 percent of the "Thousand Springs" recharged water would be used to meet these two objectives.

The "Lake Walcott" scenario is also efficient in terms of meeting key objectives. Although its capacity to satisfy both objectives is much more limited. After 20 consecutive years of "Lake Walcott" recharge at expected rate of 176,000 acre feet per year , ground-water levels in the central part of the plain could be increased 8 to10 feet, and discharge in the Kimberly to Bliss reach would be increased by about 100 cfs. More than 80 percent of the recharge water of the "Lake Walcott" scenario would be used to meet these two objectives. At equilibrium, the "Lake Walcott" scenario would also induce an increase in discharge to the river in the Blackfoot to Minidoka reach that is equivalent to about 20 percent of the water that is recharged, or about 40 cfs. Both of these Area I scenarios represent highly efficient uses of recharge technology for accomplishing the two key objectives that have been identified.

On the other hand, only about 3 percent of the water recharged in the "Hells Half Acre" scenario would go toward meeting either of the two objectives, and less than 1 percent of the "Egin Lakes" recharge water would go toward meeting these objectives. The Area II and III scenarios must therefore be considered to be a far less efficient use of this technology for accomplishing the stated objectives. Managed recharge conducted in Areas II and III does, however, have substantial impact on ground-water levels and spring discharges within the respective areas of influence, and may be important for addressing other (sub-basin) conjunctive management problems.

C. INSTITUTIONAL CONTROLS

In addition to water availability and ground-water impacts, the report evaluates several non-hydrologic factors that will affect a managed recharge program in the Eastern Snake Plain Aquifer. In accordance with federal and state laws, a large-scale managed recharge program will undergo considerable environmental review prior to obtaining necessary regulatory approvals. Review will be formalized through an Environmental Impact Statement (EIS) and compliance with the Endangered Species Act.

The Snake River and its riparian corridor provides habitat to several species listed as threatened or endangered under the Endangered Species Act, as well as species designated for special concern by the Idaho Department of Fish and Game. These species include anadromous fish, snails, white sturgeon, Yellowstone cutthroat trout, bull trout, and bald eagle. A managed recharge program must be designed to avoid adverse impacts to the habitat on which these species depend. A successful design requires extensive consultations with the agencies mandated to protect biological resources: Idaho Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service. The instream flows that were recommended by Idaho Fish and Game and incorporated into the water availability analysis in this report represent one step in the consultation process.

Managed recharge must also comply with other environmental laws. In accordance with the federal Clean Water Act, the Idaho Division of Environmental Quality (IDEQ) has developed water quality standards for the middle Snake River, has identified violations that regularly occur during spring and summer, and has developed corrective actions.

The final design of a managed recharge program must comply with the Watershed Management Plan developed by IDEQ, specifically the Plan's maximum daily loads. Compliance will be reviewed during the EIS process.

Idaho law directs IDEQ and IDWR to protect the quality of ground water from potential impacts of artificial recharge. IDEQ will review a managed recharge program for consistency with the Idaho Ground Water Quality Plan and for adequate monitoring of ground-water quality impacts.

In addition to laws and regulations associated with environmental protection, other institutional controls will affect a managed recharge project. Diversions for managed recharge can occur only within the established system of water rights administered by the IDWR. An application for a new diversion permit will be subject to the usual protest procedures, and even if not protested, will need to be considered in light of the local public interest. If issued, the permit to divert water for managed recharge will be junior in priority to all senior water rights.

Claimed flow rights by the Idaho Power Company (IPCo) have the potential to dramatically restrict recharge diversions. The magnitude of restrictions will depend on the ultimate impact on IPC power generation in the middle and lower Snake River, as well as the legal status of recharge diversions within the Swan Falls Agreement.

Canals considered in this study are subject to the Palisades contracts, which restrict diversions during winter months. An amendment to the contracts may be needed for these canals to participate in a managed recharge program during the winter months. Opinions differ among federal and state officials as to whether a contract amendment is required. A contract amendment would be subject to the same environmental review and EIS process required for the entire managed recharge program.

Managed recharge facilities will include large basins. The basins will likely be located on public lands administered by the U.S. Bureau of Land Management (BLM). Use of these lands will require a right-of-way grant from the BLM, which must conduct appropriate environmental review before issuing a grant. The review would likely include surveys of cultural resources and threatened or endangered species in the vicinity of the proposed recharge sites. Sites would be re-located, if necessary, to avoid adverse impacts.

D. ECONOMIC COSTS FOR SPECIFIC SITES

The final screening factor affecting the potential for managed recharge is economic costs, defined by direct expenditures to construct, improve, and operate recharge facilities. General costs include construction of new canal diversion facilities, improvements to existing canals and recharge basins, land purchase or leasing of recharge sites, labor and power operations and the cost of adequate water quality monitoring. Costs of new canal construction are prohibitive; therefore, managed recharge must rely on the use of existing canals. Interviews with owners and operators of canals indicate a willingness to participate in a managed recharge program, when canals are not fully devoted to irrigation deliveries. Willingness extends to use of the canal during winter months, when freezing conditions present operational challenges. The primary concern among canal company representatives is protection from any liabilities associated with managed recharge. Liability can be reduced, if not eliminated, through the development and proper execution of a well-designed and operated water quality and water level monitoring program.

Existing canals will need additional headgate control structures to divert water into recharge basins. The basins are generally natural depressions, but may need to be improved with diking or excavation. At some locations, pipelines, pumps, and canal extensions may be needed to convey water into basins.

Among 89 candidate sites for recharge, spread throughout the Eastern Snake Plain, five specific sites, described as priority sites, were chosen for cost estimation. The five sites were chosen in accordance with four criteria:

- the topography at each site is suitable for either gravity diversion of recharge water, or low head pumping over a short distance;
- a satisfactory diversion route exists to convey water from the Snake River to the recharge basin;
- the surficial material at each site appears to have adequate infiltration capacity;
- the site characteristics are considered typical of sites in the same general area.

At least one site was located in each of the three ESPA hydrogeologic areas of influence that were identified in this report. Three of the priority sites are located within Area I, and one site is located in each of Areas II and III (figure 8-1).

The westernmost site (site N-3) is located along the North Side Canal near the K-Canal diversion. The site is approximately 76 acres, with a recharge capacity of 500 cfs. Capital costs needed to improve the site are estimated to be $950,000. The site located along the Milner-Gooding Canal at milepost 31 (site K-5) is approximately 360 acres, with a recharge capacity of 1,500 cfs. Estimated capital costs needed to improve the site are $790,000. The site north of Lake Walcott (site H-1) occupies 55 acres, and would have a recharge capacity of about 330 cfs. The elevation of the site is above the Minidoka Canal, which is the nearest water source, thereby requiring a pumping station and pipeline. The approximate cost of these improvements is $5.0 million. The New Sweden Reservoir site (site F-1) is located at the end of the Great Western Canal. The site is currently used for incidental recharge, and has a capacity of 50 cfs. No improvements are needed to utilize the site in a managed recharge program. The Egin Lakes / Nine Mile Knoll site (site A-3) is located in the Fremont-Madison Irrigation District, and has an estimated recharge capacity of 500 cfs. The estimated capital cost to improve the site is $1.2 million, most of which is incurred by the expansion of the recharge canal to accommodate flows of 500 cfs.

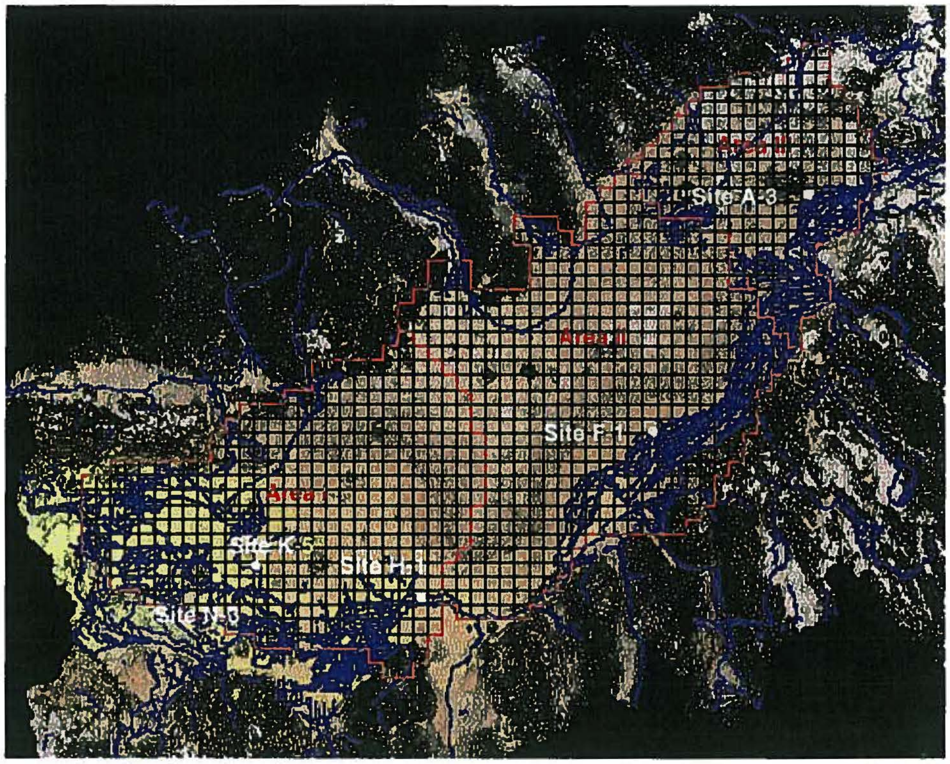

Figure 8-1. Priority Site locations Within Recharge Areas of Influence

Pilot scale recharge tests at these five sites may be the next logical step in a managed recharge investigative process that would verify the simulated hydrologic impacts of large-scale managed recharge conducted in the three areas of influence that have been identified. Pilot scale testing would also provide opportunities to test the feasibility of wintertime recharge diversion, and would provide better overall estimates of the infiltration capacity of recharge basins in these three areas as well as assure that water quality is not adversely impacted.

E. Feasibility of Large-Scale Managed Aquifer Recharge

The feasibility of large-scale managed aquifer recharge must be examined from several different perspectives, including those of *water availability, hydrologic impacts, institutional controls, environmental constraints, and economic costs.*

This report has attempted to identify and describe large-scale managed recharge scenarios for which the requirements of feasibility in these five areas could potentially be met. However, all of the scenarios assume to some extent at least, that existing institutional controls for water use would be altered in order to accommodate large-scale managed recharge activity. (Hydropower production and canal operations being prime examples.) These assumptions are crucial to the development of large-scale managed recharge scenarios.

The broadest conclusion that can be drawn at this point regarding the feasibility of managed recharge of the ESPA is that, hydrologically and economically, large-scale managed recharge appears feasible. However, with respect to institutional controls and environmental priorities there are still many uncertainties and unknowns which blur the question of feasibility.

The principal uncertainties, which would have to be addressed before large-scale managed recharge could be initiated, relate to the following:

- The costs associated with mitigating the impacts on existing hydropower rights.
- The exact mechanism and process that would enable federal project canals and facilities to be used for large-scale diversion of recharge water during winter months.
- The ability to satisfy environmental concerns (including those associated with ESA listed species) with respect to the impact of managed recharge on peak flows in the Snake River.
- The uncertainty associated with how managed recharge would be integrated into a basin-wide conjunctive management plan, and its relationship to a long-term moratorium on new ground-water development.

The main challenges to the basic feasibility of the managed aquifer recharge concept in the ESPA are institutional and environmental. Many questions of managed recharge compatibility with respect to institutional controls and environmental priorities can be addressed through better understanding of ESPA ground and surface water relationships. Enhanced conjunctive hydrologic models and an enhanced network of stream gages and monitoring wells are essential tools for quantifying the benefits of managed recharge activities. Through continued cooperative effort these management tools will be developed, and the remaining questions of large-scale managed recharge feasibility will be answered as pilot-scale testing proceeds.

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APPENDIX A. BUREAU OF RECLAMATION ISSUES

MANAGED RECHARGE OF THE EASTERN SNAKE RIVER PLAIN AQUIFER

SUMMARY

The Bureau of Reclamation operates reservoirs and other facilities that deliver water to over one million acres of land that overlie the Eastern Snake Plain Aquifer. The operation of these reservoirs is consistent with the congressional authorizations of the reservoirs and repayment contracts with water user organizations. Reservoir operation is also consistent with water rights that Reclamation holds under Idaho water law.

Reclamation was requested to provide its views on institutional issues it would face in non federal implementation of a managed recharge program, relying on newly acquired water rights. After reviewing the reservoir spaceholder contracts between the Bureau of Reclamation and water user entities (spaceholders), Reclamation believes contract amendments would be required, depending on which facilities would be used. Reclamation holds no biases against the concept of managed recharge, as long at it is accomplished in a manner that does not impair project operations, and Reclamation is willing to fairly consider contract changes to implement a managed recharge program at the request of involved spaceholders.

BACKGROUND

The Bureau of Reclamation has played a key role in strengthening and sustaining the irrigation economy along the Snake River in Eastern Idaho. The development of American Falls, Jackson Lake, Island Park, and Palisades Reservoirs, the main storage reservoirs serving irrigated agriculture, has augmented late season flows and smoothed out annual fluctuations in water supply to a significant degree. Serious water shortages to surface users, except in extreme conditions, are a thing of the past. The number of irrigated acres in production is several times that which could be sustained without these storage reservoirs.

In recent history there have been two severe droughts in the area– the infamous drought of the 1930's, and the more recent drought in the late 1980's and early 1990's. The drought of the 1990's reminded us that mother nature has not been tamed. This recent drought rivaled that of the 1930's in terms of the poor water supply available, but the impact to surface users was not nearly as severe as the 1930's, due in large part to the operation of Palisades Reservoir, which was authorized by Congress and constructed in response to the serious economic hardships that occurred during the drought of the 1930's.

the translation of these commitments into contractual assurances before the project is complete."[5]

In reauthorizing the project, the Congress expressed its will with respect to winter diversions:

> "The continuation of construction of Palisades Dam beyond December 31, 1951, or such later controlling date fixed by the Secretary as herein provided, is hereby made contingent on there being a finding by the Secretary by the controlling date that contracts have been entered with various water users' organizations of the Upper Snake River Valley in Idaho that, in his opinion, will provide for an average annual savings of one hundred and thirty-five thousand acre-feet of winter water. If in the Secretary's judgement the failure of the requisite organizations so to contract by the controlling date at any time is for reasons beyond the control of those organizations he may set a new controlling date but not beyond December 31, 1952."[6]

Contracts which incorporated the winter water savings provisions discussed above were successfully negotiated with 57 spaceholders. Aside from the Winter Water Savings provisions and the associated adjustment of storage priorities, these contracts incorporated several other significant provisions, including an exchange of space, by several spaceholders, between American Falls and Jackson Lake, subordination of power at Minidoka Dam, and other matters.[7] These provisions were the subject of lengthy study and negotiation by Reclamation and the spaceholders, and represented significant changes from historic practices. Consistent with Reclamation's practice of securing court confirmation of newly executed repayment contracts, the provisions of the Palisades contracts were made the subject of two supplemental decrees. The decree covering the upper valley users was entered in Fremont County, on March 12, 1969, and entitled Aberdeen-Springfield Canal Company et al., v Henry Eagle, Watermaster, Water District No. 36, State of Idaho. The decree covering the lower valley users was entered in Twin Falls County, on July 10, 1968, and entitled Burley Irrigation District et al., v Henry Eagle, Watermaster, Water District No. 36, State of Idaho.[8] Both decrees incorporate

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[5]June 17, 1949 letter from the Commissioner of Reclamation to the Secretary of the Interior

[6]3Act of September 30, 1950, (64 Stat. 1084)

[7]January 27, 1972 memorandum from the Field Solicitor, Boise, to the Regional Director, Bureau of Reclamation

[8] Ibid.

specific contract terms, including the winter water savings article, by reference. They further state:

> "That the contacts entered into between various of the parties plaintiff, and others, and the United States of America, Bureau of Reclamation, as the same have been amended and modified, in connection with the Palisades project and other projects, were intended to be, and are, binding upon all persons claiming rights to the use of the water of the Snake River and its tributaries, above Milner Dam, and constitute a common plan for administering the operation of the Snake River."[9]

The winter water savings provisions were considered successful. Shortages that occurred in 1961 were considered to have been significantly alleviated due to curtailment of winter diversions by the North Side and Twin Falls Canal Companies. It was observed that if the Companies had initiated curtailments in 1959, the shortages that actually occurred in 1961 would probably have been eliminated.[10]

The final contract implementing the curtailment of winter diversions was executed in 1976 by Utah-Idaho Sugar Company, Inc. (later U& I Inc.), for lands now served by the Osgood Canal Company, Ltd. A contract was never executed with Owners Mutual Irrigation Company, which was identified to curtail winter diversions and receive 290 acre-feet of preferred Palisades space. On May 31, 1994, final disposition of nearly all Palisades space was completed by the execution of a contract with Mitigation Inc. Conveyance of 18,980 (of a total 19,480 uncontracted) acre-feet of uncontracted space was stipulated in the 1990 Fort Hall Indian Water Rights Agreement. Congress approved the settlement (and disposition of space) in the Fort Hall Indian Water Rights Act of 1990 (104 Stat. 3059).

Because the contract provisions, with respect to winter diversions are very broad, and the subject of specific Congressional action. Reclamation believes that spaceholder contracts must be amended before any of the spaceholders listed above, which agreed to curtail winter diversions, may divert water outside the irrigation season for managed recharge.

Specific canals in the Basin are Reclamation Project facilities (Unit A of A&B, Cross Cut, Falls, Milner-Gooding Minidoka, and Burley Canals). The existing contracts

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[9] Supplemental Decree, County of Fremont: Aberdeen-Springfield Canal Company, et. al., v. Henry Eagle, Watermaster, Water District no. 36, State of Idaho pp 62-63

Supplemental Decree, County of Twin Falls: Burley Irrigation District, et. al., v. Henry Eagle, Watermaster, Water District no. 36, State of Idaho pp 19

[10] Bureau of Reclamation, Op. Cit. p 4-5

governing those canals only authorize their use for irrigation of land within the spaceholder's service area. If these canals are to be used for managed recharge, a use-of-facilities contract must be implemented by Reclamation and the spaceholder which operates the canal. It is noted that title to Burley irrigation District is in process of being transferred from the United States to the Burley Irrigation District.

ENVIRONMENTAL EVALUATION AND REVIEW

Contract amendments and use-of-facilities agreements for managed recharge proposals are federal actions. Prior to taking such action, Reclamation must comply with provisions of various environmental laws and regulations including: the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), Fish and Wildlife Coordination Act (FWCA), National Historic Preservation Act (NHPA), Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Protection of Wetlands, Floodplain Management, and Sacred Sites Executive Orders, and other laws, regulations, and executive orders. Reclamation must also assess impacts on Indian Trust Assets and consult with any affected tribes.

Reclamation will determine what environmental and biological compliance actions are required for each request. The environmental evaluation, and analysis of any impact concerns as well as consultation processes will be documented in accordance with NEPA regulations. Depending on the type and significance of the environmental effects that a proposed recharge program may have, it is anticipated that NEPA documentation would consist of one of the following:

1. **Environmental Assessment (EA)** - For requests that do not appear up front to have significant environmental effects, Reclamation would proceed with public scoping of issues and alternatives. Then a draft EA would be prepared and distributed for public review by Reclamation. The EA would describe the request, potential alternatives, and the affected environment and would fully analyze associated environmental impacts. If, after public review, no significant environmental effects were identified, Reclamation would finalize the EA, prepare a finding of no significant impact (FONSI), and proceed with measures necessary to provide approval of the requested actions(s). This total process may take a few months or up to a year to complete depending on the complexity of the proposed action and the issues raised.

2. **Environmental Impact Statement (EIS)** - If significant or highly controversial environmental effects are identified up front, in the public scoping process, or in the draft EA, Reclamation would proceed with preparation of a draft environmental impact statement (EIS). The EIS would describe the request, potential alternatives, and the affected environment and would fully analyze associated environmental impacts and recommend any need mitigation measures. The draft EIS would be sent out for public review and comment, and a public hearing(s) would be held. A final EIS reflecting the comments received would then be

prepared and distributed; subsequently, Reclamation would prepare a record of decision (ROD). If the decision is favorable, Reclamation would proceed with the necessary steps to provide approval of the requested action(s). This total process could take 2-3 years or longer depending on the complexity of the proposed action and the issues raised.

The NEPA and associated environmental compliance processes will require an extensive public involvement and scoping process beyond that already taken. The scoping process would need to be broad enough to flesh out all relevant environmental issues and all reasonable alternatives to groundwater recharge. The purpose and needs statement for the proposal would have to be carefully crafted to put reasonable sideboards on alternative analyses.

An alternative that may come up in the public involvement process, and will need to be addressed, is the potential to improve groundwater conditions through reduction in groundwater pumping.

There would also have to be an analysis of what will happen if no action is taken in the next few years or over time. This "No Action" or "Future Without"will also be a requirement in the NEPA analysis.

The identification and role of "lead agency(s)" would have to be defined as well as cooperating agencies. Care would have to be taken to avoid piece-mealing the NEPA process (i.e. each agency doing the analysis only for its own separate action(s)) This is contrary to NEPA regulations and circumvents the requirement to analyze and provide public disclosure of all cumulative effects.

The action agencies will be required by Department of Interior regulations to consult with any affected Tribes on these issues. The NEPA analysis would have to include Indian Tribes as potential stakeholders. Effects to Indian trust assets, traditional and cultural properties, and sacred sites will have to be addressed in the effects analysis.

ENDANGERED SPECIES ACT COMPLIANCE

Subsection 7(a)(2) of the Endangered Species Act[11] imposes a duty on Federal agencies to consult on any agency actions that the agency determines *may affect* a listed species. The *may effect* threshold is low. Virtually any anticipated impact to listed species, whether positive or negative, would trigger a may effect determination. Reclamation has not conducted a may effect analysis of a potential request to amend project storage contracts to permit managed recharge, but would observe that managed recharge would change historic flow patterns in the Snake River. Reclamation's operations of Snake River Basin projects is a subject of ongoing consultations with the National Marine

[11] The Act of December 28, 1973, 87 Stat. 884

Fisheries Service (NMFS), and it is likely that the changes proposed for managed recharge would be determined to constitute a *may effect* on listed salmon and steelhead, and trigger consultations. It is more likely that the changes in flow patterns, and reductions in flows in certain parts of the Snake River during high flow conditions would be determined to constitute a *may effect* on listed snails that live in the Snake River, and trigger consultations with the U.S. Fish and Wildlife Service (USFWS).

Reclamation would initiate consultation by requesting a list of threatened and endangered species, that might be impacted by the proposed action, from the listing agencies (NMFS and USFWS). After the species lists are provided, Reclamation (the action agency) would prepare a Biological Assessment, outlining the proposed action and identifying how Reclamation believes the species would be impacted. When complete, the Biological Assessment is submitted to the listing agencies.

If the Biological Assessment reveals that the proposed federal action is likely to adversely affect a listed species, or result in destruction or adverse modification of designated critical habitat, a Biological Opinion will be prepared by NMFS, FWS, or both (depending on the species affected). Any Biological Opinion prepared for this, or any federal action, must reach one of three conclusions: 1) that the proposed action would not jeopardize a species or adversely modify critical habitat, 2) that the proposed action would result in such jeopardy or adverse modification, but that there are reasonable & prudent alternatives to the proposed action, or 3) that the proposed action will result in jeopardy or adverse modification, and there are no reasonable & prudent alternatives. The first two possible outcomes allow the proposed action to proceed. However, no agency may proceed with an action which will result in jeopardy or adverse modification of critical habitat, unless having first received an exemption from the Endangered Species Committee (the so-called "God Squad"). The exemption process is rare, arduous, and difficult to predict; the Committee has convened only three times, granting exemption in two of those cases.

If an action may *take* individual listed species, as defined in the ESA regulations[12], but will not jeopardize the species, an incidental take statement will be included in a Biological Opinion, that protects the agency against the takings prohibitions of section 9 of the ESA. The Incidental Take Statement will contain reasonable and prudent measures, and terms and conditions, to minimize take. Reasonable and Prudent Measures, (not the same as Reasonable and Prudent Alternatives, which apply if the listing agency determines that the action is likely to jeopardize the continued existence of the species) must be limited to changes in "minor features" of the proposal deemed necessary to minimize take. Terms and Conditions are nondiscretionary actions required of an agency to implement Reasonable and Prudent Measures.

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[12] "Take is defined as a potential variety of actions, including harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect.

REQUIRED ACTIONS

Reclamation would entertain a request to amend the Palisades contracts, and change the winter water savings provisions. Reclamation would also entertain requests to amend the contracts governing Reclamation Project canals to authorize their use for managed recharge. The following major steps would be required:

- Palisades contractors representing a majority of the reservoir space, submit to the Bureau of Reclamation a formal request to amend the Palisades contracts in order to permit winter diversions of water for managed recharge, under conditions that do not impair the operation of Reclamation projects.

- Spaceholders operating Reclamation project facilities (Unit A, Cross Cut, Falls, Milner-Gooding Minidoka, and Burley Canals) request use-of-facility contracts for the purpose of managed Recharge. Title to the Burley Canal is being processed. In any event, Burley Irrigation District would need to amend its winter water savings provision in order to be able to divert water for managed recharge.

- Reclamation determines the conditions under which managed recharge may occur while operating Palisades Dam without impairing project operations (that the project can be operated substantially in accordance with the Act of September 30, 1950, 64 Stat. 1083), including a determination of how many spaceholders must approve the new provision. Reclamation understands that managed recharge would be conducted under water rights that are junior to Reclamation storage rights, and presumes at this point that the irrigation purposes of Reclamation reservoirs should not be seriously impacted.

- Reclamation determines an appropriate use of facilities charge and other provisions that would apply in use-of-facilities contracts.

- The Commissioner of Reclamation approves amendment of the spaceholder contracts and use-of-facility contracts.

- Reclamation complies with the National Environmental Policy Act. This would entail a review of the environmental impacts associated with the proposed change, and an analysis of alternatives. Mitigation measures might be proposed, if they are determined necessary. Also included would be consultation with affected native American tribes, to evaluate the impact on tribal trust assets.

- Reclamation reviews the potential effects of the proposed action on listed species, under the Endangered Species Act. If through the review Reclamation determines that the action "may effect" listed species (either negatively or positively), it must consult with the National Marine Fisheries Service and U. S. Fish and Wildlife Service (listing agencies) under Section

7(a)(2) of the Endangered Species Act[13]. The consultation would be pursuant to section 7 of the Endangered Species Act. The main species of concern would likely be listed salmon, steelhead, and snails. The apparent affect of the proposed action would be to diminish winter and spring freshet flows, which may be partly offset by increased springflows down stream at other times of the year. The listing agencies may recommend terms and conditions on the proposed operation with the intent to diminish the incidental take of listed species.

- A requisite number of spaceholders, as determined by Reclamation after discussions with spaceholder interests and others, amend their Palisades contracts. Those entities operating Reclamation project canals which desire to recharge enter into use-of-facility contracts.

- At the request of the spaceholders and Reclamation, the Snake River Basin Adjudication Court amends the two Eagle supplemental decrees, to incorporate the amended winter water savings provisions. The contract amendments and use-of-facility contracts become operative.

The current rules governing operation of the Snake River above Milner Dam do not permit significant managed recharge efforts. Contracts and decrees can be changed, however, and Reclamation is willing to fairly consider recommended changes to the contracts and decrees that will modernize the criteria for managing the waters of the Snake River.

[13]Act of December 28, 1973 (87 Stat 884)

Appended Material

Contract Article establishing Winter Water Savings
Saving of Winter Water; Special Storage Right

"(a) Beginning with the date announced by the Secretary as the time when Palisades Reservoir will be ready for operation as provided in article 12, the [spaceholder] shall, for a period of 150 consecutive days during the period from November 1 through April 30 of each storage season, make no diversion of water from the Snake River or any of its tributaries by means of its existing diversion works or by any other means.

(b) The total savings of water during each storage season as the result of curtailment of winter diversions by the Company and all other water users organizations diverting from the Snake River who have contracted with the United States to curtail or cease diversions is agreed to be 143,000 acre-feet, of which 135,000 acre-feet are attributable to curtailments by those diverting above American Falls Dam and 8,000 acre-feet below that point. The [Spaceholder], diverting above [or below, as the case may be] American Falls Dam shall be entitled to store in Palisades Reservoir during each season during which curtailment of winter diversions is made as provided in (a) of this article, [____] acre-feet. [Alternative language: The Spaceholder, not participating in the winter water savings program, shall be entitled to no storage in ___ Reservoir by reason of the program set out in this article]

(c) The right to store water pursuant to this article shall be prior in time over the storage rights held by the United States for American Falls Reservoir (the latter having a priority dated March 30, 1921), or any storage rights held by the United States or the [Spaceholder] that are junior to the American Falls rights. The [Spaceholder] hereby consents to the granting of special storage rights with a like priority to all water users organizations and all water users who, directly or indirectly, contract to curtail storage season diversions substantially as provided in (a) of this article within these maxima as to total special storage rights:

> (1) For water users organizations and water users diverting above American Falls Dam– 135,000 acre-feet.
>
> (2) For water users organizations and water users diverting between American Falls Dam and Milner Dam– 8,000 acre-feet, exclusive of the special storage rights described in (d) of this article.

(d) The [Spaceholder] also hereby consents to permitting the North Side Canal Company and the Twin Falls Canal Company to store, in either American Falls or Palisades Reservoir, during the months of November through March of any storage season under a priority like that provided in (c) above, water that would otherwise accrue to them within these rights:

The rights of the North Side Canal Company and of the Twin Falls Canal Company, respectively, to divert at Milner Dam for domestic and livestock uses during those months as follows:

North Side Canal Company ....126,000 acre-feet
Twin Falls Canal Company .... 150,000 acre-feet

> If, taking account of all storable water whether stored or not, Palisades and American Falls reservoirs fail to fill during any storage season, any water diverted during that storage season by the North Side Canal Company in excess of 126,000 acre-feet (but not to exceed the amount of deficiency in fill), and by the Twin Falls Canal Company in excess of 126,000 acre-feet (but not to exceed the amount of deficiency in fill), will be charged as of the end of that storage season against the allotment of American Falls storage to these respective companies.

This limitation in the case of the North Side Canal Company shall become operative from the date Palisades Reservoir is ready for operation, but in the case of the Twin Falls Canal Company need not be made operative until the first year in which that company exercises the special storage provision to which consent is here given."

APPENDIX B. IDAHO FISH AND GAME DEPARTMENT ISSUES

MANAGED RECHARGE OF THE EASTERN SNAKE RIVER PLAIN AQUIFER

INTRODUCTION

History

Development of the mid and upper Snake River basins began in the late 1880's when the first major irrigation diversion was built. The first hydroelectric dam (Swan Falls) was built in 1901. Milner was completed in 1905. Federally built projects soon followed. Minidoka was completed in 1906. Today, there are approximately 92 hydroelectric projects and countless diversions in the Idaho portion of the middle and upper Snake basins. For the purpose of this study, the Mid Snake Basin is defined as the Snake River and tributaries from Brownlee Dam upstream to Milner Dam. The upper Snake Basin is defined as the Snake River and tributaries from Milner Dam upstream to the Idaho State line.

Prior to development, the mid and upper Snake River basins supported commercial fisheries on salmon, steelhead, white sturgeon and resident trout. White sturgeon historically migrated freely throughout the Snake River (up to Shoshone Falls) and Columbia River to the ocean, as did salmon and steelhead. Bull trout and redband trout also freely migrated throughout the Snake River Basin up to Shoshone Falls.

The typical pre-development hydrograph was characteristic of snowmelt dominated streams. The flows peak in June and steadily decline through the summer and fall, reaching lowest flows during the winter. Flows start increasing during the late winter through spring as temperatures warm.

Present Condition

Development in the mid and upper Snake River basins has significantly changed this flow regime through much of the basin to the detriment of the native fishes (Palmer 1991; USFS and BLM 1997). The natural hydrograph no longer resembles the historic condition due to impoundments, diversions for irrigation, municipal, and industrial uses, hydropower, channelization, floodplain enchroachment, and a variety of land management activities. Often the timing of flows and volumes are insufficient for the maintenance of fisheries, other aquatic resources, and water quality. Generally, the Snake River upstream of Milner Dam and major tributaries like the Henrys Fork and

South Fork are characterized by reduced spring runoff, higher summer flows and reduced late fall and winter flows compared to pre-development flows. Downstream from Milner, the flow regime is characterized by a lack of a spring-time peak in the hydrograph, drastically reduced summer flows (down to 200 cfs), and lower than historic winter flows.

Figure 1 illustrates the changes in the hydrograph downstream of Milner Dam resulting from development. The lines represent:

1) An estimate mean monthly flows for a typical unregulated hydrograph,

2) The mean monthly regulated flows for the 1927 – 1998 period of record, and

3) The mean monthly regulated flows for 1994 – 1998. This represents recent operations since flow augmentation began and a wet period with above average snowpack.

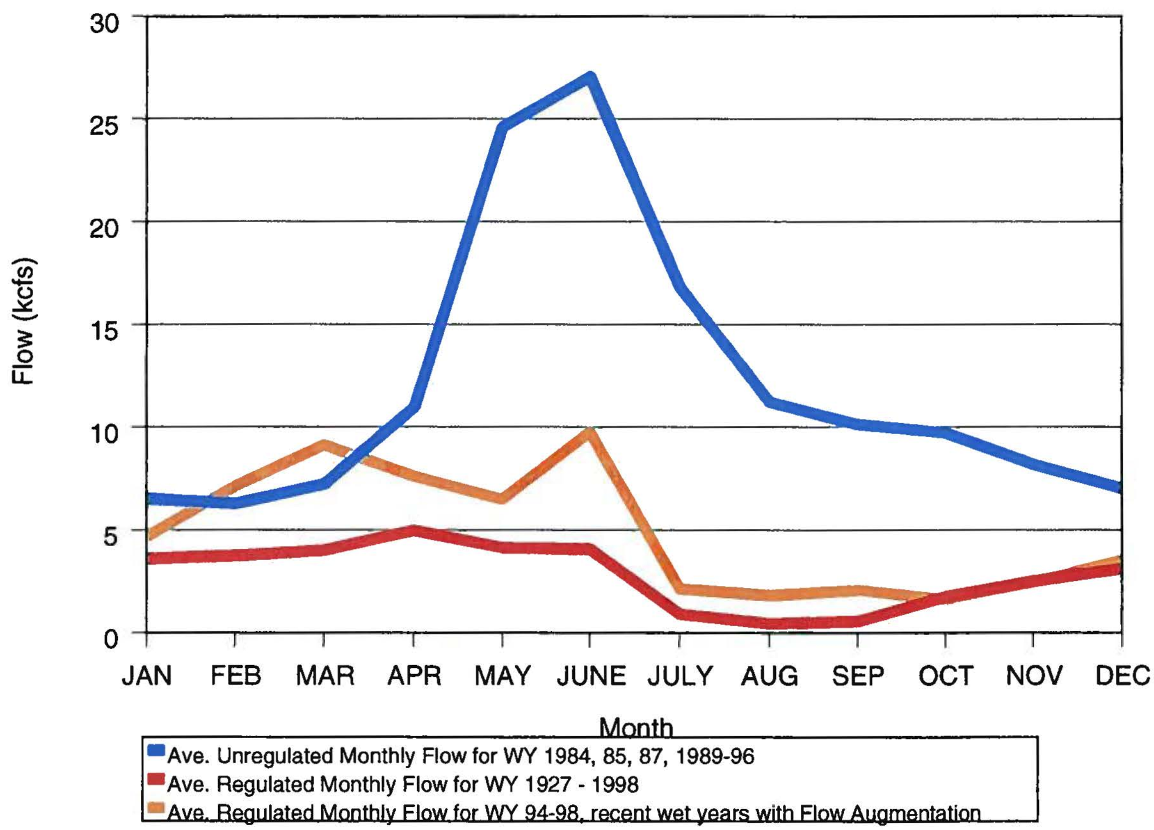

Figure 1. Estimated average unregulated and regulated mean monthly flows below Milner Dam.

Much of the mainstem Snake River has been designated as "water quality limited" by the Environmental Protection Agency (EPA). The primary pollutants are nutrients, increased sediment levels, and increased water temperature. The sources of these pollutants are agriculture, municipalities, and the aquaculture industry. Lower flows in the river exacerbate the pollution problems by reducing the ability of the river to assimilate and flush the pollutants through the system as well as by reducing the dilution of the pollutants. Lower flows during the summer result in increased warming of the river.

Upstream of Milner Dam, the non-irrigation season has been identified as a critical time period for fish (mainly trout) with low flows during this time identified as a major factor limiting fish survival and population size. The river downstream of Milner Dam is considered water-short year round. A spring-time peak in the hydrograph is critical for successful sturgeon spawning and early development. Summer and winter flows are extremely low, resulting in water quality problems and negative impacts to the fishery. The importance of periodic high flows during the spring has been recognized for creating and maintaining riparian, floodplain, wetland, and instream habitats for fish and wildlife throughout the basin, as well as improving water quality by flushing sediment and nutrients. These flows have also been lacking in the basin. The removal of this springtime peak has lead to extensive human encroachment into the floodplains.

The distribution and abundance of white sturgeon, bull trout, redband trout, and Yellowstone cutthroat trout have declined throughout their range. In 1998, the U.S. Fish and Wildlife Service listed Columbia Basin bull trout and in 1999 the Jarbidge River bull trout population as threatened species under the Endangered Species Act (ESA). Redband and Yellowstone cutthroat have been petitioned for listing under ESA. All four species have been listed by IDFG as species of special concern, category A, the highest priority, and by the Bureau of Land Management as sensitive species. The U. S. Forest Service has identified the three trout as sensitive.

Bull trout are absent from the mainstem Snake River and the lower reaches of most tributaries in the Mid Snake Basin below Shoshone Falls. Redband trout numbers are greatly reduced in the mid Snake River. Bull trout, and in some drainages redband trout, are restricted to the upper reaches of the tributaries primarily due to degraded habitat, increased water temperatures, decreased water quality, and decreased flows resulting from development as well as physical barriers to movement from dams, diversions, and improperly constructed river crossings.

White sturgeon numbers in the Mid Snake River have been drastically reduced and fragmented by dams on the mainstem Snake River. The development of the Snake River has significantly altered habitat, modified flows, blocked migration, and reduced food sources for white sturgeon. Between Brownlee Pool and Shoshone Falls, white sturgeon have been fragmented into five isolated populations. The drastically altered flow regime has limited successful white sturgeon reproduction. White sturgeon spawn in the spring with higher flows and cooler water temperatures provided by the snowmelt. Poor water quality has also impacted white sturgeon in the Snake River. In the summer of 1990, extremely low dissolved oxygen levels associated with poor water quality resulted in the death of more than 90 white sturgeon in the upper one-third of Brownlee Reservoir.

AQUIFER RECHARGE IMPACTS ASSESSMENT

IDFG has worked cooperatively with IDWR by assisting in evaluating potential impacts to fish and wildlife resulting from large-scale managed recharge and to develop flow regimes that would attempt to minimize negative impacts from a recharge program.

The questions IDWR has asked IDFG to answer are: 1) What flows are needed that will provide long-term protection of the existing fish and wildlife resources in the Snake River basin and perhaps allow for some improvement in the fish populations? and 2) What will be the impacts of aquifer recharge on these fish and wildlife resources? These flows would be used by IDWR along with information from other entities to assist in determining the feasibility of large-scale managed recharge in the mid and upper Snake River basins. The specific reaches where flow recommendations were requested are the Snake River from Milner Dam downstream to approximately C. J. Strike Reservoir, from American Falls Dam downstream to Minidoka Dam, from Blackfoot downstream to American Falls Reservoir, and the Henrys Fork from St. Anthony downstream to the mouth.

The information necessary to assess the impacts to fish and wildlife from large-scale managed recharge is limited. Only theoretical estimates of the average water availability on a mean monthly basis are provided. The range of potential flows to be diverted is not known. It should be noted that impacts of large-scale managed recharge will be underestimated when only averages are considered and not the full range of possibilities. Biological data, such as the effects of various flows on fish populations and habitat on a seasonal basis, is also limited. This information is needed in order to quantify the impacts resulting from large-scale managed recharge.

The effect of recharge on terrestrial habitats and wildlife in those areas can not be assessed until specific recharge proposals are presented that identify the specific sites, the timing of inundation, and the amount of land flooded at each site.

There are many other factors that come into play when assessing the impacts of large-scale aquifer recharge. Many of these are beyond the scope of this project and can not be addressed until specific recharge projects are proposed. For example, it is unknown how the canals will be operated. Will they run at a specified flow all winter or will they be opened and closed repeatedly, thus causing repeated fluctuations in river flow? What will be the timing and actual rate of diversion? What will be the cumulative impacts of multiple recharge projects occurring simultaneously?

By necessity, because this is a feasibility study with few specifics and not a proposal for recharge, much of the assessment is qualitative.

Downstream of American Falls Dam

Milner – C. J. Strike Reservoir

Fishery

White sturgeon are the primary focus of IDFG's fisheries management in this river segment. The reach is characterized as often having inadequate flows during the spring and summer (March through July) for successful white sturgeon spawning and early development, low summer flows and associated water quality problems, and low winter flows that can result in acute ammonia toxicity to aquatic organisms. Further flow reductions in this reach will exacerbate these existing problems.

There are also naturally reproducing rainbow trout and cutthroat trout populations in this segment. Spawning and juvenile rearing occurs primarily in side channels and spring-fed creek systems. These side channels are typically the first areas to dry up as flows are decreased. As is the case throughout much of the basin, the trout population size is determined primarily by young-of-the-year survival through the non-irrigation season. Keeping the flow high enough to keep water in the side channels through the non-irrigation season is critical. Peaks in the hydrograph are also necessary to rejuvenate gravel in side channels for fish spawning and macroinvertebrate production.

Irrigation diversions for the Northside and Twin Falls Canal systems take the majority of water from the Snake River during the irrigation season. Entrainment of fish has been noted in both canal systems, but has not been quantified. Entrainment rates for winter diversion into these systems should be researched prior to implementation of large-scale recharge.

Water Quality

In the spring through late summer, high water temperatures can pose a threat to aquatic life. High water temperatures can prevent or stop sturgeon and trout spawning, kill larval sturgeon, and promote fungal and bacterial growth on eggs and juvenile trout. Higher water temperatures reduce the dissolved oxygen in the water. At times, there has not been sufficient oxygen in the water to support aquatic life. Chapman and Associates found diel oxygen content of less than 1 mg/l during research on the Mid Snake River in the summer of 1992. This was attributed to a combination of high temperatures, low flow, and extensive macrophyte growth.

Acute ammonia toxicity can occur during the non-irrigation season. Low flows coupled with cold water temperatures reduce the Snake River's natural ability to assimilate nitrogenous inputs. Major sources of ammonia discharge to the Mid Snake River include municipal sewage treatment plants and aquaculture facilities. Extensive improvements in wastewater systems, such as the city of Twin Falls plant, over the past 10 years have reduced ammonia input and problems associated with ammonia toxicity. However, levels sufficient to chronically impact aquatic organisms still exist (Idaho Health and Welfare, Division of Environmental Quality 1998a).

Winter/Icing

The main concern is surface ice forming on the river, especially in the shallower near-shore areas and side channels. The ice can prevent waterfowl from foraging on aquatic vegetation and raptors such as bald eagles from capturing food. Icing can also concentrate waterfowl, which increases the risk of transmitting diseases such as avian cholera.

Ice formation in the side channels can also reduce or eliminate young-of-the-year and juvenile trout habitat, thus decreasing over-winter survival and negatively impacting the population.

Waterfowl

Trumpeter swans winter in this reach of the river as well as the Henrys Fork. Sufficient flows are needed so icing will not prevent swans and other waterfowl from utilizing the aquatic vegetation.

Unknowns

There are five species of aquatic snails listed as either threatened or endangered by the U. S. Fish and Wildlife Service (USFWS). The flow and habitat requirements for these species are not well understood. Of the five species, the Bliss Rapids (*Taylorconcha serpenticola*), Idaho Springsnail (*Pyrgulopsis idahoensis*), Utah Valvata (*Valvata utahensis*), and Snake River Physa snail (*Physa natricina*) are all found in the main Snake River. Additionally, the California floater (*Anodonta californiensis*) and Columbia pebblesnail (*Fluminicola columbiana*) are considered "species of concern" by the USFWS along with the Shoshone sculpin (Cottus greenei) (USFWS 1995).

Specific ramping rates that limit negative impacts on fish populations (e.g. false spawning cues) and fish habitats have not been identified. Additional site specific research needs to be conducted to accurately quantify tolerance limits of native aquatic organisms to artificial flow manipulation.

It is understood in a general, qualitative way how the ecosystem operates and how biotic and abiotic factors interact to make the system function. But, detailed site specific data is lacking throughout much of the Snake River basin. In addition to the unknowns previously mentioned, specific detailed studies have not been conducted to adequately determine flows that:

1) Protect important side-channel young-of-the-year trout habitat from dewatering and/or icing.

2) Provide sufficient ice-free, shallow, low velocity areas with ample aquatic vegetation for swan foraging and other waterfowl needs,

3) Maintain the diversity and structure of the stream channels,

4) Protect riparian and floodplain wetland habitat,

5) Adequately transport sediment and nutrients to protect water quality and aquatic species habitat quality,

6) Protect aquatic resources from excessively high summer water temperatures.

Studies are also needed to determine:

1) Flows and depths necessary to prevent dewatering or icing over of side-channels,

2) Factors affecting young-of-the-year trout survival and trumpeter swan foraging habitat,

3) Site specific trout spawning requirements,

4) Fish losses to canal diversions,

5) The relationship between flows and high water temperatures, and

6) The impacts to the wide riverine/wetland complex supported by late spring and summer flows.

<u>American Falls Dam – Minidoka Dam</u>

This reach of the Snake River system is a river-reservoir system. The reach from American Falls Dam to the upper end of Lake Walcott is riverine in nature with the same fish and wildlife habitat needs for a mix of side channels and open flowing water with a pool, riffle, run type structure. During low flow - cold weather conditions, dissolved oxygen levels lethal to trout have been documented below American Falls Dam. These conditions are usually associated with release of anoxic water from ice covered American Falls Reservoir. Low dissolved oxygen levels below American Falls Dam are also associated with mid summer releases of high temperature water. As mitigation for power production, the Federal Energy Regulatory Commission has required Idaho Power Company to install turbine oxygen "blowers" to be used when dissolved oxygen levels are less than 5.5 mg/l. Fish kills attributed to low dissolved oxygen levels were documented in this river reach in 1998 (pers. comm. Dick Scully, IDFG Regional Fisheries Manager).

Fishery

The fishery in this reach is dominated by non-native fish species. Rainbow and brown trout, along with native mountain whitefish are the predominant gamefish in the river while perch, smallmouth bass, brown bullhead, crappie, and stocked rainbow trout comprise the reservoir fishery. Other native fish species include Yellowstone cutthroat, Paiute sculpin, and mottled sculpin. In addition to stocking efforts by IDFG, a number of fish are entrained through American Falls Dam and contribute to a very popular downstream fishery. The two primary tributaries in this reach of the Snake River are Rock Creek and Fall Creek – both heavily degraded by agricultural return flows (pers. comm. Tom Miller, IHW-DEQ Twin Falls). Extremely high substrate sedimentation rates provide for little spawning or juvenile winter rearing habitat for native fishes.

Two major irrigation diversions take water both east and west of Minidoka Dam. Exact fish loss into these systems is unknown at present, however, anecdotal information suggests that significant numbers of both game and nongame fish enter the canal system during the irrigation season. Entrainment of fish into the canals during winter operation needs to be researched if recharge is pursued.

Winter storage of water in the reservoir reduces river flows and can place additional stress on trout, particularly during dry periods. In the winters of 1988 to 1991, minimum flows dropped to only about 300 cfs. Ideal or bankfull flows in this stretch would be 7,000 cfs (Cochnauer 1978).

Water Quality

Water quality impacts are similar to those experienced in the Mid-Snake River below Milner Dam. High summer temperatures and sediment loads combined with an abundance of nutrients influence fish and wildlife habitat. Results are excessive algal growth, excessive bacterial growth, and dissolved oxygen depressions (Idaho Health and Welfare, Division of Environmental Quality 1998b).

Regional agriculture and industrial food processor discharges are the primary nutrient and sediment contributing entities, however, aquaculture facilities and municipalities do contribute to water quality degradation in this reach of the Snake River. Non-irrigation season flows in the Snake River directly impact the river's ability to assimilate nutrient and sediment inputs.

Winter/Icing

Icing of the reservoir and river side channels result in a loss of waterfowl habitat and spawning/juvenile fish habitat in this reach, much like the area below Milner Dam. Impacts are exacerbated by low river flows and greater temperature extremes associated with higher elevation.

Waterfowl

Waterfowl requirements for open-water habitat are more critical in this area versus below Milner. The USFWS waterfowl refuge at Lake Walcott holds significant numbers of waterfowl until Lake Walcott becomes ice-covered. As an example of the impact of icing on waterfowl in this reach, in January of 1998, the annual mid-winter waterfowl count found over 11,000 waterfowl in the reach from American Falls Dam to Minidoka Dam. Open water was noted on the river and Lake Walcott. During the January 1999 count, the lake was completely frozen and ice was noted on side-channels in the riverine section. Only 1,300 total waterfowl were counted in the same reach. It was also noted that waterfowl were concentrated around springs and higher velocity sections of the river.

Unknowns

There are five species of aquatic snails listed as either threatened or endangered by the USFWS. The flow and habitat requirements for these species are not well understood. Of the five listed species, the Utah Valvata is the only one found in the riverine habitat of the main Snake River in this reach (USFWS 1995).

As mentioned for the reach downstream of Milner, specific ramping rates that limit negative impacts on fish populations (e.g. false spawning cues) and fish habitat have not been identified for the channel configuration found below American Falls Dam. Additional, site specific research needs to be conducted to accurately quantify tolerance limits for native aquatic organisms from artificial rates of flow manipulation.

The same list of research needs listed for below Milner Dam applies to the river reach below American Falls Dam. Detailed studies need to address the questions of how much flow is needed to:

1) Protect important side-channel young-of-the-year trout habitat from dewatering and/or icing,
2) Provide sufficient ice-free, shallow, low velocity areas with ample aquatic vegetation for swan foraging and other waterfowl needs,
3) Maintain the diversity and structure of the stream channels,
4) Protect riparian and floodplain wetland habitat and
5) Adequately transport sediment and nutrients to protect water quality and aquatic species habitat quality,
6) Protect aquatic resources from excessively high summer water temperatures.

Studies are also needed to determine:

7) Flows and depths necessary to prevent dewatering or icing over of side-channels,
8) Factors affecting young-of-the-year trout survival and waterfowl foraging habitat,
9) Site specific trout spawning requirements,

10) Fish losses to canal diversions,
11) The relationship between flows and high water temperatures, and
12) The impacts to the wide riverine/wetland complex supported by late spring and summer flows.

<u>American Falls Reservoir</u>

American Falls Reservoir annually provides over 125,000 hours of fishing opportunity for the public. Hatchery rainbow trout comprise the major fishery in American Falls Reservoir. In dry years, American Falls Reservoir is often nearly drained for irrigation purposes. Turbidity values and associated suspended sediment in the dam discharge rises dramatically as the reservoir pool drops to 50,000 acre feet and below (1995 IHW-DEQ letter to BOR). Newly suspended material and reduced pool volumes can reduce dissolved oxygen (D.O.) and increase water temperatures. Both can be lethal to trout. In addition, poor water quality conditions are passed on to the river below. In order to better protect existing fish resources, IDFG has recommended a minimum reservoir pool of 170,000 acre-feet, 10 percent of the total storage.

Most of the large trout in the river reach below American Falls Dam were reared in American Falls Reservoir. Trout planted in American Falls Reservoir annually migrate downstream in mid-summer because the reservoir becomes too warm, may be drawn down too low, and may lack sufficient oxygen (IDFG 1996).

Upstream of American Falls Reservoir

<u>Blackfoot - American Falls Reservoir</u>

Fisheries

The reach of the Snake River from Blackfoot to American Falls Reservoir historically supported substantial numbers of native Yellowstone cutthroat trout (Holden and Crist 1986). Irrigation diversions and return flows, the Teton Dam failure, and hydroelectric development have combined to reduce habitat potential in this reach. During April of 1992, this reach of the Snake River was essentially dried up due to irrigation diversions upstream. Summer water temperatures are often a problem in this reach of the river (Holden et al. 1987) The fisheries is now mostly supported by hatchery reared rainbow trout, with small numbers of brown trout, small-mouth bass, and wild Yellowstone cutthroat trout present. Native mountain whitefish are common. Although Yellowstone cutthroat trout are currently limited in numbers, it is a policy of IDFG that wild native populations of resident fish species will receive priority consideration in management decisions (IDFG 1996).

Portions of this reach of the river are highly braided. In those areas, much of the habitat is found in medium and small channels (Holden et al. 1987). These channels appear more sensitive to flow changes than the main channel (Holden et al. 1987). In many streams, the major factor limiting trout densities appears to be the amount of overwintering habitat rather than summer rearing habitat (Bustard and Narver 1975a in Hickman and Raleigh 1982). This appears to be the case in this reach of the Snake River. Research on the South Fork Snake River (Schrader and Griswold 1994) indicates that side channels provide the most important habitat for young-of-the-year trout. It is reasonable to assume that side channels in the reach of the Snake River from Blackfoot to American Falls Reservoir provide a similar function.

Stovall (1994) illustrated that flows at flows of 2,000 cfs or less, medium channels are cut-off from the main channel and side channels are mostly de-watered. Increasing flows from about 2,000 cfs to 5,000 cfs resulted in 71 percent and 53 percent increases in wetted perimeter in medium and small side channels, respectively. As channels were filled and connected to the mainstem, willows and other vegetation along the bank began to provide cover for fish and wildlife.

Recreation

Numerous gravel diversion dams span this segment of the Snake River. Low flows in the spring and summer create problems for boaters attempting to move up and down the river.

Wildlife

This portion of the Snake River supports a significant cottonwood riparian forest. It is reasonable to assume that cottonwood forests in this area need spring high water events similar to the South Fork Snake (Merigliano 1996). This reach also provides winter habitat for large numbers of waterfowl and bald eagles. The river typically freezes over above Tilden Bridge, forcing waterfowl and bald eagles to concentrate on the lower portion of the river adjacent to American Falls Reservoir. Low flows in the spring and summer result in dry side channels, thus allowing cattle and small predators access to islands, thus decreasing habitat quality and nesting success of waterfowl and other birds.

<u>Henrys Fork</u>

Winter/Icing

The Henrys Fork typically experiences severe winter conditions. Icing is a significant problem to fish and wildlife. In the reach potentially impacted by managed recharge, the Henrys Fork is a relatively shallow, braided complex consisting of a main channel, side channels, sloughs, and wetlands.

The non-irrigation season has been identified as a critical time for fish and wildlife in the basin. The majority of the recharge would occur during this period when the river is most prone to icing. The risk of icing increases as flows decrease (Snyder 1991, Ashton 1980, Ashton 1982). Opening and closing the canals during this period would lead to lower flows and increased icing, followed by higher flows and scouring of the vegetation and the channel by the ice.

Fishery

This fishery is likely limited by over-winter (non-irrigation season) survival of young-of-the-year trout. Trout survival is most directly limited by low winter flows. Fish research in the upper Henrys Fork indicates young-of-the-year trout survival increases as flows increase (Mitro 1999). Higher flows during wetter years provide strong year classes of trout that maintain the fishery during drier years when young-of-the-year survival is low. Higher flows improve access to and from tributaries used for spawning and early rearing.

Research on the South Fork Snake River (Schrader and Griswold 1994), in habitat similar to the lower Henrys Fork, indicates that side channels provide the most important habitat for young-of-the-year trout. These are the areas prone to dewatering and/or icing when flows are reduced.

Cutthroat trout spawning in the lower Henrys Fork and mainstem Snake River usually begins in April. Embryo development occurs from April through June. Rainbow trout spawning begins in February and embryo development continues into June. Reductions in flow during these times would be contrary to cutthroat trout restoration efforts and would reduce the natural recruitment of rainbow trout to the popular fishery.

Excessively high water temperatures during the summer adversely impact fish and other aquatic species. Flow reductions during periods of hot weather result in increased water temperatures. Irrigation diversions from the lower Henrys Fork are commonly detrimental to the fishery, especially in late summer. Increased diversions for aquifer recharge during the summer will exacerbate the existing late-summer problems of low flow, high water temperatures, and exceedence of state water quality standards.

There are many canals diverting water from the Henrys fork. Exact fish losses into these systems is unknown at present, however, anecdotal information suggests that significant numbers of both game and nongame fish enter the canal system during the irrigation season. Entrainment of fish into the canals during winter operation needs to be researched if recharge is pursued.

Water Quality

High summer water temperatures, sediment loads, and agricultural nutrients and chemicals impact water quality, fish, and wildlife through the reach potentially affected by recharge. There are concerns regarding excessive ammonia, nitrogen, and phosphorous. Monitoring data indicate that present flow management already commonly causes summer water temperatures to exceed state water quality standards for both salmonid spawning and cold water biota. Many pH measurements of 9.0 to 9.5 have been recorded (Henrys Fork Foundation, pers. communication). Idaho's standard is 9.5. It is possible that negative impacts to fish occur at these levels.

Trumpeter Swans

The tri-state/greater Yellowstone nesting population of trumpeter swans is the only trumpeter swan population in North America that has declined in the last decade and contains only about 300 adults. IDFG's stated intention is to protect this highly at risk population. Until a southward migration of these tri-state swans is successfully established, there is a critical need to provide adequate ice-free habitat to prevent a catastrophic die-off during severe winter conditions (IDFG 5-year nongame plan; Henrys Fork Watershed Council letter dated August 2, 1999).

Trumpeter swan winter foraging habitat is primarily in low velocity, shallow water areas. These are the areas most prone to icing.

Within the winter range of swans in the tri-state area, foraging habitat that is iced over places swans at risk, and also places other areas of swan winter habitat (e.g. upper Henrys Fork in the Harriman State Park reach) at risk. The Harriman Park reach is one of the last places to freeze, and large numbers of swans congregate there when other areas are frozen over. During the winter of 1989-1990, swan foraging nearly eliminated the aquatic macrophyte community in this reach. The fish population and fishing were adversely affected for several years.

The subcommittee on Rocky Mountain Trumpeter Swans (1998) includes a strategy to seek flow regimes for the Henrys Fork that will 1) provide higher winter flows without abrupt fluctuations (especially when ice is present), and 2) reduce the variation between winter and early spring peak flows while avoiding adverse impacts to fish and submerged macrophytes. Diversions for recharge during the winter would be contrary to both objectives.

Wetlands

The Conservation Strategy for Henrys Fork Basin Wetlands (Jankovsky-Jones 1996) includes two significant wetland sites, which cover 24 of the 30 river miles between St. Anthony and the mouth of the Henrys Fork. The recommendations for these sites are 1) maintaining and improving wildlife values and 2) hydrologic restoration.

Rare species inhabiting the Henrys Fork and adjacent wetlands downstream of St. Anthony include state listed endangered species: bald eagles (nesting and wintering area), and peregrine falcons, and state listed species of special concern: trumpeter swans, yellow-billed cuckoo, black tern, Yellowstone cutthroat trout, spotted frog, and northern leopard frog.

Topographic maps indicate there are 30 miles of mainstem, at least 27 miles of side channels and sloughs, and at least 13,000 acres of wetlands in the immediate floodplain downstream of St. Anthony. Flows during the growing season (April – October) are essential for maintaining these wetlands.

Floodplain/Riparian Maintenance

During the May-June period, wetland vegetation is supported and human encroachment minimized when natural flooding occurs. If large-scale recharge diversions occur during the May-June period, a permanent reduction in wetland acreage will occur and increased human disturbance will occur in the floodplain.

Waterfowl

The icing problems described above for trumpeter swans also applies to other waterfowl. Duck and goose hunting is popular in this reach. Low flows, icing and flow fluctuations adversely affect waterfowl habitat quality and recreation.

Unknowns

Specific ramping rates that limit negative impacts to fish populations (e.g. false spawning cues) and fish habitats have not been identified. Additional site specific research needs to be conducted to accurately quantify tolerance limits of native aquatic organisms to artificial flow manipulation.

We know in a general, qualitative way how the ecosystem operates and how biotic and abiotic factors interact to make the system function. But, detailed site specific data is lacking throughout much of the Snake River basin. Specifically, detailed studies have not been conducted to adequately determine flows that:

1) Protect important side-channel young-of-the-year trout habitat from dewatering and/or icing during the non-irrigation season,
2) Provide sufficient ice-free, shallow, low velocity areas with ample aquatic vegetation for swan foraging during the non-irrigation season,
3) Maintain the diversity and structure of the stream channels,
4) Protect riparian and floodplain wetland habitat and
5) Adequately transport sediment and nutrients to protect water quality and aquatic species habitat quality,
6) Protect aquatic resources from excessively high summer water temperatures.

Studies are also needed to determine:

7) Flows and depths necessary to prevent dewatering or icing over of side-channels,
8) Factors affecting young-of-the-year trout survival and trumpeter swan foraging habitat,
9) Site specific trout spawning requirements,
10) Fish losses to canal diversions,
11) The relationship between flows and high water temperatures, and
12) The impacts to the wide riverine/wetland complex supported by late spring and summer flows.

Summary of Henrys Fork Impacts

If a large-scale managed recharge program is implemented, flows greater than the recommended fish and wildlife flows would be diverted for recharge. The benefits those flows would have provided would be lost, resulting in a negative impact to fish and wildlife.

Henrys Fork fisheries research indicates that higher winter flows increase young-of-the-year trout survival and recruitment to the fishery. Recreational demand is increasing rapidly. Annual numbers of angler user-days is doubling at a rate of perhaps every 10 years. Thus, protecting today's fisheries resources will not provide for the demand in the near future.

Water quality degradation and violations of state water quality standards would be exacerbated by further reductions of river flows during spring, summer, and early fall.

Higher winter flows also benefit trumpeter swans. Flows needed for swan protection are dependent on the severity of the winter. Flow reductions generally cause increased ice formation. The areas most prone to icing are the shallower, low-velocity areas that are also the primary foraging areas. This applies to all waterfowl and other riverine-dependent species.

Wetlands and woody riparian communities are crucial for maintenance of fish and wildlife habitat. Flow reductions during either the spring time runoff or the growing season will reduce the quality and quantity of wetlands (designated as "significant wetland sites").

RATIONALE FOR FLOW RECOMMENDATIONS

The flow recommendations are presented as mean monthly flows for the purposes of modeling general large-scale aquifer recharge scenarios for this feasibility study. But, these "trigger flows" are viewed as flows that should be maintained or exceeded at all times before recharge could occur. They are estimates based on the best information available. The numbers may change as new information becomes available, or as specific recharge projects are proposed.

Downstream of American Falls Dam

The flow recommendations downstream of American Falls Dam are driven primarily by the spawning and adult habitat needs of white sturgeon downstream of Milner Dam. However, an adequate minimum pool is needed to protect American Falls Reservoir and adequate flows are also needed to protect the Snake River below American Falls Dam.

Milner Dam – Brownlee Pool

Idaho Power Company (IPC) studies downstream of Bliss and Lower Salmon Falls dams indicate white sturgeon may attempt to spawn over a range of flows from approximately 8,000 cfs to greater than 20,000 cfs. However, at flows less than 15,000 cfs egg and larval survival declined dramatically. The decreased survival is due to increased water temperatures, decreased water velocities, load following operations at hydroelectric facilities, and in general, the shorter duration of high flows. In IPC's Lower Salmon Falls Instream Flow Study, the available sturgeon spawning habitat was still increasing rapidly at 20,000 cfs – the highest value on the chart. This indicates that there would be substantially more spawning habitat available at flows higher than 20,000 cfs. In IPC's Survey of White Sturgeon in the Bliss Reach of the Middle Snake River, Idaho, available sturgeon spawning habitat is still increasing at 30,000 cfs – the highest flow on the curve. The rate of increase in spawning habitat begins to slow down at about 15,000 cfs. It appears that flows in the 20,000 – 30,000 cfs range would provide adequate sturgeon spawning habitat. The curve looks to be leveling off at flows greater than 30,000 cfs; indicating available habitat does not substantially increase with increased flow above 30,000 cfs.

Based on the Lower Salmon Falls Instream Flow Study, we also know that flows for adult white sturgeon below Lower Salmon Falls Dam should be near 10,000 cfs or greater for the rest of the year.

The spawning requirements for white sturgeon are fairly specific. Spawning is typically during spring runoff, from April – June. Rising flows are one of the primary cues that trigger sturgeon spawning migrations and prespawning behavior. White sturgeon will spawn at temperatures from 10° - 18° C, but optimal temperatures are from 13° - 16° C. Optimal temperatures for egg and larval development are 14° - 16° C. Survival of eggs and larvae decrease as temperatures rise above 16°C, with 20°C being lethal. Thalweg velocities need to be greater than 1.7m/sec to trigger spawning. Flows of 15,000 cfs and greater (20,000 – 30,000 cfs would be better) below Bliss Dam from April – June will provide these conditions.

A linear regression analysis was performed on USGS gaging station mean monthly flow data for the period of record for each gage to determine if there was a strong correlation between flows past Milner Dam and flows at other gages. Linear regression equations were developed for each of these gages: Buhl, Lower Salmon Falls, King Hill, C. J. Strike, Murphy, and Weiser. R^2 values ranged from 0.80 to 0.99, indicating there is a very strong correlation between flows past Milner Dam and flows at these downstream gages (see attached summary table). Therefore, the linear regressions could be used to predict the flows at various gages in the Snake River with a given flow past Milner Dam. An iterative process was then used to determine what flows past Milner would provide the sturgeon flows described above.

The regression analysis indicates that in order to have 15,000 cfs flow below Bliss Dam (measured at the King Hill gage), for sturgeon spawning and early development, 6,700 cfs (95% confidence interval of ± 1,736 cfs) needs to flow past Milner. This analysis also indicates that in order to maintain a minimum flow of 10,000 cfs below Lower Salmon Falls Dam, 3,800 cfs (95% confidence interval of ± 815 cfs) needs to flow past Milner Dam.

White sturgeon evolved in an unregulated river. The typical, unregulated hydrograph had a peak flow in June, followed by steadily decreasing flows through the fall, with the lowest flows occurring during the winter months (December – February). Flows began increasing late winter/early spring until the peak in June. The recommended flows presented in this report attempt to mimic the shape and timing of the natural hydrograph but not the volume. Under this recommendation, peak flows approach the 20,000 cfs level below Lower Salmon Falls Dam and are in the 20,000 – 30,000 range below Bliss Dam. The recommended flows are designed to provide the conditions needed for successful sturgeon spawning, and egg and larval development. They do not maximize sturgeon spawning habitat.

American Falls Dam – Minidoka Dam

Flow recommendations for the reach below American Falls are the result of the regression analysis conducted on recommended sturgeon flows below Milner. (Table 2) Adequate releases from American Falls are required in order to meet recommended flows for sturgeon spawning and rearing below Milner.

Upstream of American Falls Reservoir

Blackfoot – American Falls Pool

The recommended flows for the gage near Blackfoot represent the best estimate of flows needed for the long-term maintenance of the existing fish resources in the Snake River between Blackfoot and American Falls Reservoir. These flows were based on historic mean monthly flows described in USGS gaging station reports for the gage near Blackfoot from 1959 to 1997. This time period was chosen because Palisades Dam was completed in 1958 and operations reshaped the flow patterns in the Snake River. The rationale is that the post-Palisades flows created the instream habitat that exists today, and that habitat is responsible for the fishery that exists today.

The recommended flows for each month are the mean monthly flow from 1959 - 1997 for that month plus 50% of the flow above the mean. This recognizes several important biological and ecological principles. It maintains the shape of the hydrograph. It recognizes the importance of high flows for habitat formation and maintenance, and it partially protects juvenile trout during low flow periods. Research on the South Fork Snake River has shown the importance of periodic high flood flows for creating fish habitat and maintaining cottonwood riparian forests. Other South Fork research has shown the importance of keeping water in the side channels, especially during the non-irrigation season, to maintain or improve juvenile trout survival.

Henrys Fork

Please note that in most cases, the water years 1972 – 1997 are used as the period of record. This time frame was selected because 1972 was the year that Island Park Dam operations were significantly changed. Operational strategies have been fairly consistent from 1972 to the present.

Winter (November – *March)*

The winter flows presented in Table 1 are the mean monthly flows rounded to the nearest 100 cfs for the 1996, 1997, and 1998 water years. These are the last three years for which there are USGS published flow records. Flows during this period have been high enough that negative impacts of low winter flows on fish and wildlife probably have been less than average.

During periods of extreme cold weather, we recommend that no diversions for recharge occur. The main conditions that cause icing in the lower Henrys Fork are reduced depth, reduced velocity, and air temperature. Significant ice formation, limiting swans to a few open-water areas, have been observed by swan researches when air temperatures fall below 10 °F.

For recharge modeling purposes, the winter severity index of R. Shea may be useful. The last significant swan die-off occurred during the winter of 1988 – 1989. Shea's (pers. communication) weather severity index indicates that winter severity on the upper Henrys Fork is equal to or worse than the severity of that 1988 – 1989 winter for 25 % of the winters over the period of record.

Riparian Maintenance (April – June)

High flows in the river and side channels define the width of wetland habitat, limit human development in the floodplain, contribute to sediment transport, and provide high quality trout spawning and rearing habitat.

The recommended flows for each month are the mean monthly flow from 1972 – 1997 for that month plus 50% of the flow above the mean. This recognizes the same important biological and ecological principles described for the Blackfoot – American Falls Reservoir segment.

Floodplain Maintenance (June)

Spring runoff high water events have been demonstrated to be essential to maintain cottonwood communities (Merigliano 1996). A flow scenario expected to maintain most of the woody riparian communities would be for the mean of the 10% exceedence of the monthly mean flows (the average 10 year flow event, WY 1928 – 97 estimated unregulated flows) to occur about once every 10 years for up to two weeks each occurrence.

July – October

Flows left in the river benefit fish and wildlife, especially during hot weather. Between July 13 and August 20, 1998, Rexburg gage flows of less than 2,900 cfs were associated with mean daily water temperatures of greater than 19°C. Any diversions specifically for recharge during the warm weather period would reduce available fish and wildlife habitat, adversely affect wetland vegetation during the growing season, and potentially cause water temperatures to exceed state water quality standards.

The recommended flows for each month are the mean monthly flow from 1972 – 1997 for that month plus 50% of the flow above the mean. This is consistent with the flows for the Blackfoot reach and the April – June flows for the Henrys Fork. For protection of aquatic resources and compliance with state water quality standards, recharge diversion should not be permitted when mean daily water temperature exceeds 19°C.

CONCLUSIONS

Impacts Assessment

Today's river operations in the heavily managed Snake River on average decrease non-irrigation season flows. Low flow during this period is a critical factor limiting naturally reproducing trout populations throughout the Snake River basin. Additional reductions in flow will have negative impacts on trout populations.

Winter recharge diversions would reduce flows and result in increased ice formation. The aquatic and wetland-dependent resources would be adversely affected by flow reductions.

Below Milner Dam, low non-irrigation season flows can also lead to acute ammonia toxicity to all aquatic life, including white sturgeon.

Additional water withdrawal from the Snake River, especially during the water-short periods, can only have a negative impact to the fish and wildlife resources. The magnitude of these impacts can not be assessed until specific recharge proposals are presented that outline the volume, location, and timing of the recharge diversions.

The removal of the peak of the hydrograph has had negative impacts to fish, wildlife, wetlands, and riparian and floodplain habitats. High spring flows are critical for sturgeon and trout spawning, maintaining and creating side channel, riparian and floodplain habitats, wetlands, and for sediment transport and cleansing spawning gravel. Further reductions in the peak of the hydrograph will increase the negative impacts to these resources.

Large-scale managed recharge diversions in Hells Half Acre or other areas in the upper Snake in the winter will reduce the amount of water available to meet the recommended flows below American Falls in the winter. Managed recharge activities above American Falls Reservoir will also likely reduce the likelihood of maintaining an adequate minimum pool in American Falls. It also appears that large-scale managed recharge diversions in the Hells Half Acre or the Henrys Fork will create additional empty space in American Falls Reservoir, leading to a further dampening of the peak of the spring hydrograph and increased floodplain encroachment.

Large-scale managed recharge could also result in reduced flows during the summer in certain reaches of the river. This could lead to water quality problems, namely higher water temperatures and lower dissolved oxygen levels that could violate state water quality standards. These standards have been violated in the past even without large-scale recharge activities occurring. Conditions have become lethal and fish kills have been documented.

Also, managed recharge will have a significant negative effect on the existing vegetation at the recharge sites. Again, the magnitude of these impacts can not be determined until specific recharge proposals are presented.

Flow Recommendations

Even if flow recommendations are met during managed recharge activities, adverse impacts to fish, wildlife, and recreation will occur. Large-scale managed recharge may exacerbate existing resource problems. These flow recommendations do not fully protect fish, wildlife, or wetlands primarily because they do not protect the highest flows. These highest flows (~ the wettest 25% of the historic record) are those that theoretically would be available for recharge. These wettest years are the most important from a biological standpoint in terms of fish production, habitat formation, habitat maintenance, riparian maintenance, side channel formation and maintenance, as well as sediment transport. Because an aquifer recharge program would reduce these highest water years, we can only conclude that aquifer recharge would have a negative impact to the fishery as well as to the overall health of the ecosystem. The severity of the impacts can not be determined at this time because they are dependent on the timing of recharge and the total volume diverted.

Table 1. Flows (cfs) to Partially Protect Fish and Wildlife Resources in the Snake River Near Blackfoot and the Henrys Fork

Month Gage	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.
St. Anthony	1,450*	2,100	2,100	2,100	2,100	2,100	2,300*	4,440*	3,370* 7,580**	1,680*	1,470*	1,360*
Rexburg	1,860*	2,500	2,500	2,500	2,500	2,500	2,540*	5,170*	4,760* 11,460**	2,070*	1,640*	1,640*
Near Blackfoot	2,070*	3,750*	3,750*	3,750*	3,750*	5,100*	7,030*	10,450*	9,040* 42,860***	4,600*	2,070*	2,490*

* = The Henrys Fork and Blackfoot reach recharge "triggers" would be these mean monthly flows plus 50% of the flows above this. Also, for protection of aquatic resources and compliance with state water quality standards, recharge diversions should not be permitted when water temperatures exceed 19°C.

** = A flow scenario expected to maintain most of the woody riparian communities would be to have the mean of the 10% exceedence of monthly mean flows (average of the 10 year flow events for the appropriate period of record) for up to two weeks for each event.

*** = This flow would be expected to protect the woody riparian communities if provided for up to a two-week period once every 10 years. The number represents the average of the maximum estimated unregulated mean monthly flow for each 10-year period since 1928. Because of the existing floodplain encroachment, this flow may not be feasible today.

Table 2. Recommended mean monthly flows at Milner (Dam plus bypass), plus predicted flows and associated 95% confidence intervals at the Buhl, Lower Salmon Falls, King Hill, C.J. Strike, Murphy, and Weiser gages on the Snake River. All values are rounded to the nearest 10 cfs.

MONTH	MILNER FLOW (Milner to Lower Salmon Falls - measured at Milner Dam)	FLOW AT BUHL (Milner - Upper Salmon Falls Dam) r^2 = 0.99 (95% C.I.)	FLOW AT LOWER SALMON FALLS (Lower Salmon – Bliss Dam) r^2 = 0.95 (95% C.I.)	FLOW AT KING HILL (Bliss to CJ Strike Pool – measured at King Hill) r^2 = 0.89 (95% C.I.)	FLOW AT CJ STRIKE DAM (CJ Strike - Swan Falls) r^2 = 0.83 (95% C.I.)	FLOW AT MURPHY (Swan Falls – Boise R.) r^2 = 0.94 (95% C.I.)	FLOW AT WEISER (Payette R. – Brownlee Pool) r^2 = 0.80 (95% C.I.)	FLOW AT AMERICAN FALLS (American Falls Dam – Minidoka Pool) r^2 = 0.88 (95% C.I.)	FLOW AT MINIDOKA (Minidoka Dam - Milner Pool) r^2 = 0.95 (95% C.I.)
OCTOBER	4,850	7,330 (± 420)	10,990 (± 860)	13,090 (± 1,500)	12,310 (± 1,930)	13,750 (± 1,300)	26,150 (± 7,570)	5,240 (± 1,010)	5,050 (± 490)
NOVEMBER	4,080	6,550 (± 420)	10,290 (± 820)	12,280 (± 1,440)	11,490 (± 1,850)	12,760 (± 1,240)	23,240 (± 7,260)	4,410 (± 750)	4,380 (± 360)
DECEMBER	3,800	6,270 (± 420)	10,040 (± 820)	11,980 (± 1,420)	11,190 (± 1,830)	12,400 (± 1,230)	22,170 (± 7,180)	4,110 (± 690)	4,140 (± 330)
JANUARY	3,800	6,270 (± 420)	10,040 (± 820)	11,980 (± 1,420)	11,190 (± 1,830)	12,400 (± 1,230)	22,170 (± 7,180)	4,110 (± 690)	4,140 (± 330)
FEBRUARY	3,800	6,270 (± 420)	10,040 (± 820)	11,980 (± 1,420)	11,190 (± 1,830)	12,400 (± 1,230)	22,170 (± 7,180)	4,110 (± 690)	4,140 (± 330)
MARCH	6,700	9,210 (± 510)	12,670 (± 1,000)	15,054 (± 1,740)	14,280 (± 2,240)	16,120 (± 1,500)	33,170 (± 8,780)	7,220 (± 1,860)	6,650 (± 900)
APRIL	7,230	9,750 (± 540)	13,150 (± 1,050)	15,620 (± 1,820)	14,850 (± 2,350)	16,790 (± 1,580)	35,170 (± 9,210)	7,790 (± 2,120)	7,110 (± 1,020)
MAY	12,300	14,910 (± 850)	17,760 (± 1,650)	21,000 (± 2,870)	20,260 (± 3,690)	23,280 (± 2,480)	54,390 (± 14,500)	13,220 (± 4,690)	11,510 (± 2,270)
JUNE	13,530	16,160 (± 930)	18,880 (± 1,810)	22,300 (± 3,150)	21,570 (± 4,060)	24,860 (± 2,730)	59,050 (± 15,950)	14,540 (± 5,320)	12,580 (± 2,580)
JULY	8,400	10,940 (± 600)	14,220 (± 1,190)	16,860 (± 2,030)	16,100 (± 2,620)	18,290 (± 1,760)	39,610 (± 10,290)	9,040 (± 2,700)	8,130 (± 1,310)
AUGUST	5,600	8,100 (± 470)	11,670 (± 910)	13,890 (± 1,590)	13,110 (± 2,040)	14,710 (± 1,370)	29,000 (± 7,990)	6,040 (± 1,340)	5,700 (± 650)
SEPTEMBER	5,050	7,540 (± 490)	11,170 (± 870)	13,300 (± 1,520)	12,520 (± 1,950)	14,000 (± 1,310)	26,910 (± 7,670)	5,450 (± 1,100)	5,220 (± 530)

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APPENDIX C. IDAHO POWER COMPANY ISSUES

MANAGED RECHARGE OF THE EASTERN SNAKE RIVER PLAIN AQUIFER

In 1997, the Idaho Department of Water Resources (IDWR), in collaboration with the U.S. Bureau of Reclamation, initiated a managed recharge study to evaluate the potential for conducting recharge projects within the Eastern Snake Plain Aquifer (ESPA). The IDWR was to select five or more candidate recharge sites and determine the feasibility of conducting recharge events at those sites from a hydrologic, environmental, economic and institutional perspective. *Eastern Snake River Plain Managed Aquifer Recharge*, IDWR. The study was to be divided into two parts. Part I was to focus on the feasibility of managed recharge in the context of the "recurrent availability" of recharge water in the Snake River reaches above Milner Dam, the impact of the recharge on groundwater elevation and spring discharge, and the impact of recharge on seasonal augmentation return flows. Part II of the study was to focus on the institutional, economic and environmental feasibility of managed recharge. Key issues the study was to address included the availability of water rights for managed recharge, injury mitigation to other affected water rights, the cost of constructing recharge facilities and the environmental and water quality impacts of managed recharge. *Id.*

In October of 1998, the IDWR issued *The Eastern Snake Plain Aquifer Managed Recharge Project Interim Report.* This *Interim Report* concluded that in most years water was available (up to <u>300,000</u> acre feet) for managed recharge purposes provided recharge was not subordinate to existing water rights for power purposes held by the Idaho Power Company (IPC) on the Snake River below Milner Dam. If recharge was subordinate to these hydropower rights, the *Report* went on, in most years water would not be available for managed recharge purposes. In 1994, the Idaho Legislature enacted legislation authorizing the director of IDWR to issue water right permits and licenses for recharge purposes. Because recharge was not recognized as a beneficial use of water (and therefore could not be the basis for a water right appropriation) at the time the Swan Falls Agreement was negotiated, the 1994 legislation further provided that any permits or licenses issued by the director for recharge purposes were "secondary to all prior perfected water rights", including any water rights held by IPC that may have been subordinated by the Swan Falls Agreement. See: I. C. § 42-4201A.

Subsequent to the enactment of this legislative package, the Idaho Water Resource Board (IWRB) filed applications with the IDWR to appropriate waters of the Snake River for recharge purposes. The priority dates for these water rights, if approved, will be junior or secondary to the water rights for power purposes held by IPC below Milner Dam.

In May of 1999, IDWR asked whether IPC could complete an analysis of the impact of the proposed recharge events on IPC's power generation below Milner Dam. Based on the 1998 *Interim Study*, IDWR concluded that managed recharge appeared to have the best potential under four scenarios: Thousand Springs, Lake Walcott, Hells Half Acre and Egin Bench. IDWR asked that IPC evaluate the impact of the Thousand Springs and Hells Half-Acre scenarios.

IPC performed the requested analysis using the averaged water data supplied by the IDWR together with the IDWR Depleted Flow Model numbers and IDWR Groundwater Model. The analysis (Attachment 1) showed substantial economic loss to IPC ($2 million to $20 million the first year) over a sixty-year period. Upon reporting the results, IDWR requested that IPC re-analyze the impact using individual water flow data for the years 1928-1992 and that the analysis only consider the impact of recharge events to the Bliss hydro project. IPC conducted a second analysis using the data supplied by IDWR but included the expected impact to the Twin Falls Project as most of the return flow from springs to the Snake River bypass that project. This second analysis indicated an economic loss to the Twin Falls Project over the sixty-year study period and an economic gain to the Bliss Project over the same period (there were gains and losses to each project depending on the specific year). See Attachment 2.

While IPC considers each of these analyses to generally be accurate based upon the data utilized, the results are necessarily shaped by the assumptions used in the modeling programs as well as by the assumed market prices for power sales. For instance, the ground water model assumes that an average volume of recharge will occur every year and that this annual recharge in turn generates a continuous linearly escalating return flow to the river. In reality, this is not the case. In drought and low flow years recharge will not occur and the return flow to the river will therefore not increase at a linear rate. Also, the IDWR Depleted Flow Model shows good water years in 1928, 1929, 1930 and 1931, which are the initial starting years for the modeling analysis by IDWR. Had these initial years been low water years, recharge would not have occurred. Nonetheless, the model would still have assumed an average recharge rate during these initial years resulting in an inaccurate analysis. These deficiencies make projecting the impact of recharge events on IPC's hydro generation difficult at best. Yet, IPC believes that its current analyses illustrate that recharge will adversely impact hydro generation and pose economic risk to IPC's ratepayers and shareholders.

Not only is the predictive reliability of the models used by IDWR subject to serious questions, other issues also influence one's ability to quantitatively evaluate the impact of the proposed recharge scenarios. Currently, there is <u>no</u> physical or gauging process for tracking the amount of water that may come out of springs that may be attributable to an aquifer recharge program. Such a process must necessarily start with the physical measurement of reach gains and losses along the river – in other words knowing what currently flows into and out of the river is critical to determining the net benefit to be realized from a recharge program.

Model output alone will not cure this deficiency. The groundwater model as it is now calibrated does not have sufficient predictive reliability to estimate with any confidence what might actually result from a recharge program. In November of 1998, the Eastern Snake River Plain Aquifer Modeling Committee prepared an initial proposal entitled *Enhancement of the Snake River Plain Aquifer Model* that addressed the accuracy of the existing model and suggested alternatives for its improvement. As part of the *statement of need*, that 1998 proposal concluded:

> The Snake River Plain aquifer model is being increasingly called upon to address planning and management issues including those of conjunctive management of surface and ground water. Predictive reliability and the inability to express the uncertainty associated with predictions are issues that plague the existing model. This proposal seeks to improve model reliability and quantitatively express the uncertainty associated with model predictions through the application of emerging technology and the acquisition of new hydrologic information.

This theme was carried forward in the final *Strategy for Enhancement of the Eastern Snake River Plain Aquifer Model* issued by the Modeling Committee in November of 1999. (The 1999 Committee report is attached as Attachment 2.) In IPC's view, before the model can be used with any confidence to address planning and management issues involving ground water recharge associated with the ESPA, the proposals of the Modeling Committee should be implemented.

Other associated issues also influence the reliability of any analysis of impact:

- Assuming spring and river flows do benefit from recharge, there is no precise process in place to track any increased flows through the river and IPC's hydro system. Under the current regime, during low flow or drought years any additional or increased flow in the river could be diverted before it passes through IPC's main stem projects.

- The existing moratorium on ground water pumping would have to remain in place. If not, any additional recharge flows may be pumped out of the aquifer prior to being able to return to the river through the springs.

- As aquifer levels rise, the volume of water pumped through existing pumps may also increase. For a given pump's capacity, the rate of flow is directly proportional to the head or water level of the aquifer. Consequently, as the head or water level increases a pump may pump more water. This needs to be considered in any analysis.

- Assessing energy pricing impacts would necessarily need to occur on an annual or real-time basis. Energy pricing is influenced by various factors, including hydrologic and seasonal climatic conditions and supply and demand. Even if all of the technical issues that relate to an on-going recharge program are adequately addressed, the economic impacts to IPC would have to analyzed, and mitigated, on an annual basis to insure that the energy pricing data used is current and reflective of market conditions.

- Diverting water from the Snake River for aquifer recharge also raises issues that are not readily addressed through an economic impact analysis. IPC's generation and transmission system has finite limits. Diverting water away from generation facilities during peak load periods, such as the winter months, may impact the ability of IPC to respond to load demands. Moreover, constraints in the transmission system, as well as the availability of power from outside sources, may affect the ability of IPC to import power to meet those demands. In short, economic mitigation of the impact of a recharge program may not resolve all of the impacts to IPC and its ratepayers.

IPC's current analysis indicates that the proposed recharge scenarios will adversely impact its hydro production, and potentially its ability to meet load demands, and will result in economic loss to ratepayers and shareholders. While some intuitively conclude that managed recharge projects should benefit all Idaho water interests, including IPC, there is simply insufficient data and technical tools available to verify that conclusion. IPC therefore believes that before any proposed recharge program is implemented, each of the foregoing concerns must be adequately addressed.

AQUIFER RECHARGE ECONOMIC ANALYSIS
THOUSAND SPRINGS AND HELLS HALF ACRE SCENARIOS

Representatives from Idaho Power Company met with IDWR on May 25, 1999 to discuss the Eastern Snake River Plain Aquifer Recharge Program. IDWR is investigating four initial recharge scenarios: Thousand Springs, Lake Walcott, Hells Half Acre and Egin Bench.

Diversion and return flow numbers for two of the four aquifer recharge scenarios, Thousand Springs and Hells Half Acre, were provided by the IDWR. The numbers have been reviewed and an economic analysis has been performed to estimate the impacts of the Thousand Springs and Hells Half Acre scenarios on Idaho Power Company. The analysis was performed using an Excel spreadsheet. The following observations and assumptions were used in the analysis:

1. Estimated first year monthly recharge diversions from graphs provided by IDWR.
2. Actual averaged historic flows (1961 – 1999) at the projects were used for the base flow.
3. Spill is accounted for in impacts. If water would normally spill it was not charged.
4. Spot market prices experienced by Idaho Power Company were used for monthly comparisons (average 1990 – 1998 light load and heavy load prices).
5. Prices are not escalated over time in initial analysis.
6. Escalated rate for alternate 60 year impact is 785% and is based on averaged increase in wholesale prices since 1955 experienced by Idaho Power Company.
7. Corrected IDWR reach impact numbers, due to recharge, for Buhl 10 year response were used.
8. No return flow to river in first year.
9. 80% of depletions occur November through February.
10. Return flows are spread over the year.
11. Assumes aquifer reaches equilibrium after 60 years.
12. Difference in diversion and return is negative, even after 60 years, 12% loss at Thousand Springs and 27% loss at the Hells Half Acre.
13. Approximate 2,000 cfs reduction in Dec, Jan & Feb, return 620 cfs after 5 years and 800 cfs after 60 years during Jul, Aug & Sep, at Thousand Springs.
14. Return flows from the Thousand Srpings scenario bypass MLNR, TFPR, SFPR, and USPR
15. The current ground water pumping moratorium remains in effect through the analysis period.
16. Plant hydraulic capacities do not change.
17. Scenarios are analyzed separately. Analysis does not show combined effects to return flows.

Prices used in the monthly analysis are:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low	8.27	4.88	4.39	5.43	5.27	3.96	6.72	10.29	13.35	11.03	11.31	6.15
High	39.13	34.10	30.56	24.24	20.85	20.05	26.42	51.03	41.91	29.62	30.10	31.98
Low*	64.92	38.31	34.46	42.63	41.37	31.09	52.75	80.74	104.80	86.59	88.78	48.28
High*	307.16	267.67	239.93	190.28	163.71	157.37	207.40	400.59	328.99	232.52	236.29	251.02

*The average 1990 to 1999 wholesale prices increased 785% over the average 1955 wholesale prices experienced by Idaho Power Company.

Impacts from low and high pricing are as follows in $ millions:

	Thousand Springs		Hells Half Acre	
Year	Low	High	Low	High
1	-4.09	-20.10	-2.09	-9.47
5	-1.42	-8.80	-1.08	-5.29
10	-1.10	-7.50	-0.59	-3.27
60	-0.47	-4.85	0.17	-0.14
60*	-3.69	-38.08	1.31	-1.09

Attachment 2

The following is a sample of the spread sheet used to evaluate impacts from the aquifer recharge program.

Prices are recent average heavy load, historic river flow if from IDWR Depleted Flow Model and change in river flow is from IDWR Groundwater Model.

Water Year 1992
Twin Falls

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Price	29.62	30.10	31.98	39.13	34.10	30.56	24.24	20.85	20.05	26.42	51.03	41.91	
Change in river flow	234.25	-238.11	-269.66	-200.55	-502.36	243.57	245.98	250.78	248.24	244.99	242.73	239.90	
Days	31.00	30.00	31.00	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	
K Factor	10.42	10.42	10.42	10.42	10.42	10.42	10.42	10.42	10.42	10.42	10.42	10.42	
Hydraulic Cap,	4960.00	4960.00	4960.00	4960.00	4960.00	4960.00	4960.00	4960.00	4960.00	4960.00	4960.00	4960.00	
Avg Hist Flow	360.00	767.00	897.00	931.00	1240.00	220.00	220.00	10.00	5.00	220.00	220.00	220.00	
Flow after Rchg	594.25	528.89	627.34	730.45	737.64	463.57	465.98	260.78	253.24	464.99	462.73	459.90	
Difference flow/hydraulic cap	-4365.75	-4431.11	-4332.66	-4229.55	-4222.36	-4496.43	-4494.02	-4699.22	-4706.76	-4495.01	-4497.27	-4500.10	
Flow Lost Gen	234.25	-238.11	-269.66	-200.55	-502.36	243.57	245.98	250.78	248.24	244.99	242.73	239.90	
Lost Gen MwH	1816.03	-1786.38	-2090.54	-1554.80	-3517.64	1888.31	1845.42	1944.18	1862.37	1899.27	1881.74	1799.84	8048.69
Lost $	53790.81	-53769.95	-66850.09	-60837.66	-119945.09	57715.24	44733.08	40545.46	37334.36	50178.60	96025.14	75431.13	221180.24

Impact based on individual year analysis from 65 years (1928 - 1992)

	Twin Fall Project	Bliss Project
1928	($1,112,324)	($830,436)
1929	($1,085,796)	($508,148)
1930	($1,111,057)	($281,166)
1931	($1,176,666)	($71,417)
1932	$261,614	$694,474
1933	$230,101	$701,900
1934	$130,773	$669,088
1935	$308,572	$771,551
1936	$146,707	$700,785
1937	($685,750)	$289,481
1938	($734,380)	$272,187
1939	($744,017)	($77,537)
1940	($1,226,541)	$37,622
1941	($253,040)	$533,197
1942	($128,483)	$600,802
1943	($1,517,516)	($280,847)
1944	($663,314)	($1,775)
1945	($1,020,171)	($69,812)
1946	($540,466)	$29,220
1947	($766,008)	($97,947)
1948	($606,669)	$25,497
1949	($1,013,588)	($114,430)
1950	($1,066,247)	($187,343)
1951	$197,387	$391,005
1952	($656,553)	$146,352
1953	($511,645)	$346,925
1954	($693,793)	$4,827
1955	($618,571)	$71,116
1956	($672,111)	($175,257)
1957	($792,145)	($179,487)
1958	($740,251)	($16,751)
1959	($847,388)	$7,639
1960	($973,736)	($18,838)

	Twin Fall Project	Bliss Project
1961	($280,218)	$570,165
1962	($681,356)	$294,759
1963	($982,962)	($77,471)
1964	($925,369)	($26,256)
1965	($460,725)	($137,290)
1966	($449,607)	$258,106
1967	($810,227)	$25,677
1968	($924,589)	($133,266)
1969	$68,853	$222,154
1970	($643,811)	$119,707
1971	($47,617)	$44,981
1972	$216,879	$364,398
1973	($733,572)	$254,522
1974	($386,330)	$130,577
1975	($691,177)	($107,835)
1976	$55,213	$136,029
1977	($251,526)	$141,203
1978	$20,370	$677,868
1979	($588,289)	($76,886)
1980	($1,287,113)	($54,432)
1981	($325,498)	$153,096
1982	($1,423,890)	($315,990)
1983	($293,864)	$92,252
1984	($251,487)	$96,678
1985	($594,618)	$206,324
1986	($187,931)	$133,231
1987	($502,026)	$375,266
1988	($923,681)	$210,986
1989	$306,714	$880,884
1990	($502,988)	$472,925
1991	$442,035	$949,064
1992	$221,180	$837,789
Total	($34,502,296)	$10,101,692

STRATEGY FOR ENHANCEMENT OF THE EASTERN SNAKE RIVER PLAIN AQUIFER MODEL

Prepared by:
Eastern Snake Hydrologic Modeling Committee

(11/30/99)

THE EASTERN SNAKE HYDROLOGIC MODELING COMMITTEE (ESHMC) is composed of hydrologists and modelers from state and federal agencies, private industry and the University of Idaho. The group was formed in 1998 with the following mission:

> Evaluate the status of hydrologic modeling on the Eastern Snake River Plain and tributary basins, define objectives for modeling efforts, assess data and technical needs, and provide technical support and peer review for the modeling process.

This report represents the committee's opinion on the procedures that should be adopted and funded to improve the capabilities and reliability of the Eastern Snake River Plain Aquifer Model (ESRPAM), previously referred to as SRPAM.

STATEMENT OF NEED

The Eastern Snake River Plain aquifer model is being called upon increasingly to address planning and management issues including those of conjunctive management of surface and ground water. The strategy described in this document seeks to improve model reliability and quantitatively express the uncertainty associated with model predictions through the application of emerging technology and the acquisition of new hydrologic information.

OBJECTIVES

1) Establish a coordinated, inter-agency approach to improve the ground-water flow modeling system of the Eastern Snake River Plain to address the demands of current and emerging water resource issues within a reasonable cost and timeframe. The coordination will pull together what may otherwise be piecemeal efforts of agencies into an organized and comprehensive program.
2) Enhance and refine the existing model to better represent the physical system, with an emphasis on the interactions of surface water and ground water.

3) Develop a framework (process/procedure) to quantify estimates of uncertainty in model parameters and predictions.
4) Establish a framework within which modeling work is implemented, coordinated and reviewed among experts in state and federal agencies and universities.

PROCEDURE

The Eastern Snake River Plain aquifer model enhancement program will be implemented through partnerships between the Idaho Department of Water Resources, the U.S. Bureau of Reclamation, the U.S. Geological Survey, the University of Idaho, the U.S. EPA and Idaho Power Company. The program plan consists of three phases; however this planning document focuses on the first phase of model enhancement. Phase I plans are presented in the context of work that is ongoing, and in the context of phases II and III of this plan.

PHASE I

Phase I is composed of four main elements and associated tasks, as shown on the addendum sheet, "Phase 1 Strategy". Separate workplans are being developed for each of the four elements, detailing specific objectives, approaches, tasks, and deliverables. Investigations related to these four main elements are expected to proceed in parallel. All four contribute toward reducing the level of uncertainty and increasing the reliability of the ESRPAM model.

The four Phase I elements that proceed in parallel are identified as: A) numerical model refinement, B) development of data processing tools, C) advancement of the conceptual model and D) combining surface and ground-water models. Within each element, major tasks are identified which proceed sequentially. The organization of parallel elements and sequential tasks is diagrammed on the attached figure.

Some of the tasks identified in the figure and described below are interrelated, and consequently work on these tasks must be carefully coordinated. The coordination of activities will be accomplished through the Eastern Snake Hydrologic Modeling Committee (ESHMC), which will review workplans and reports, and provide feedback and guidance to individual investigators.

Element A - Numerical Model Refinement

The present ESRPAM calibration is based upon hydrologic conditions that are representative of a single year: 1980. Uncertainty increases when a model is used to represent hydrologic conditions moderately different from the conditions under which it was calibrated. Calibration using multi-year data sets will improve the confidence in the ESRPAM by calibration to a wider range of Snake River Plain hydrologic conditions.

Task A1 Response Functions Application to Historical Conditions

This task will determine how well the ESRPAM model reproduces changes in spring discharge that occurred during the period 1890 to 1980. The recharge data (1890-1980) from the USGS Snake River Plain aquifer model (Garabedian, 1993) will be aggregated using management zones and mapped to the ESRPAM model grid. Response functions which predict discharges to the Snake River in four hydraulically connected reaches will be applied to the historic recharge data and results will be compared to historical measurements of discharge during this 90 year period.

Status: Funded Source: USBR Amount: $10,000

Task A2 Model Recalibration using Multi-Year Conditions

Model recalibration involves development of a multi-year data set, and estimation of aquifer properties using statistical methods (inverse models) which minimize total model error. This task is intimately linked to the inverse modeling task of A3, and the two will be jointly scoped in a work plan. It is expected that the multi-year recalibration data set will span a twenty-year period from 1980 to 2000. The present ESRPAM is calibrated to 1980 transient conditions. Calibration to a longer-term data set may improve the capability of the model to represent a wider range of hydrologic conditions and will improve confidence in the parametization and conceptual validity of the model.

All available hydrologic data will be used to develop recharge and discharge data sets and provide calibration targets (ground-water levels and spring discharges) for the 1980-2000 period. The time-domain recalibration will be performed at six month intervals. Hydrologic data which must be collected, analyzed and formulated for use by the ESRPAM model include irrigated acres, ground-water and surface-water use, irrigation returns, canal seepage, stream gains, tributary basin underflow, irrigation diversions, crop distribution, and precipitation/climate information. Calibration targets will be developed from monthly or semi-annual measurements of ground-water levels and spring discharges.

The conceptual model will be evaluated and revised as might be warranted by the current understanding of the physical system. A parallel effort to collect data in support of conceptual model development (Element C) will be coordinated with this effort. The parallel development of a GIS-based data processing platform and data sets (Element B) will also be coordinated with Element A tasks, to ensure that the model calibration data can ultimately be incorporated into the data processing platform.

Status:	Source:	Amount:
Funded	**IDWR/USBR**	**$ 30,000/$80,000**
Unfunded	**New**	**$ 670,000**

Task A3 Inverse Modeling and Uncertainty Analysis

Inverse modeling involves the development of an objective function which represents the discrepancy between model predictions of ground-water levels and discharges and the calibration targets. Model calibration is achieved by minimizing the objective function through application of statistical methods. Application of inverse modeling methods also produces information on parameter sensitivities which are key elements for uncertainty analysis. Calibration target data and model parameters are weighted to reflect varying levels of uncertainty. This uncertainty can be propagated within the model and expressed through confidence bands placed on model predictions.

Inverse modeling and uncertainty analysis are used to identify areas of the plain where additional data is most important for improving model reliability. They also indicate the types of data that are most valuable (e.g. measurements of ground-water levels, or spring discharges). Given the high cost associated with data collection, this is a vital step of the design process that leads into Phase II. Inverse modeling and uncertainty analysis will be used to improve model calibration and reliability.

Status: Funded	**Source: USBR/IDWR**	**Amount: $ 120,000**
Unfunded	**New**	**30,000**

Task A4 Updating the ESRPAM Base Study Model

The base study scenario is envisioned to be a baseline for long-term comparison of impacts resulting from changes in aquifer recharge and discharge. The base study model will represent average conditions over the 20 year calibration period, incremented in monthly time steps. It will be run to steady state conditions and then used to evaluate changes in aquifer stresses (recharge and discharge).

Status: Funded **Source: IDWR**

Element B Development of Data Processing Tools

Task B1 Adaptation of Recharge Program to GIS-Based Data Management Platform

The majority of effort in construction of a regional ground-water model is in collection and processing of hydrologic data, much of it spatial data. In order to make processing of hydrologic data more efficient, the data manipulation process associated with developing new model data sets will be adapted to take advantage of GIS-based data management software. By enabling graphical display of data, GIS will also reduce the potential for error in data processing, thereby enhancing model reliability. A work plan will be prepared that describes this specific task.

Status: Funded **Source: USBR/UI** **Amount: $ 80,000**

Element C Advancement of the Conceptual Model

Possibly the greatest potential for enhancement of the existing model is in addressing the lack of adequate understanding and representation of river and aquifer interaction. This is especially important for a model that is expected to be used more and more to address conjunctive management issues.

Task C1 Refining Understanding of Surface- and Ground-Water Interaction
Additional data will be collected in this task to improve the river/aquifer conceptual model. New technologies will be employed that enable more efficient and accurate determination of river gains and losses. In areas along the Snake River, existing and new aquifer water level data will be compared with river stage data and estimates of river gains and losses. The comparison will be used to 1) evaluate the conceptual model of gains and losses, 2) estimate properties controlling gains and losses, and possibly 3) to refine the model representation of river reach/aquifer boundaries. The improved conceptual model and property estimates will be incorporated into the regional ground-water flow model and will be useful for identifying limits on the magnitude and direction of interaction between surface and ground water for the surface water models that are used by the Department of Water Resources and the Bureau of Reclamation. Some work on this task has been initiated in the Thousand Springs area under funding by the U.S. Environmental Protection Agency, and on the Snake River between Shelley and King Hill through a cooperative agreement between the IDWR and the USGS. Further work is required for the Upper Snake and the American Falls area.

Although it would be ideal to have all conceptual model development done prior to Tasks A2 through A4, this sequential arrangement is not practical. Efforts to improve our understanding and representation of the system must continuously progress and be incorporated into models at convenient opportunities. Results from this work will be incorporated into the regional model in Phase III of the strategy. A work plan for this task is being prepared.

Status: Unfunded **Source: New** **Amount: $250,000**

Task C2 Collection of Irrigation Seepage/Return Data
At the current time, little is understood about the rate of seepage from irrigation canals or about the rate of irrigation return flows. This task would entail a combination of field work and literature review to improve the current understanding of these two areas. The field work would involve measuring seepage losses and irrigation returns from several irrigation canals ranging from large to small. The literature review would involve researching publications on this topic, to see how these two rates are estimated in other basins. These measured and published numbers would then be applied to canals throughout the Snake River plain.

Status: Unfunded **Source: New** **Amount: $150,000**

Task C3 Study of Incidental Recharge Due to Ground-water Pumping
This task is comprised of a research task to determine how much of pumped ground water is consumptively used, how much returns to the aquifer and what the delays of the returns are. This task is envisioned as a literature research effort. Field investigations are beyond the proposed scope.

Status: Unfunded **Source: New** **Amount: $ 50,000**

Task C4 Field Verification of Ground-Water and Surface-Water Irrigated Areas

This task entails the field verification of current estimates of ground and surface water-irrigated acres. For the long-term calibration, it is assumed that the total number of irrigated acres in the Snake River plain would be determined from satellite imagery. The assignment of these acres to ground water-irrigated acres and surface water-irrigated acres is more complex. This task would involve field work to help delineate the difference between surface and ground water-irrigated acres.

Status: Unfunded Source: New Amount: $75,000

Element D Combining Surface and Ground-Water Models

Task D1 Evaluation of Combining Surface- and Ground-Water Models

Surface and ground-water systems in the basin interact with one another, and a significant change in one system elicits a response in the other. However, there is no single model code available that represents the detailed processes in both surface and ground-water systems simultaneously. General surface and ground-water codes were developed to focus on either one system or the other with iterative mechanisms to account for interaction between the two systems.

Separate surface and ground-water model codes were selected and configured with data to represent conditions in the eastern Snake River Plain. These models adequately represented each system, but were not run simultaneously. In this task, alternative options for developing a single model will be evaluated. This task can proceed relatively independently of other tasks and will be coordinated through the ESHM committee.

Status: Funded Source: USBR Amount: Ongoing
No State funding being pursued for this element at this time

PHASE I RESULTS

At the end of Phase I, the results of the four parallel elements of work will come together to produce a more representative ground-water flow model with improved data processing capabilities, and improved understanding of model uncertainty and predictive reliability. Phase I will also produce both quantitative and qualitative information on how to most effectively improve predictive reliability of the model by additional data collection. A follow-on data collection program will be implemented in Phase II, provided funding is available. If funding is not available, the utility of Phase I has not been compromised to any great degree, since model improvements have directly resulted from the first phase.

PHASE II

Confidence bands on model predictions developed in Phase I are correct so long as the conceptual model correctly represents the real system. However, the degree to which the ground-water model represents the real world is largely limited by our understanding of the real world. The improvement in that understanding is largely based on observations of the real world, or data collection. The second phase will be the implementation of a carefully guided data collection effort. Data collection is costly, thereby emphasizing the importance of the first phase in identifying types and locations of data collection, possibly including water quality and water chemistry data, that will be most important for improving understanding and reducing model uncertainty.

PHASE III

The third phase will involve the use of newly acquired hydrologic data, in combination with previous data and inverse modeling techniques, in order to direct improvements in the underlying conceptual model and parameter distributions which will extend the scope and utility of the model. This phase will likely include the testing of new conceptual model elements such as three dimensional flow in a layered aquifer, and movement in ground water of non-reactive solutes and chemical tracers.

PARTNERSHIPS AND SCHEDULE

The proposed project elements will be accomplished through a partnership of the Idaho Department of Water Resources, the U.S. Bureau of Reclamation, the U.S. Geological Survey, the University of Idaho, the U.S. Environmental Protection Agency and Idaho Power Company. This strategy provides a means of drawing together into a holistic approach what would otherwise be independent research projects. Funding is being sought to address those elements not already proposed as shown in the table below. The duration of the first project phase is expected to be three years.

FUNDING

Proposed Funding for Eastern Snake River Aquifer Model Enhancement

Task	Current Funding	New Funding Req'd	Total	Funding/ Responsibility
A1	$10,000		$10,000	USBR
A2	$110,000	$670,000	$780,000	USBR[1]/IDWR[1]/New
A3	$120,000	$30,000	$150,000	USBR[2]/IDWR/New
A4	$30,000		$30,000	IDWR
B1	$80,000		$80,000	USBR/UI
C1		$250,000	$250,000	New
C2		$150,000	$150,000	New
C3		$50,000	$50,000	New
C4		$75,000	$75,000	New
Total	**$350,000**	**$1,225,000**	**$1,575,000**	

1 USBR - $ 80,000, IDWR - $ 30,000

2 USBR - $ 120,000

Proposed Distribution of Funding for Eastern Snake River Aquifer Model Enhancement

Task	Current Funding	FY 2001	FY 2002	FY 2003	Totals
A1	$10,000				$10,000
A2	$110,000	$225,000	$225,000	$220,000	$780,000
A3	$120,000	$30,000			$150,000
A4	$30,000				$30,000
B1	$80,000				$80,000
C1		$100,000	$75,000	$75,000	$250,000
C2		$50,000	$50,000	$50,000	$150,000
C3		$20,000	$20,000	$10,000	$50,000
C4		$25,000	$25,000	$25,000	$75,000
Total	**$350,000**	**$450,000**	**$395,000**	**$380,000**	**$1,575,000**

EASTERN SNAKE HYDROLOGIC MODELING COMMITTEE (11/22/99)

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