WATER RESOURCES MANAGEMENT PLAN

HAGERMAN FOSSIL BEDS NATIONAL MONUMENT
IDAHO

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EXECUTIVE SUMMARY

Hagerman Fossil Beds National Monument (HAFO) enabling legislation states clearly that fossils are the primary resource along with research and education as secondary missions. Natural resource protection programs are designed in accordance with unique fossil resource needs necessary for effective implementation of mandates. The Water Resource Management Plan (WRMP) plays a critical role to provide the framework by which short-term and long-term goals can be systematically implemented. Although HAFO is located in a desert environment, the importance of the WRMP is third only to the General Management Plan and Resource Management Plan. The number one impact to fossil resources are massive landslides caused by agricultural irrigation water, which destroy not only fossil resources but also endangered plant and animal species. The WRMP serves as a working, applied document for effective implementation of natural resource protection.

INTRODUCTION

Water is a significant resource in every unit of the National Park Service (NPS), whether in the support of natural systems or providing for visitor enjoyment and use. The NPS strives to preserve water quality and to restore contaminated water in accordance with all applicable laws and regulations. Surface and groundwater are also viewed as integral ecosystem components. The NPS manages water and natural water-related processes to maintain the health of aquatic ecosystems. Water resources planning activities are essential components of park resource management.

The WRMP focuses on current water resource conditions and issues facing the NPS at HAFO. The objective of this report is to provide park managers with an up-to-date assessment of existing hydrologic information, and to develop statements on water resource issues. The information in this report has been collected from a variety of sources including a thorough review of NPS files, interviews with local and regional water resources professionals, and contacts with appropriate regulatory agencies and adjacent land managers. Reviewers besides the authors include: Larry Martin (WRD Hydrogeologist), Bob Willhite (HAFO retired Chief Ranger) and Fran Gruchy (HAFO Operations Chief).

EXISTING RESOURCE CONDITION

Water resources at HAFO are limited due to the arid climate and relatively small size of this NPS unit. Nonetheless, there are significant water resource issues at the Monument. Managing these issues requires a broad understanding of the enabling legislation, past land use activity and the geological, hydrological, and ecological nature of the unit.

Location, Legislation and Management History

HAFO is located in south-central Idaho along the Snake River near the town of Hagerman, Idaho (Figure 1), about 90 miles southeast of Boise and 30 miles downstream of Twin Falls in the Hagerman Valley. The Snake River roughly divides the Hagerman Valley in half (Fig. 1). The Monument lies on the border between Twin Falls and Gooding Counties in south-central Idaho. Although, the monument is in Twin Falls County, the current and proposed administrative, visitor and research facilities will remain on the east-side of the Snake River in Gooding County. The legal boundary along the Snake River extends down to the pre-dam high water mark for the river and is now submerged now due to the construction of the Lower Salmon Falls Reservoir. HAFO purchased 54 acres of new property on the east side of the Snake River in 1998 for the Research Center/Museum which also extends out into the reservoir to the original submerged high water mark of the river.

The Bureau of Land Management (BLM) originally managed the area of the Monument through the Jarbidge Resource Area. In 1988, management of 3,974 acres was transferred from the BLM to the NPS by the Arizona-Idaho Conservation Act (PL 100-696), and included 420 acres of state land. Recent boundary surveys indicate the true area of the Monument to be 4,350 acres. All of the land transferred to the NPS in 1988 is on the west side of the Snake River near the town of Hagerman (Figure 1).

The NPS management of the fossil beds was established by Congress "in order to preserve for the benefit and enjoyment of present and future generations the outstanding paleontological sites known as the Hagerman Valley fossil sites". Enabling legislation provided some specific management direction in language that says "…there are little or no water or water-related resources that require the protection of a Federal reserved water right".

Further, the legislation states that "Nothing in this title shall affect electrical generating and transmission and irrigation pumping and transmission facilities in existence within the boundaries of the monument, or the right to operate, maintain, repair, upgrade and modify such facilities. Such facilities are hereby expressly determined to be compatible and consistent with the purposes of this title". These statements were directed toward Idaho Power's Lower Salmon Falls Hydroelectric project adjacent to the monument and to the Bell Rapids Mutual Irrigation District facilities within the monument.

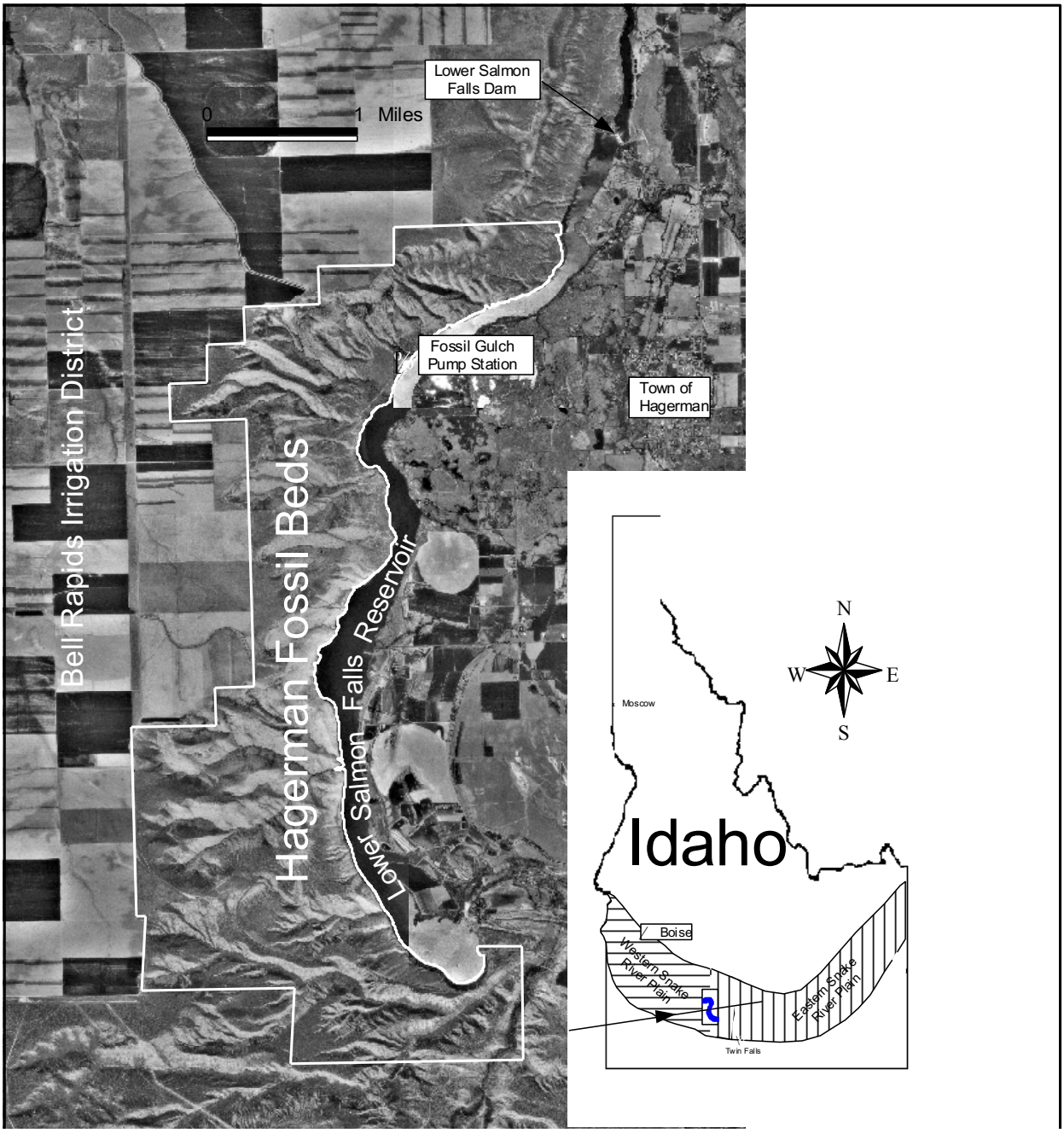

Figure 1. Location of Hagerman Fossil Beds National Monument.

NPS management of HAFO was originally conducted from the USFS office in Twin Falls, Idaho. The Superintendent of the monument also acted as Superintendent of City of Rocks National Monument. In 1990, the NPS moved into its own office in Twin Falls, and hired a Unit Manager, who set up an office in Hagerman in spring 1991. By summer 1995, the Unit Manager position was upgraded to Superintendent. There are currently 8 permanent staff positions at HAFO and during the summer permanent staff is supplemented by seasonal employees and volunteers.

A General Management Plan was completed for the Monument in 1996. Among other items, this plan identified management zones within the unit (Figure 2), and some water resource issues and information. Management of the Monument relies on a number of cooperative agreements and memorandums of understanding with several Idaho State and Federal agencies. These agreements are listed in Table 1. The State currently owns section 16 (640 acres) within the boundaries of the monument, but the NPS is seeking acquisition to federal ownership. An agreement is currently in place between the NPS and Idaho that ensures the state will manage these areas in a compatible fashion with the rest of the Monument.

Management topic	**Other agency**
Regional trail system	Bureau of Land Management
Fire management	Multiple federal and state agencies
Monitor well access	Bureau of Land Management & private land owners
Exchange of resource information	Idaho Power
Design of canal lining alternatives	Bureau of Reclamation

Table 1. Cooperative Management Agreements at HAFO.

NPS management of water resources on the Snake River is influenced by the 1993 Comprehensive State Water Plan, which designates parts of the Middle Snake Reach for multi-objective resource planning with three rating categories: 1) outstanding, 2) high and 3) moderate/low. The water plan classifies the Hagerman reach of river as: A) 'high' scenic value, B) 'outstanding' geologic features, C) 'outstanding' recreational evaluation, and D) 'not outstanding' biological evaluation (Idaho Water Resources Board, 1993). The plan's recreational designation of areas adjacent to the monument prohibits construction or expansion of dams, or impoundment's, construction of hydropower projects, and mineral or sand excavation. Within the stream channel, alterations are prohibited unless they maintain existing facilities, or involve development of visitor use facilities by public agencies.

Climate

Because of latitude and location downwind from the Cascade Mountains, the Monument has a semi-arid continental climate (Caldwell, 1985). Due to orographic uplift, most moisture from Pacific Ocean cyclones falls several hundred miles west of the Monument on the Cascade Mountains. Variation in the position and strength of semi-permanent pressure regions over the Pacific Ocean and prevailing westerly winds impart a seasonal aspect to precipitation. As a result, most precipitation falls during the winter months when the Aleutian Low dominates the northern Pacific and westerly winds bring storms to the latitude of southern Idaho.

Approximately 96% of the annual precipitation falls as snow during the winter months. Mean annual precipitation at Bliss, Idaho, (elev. 3,265 ft) was 9.6 inches from 1951 to 1980. High potential evaporation greatly reduces effective precipitation. Mean annual temperature for the same period of record at Bliss was 51^0 (F), with temperature extremes recorded at a low of -22^0 (F), and a high of 106^0 (F). Annual variation in temperature and precipitation is known to vary widely from year to year and over extended time periods. During the Little Ice Age, approximately 1300 to 1850 A.D., the climate of this region was believed to be wetter and cooler.

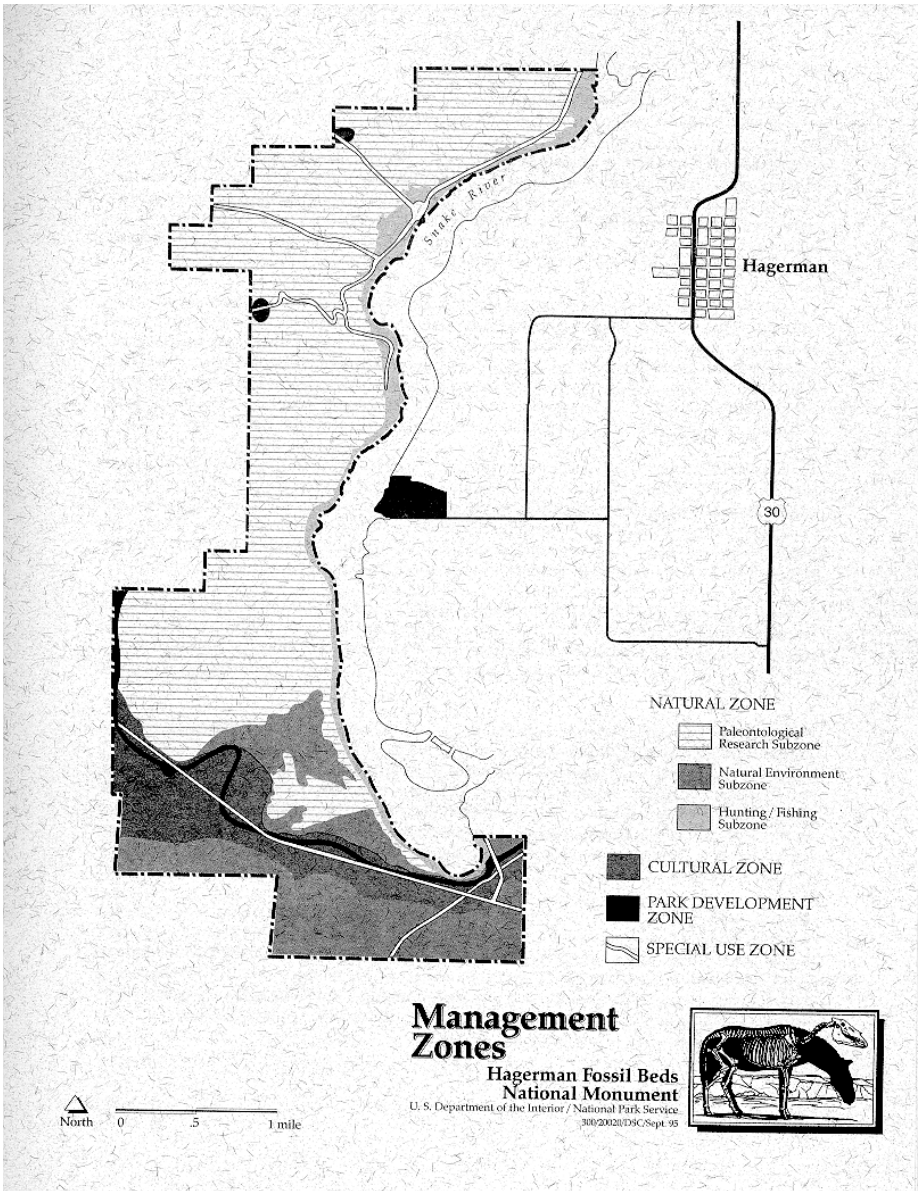

Figure 2. Management Zones.

Geographic Setting

As shown in Figure 1, the Monument is located along the west bank of the Snake River. A broad, flat agricultural area known as the Hagerman Valley lies east of the Snake River. Sand and gravel deposits and thin, poorly developed soils cover basalt flows in the valley. Geologic and geomorphic features within the valley were created or influenced by the Bonneville Flood, which produced scoured surfaces of basalt, known as scablands, and enormous sand and gravel bars (Maley, 1987).

Nearly the entire monument is located on the arid slopes of the Snake River Plain between the west bank of the Snake River and the Bruneau Plateau. Malde (1965) described the western Snake River Plain as containing a considerable thickness of primarily clastic sediments. Bluffs that rise 600 feet above the Snake River contain rich fossil-bearing sediments deposited 3 – 4 million years ago. The Monument boundary generally follows the top edge of the bluffs to the west, and the mid channel of the Snake River to the east (Figure 1). The river is held at a nearly constant elevation of 2,800 feet by the Lower Salmon Falls hydroelectric dam. Closure of the dam flooded falls used by Native Americans to intercept salmon migrating along the main stem of the Snake River.

The bluff face consists of sedimentary and volcanic layers that are deeply incised by arroyos and gullies that range from a half to one mile in length. Slope angles between the gullies commonly exceed 35^0 with some as steep as 70^0.

Geologic Setting

The Snake River Plain is a major late Cenozoic tectonic/volcanic feature at the north end of the Basin and Range Physiographic Province (Bonnichsen and Breckenridge, 1982). The plain extends in a crescent shape across southern Idaho for roughly 300 miles and it is divided into two main regions identified as the western and eastern Snake River Plain. The town of Hagerman is located on the eastern plain while the Monument lies in the western plain. The western Snake River Plain is about 40 miles wide, bounded by normal faults, and has a northwest-southeast trend. Displacement started about 17 million years ago by rifting and down warping of the plain. The subsequent stretching of the crust produced a basin that began filling with sedimentary and volcanic rocks of considerable thickness during the Miocene, Pliocene and Pleistocene.

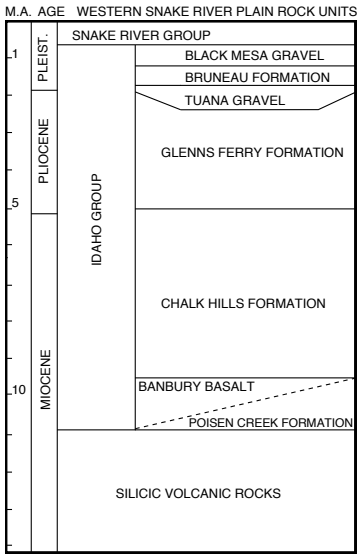

Figure 3. Sequence of rocks in the western Snake River Plain (modified from Malde, 1991).

Strata at the monument are typically characterized by a series of sediments named the Idaho and Snake River Groups (Figure 3). Deposition of the Idaho Group began eleven million years ago on the silicic Idavada Volcanics. Cope (1883) identified and named these sediments "The Idaho Group" and the body of water where these sediments collected "Lake Idaho". The Idaho Group is composed of seven formations identified by Malde and Powers (1962), which include the Glenns Ferry and Tuana Formations. These Cenozoic sediments crop-out (Figure 4) on the steep

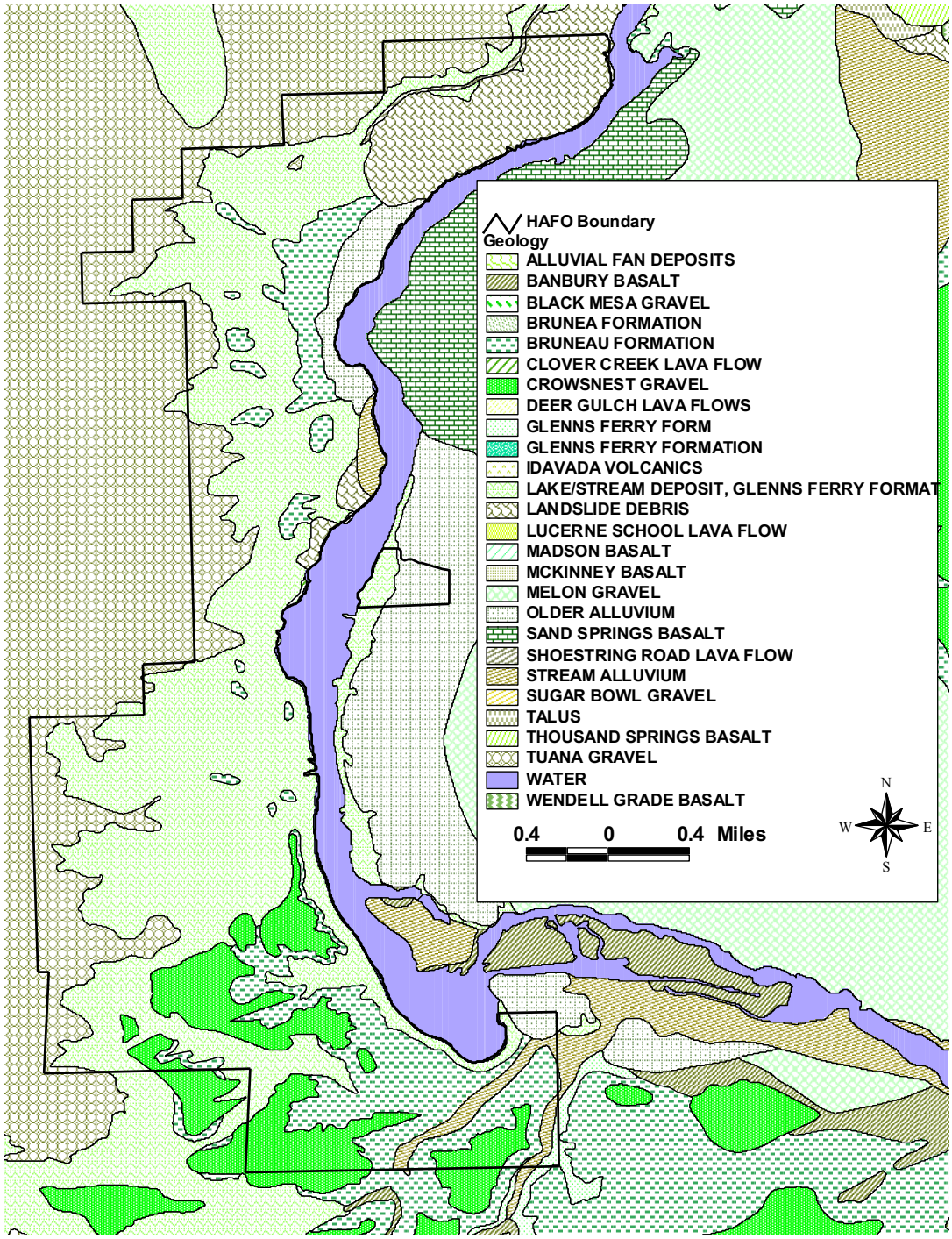

Figure 4. Geologic map of the Monument based on Malde (1972).

bluffs west of the Snake River and are composed of clastic deposits inter-bedded by occasional basalt flows, silicic volcanic ash, and basaltic pyroclastic deposits. Most of the sediments are poorly consolidated and range in texture from clays to gravels.

The age of the Glenns Ferry Formation is broadly constrained from Pliocene to early Pleistocene, or 5 to 1.5 MA. (Malde, 1991). Deltaic, fluvial and flood plain environments are the primary constituents of the Glenns Ferry Formation exposed on the bluffs of the monument (Figure 4).

Malde (1972) suggests the depositional setting as a highly sinuous meandering stream, its flood plain, and its delta near the east end of Lake Idaho. The climate was predominately humid but also semi-arid at times. These deposits are commonly characterized by monotonous fine-grained, graded, calcareous, pale-olive silt beds from one to three feet thick and capped with a dark, carbonaceous clay from one to several inches thick (Malde, 1965).

The Tuana Gravel Formation rests unconformably on the Glenns Ferry Formation. Saddler (1997) describes the composition of the Tuana gravels as coarser grained sediments in the silt, sand and gravel fractions. The base of the Tuana exhibits cut and fill stream channels in the underlying silts and clays of the Glenns Ferry Formation. These stream channels are commonly filled with fine sand. A caliche layer has formed several feet below the surface on the bluff tops, although no significant deposits exist on the hillsides. The caliche covers most of the plateau and reflects a climatic change from the Tuana environment and is considered to have formed during arid interglacial periods of the Pleistocene (Bjork, 1968). Outcrop observations indicate the
caliche is a very dense layer averaging several feet thick, which thins to less than one foot in thickness in some locations. The caliche is resistant to weathering and forms a cap rock near the top of the bluff in most of the Monument and surrounding area.

Soils

The Monument contains ten soil series described by the Natural Resources Conservation Service (NRCS) and listed in Table 2. Soil development is a function of the geology, landforms, relief, climate and natural vegetation, and each type is associated with a particular element of the landscape. The permeability of these soils has been divided into seven textural classes. The Purdam and Rakane-Blacknest series is moderately slow with 0.2 to 0.6 inches per hour. The Sluka, Bahem and Dolman series are moderate with 0.6 to 2.0 inches per hour.

Series	Texture	Permeability
Antelope Springs Loam	Loam	Slow (0.06" - 0.2"/hr.)
Badlands-Kudlac	Sandy Loam - Silty Clay	Very Slow (< 0.6"/hr.)
Bahem	Silt Loam	Moderate (0.6" - 2.0"/hr.)
Dolman	Silt Loam	Moderate (0.6" - 2.0"/hr.)
Kudlac	Silty Clay	Very Slow (< 0.6"/hr.)
Purdam	Silt Loam	Moderately Slow (0.2" - 0.6"/hr.)
Quincy	Loamy Sand	Rapid (6.0" - 20.0"/hr.)
Rakane-Blacknest	Loam - Clay Loam	Moderately Slow (0.2" - 0.6"/hr.)
Scoon	Fine Sandy Loam	Moderate (0.6" - 2.0"/hr.)
Sluka	Silt Loam	Moderate (0.6" - 2.0"/hr.)

Table 2. Soil types within Hagerman Fossil Beds National Monument. Modified from Natural Resources Conservation Service (1996).

All series are well drained and described by the SCS as having intermediate water holding capacity, which retain optimum amounts of moisture, but are not wet close enough to the surface

or long enough during the growing season to adversely affect yields. All series, except the Bahem, have a hardpan which starts about two feet down and continues to four foot depth. The Bahem had no hardpan down to six feet which is the maximum depth of survey data (NRCS, 1996). A common name for the 'hardpan' soil classification is caliche.

Vegetation and Ecology

Arid climate on the western Snake River Plain supports steppe vegetation cover producing a cool desert ecosystem. Prentice (1995) identified four major groups, which include the shadscale, greasewood, sagebrush, and wetland associations. Sagebrush dominates on gentle slopes, while shadscale and greasewood associations are found on steeper, better-drained slopes. Grasses dominate the understory of the upland associations, while the wetland association includes willow and occasional cottonwood overstory with grass and sedge ground cover.

Non-native terrestrial species include cheatgrass, medusahead, Russian olive, tamarisk, Canada thistle, Russian thistle, spotted and diffuse knapweed and rush skeleton weed. Crested wheatgrass has been used to revegetate fallow agricultural areas and was introduced from Asia. Since the 1970's artificial perched aquifers have created flowing seeps and ponds within the Monument which support unusual mesic species. The most prevalent non-native aquatic plant is purple loosestrife, but cattails and other aquatic plants are found in ponds within the Monument.

Native species include blacktail jackrabbit, cottontail rabbit, mule deer, ground squirrel, canyon mouse, wood rat, marmots and kangaroo rats. Predators include coyote, badger, spotted skunk, striped skunk, weasel, mink, and bobcat. Game birds include gray partridge, chukar, and California quail, and the introduced ring-necked pheasant. Important habitat is also provided to raptors and songbirds. Wildlife use of the Monument has been altered by nearby residential, agricultural and hydroelectric development.

Aquatic species are generally absent from the steep, arid slopes of the Monument. Along the Snake River, waterfowl include transitory ducks and Canada geese. Species of fish found in the Snake River include rainbow trout, smallmouth bass, chubs, suckers and carp. Carp and smallmouth bass are non-native species. Sturgeon used to be plentiful on the river, but native populations are now low. Due to the presence of dams, no anadramous fish runs remain this far up-river on the Snake River but landlocked coho salmon have been identified. Species of amphibians, reptiles, insects and other invertebrates have not been inventoried.

Historic Land and Water Use

Livestock from early homesteaders grazed the Monument, and grazing continued for decades until 1984. That same year, the BLM terminated off road vehicles use to protect the fossil resources. The Gridley family released horses that ranged freely and were periodically rounded up as "Mustangs" and sold in Bliss for railroad shipping. A ferry, located on the Monument once transported sheep across the Snake River to the Conklin/Brailsford flat where they grazed in the early 1900's.

Idaho leads the US in trout production, annually accounting for 70% of US farm-raised trout. Most of this industry is located upstream of HAFO on the Snake River where 75% of the state's

private hatcheries are located. The trout industry is focused at this site because of the abundant springs along the Snake River bluffs.

Cities near the Monument include Hagerman, Bliss and Wendell in Gooding County. Hagerman had a population of 669 in 1992, and an annual growth rate was of 5.8%. The Twin Falls County zoning regulations designate lands surrounding the Monument as agricultural.

Placer mining was conducted in the valley primarily on the Hagerman side of the Snake River. Several artifacts have been identified and landscape features that are associated with the mining on the new Museum/Research Center property. Fred Benoit provided the following information from letters and news articles about the family and property.

"*Ray Bell purchased the property in 1902 from a homesteader named Jacob Stotz who was actively mining placer gold from the sand and gravel deposits. In 1890, Jacob Stotz of Alturas County, Idaho Territory, purchased 240 acres of desert land. The deed was signed by President William McKinley and Secretary F.M. McKean. A mining certificate was granted to Stotz under the name of Standard Placer Mining Claim in 1902 and was signed by Theodore Roosevelt and Secretary McKean. The water rights for the ranch date back to 1884, obtained by I.B. Perrine (of Twin Falls) and M.F. Thompson. Two (2.0) inches were secured in the right and it was taken from Billingsly Creek . C.M. Peters (Charlie) also mined the gravel for years after E.M. Bell bought the ranch. He made wages panning for gold and lived in a sort of dugout along a bank. E.E. Decker and Leo Bell were crossing the Snake River in rowboats one evening while duck hunting. Decker was swept into the 'Bell Rapids' where his boat overturned and he drowned. At least two other people drowned in the rapids because they were very swift and dangerous before the Lower Salmon Falls Dam was constructed and they were inundated.*"

A two and one-half mile section of The Oregon Trail crosses the Monument on the south end and is intertwined with the Bell Rapids road up to the top of the plateau. Road construction has destroyed some segments of the trail but other segments are in excellent condition. Emigrants used the trail from about 1843 to 1860's and traded with local Native Americans for salmon from the Snake River.

HYDROLOGY

General Surface Water Hydrology and Water Quality

Surface water resources at the Monument consist of two components: 1) the Snake River Lower Salmon Falls Reservoir and 2) small tributary streams that discharge into the river from within or across the Monument and the proposed Museum/Research Center property. Snake River water is used for irrigation and hydroelectric power production, while smaller tributary systems within the Monument are strongly influenced by irrigation runoff and associated ground water discharge. Irrigation return water flows through the 'Bell Ditch' across the Museum/Research Center site and into the reservoir. The Bell ditch originates 4 miles to the north at a diversion on Billingsley Creek, and supplies water to agriculture lands. Billingsley Creek is 303d listed for impaired parameters of nutrients and sediment.

Lower Salmon Falls Reservoir is designated by the State of Idaho as an impaired water body documented in the 303d list. The table below provides information for parameters of concern from the 303d list.

Watershed	HUC	ID	Waterbody	Parameter of Concern	Priority for TMDL development	Is the Waterbody Targeted for TMDL development before the year April, 2000?	Potential sources of Impairment
Upper Snake-Rock	17040212	ID2372-1998	LOWER SALMON FALLS RESERVOIR	DISSOLVED OXYGEN FLOW ALTERATION SEDIMENT		Yes	

Table 3. State of Idaho 303d List for Salmon Falls Reservoir (EPA, 2000).

The Snake River upstream of the Monument drains an area of 35,875 square miles in four states. Figure 5 illustrates the Snake River hydrograph at Lower Salmon Falls gauging station from 1938 through 2000. Since most precipitation falls in winter within the basin, peak flow on the river typically occurs during spring snowmelt runoff. However, August and September are the only months that haven't had an annual peak flow, and 25% of all annual peak flows have occurred in response to late fall or early winter storms.

In addition to surface water runoff, river flow rates are also supplemented by groundwater discharge from thousands of springs about 2 miles upriver from the Monument. River flow rates along the Middle Reach of the Snake River are monitored at five USGS gaging stations. At Lower Salmon Falls Dam, long term average flow on the Snake River is 9280 cubic feet per second (cfs), and groundwater discharge into the river accounts for nearly one-half of this amount.

Flow along the Middle Reach of the Snake River is regulated by several dams, diversions and associated reservoirs, and is managed by the Bureau of Reclamation and Idaho Power. Tailwater from the Upper Salmon Falls Plant may affect the southernmost portion of the Monument due to

supersaturation of oxygen and nitrogen, and its effects on the aquatic system. Lower Salmon Falls Dam impounds the Snake River just downstream from the northern Monument boundary. In general, the Salmon Falls projects are operated as a run-of-the-river facility, with very little storage capacity. Operation of the reservoir is described in the next section.

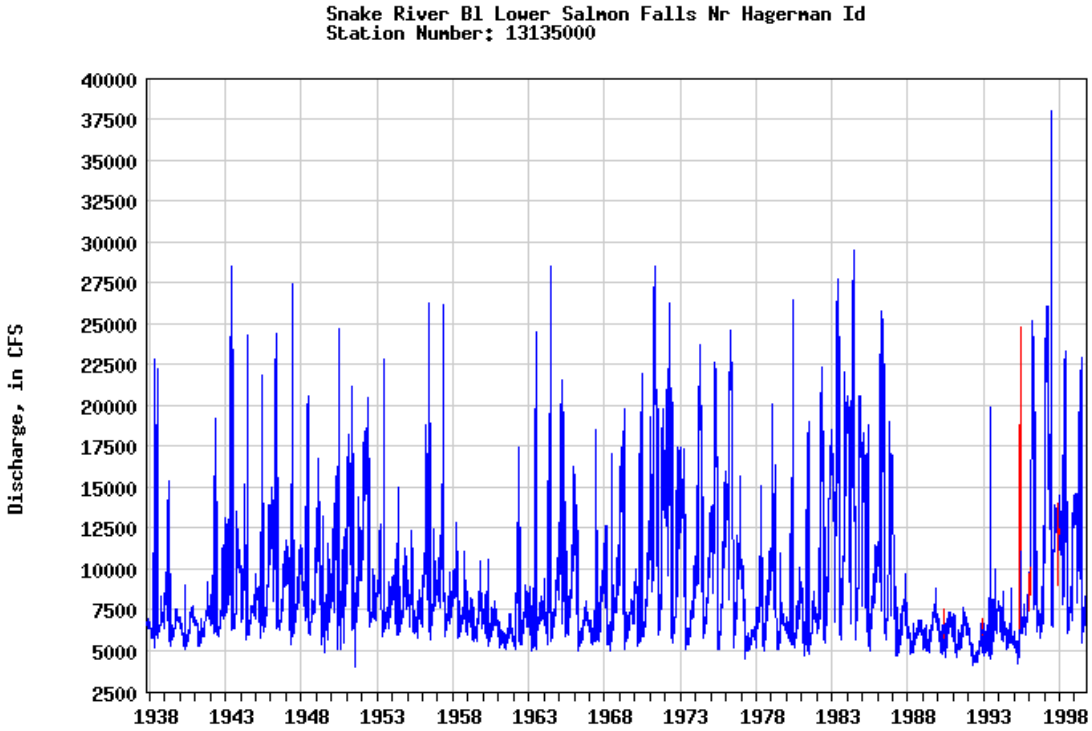

Figure 5. Snake River flow rates at Lower Salmon Falls gauging station from 1938 through 2000 (U.S.G.S., 2000).

Land use change on the plateau west of the Monument, from sagebrush steppe to irrigated farmland, have caused the formation of perched groundwater systems, which discharge along the bluffs within the Monument. Arroyo and gully erosion of unconsolidated sediments along the steep, poorly vegetated slopes of the Monument has proceeded at a rapid pace. Down-cutting by streams whose flow is supplemented by irrigation water has resulted in slope instability problems in upper reaches of these small streams, and in rapid deposition of fine-grained sediment in lower reaches as well as the Lower Salmon Falls Reservoir. The Bell Rapids Mutual Irrigation Company operates and maintains an irrigation system that pumps water from the Snake River, and irrigated approximately 17,500 acres of land on the plateau west of the Monument during the year 2000.

A two-year baseline surface water quality inventory project started in 1998 with funding from NPS-WRD. Although the project formally ended in FY2000, some aspects continue with equipment purchased from the project and ONPS base funds. The successful data collected occurred from 20 separate field locations, even though the original funding was for seven locations. Overall, baseline water quality parameters are good within the Monument. Nitrates approached or very slightly exceeded drinking water standards at several locations.

Lower Salmon Falls Hydroelectric Project

The Snake River is impounded approximately one-half mile downstream of the northern boundary of the Monument by the Lower Salmon Falls Dam (Figure 1). The Lower Salmon Falls project began in 1909 as a small part of the Greater Shoshone and Twin Falls Power Company. The dam and facilities were upgraded in 1919 and 1935 by Idaho Power Corporation, and reached their present configuration in 1948-49. Snake River flow rates are monitored immediately below the dam at USGS gauging station #13135000.

The Dam is approximately 50 ft tall, and impounds the Snake River for approximately 6.6 miles upstream, creating a 750 acre reservoir that can store 10,900 acre-feet of water at full pool. Useable storage, as constrained by Idaho State Water License, is 4,100 acre-feet with a 1,000 cfs flow requirement. Normal maximum surface elevation of the reservoir is 2798 ft, while minimum surface elevation is 2792 ft, making periodic fluctuations of 2-3 feet typical, and up to 6 feet on occasion. Raytheon (1995) identified 44 shoreline erosion and landslide sites. No data collection monitoring program is in place to document impacts to Monument resources.

The lower Salmon Falls Dam project is licensed by the Federal Energy Regulatory Commission (FERC; Project no. 2061). Idaho Power filed an application for a new license in 1995. A land management plan was submitted as part of the new license for the Lower Salmon Falls Project to help Idaho Power implement a comprehensive, coordinated approach to resource management. The plan contains policies for managing terrestrial, aquatic and cultural resources, recreation, aesthetics, land use and access and public use and safety. The plan contains land use zoning based on six types of use designed to provide a buffer to ensure continued public access and resource protection. Land use designations include protection, conservation, recreation, agriculture/grazing, utility facilities and special management areas. The license application also included a Protection, Mitigation and Enhancement Plan. Resources and issues addressed by this plan included water quality, fish and mollusks, wildlife, non-native and rare plants, cultural, aesthetic and recreation.

Bell Rapids Mutual Irrigation Company Project

Irrigation water from the Snake River is pumped to fields west of the Monument. Approximately ten acres within the Monument are used for pumping stations and pipelines. The Bell Rapids irrigation project began with the transfer of public lands to private farming interests under the Desert Land Entry Act of 1968. The water license priority for the irrigation district was established in 1963. Construction of facilities, including the canals began in 1969, and the first irrigation season was 1970 (Vector, 1994). The irrigation system consists of river pumps, three penstocks, ten miles of delivery canal system, a canal transfer pump station, regulating ponds, canal lateral line pumps, and more than 110 miles of lateral and mainline distribution pipe. This system provides pressurized irrigation water to approximately 17,500 acres for 40 individual farms with about 25 owners (Bell Rapids Mutual Irrigation District, 2000). Since the 1980's center pivot sprinkler systems are replacing hand lines and usage was increasing in the 1990's. Currently, there are 71 pivots in the project. Each pivot covers 130 acres and purchase price in CY-2000 was $40,000 per pivot. The total acreage under active cultivation has decreased mainly from non-irrigation of pivot 'corners' (BRMID, 2000). Each non-irrigated

pivot corner is about 7 acres for a total of 28 acres per pivot. The average water delivery rate for pivots is about 900 gallons per minute.

Water is pumped via high-lift stations from the Lower Salmon Falls Reservoir some 600 feet up the bluffs to the plateau and then distributed through mostly unlined canals. When the irrigation project began, there were two pump systems. However, a landslide destroyed the Bell Rapids 'south' pump station and pipeline in 1987. During the 1987 irrigation season, the Fossil Gulch canal carried larger volumes of water in response to the non-usable Bell Rapids canal so lateral line aqueducts could transfer water to the areas previously supplied by the Bell Rapids canal. Water is still transferred to the western portion of the Bell Rapids canal from the Fossil Gulch canal via an underground pipe. After the 1987 season the first one-half mile of Fossil Gulch canal was realigned to straighten it, and lined with concrete. Water is pumped from the canal system for field application using sprinkler system technology. Pumping season typically begins in April, and lasts approximately six months. Sugar beets, potatoes, winter wheat, beans and corn are the primary crops. Approximately 7,000 acres are fallow in a land set-aside program.

Total amounts of water pumped into the irrigation system averaged about 43,500 acre-feet per year from 1988-1997, roughly four times the volume of the Lower Salmon Falls Reservoir (Figure 6). The first irrigation season and recharge to the perched aquifers began in spring 1970. Perched groundwater began to discharge on the hillsides within about 10 years after the start of the irrigation project in 1970. Landslides and erosion associated with the perched groundwater systems set in motion a series of private and government agency studies addressing the hydrologic conditions within the plateau. Results from these studies indicate the irrigation system is the source of recharge to the perched aquifers that are causing slope stability problems.

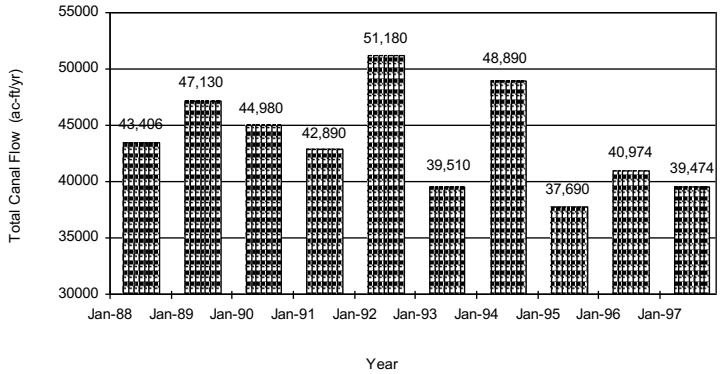

Figure 6. Yearly volume of Snake River water diverted by the Bell Rapids Irrigation District from 1988-97 (acre-feet/year).

Summary of Canal Leakage Studies

Recharge to the perched aquifers from the Bell Rapids Mutual Irrigation Company canal system has been studied during five separate leakage investigations. These leakage estimates are summarized in Table 4. The first study by Young (1984) measured flow within the Fossil Gulch canal at two locations and then indirectly calculated the amount of water leaking from the canal based on the difference between the two flow rates. Young (1984) reported about 1,900 acre-feet of water leaks from the first mile of the Fossil Gulch canal per 120-day irrigation season. This value was determined before a portion of the canal was lined with concrete in 1988. The

second study by Worstell (1985) measured the first half-mile of canal with a seepage meter that is commonly used for such studies. His results indicate a lower leakage rate of 193 acre-feet per 180-day irrigation season. A third canal leakage study, conducted by Montgomery (1988), involved constructing a water impoundment in the first one-half mile of Fossil Gulch canal. The calculated leakage was 299 acre-feet per season. The fourth canal leakage study, performed by Martin (1992), tested three sections of the Fossil Gulch Irrigation canal and two irrigation holding ponds. The results from his study show 360 acre-feet of water per irrigation season is lost from the first one-half mile segment of unlined canal (Martin, 1994).

Vector Engineering, Inc. (1994) performed a fifth leakage study. This study was designed to measure the canal flow at 500-foot intervals for the entire length and to use this flow rate data to indirectly calculate canal leakage, similar to Young's study in 1984. The results of the Vector study were stated as "inconclusive", but a leakage rate of 5,000 acre-feet/season (**10%** of the total volume of canal water) for the **entire** canal system was reported. Assuming a constant leakage rate along the canal may over or under estimate leakage because of variable geologic conditions. If groundwater divides exist within the plateau, then water leaking from the canals on one side of a divide may not be flowing towards the Monument. Identifying the location of these divides is important for efficient canal lining efforts.

Year	Researcher	Average Leakage Rate (ft./day /first **unlined** 1/2 mile)	Leakage Rate (ft./day **lined** section	Leakage Volume (acre-feet/ /180 day season/ /first **unlined** 1/2 mile)	Leakage Volume (acre-feet/ /180 day season/ /first **unlined** mile)	Leakage (acre-feet/ /180 day season/ /**entire system**)
1984	Young			1,425	2,850	
1985	Worstell	0.8		193	386	
1987	Montgomery			293	586	
1992	Martin	1.45	0.015	360	720	
1994	Vector Eng.					5000 (= 10% loss)

Table 4. Estimated rates and volumes of water loss from the Fossil Gulch canal by separate studies.

The Fossil Gulch Irrigation Pond leakage study performed by Martin (1994) indicated a water leakage of 140 acre-feet per season, which would account for roughly 33% of the annual discharge from the perched aquifer (Young, 1984). Groundwater level data collected in 1998 and 1999 by park staff suggests the pond is not a significant recharge contributor to the main basalt perched aquifer system connected to monitor well NPS-5. Although the pond is leaking, the leakage may be located on the distant side of a groundwater divide that possibly flows toward Tuana Gulch to the north. Tuana Gulch Creek has an estimated flow rate of about 150 to 200 g.p.m. Even if the pond leakage is located on the Monument side of a groundwater divide, the contribution of leaking water from the pond may be insignificant, relative to the contribution of water leaking from the canal into the basalt aquifer system, thereby masking the effects from the pond leakage.

General Groundwater Conditions

Groundwater conditions at the Monument consist of two main aquifer systems: a regional system and a local perched system. The regional aquifer is located at roughly the same elevation (2,800 feet) as the Snake River (Moffatt and Jones, 1984), while the perched aquifers are located at

about 3,200 feet in elevation, or 400 feet above the regional aquifer. The perched aquifers are referenced by two geographic areas: 1) The 'southern' Bell Rapids canal area, 2) The 'northern' Fossil Gulch canal area. The hydraulic connection between the two hydrogeologic areas is undefined.

Research has shown the perched aquifers have developed simultaneously with irrigation operations on the plateau west of the Monument. The hydrologic cycle for the perched aquifers consists of four main elements: 1) recharge or input from seasonal irrigation, 2) groundwater interflow, 3) aquifer discharge or output and 4) change in storage. There is a cyclic pattern in the hydrographs for input, interflow and output for the system providing evidence of the close relation between each element. Three groups of hydrographs and one set of groundwater contours are discussed in the following sections. Overall, the long-term trends show steady state conditions between the periods of January 1997 through January 2002 with a few important exceptions.

Monitor Wells

Data collection for the perched aquifers started in 1986 when eleven monitor wells were installed by the B.L.M.. Montgomery (1987) installed five more shallow wells, and in 1994 the N.P.S. added six more for a total of 22 wells. Figure 7 shows the location of the wells and Table 5 provides construction data. Currently, only 14 wells are usable or have water in them. The identification number applied to the wells in Table 5 is the standard U.S.G.S. legal description of range, township, section and quarter section referenced to the Boise base line and meridian. The six wells constructed in 1994 are noted with the acronym NPS-# for additional clarification.

All of the wells drilled in 1986 and 1994 used six-inch diameter PVC casing. The wells drilled in 1987 used two-inch PVC casing. The 1986 wells that encountered basalt penetrated only a short distance into the upper surface of the basalt while the 1994 wells drilled completely through the basalt into the underlying Glenns Ferry Formation. None of the 1987 wells encountered the basalt flow, but they typically had shallow depths. Long effective screen intervals on some wells have likely interconnected different perched aquifers, producing a composite affect for some of the monitor well hydrographs. The U.S.G.S. collected water level measurements in wells from March 1986 through May 1987 and January 1992 through April 1996. NPS staff have collected monthly water level data since April 1996.

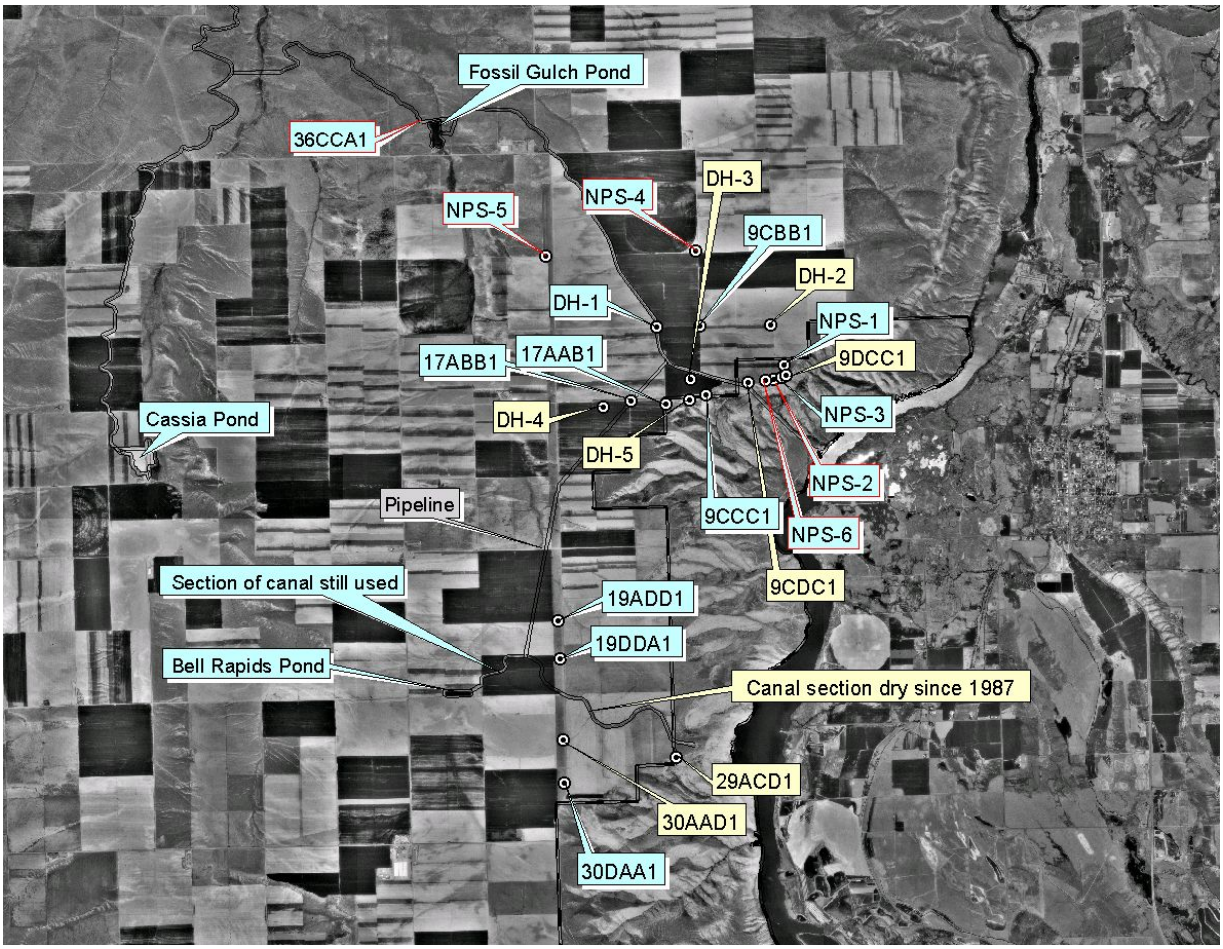

Figure 7. Location of monitor wells, irrigation canals and ponds.

	Monitor Well ID	Drill Date	Well Depth (ft.)	Approximate Depth to Water (ft.)	Land Surface Elevation (ft.)	Current Status
(Bell Rapids South Area)						
1	7S 13E 19ADD1	1986	122	75	3388	water
2	7S 13E 19DDA1	1986	154	121	3411	water
3	7S 13E 29ACD1	1986	143		3440	dry
4	7S 13E 30AAD1	1986	90		3433	dry
5	7S 13E 30DAA1	1986	166	146	3445	water
(Fossil Gulch North Area)						
6	7S 13E 17ABB1	1986	172	150	3374	water
7	7S 13E 17AAB1	1986	165	124	3346	water
8	7S 13E 9CCC1	1986	209	185	3342	water
9	7S 13E 9CDC1	1986	169		3374	dry
10	7S 13E 9CBB1	1986	114	95.74	3345	water
11	7S 13E 9DCC1	1986	212		3401	dry
12	7S 13E 8ACD1 (DH-1)	1987	36	25	3340	seasonally wet/dry
13	7S 13E 9BDD1 (DH-2)	1987	56		3400	dry
14	7S 13E 8DDA1 (DH-3)	1987	74.5		3340	dry
15	7S 13E 17BAB1 (DH-4)	1987	56		3400	destroyed
16	7S 13E 8DDD1 (DH-5)	1987	123		3340	destroyed
17	7S 13E 9DCB1 (NPS-1)	1994	235	233	3402	water
18	7S 13E 9CDD1 (NPS-2)	1994	240	220	3401	water
19	7S 13E 9DCC2 (NPS-3)	1994	224	220	3402	water
20	7S 13E 5DDD1 (NPS-4)	1994	250	176	3379	water
21	7S 13E 7AAA1 (NPS-5)	1994	249	180	3395	water
22	7S 13E 9CDD2 (NPS-6)	1994	252	220	3403	water
23	6S 12E 36CCA1 (privately owned)	1974	190	110	3334	water

Table 5. Monitor well information.

Bell Rapids Area Groundwater Hydrographs

There are five monitor wells (19ADD1, 19DDA1, 29ACD1, 30AAD1, 30DAA1) in the south part of the Monument adjacent to the Bell Rapids Canal. They are located between the water filled pond/canal segment and the plateau hill sides, where perched aquifers discharge and four landslides have occurred. A source of recharge to these aquifers was shut off in 1987 due to a massive landslide that destroyed the Bell Rapids hi-lift pump station, which supplied water to the canal. In response, the irrigation company installed a pipeline to transfer water from the 'north area' (Fossil Gulch Canal) to a short 1,000-foot section of the Bell Rapids canal where it then flows into the Bell Rapids Pond. The short section of canal and pond have been filled with irrigation water each season since 1987, and represent a possible source of recharge to the perched aquifers in the 'south area'.

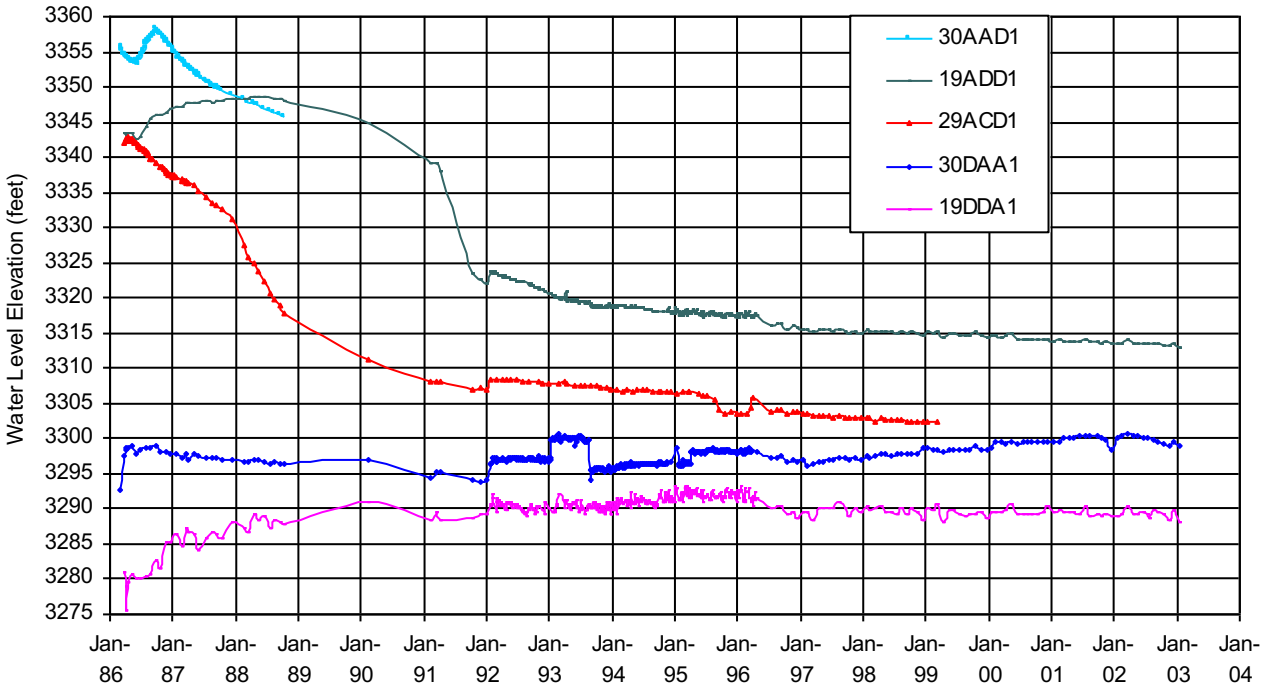

Figure 8. Monitor well hydrographs for the Bell Rapids 'south area'.

The hydrographs for 30AAD1, 19ADD1 and 29ACD1 (Figure 8), exhibit a significant water level drop in the subsequent years after the 1987 landslide. Monitor well 30AAD1 has remained "dry" since 1988 and 29ACD1 since 1999. But, the water levels for monitor wells 30DAA1 and 19DDA1 do not appear to have responded to the non-use of the canal after 1987. There appears to have been at least 2 perched aquifer systems in this area with the shallow system apparently drying up. Shifts in the hydrographs, for example in 1993 for 30DAA1, are attributed to different data collection methods from different agencies and aquifer tests. HAFO has collected data since late 1996 using consistent methods and equipment. The drop in water level for 29ACD1 in 1995 is attributed to the 1995 landslide that occurred a few hundred feet from this well. The hydrograph for 19DDA1 exhibits confined aquifer characteristics, possibly from a sand unit 'pinching out'.

Hydrograph trends shown in Figure 9 from 1997–2000 for wells 19ADD1, 29ACD1 and 19DDA1 indicate that water levels are slightly decreasing. But, it is important to note that water levels in monitor well 30DAA1 are increasing, based on the trend line. Water level responses from these wells may be influenced by recharge from the nearby Bell Rapids Canal and pond. Also, note that Figure 6 shows a decrease in the amount of water pumped by Bell Rapids.

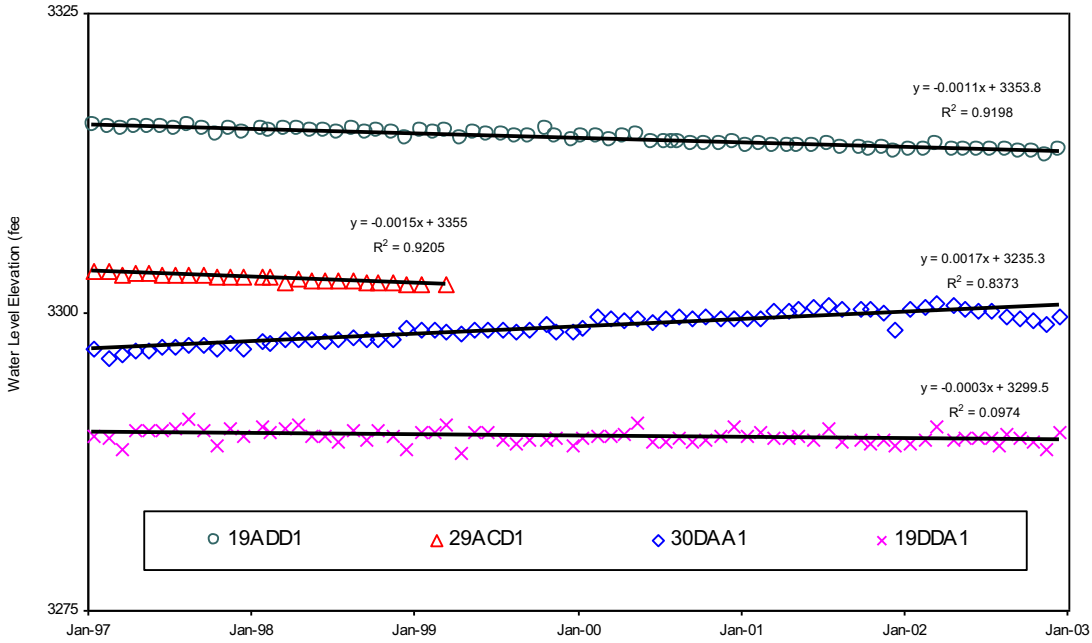

Figure 9. Water level trends from 1997-2002 for the Bell Rapids monitor wells. The trends show water levels dropping slightly except for 30DAA1 which is increasing.

Fossil Gulch Area Groundwater Hydrographs and Water Level Contours

There are 11 monitor wells with water in the Fossil Gulch area. Six additional monitor wells are located in this area but are either dry or have been accidentally destroyed by machinery. Generally, the long-term water levels are in a steady state condition but Figure 10 shows how yearly irrigation cycles influence the monitor well hydrographs. Hydrograph characteristics are mainly a function of recharge events, aquifer parameters, lengths of flow paths and monitor well design. Cyclic groundwater levels are responding to temporal changes in recharge due to seasonal irrigation practices.

Monitor well hydrographs for NPS-5, NPS-4 and NPS-3 have been chosen to demonstrate how changes in recharge conditions effect water levels in the middle perched aquifer composed of basalt. Other monitor wells in the Fossil Gulch area were not used in Figure 10 because some wells have nearly identical hydrographs as other wells such as NPS-6 and NPS-3, while others have complex hydrographs attributed partially to well construction and design and different perching systems such as 9CBB1.

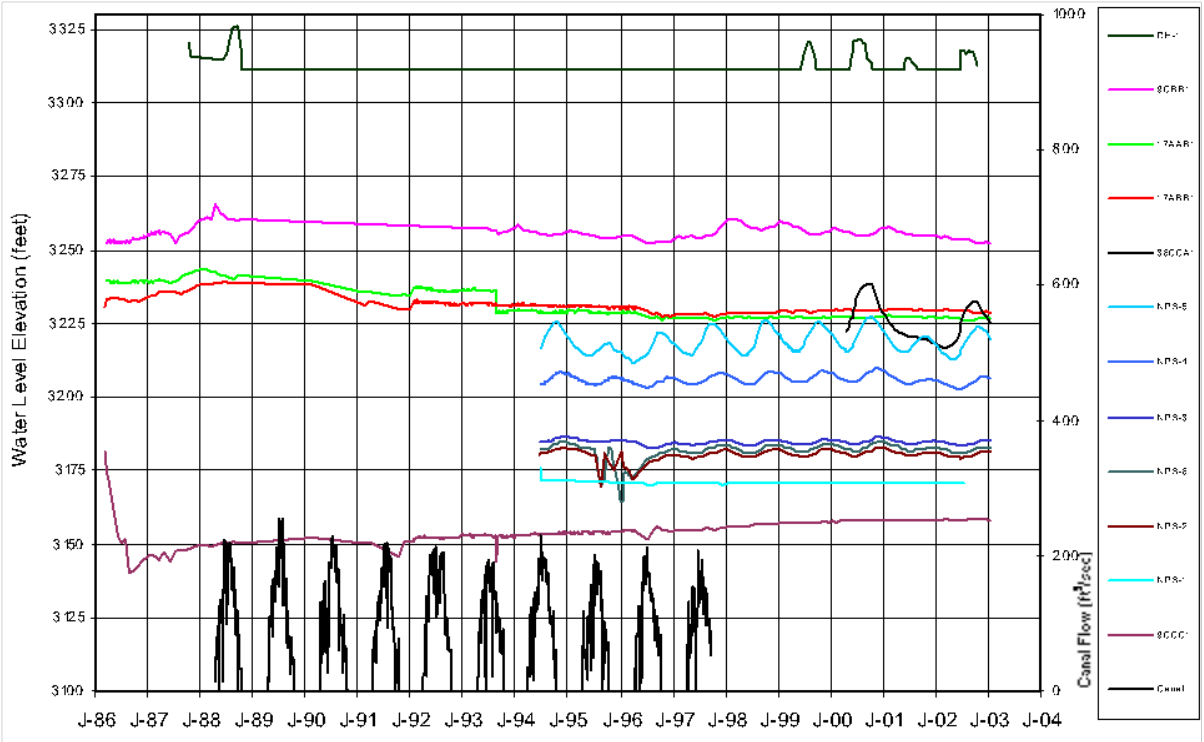

Figure 10. Monitor well and canal hydrographs for the Fossil Gulch area from 1986-2002.

Well NPS-5 has the earliest rise in water levels, highest water level elevation and greatest hydrograph amplitude, which indicates that it is closer to a source of recharge then NPS-4 or NPS-3. Water levels start to rise during the early part of June for NPS-5, July for NPS-4 and August for NPS-3. This provides evidence for a recharge pressure wave propagating down gradient reaching NPS-5 first, then NPS-4, and finally NPS-3 and aquifer discharge zones are reached last. The pressure response takes about 100 days to travel a horizontal distance of 15,000 to 20,000 feet from the recharge area to the discharge zones; this equates to a range of 150 to 200 feet/day. Since early 2000, a private supply well (36CCA1) has been monitored by NPS staff under a gentlemen's agreement with Bell Rapids Irrigation District Manager. 36CCA1 appears to have an even greater hydraulic connection with the recharge sources, but a longer monitoring period is needed to evaluate the relevance of this hydrograph.

Groundwater contours (Figure 11) indicate a 36-foot loss in head from NPS-5 to NPS-3, over a distance of 9,000 feet. This equates to a hydraulic gradient of 0.4 percent, compared to a gradient of 0.6 percent for the basalt flow. The downward hydraulic gradient from NPS-5 to NPS-3 indicates water flowing in the basalt aquifer from northwest to southeast, where it daylights and discharges on the hillsides in the Monument (Farmer, 1999).

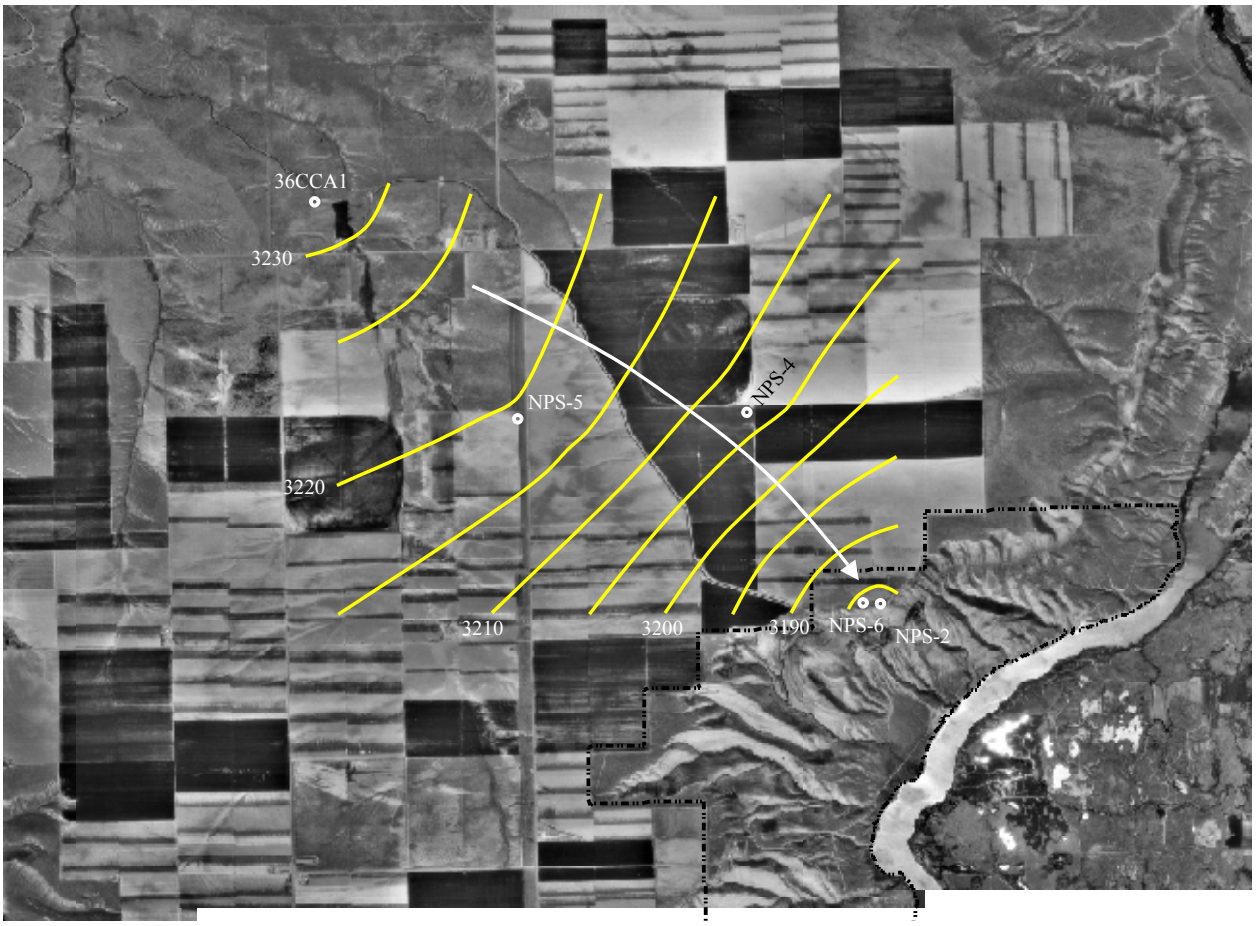

Figure 11. The horizontal hydraulic gradient from ground water contours (5-foot intervals) shows general flow path illustrated by the arrowhead line.

Discharge from Perched Aquifers

Perched aquifer discharge hydrographs (Figure 12) generally show cyclic patterns attributed to the seasonal groundwater level fluctuations. Table 6 lists the monitoring stations for the Fossil Gulch area, average flow rate in gallons per minute and the total annual volume of water based on the average flow rates. Flow rates are collected on a monthly basis using volumetric methods of a calibrated container and stopwatch.

Total perched aquifer discharge for the entire plateau is estimated to exceed 700 acre-feet/calendar year. This value includes the data from Table 6, one flow rate estimate for Tuana Gulch Creek, and other perched aquifer discharge locations about 3 miles north and northwest of the Monument's boundary. These locations do not flow into the Monument but are probably on the north side of a groundwater divide that is still part of the perched systems. The amount of groundwater flow to the southwest out into the plateau, which does not discharge on hillsides is unknown. The effects of potential evapotranspiration and aquifer storage are not quantified.

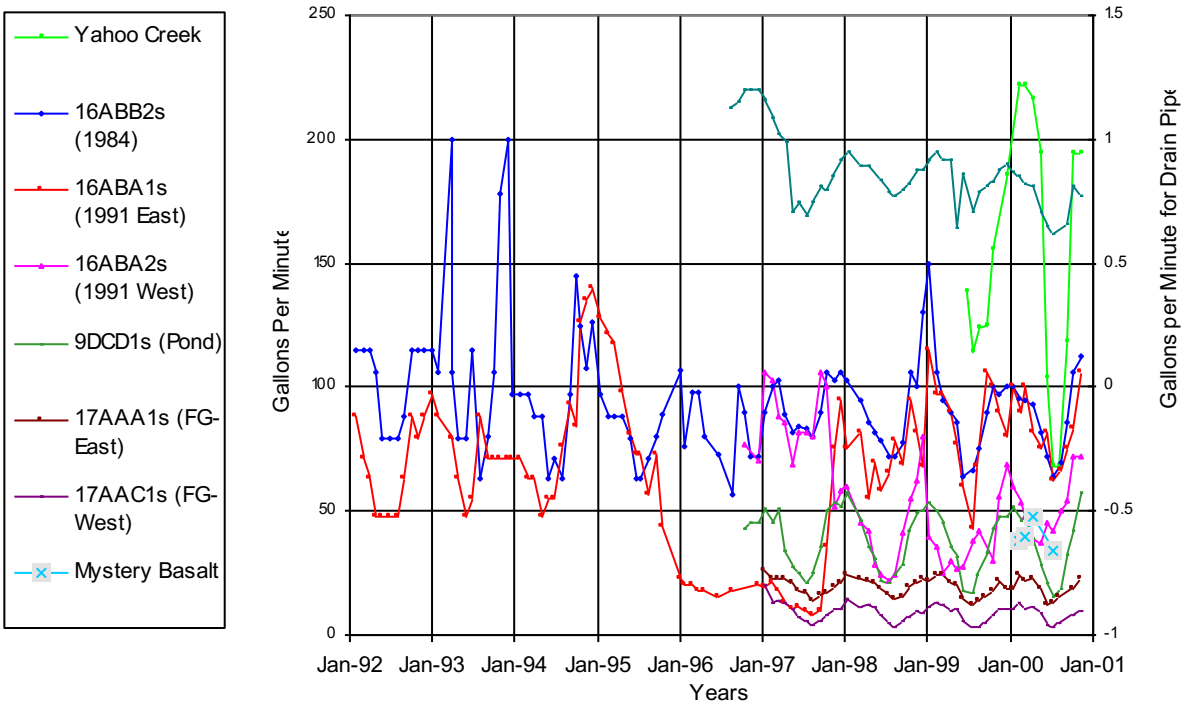

Figure 12. Perched aquifer discharge hydrographs.

Monitoring Station Identifier	Gallons/Minute based on Trendline	Acre-feet/calendar year
1984 Area Combined	93	149
1991 Landslide West Fork	42	67
1991 Landslide East Fork	80	129
1979 Landslide Area Combined	39	63
Fossil Gulch North Fork	20	32
Fossil Gulch South Fork	10	16
Drain Pipe south of Pipeline	0.75	1
Total for Fossil Gulch Area		**457**
Mystery Basalt Canyon	40	64

Table 6. Average rates and volumes of perched aquifer discharge measured at weirs.

Groundwater Quality and Chemical Data

A 'snapshot' of groundwater quality for the perched aquifer systems was performed by the U.S.G.S. in 1993 on six wells, three seeps and one canal; and in 1994 on just three wells. Samples were analyzed for common ions (Lab Schedule 42), nutrients (Lab Schedule 25) and baseline parameters. This data provided valuable information on the different groundwater flow systems and different areas of recharge. Nitrate concentrations in two wells exceeded E.P.A.

drinking water standards of 10 ppm by two (23 ppm) to four times (39 ppm). The concentrations in five other wells were just below the drinking water standard for nitrates.

These data shows a need for detailed groundwater sampling and monitoring to establish spatial and temporal changes in chemistry for the perched aquifers related to irrigation and landslides. No long term monitoring has been completed to establish detailed chemical trends to effectively discriminate between different flow systems and their associated recharge areas from irrigation. High nitrate values are typically an indicator that other organic chemicals from agricultural activities are also present at elevated levels. There have been two samples analyzed for the presence of ag-chemicals (organochlorines, carbamates, pesticides) with the results currently being assessed.

Water Rights

The history of the water rights adjudication in Idaho started with a dispute between the state of Idaho and Idaho Power Company. The Swan Falls Dam, owned by Idaho Power Company, held an instream water right to Snake River water, but the right was for far more than the amount of water actually flowing through the dam. During the late 1970's and early 1980's the state of Idaho claimed that since Swan Falls Dam was not using all of their water right, the water was subject to 'partial forfeiture' and the state could therefore appropriate the water. Idaho Power Company challenged this claim and won the court case.

Part of the agreement required Idaho Department of Water Resources to start the Snake River Basin Adjudication process in 1988 for 135,000 water right claims. In 1991, the Idaho Supreme Court selected a location for the adjudication court to reside at Twin Falls, Idaho and start the process of judging all water rights in the State for 38 out of 44 counties. Claimants needed to file with the court so the review process could identify the elements of the claim such as the priority date which is typically defined by the earliest date the water was put to beneficial use. The hierarchy of beneficial use is defined as: 1) domestic use or municipality, 2) irrigation, 3) mining, 4) manufacturing and hydropower. Historically, the Idaho Department of Water Resources or state managers have treated surface water and groundwater as separate entities. Now, they are shifting to conjunctive management strategies that are integrated with adjudicated water rights. The adjudication process is scheduled to be finished by 2005.

Section 304 of the Arizona-Idaho Conservation Act of 1988 (Public Law 100-696), referring to the Monument, states "Congress finds that there are unique circumstances with respect to the water or water-related resources within the Monument designated by this title. The Congress recognizes that there is little or no water or water related resources that require the protection of a federal reserve water right. Nothing in this title, nor any action taken pursuant thereto, shall constitute either an expressed or implied reservation of water or water right for any purpose." This language represents an expressed congressional intent. Therefore, the United States filed no claims for Federal reserve water rights in the ongoing Snake River Basin Adjudication.

When the park was created, several water right applications and permits previously held by the B.L.M. (Numbers 47-08110 through 47-08117) transferred to the NPS. These were for irrigation and domestic uses. The NPS later relinquished several of the permits and allowed the

applications to lapse after park management determined that the water was not needed for park purposes or to meet management objectives.

Water for domestic and administrative uses at the Monument is supplied by a well located in Section 28, T7S, R13E. The Monument does not have water rights documentation for this well. The Monument will need to contact the Idaho Department of Water Resources to determine if any water rights documentation for this well exists. If it is determined that State appropriative rights do exist for the well, the Monument will file the necessary information with the Department to initiate a new water right.

The NPS acquired a water right permit (Number 36-0021) when it acquired the land for the new Museum/Research Center. This water right is for irrigation purposes on approximately 12 acres of land, to be delivered from Billingsley Creek through the Bell Ditch, and equal to 0.3 cubic feet per second (cfs) or 15 inches. The park will continue to use this water for irrigation purposes and to create and expand existing wetlands on this property. The Monument will need to contact the Department and determine if a change of use application is necessary to show the new uses and location of use for this right.

The NPS currently pumps ground water from wells to stabilize the slopes, which protects the fossil beds from slope failures. The pumped water is discharged into a nearby irrigation canal and delivered to land administered by the B.L.M.. This pumping may or may not require a permit from the Department. The Monument will notify the Department of their pumping program and, if required, submit any necessary documentation. A new drinking water supply well may be drilled to replace the current well described above. If the NPS drills a new well, the necessary documentation will be filed with the Department and the old well will be properly abandoned.

Staffing and Programs

The Superintendent leads the Monument staff, which is organized into three operational areas: Resource Management, Interpretation/Education/Visitor Services and Administration. Staff expertise and specialties in the Resource Management Division include one Physical Scientist and one Museum Curator. The Interpretation/Education/Visitor Services Division is managed by one Chief of Operations and includes one Visitor Service staff and one Education Specialist. The Administration Division includes one Administrative Officer and one Administrative Assistant. The seasonal staff included in these areas of operation is usually supplemented and/or supported using special project funds, contracts and/or the assistance or expertise from various NPS and other organizations as available.

On-going RM Division programs include groundwater tracer tests, baseline water quality monitoring, coliform monitoring (cooperatively with USDA), groundwater monitoring, aquifer de-watering, landslide and surface water flow rate monitoring. The Monument staff has collected groundwater and surface water data since 1996, when a contract with the U.S.G.S. expired. Due to lack of funding some monitoring has been suspended. For example, there is no monitoring of water quantity pumped by Bell Rapids Mutual Irrigation Company from the Snake River. Quantifying recharge events to the perched aquifers causing landslides is important. Currently, there is no detailed or encompassing groundwater quality program in place. However

additional RMP projects have been submitted for funding requests. Some baseline data is being collected on a few selected wells on a sporadic basis. A surface water quality project was funded in 1998 and has expired.

WATER RESOURCE ISSUES

Role of NPS in Management of Water Resource Issues

The Monument's enabling legislation directs the NPS to focus on management of the fossil resources, while stating that: "Nothing in this title shall affect electrical generating and transmission and irrigation pumping and transmission facilities in existence within the boundaries of the Monument, or the right to operate, maintain, repair, upgrade, and modify such facilities. Such facilities are hereby expressly determined to be compatible and consistent with the purposes of this title." (PL 100-696, sec. 305 Effect on Existing Facilities)

Nonetheless, operations associated with these industries are currently damaging, or have the potential to damage fossil and other resources of the Monument. Studies show that irrigation water from the Bell Rapids Irrigation Project is causing massive landslides, which threaten large areas and significant resources, like the Smithsonian Institution Horse Quarry. The NPS role in managing threats appears unclear when caused by electrical facilities, deemed 'compatible' by Congress.

The Monument's boundaries extend into the reservoir and now to the original Snake River high water mark, defined by pre-dam conditions, and now are submerged. This boundary delineation also occurs for the new research center property. Historically, the Monument has not taken an active role in managing the aquatic resources within these submerged zones, even though documented rare and threatened species inhabit them.

Relevant questions include:

- Can the NPS seek appropriations to mitigate off-site threats from irrigation and hydroelectric industries?
- What role should the NPS play in managing resources within and adjacent to the Lower Salmon Falls Reservoir inside its legislative boundaries?

Landslides and Perched Aquifers

Lindsey McClelland, NPS-GRD, stated that the landslide problem at the Monument was the worst in the park system (personal communication, 1999). Perched aquifers continue to expand both horizontally and vertically in the northern, Fossil Gulch Area, but appear to be decreasing or contracting in the southern Bell Rapids area. In both areas the landslides are still active, with a total displaced area of about 60 acres. The 1983, 1987 and 1995 landslides in the southern Bell Rapids area have coalesced together into one massive slide. The 1991 slide in the northern area joined with the 1979 failure and sheds mud/rock debris flows on a monthly basis, which buries weirs and re-routes the existing drainage. The slide area has shown significant headwall scarp failures and lateral growth to the west within the last year.

Figure 13 illustrates six major 'irrigation related' landslides that have occurred in 1995, 1991, 1989, 1987, 1983 and ca. 1979. The slides are directly related to irrigation water from the plateau surface. The volume of material displaced is approximately 1.5 million $ft.^3$ with a surface area of about 60 acres. The six irrigation related landslides do not appear to be directly related to landslides and mass wasting along the edge of the river. The basalt perched aquifer in the northern Fossil Gulch Area appears to have reached a quasi-steady state condition based on trend lines applied to monitor well hydrographs.

Since 1986, water levels in monitor well (9CCC1) have continued to rise by 15 feet which equates to an increase in hydraulic pressure of 935 pounds/ft.^{2}. This is the only well completed in the lower perched aquifer that correlates to the lower rotational failure plane for the 1991 and ca. 1979 landslides. The increased phreatic water surface and pore pressure typically reduces shear strengths and increases slope stability problems. The aquitard for the lower system is composed of finely laminated 'paper' shales that have very low shear strengths and are composed of expanding clays. The combination of increased water levels and expanding low shear strength clays provides optimal conditions for slope failures. Water levels in monitor well 29ACD1 appear to have dried up since April 1999. This well is in the southern area where the 1987 landslide destroyed the Bell Rapids pump station. The canal has not been used since that time.

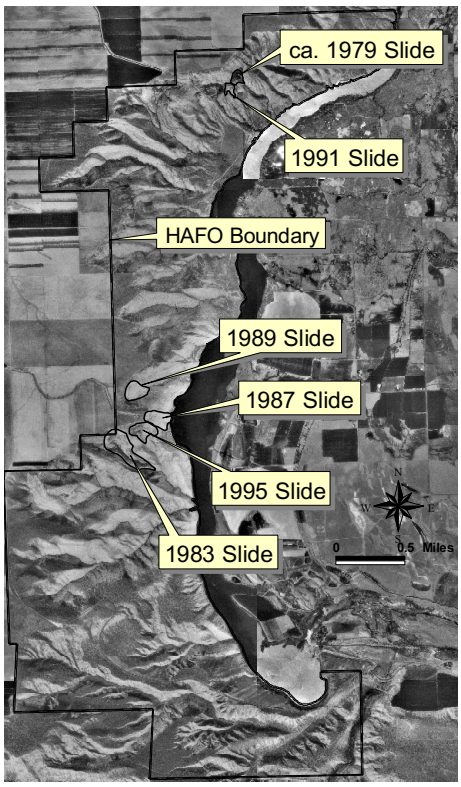

Figure 13. Locations of irrigation water related landslides.

Issues and recommendations include:

- Map and monitor growth of perched aquifer systems (PMIS #1085).
- Continue to monitor slope movement and seepage conditions as recommended by U.S.G.S. report by Chleborad and Schuster (1995).
- Analyze map and monitoring data to discern patterns, and to develop capability to predict landslide behavior and assess non-native vegetation expansion.
- Analyze landslide map data to calculate impact to fossil resources and provide for effective fossil salvage operations.
- Install six deep monitor wells into the lower perched aquifer to provide information and landslide prediction (PMIS #49957).

A numerical computer model needs to be developed for the perched aquifer systems related to irrigation and landslides. The model would quantify variable canal recharge conditions and assist identification of canal segments for lining. The model is under development using a software package ('Groundwater Vistas') that was purchased and formal training finished on Oct. 27 – Nov. 3, 1999 by Neal Farmer (Physical Scientist/groundwater geologist).

Two large-scale groundwater tracer tests are necessary to show hydraulic connections between canal recharge areas and landslides for the perched aquifer systems related to irrigation. Three tracer tests have been completed with good results defining critical aquifer parameters. A fourth

test is underway. These tests are on the scale of about 700 feet between injection point and discharge point. Successful results provide support for the feasibility and viability of larger scale tests. Two additional tests are necessary on a scale of 1,800 feet and 5,000 feet, which would target sections of the canal that are leaking more than others, in order to apply mitigative efforts more efficiently. Three small-scale tracer tests are necessary to provide computer model input parameters for the fine-sand aquifers.

Introduction of Irrigation Water to Fossil Beds

Irrigation water from the Bell Rapids Irrigation Project is the main causative agent for massive landslides that threaten large sections of the Monument. This conclusion is summarized in several reports during the past 10 years (Riedel, 1992; Farmer, 1999). Since the destruction of Bell Rapids Canal by a landslide in 1987, the Fossil Gulch Canal has become the primary source of recharge water to the perched aquifers.

Issues and recommendations include:

- Implement funds to halt leakage from the irrigation system (PMIS #1082).
- Monitor discharge from the Fossil Gulch Canal, wells, and seeps (PMIS #36531).
- Mitigation of the landslide damage by monitoring movement, fossil salvage, close areas for public safety and revegetation of disturbed lands if viable.

Discharge of Irrigation Water into Surface Streams

Occasional flushing of irrigation pipes cause surface erosion along the steep face of the bluff at certain locations in the Monument. In several locations channeled surface water runoff has created deep gullies and arroyos. Down-cutting by these ephemeral streams also triggers small landslides in stream banks. Landslides and down-cutting destroy small channels, threaten fossil beds, and result in deposition of larger quantities of fine-grained sediment into lower Salmon Falls Reservoir. Near the north end of the Monument, erosion and deposition threaten a pump station access road. Slope stability problems are a function of several agents that include unnatural groundwater, naturally steep slope angles up to 70 degrees, poorly consolidated fine-grained soils, naturally sparse vegetative cover and road construction.

Issues and recommendations include:

- Map the temporal and spatial distribution of perched aquifer discharge (PMIS #1085).
- Expand monitoring to increase resolution of hydrologic characterization for flow rates and water quality (PMIS #36531).
- Mitigate surface water erosion problems by averting flushing of irrigation pipes, placing culverts and stopping aquifer discharge.

Fisheries and Aquatic Ecology in Lower Salmon Falls Reservoir

Several species of Snake River-Columbia Basin salmon are currently being reviewed for Rare, Threatened and Endangered Species listing by the U.S. Fish and Wildlife Service (USFWS). Future operation of Lower Salmon Falls Reservoir may be changed to accommodate species

recovery plans. These changes have the potential to exacerbate erosion problems, and to effect wildlife in and near the Monument.

Idaho Power (1995), using electrofishing evaluated the status of the game and non-game fish community in Lower Salmon Falls Reservoir. Fish species identified were: rainbow trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), peamouth (*Mylocheilus caurinus*), northern squawfish (*Ptychocheilus oregonensis*), chiselmouth (*Acrocheilus alutaceus*), redside shiner (*Richardsonius balteatus*), speckled dace (*Rhinichthys osculus*), common carp (*Cyprinus carpio*), Utah chub (*Gila atratria*), bridgelip sucker (*Catostomus columbianus*), largescale sucker (*Catostomus macrocheilus*), brown bullhead (*Ictalurus nebulosus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), Shoshone sculpin (*Cottus greenei*), mottled sculpin (*Cottus bairdi*), torrent sculpin (*Cottus rhotheus*), sculpin spp. (*Cottus spp.*), and yellow perch (*Perca flavescens*).

Rainbow trout were stocked annually from 1978 through 1989 (ave. 22,000/yr.). Idaho Fish and Game attempted to improve the brown trout fishery in 1988, 1989 and 1992 by stocking fingerlings, but were apparently unsuccessful, according to Idaho Power (1995). Other game species include a self-sustaining largemouth bass and bluegill population. Non-game species such as large-scale suckers and yellow perch dominate the fishery.

White sturgeon were identified by Idaho Power downstream and outside the Monument's northern boundary in the Snake River below Lower Salmon Falls Reservoir dam. They are classified by the State of Idaho as a Species of Special Concern (Idaho Power 1995, Appendix E.3.1-B). Gonad tissue from three sturgeon caught directly below the dam were analyzed for contaminants through the Idaho Power study. Organochlorine pesticides (DDT, DDE, DDD) were the most common residue compounds detected in all three fish. DDE ranged from 3.2 ppm to 9.6 ppm.. The maximum contaminant level (MCL), set by the Environmental Protection Agency, is 5.0 ppm.. PCB 1260 ranged from no detection to 4.3 ppm with the MCL for PCB's set at 2.0 ppm.. The higher concentrations are from one of three fish. Other chemicals identified in tissue samples were Lindane, Trans nonachlor, Dieldrin and x-endosulfan.

Another recent study by the USGS (Maret and Ott, 1997) identified and quantified a suite of 28 organochlorine compounds in fish tissue and 32 in bed sediment at 20 sites within the upper Snake River basin. Concentrations in sediments were lower than in fish tissue, but overall the most frequently detected compound was DDE in 80% of fish samples. Upstream from the Monument approximately five miles, at USGS site #16 near the town of Buhl, concentrations of DDT (1,307 ug/kg) and DDE (1,300 ug/kg) exceeded national guidelines for eating fish. PCB (100 ug/kg) was also present. Downstream from the Monument approximately 20 miles, at USGS site #20 near King Hill, compounds such as total DDT (213 ug/kg), DDE (280 ug/kg) and PCB (72 ug/kg) were detected.

The existence of these contaminants upstream and downstream from the Monument's boundary may indicate similar conditions *within* the Monument's boundary in the Snake River. During the 1987 landslide that destroyed the Bell Rapids Pump Station, debris was transported into the river. Verbal communication with irrigation company employees state that all but a few items from the pump station were salvaged. It is unknown if there are any equipment and chemical

remnants that may be impacting water quality at this time. The landslide did not effect the main electrical substation for the pump station, but several tank transformers on poles were destroyed by the slide.

Issues and recommendations include: It is unknown if this is an issue of concern, but it may be prudent to inventory fish and sediment resources to identify and quantify any harmful chemicals in the ecosystem. It is also recommended that a geophysical study be implemented to locate any buried metal objects prior to sampling.

Non-native Species

Non-native species of plants have been introduced to the Monument from several sources. Eurasian milfoil was introduced to Lower Salmon Falls Reservoir by motorboats. Numerous non-native terrestrial plant species have been introduced along roads and by agriculture, and at other sites of ground disturbance.

A non-native invasive invertebrate specie of snail (New Zealand mudsnail – *Potamopyrgus antipodarum*) has been identified 70 miles upstream in the Snake River at Lake Walcott, and the populations are increasing. This species poses a potential threat to the five endemic snail species that are listed as endangered or threatened (Weigel et al., 2002).

Issues and recommendations include:

- Monitor pilot control project implemented in 2000.
- The NPS needs to identify its role in the management of non-native fish associated with Lower Salmon Falls Reservoir, and in the control of non-native plants cooperating with other agencies.
- An inventory is necessary to document the presence or absence of native and non-native snail species.

Snake River/Lower Salmon Falls Reservoir Corridor Mass Wasting

Raytheon (1995) identified 44 shoreline erosion and mass wasting sites along the edge of the Snake River. However, no in-depth studies have been done on causal dynamics. These sites and processes are separate from and not related to the 'irrigation landslides'. Currently there is no monitoring or data collection for these sites. Air photos dating back to 1950 show impacts to the riverbanks from erosion of the steep bluffs along the Snake River. At most sites the toe of steep slopes are undercut, which leads to the development of shoreline erosion, slumps and landslides. Figure 14 shows an air photo time series for two shoreline slope failures. These sites are active and expected to expand in the future. Wave action and fluctuations in the surface elevation of the reservoir are possible causal agents.

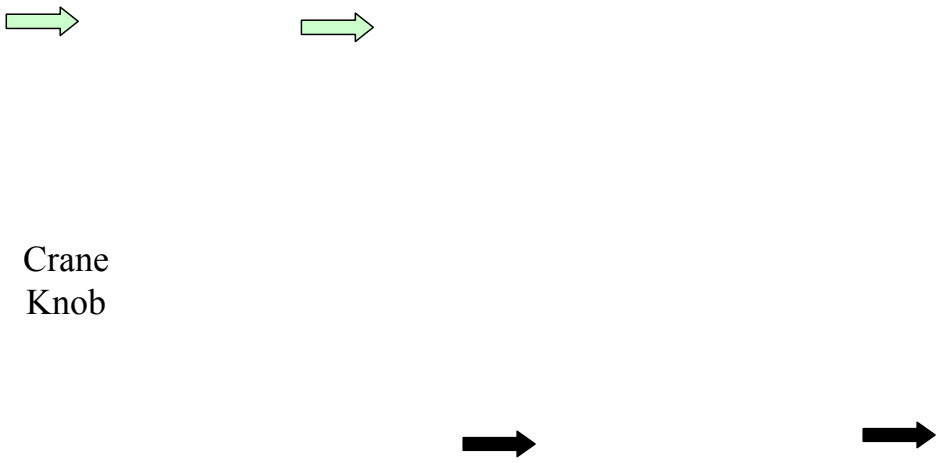

Figure 14. Two of 44 shoreline slope failures identified by (Raytheon, 1995). Dimensions of the large failure are approximately 350 feet by 600 feet.

Issues and recommendations include:

- Establish relation between mass wasting processes and reservoir fluctuations (PMIS #36721).
- Classify sites by type of erosion and level of impact to resources or facilities.
- Monitor the rate of erosion at selected sites.
- Develop an erosion control plan.

Monitor Wells and Piezometers

NPS currently monitors 15 wells and maintains three de-watering wells. In 1999, de-watering well NPS-5 was shut down and the pump pulled because the discharge pipe had rusted out just above the pump, sacrificing the integrity of the support system. This de-watering well will be out of service until support for maintenance costs are acquired. The other two de-watering wells need maintenance to abate the same problem. There is a possibility for the pipe to break off from the torque of the pump turning off and on. If this occurs the pump will fall to the bottom of the well. Other monitor wells need maintenance due to farm machinery striking them and locks deteriorating.

Issues and recommendations include:

- Six monitor wells and eight shallow piezometers need to be installed at strategic locations to complete the USGS monitoring system and implement large-scale tracer tests. The location of these wells will fill in gaps in the monitoring grid and complete the system so that tests and monitoring can be implemented to efficiently apply canal lining.

Surface Water Quality

Baseline surface water quality parameters were collected from 1999 to 2000. Funding was acquired to purchase equipment and sample analysis for nine parameters at seven sites. The Monument expanded sampling to 20 sites because of the vital need for the data. These efforts have revealed critical information with one site, (un-named basalt flow UTM E-667,093, N-4,742,545, NAD 83) discharging high Total Dissolved Solids (TDS) concentration (2,000 mg/L) which classifies the water as 'brackish' according to Drever (1988). Assuming a constant flow rate and concentration, this site discharges 166 tons of TDS per year. The salts may have been transported to the Snake River and killed a grove of native Cottonwood trees. These water analyses have provided insight for discriminating between complex perching systems and their associated recharge areas from the irrigation system. This water analysis will aid optimal application of canal lining efforts for landslides at the Monument and protection of natural resources. Flow measurements are currently being collected on a monthly basis at a few small watersheds within the Monument.

Issues and recommendations include:

- All surface water flows need to be measured by installing additional weirs and by expanding the monitoring program.
- Surface water at the Museum/Research Center Site need to be monitored for both flow rate and quality.
- Need for additional baseline water quality data collection programs (PMIS #36622).
- Additional equipment for flow measurements such as weirs.
- Detailed investigation of dead Cottonwood trees by sampling root zone groundwater.
- Reactivate the collaborative partnership with USGS to identify, quantify and monitor agricultural chemicals discharging in the groundwater flow systems, which discharge into riparian zones, Snake River and possible wetlands (PMIS #36661). Laboratory analyses may include: major cations and anions suite, nutrient suite, pesticide suite, deuterium/protium ratio, oxygen-18/oxygen-16 ratio, nitrogen-15/nitrogen14 ratio; samples from 11 wells, 6 springs, and 1 canal plus 1 replicate and 1 equipment blank; samples taken before irrigation begins (March or April 2001, FY01) and during late irrigation season (September or October 2001, FY02); and analyses by the USGS National Laboratory in Denver, Colorado. Visitor, staff and animal safety cannot be determined without a complete analysis. Ag-chemical information will also assist with tracking groundwater flow paths and associated recharge areas.

Baseline Inventory and Mapping

The management of safety and resource issues identified throughout this document depends on the timely acquisition of adequate baseline data. Necessary data includes:

- Wetlands Inventory (PMIS #1086).
- Inventory agricultural chemicals in water systems (PMIS #36702).
- Baseline water quality and quantity (PMIS #36622).
- Groundwater tracer tests (PMIS #57325).
- Detailed and systematic water chemical analysis (PMIS #36661).
- Discharge measurement of Fossil Gulch canal (PMIS #72293).
- Inventory of native and non-native species and their distribution in Lower Salmon Falls Reservoir (PMIS #1090 & 37033)
- Quantify and monitor 44 reservoir shoreline erosion sites (PMIS #36721).
- Map the distribution of fossils throughout the Monument (PMIS #6861).

Drinking Water Supply

The water supply well currently located at the Monument's Museum/Research Center site (SE,NE,NE, Sec. 28, T7S R13E) provides a domestic supply of water. Construction date for the house is recorded at 1918 and 1925 at the Gooding County courthouse, and infers that the well was drilled at that time but this may not be the case because there was another shallow well (about 20 feet deep) located 5 feet west and 12 feet north of the northwest corner of the loading dock on the fossil collections lab. This shallow well was reconstructed in 2002 as a flush grade monitor well. The construction and design of the current water supply well is unknown. In September 1999, the well was sampled and screened for a suite of chemicals. Results indicate no presence of coliform bacteria, nitrates of 0.20 mg/L and no detection for an array of ag-chemicals, including analysis for EPA 507 (nitrogen and phosphorus pesticides), EPA 508 (organochlorine pesticides), EPA 515.1 (chlorinated acids) and EPA 531.1 (carbamates/carbamoyloximes). In 2003, iron reducing bacteria were detected in a water sample. Water quality of this well appears to be good with the exception of iron-reducing bacteria that are creating sulphur smelling water and iron staining on sinks, toilets, showers etc.. The well also needs immediate maintenance to the delivery system as noted below.

Issues and recommendations include:

- Inorganic and organic chemical testing (PMIS #36702).
- Valves, pipes and fittings are in very poor condition, poorly designed and corroded enough that they are leaking or no longer functioning.
- The well head electrical wiring does not comply with current construction and safety codes.
- Well head protection provided by the well house is poor and needs to be dismantled and rebuilt to keep rodents and their droppings out, protect against freezing and to comply with codes. The above ground delivery system may be an indicator of the condition for subsurface well components.
- An access port needs to be installed to allow for water level monitoring.
- Water analysis need to comply with DO-83.
- OR, drill and complete a new water supply well. It is advised to not place a new well near the old well because of possible cross contamination and to place the new well away from petroleum contamination on adjacent property of Brad Gisler noted in a later section (UTM 669,676 easting, 4,740,213 northing, NAD 83).

Wetlands Inventory

The National Wetlands Inventory mapped the area of the Monument on a 1:24,000 scale, which provides useful information and a baseline of data to build from. Higher resolution mapping is necessary to provide resource managers the detail needed for compliance issues. The Museum/Research Center will be constructed in the near future and there are wet areas that need a formal analysis to determine if they are wetlands. The river corridor also needs a higher resolution mapping to assist with endangered species protection and background information for impacts from landslides and reservoir drawdown cycles that leave invertebrate species high and dry.

Issues and recommendations include:

- Identify, classify, document and map all wet areas at the Monument at a scale of 1:6,000 to assist managers with necessary information for sound decisions.

Engineered Wetlands

The Monument has preliminary plans to construct an engineered wetland that will be located at the Museum/Research Center property. The wetland is proposed to process waste water from both the research center facilities and the city of Hagerman, as well as to improve water quality of the 'Bell Ditch' irrigation water before it discharges into the Snake River. The 'ditch' receives irrigation water return flows from private land, then flows through the Museum/Research Center property and then discharges into the Snake River. This section of the Snake River is an EPA TMDL listed segment and an engineered wetland would likely improve water quality parameters. The ditch was originally constructed during the late 1800's to convey water to gold placer mining operations, as were most other canals/ditches in the Hagerman Valley.

Issues and recommendations include:

- The Monument may need to drill a new water supply well and the location needs to be determined relative to the wetland. A private domestic supply well is located about 700 feet to the north of the proposed wetland area and the Monument's supply well is about equal distance to the east.
- The site hydrogeology needs to be defined prior to wetland construction or operation by drilling exploratory wells, which can be completed as monitor wells. Water quality samples are necessary to establish a natural baseline of data. Aquifer tests on the NPS supply well, with a sufficient number of monitor wells, are necessary to define aquifer characteristics such as cone of depression, transmissivity and storage values, which provide necessary information for well head protection in accordance with state and federal laws.
- The surface geologic strata are composed of alluvial sand/gravel and soils. If it is deemed necessary to prevent leakage then lining the wetland will be necessary to prevent possible migration of contaminants into a nearby private water supply well, the NPS supply well and the Snake River. If wetland water is designed to allow for seepage into the subsurface then the unnatural increase in groundwater pore pressures may pose slope stability issues. If there are any heavy metals in the near-surface strata (soils/sand/gravel) or in the groundwater, then

an increase of hydraulic head from the wetland leakage will provide a driving force that may spread plumes laterally off-site.

- If the wetland is 'open' then it may generate odors that will impact visitors experience and adjacent homeowners. If the wetland is not 'open' then the educational/visitor experience may be diminished.
- Processing sewage effluent from a municipality in the wetland may create liability issues that must be addressed. A complete surface and groundwater monitoring system needs to be in place at least one year prior to construction of the wetland to provide adequate hydrogeologic baseline data, aquifer characteristics from tests and time for recommendations upon analysis of field data and report writing.
- Wetlands in the climate at Hagerman are typically only productive about eight months of the year and methods of accommodating the sewage for the remainder of the year needs to be considered.
- Specific wetland construction and sewage mandates must be reviewed and incorporated through NPS and EPA procedures.

Confined Animal Feed Operations

Confined animal feed operations (CAFO's) including dairies are being proposed for development adjacent to the Monument in agricultural areas. The 'Bloxham CAFO' was proposed in February 7, 2001 during an Idaho Department of Water Resources administrative hearing. The location for the dairy is west of the Monument's boundary. The prevailing westerly winds would likely transfer odors and insects toward the Regional Trail Head 1.5 miles to the east.

Issues and recommendations include:

- Insects and odors impacting visitors experience and activities.
- Disease transmission by insects and air borne particulate matter.

Research Center

A Museum/Research Center has been proposed at the Monument's 54 acre property site. Water supply, usage and quality need to be defined to allow for science and safety based management decisions and meet NEPA mandates. In 2002, a hydrocarbon contaminated site was encountered on Brad Geisler's property by telephone company workers. The contaminated site is located in the middle of the dirt road in front of a workshop east of the Museum/Research Center property by about 700 feet with coordinates UTM 669,676 easting, 4,740,213 northing, NAD 83. Idaho Department of Environmental Quality (IDEQ) was on site to assess the situation and collect samples. Their sample methods were not consistent with EPA protocols because they were collected in a ziplock sandwich bags. Monument staff collected samples in new laboratory glass containers with a seal. IDEQ requested the backhoe operator to excavate further down and stopped at about 12-15 feet below land surface when they encountered groundwater. Contamination was observed for the entire depth of the hole and in the groundwater. NPS sample results show all of the BTEX chemical compounds are higher in concentration than the IDEQ data, some by an order of magnitude.

Potential issues and recommendations include:

- Surface water runoff from facilities and erosion of unstable sand/gravel into the Snake River. This section of the Snake River is listed on the TMDL State of Idaho 303d impaired water quality parameter for sediment described on page 11.
- There is a possible mercury contamination from gold mining activities at the Museum/Research Center site. Active placer flour-gold mining was occurring prior to the 'Bell' family purchasing the property in about 1920 (Bell, 2001). A complete and systematic soil and groundwater sampling must be completed prior to any project planning or ground breaking.
- Groundwater requirements, supply and quality need to be defined by aquifer tests performed on existing wells prior to drilling future supply wells.
- Water needs should be defined prior to drilling water supply wells.
- A complete and systematic soil and groundwater sampling for hydrocarbons and agricultural chemicals must be completed prior to any project planning or ground breaking. Several 55-gallon drums on the site and some small containers labeled with common farm chemicals and equipment fluids have been observed. A Superfund HazMat assessment will be necessary.

- Chemical spills and leaking underground storage tanks from new facilities, past farming activities and future parking areas are possibilities. A complete and systematic soil and groundwater sampling must be completed prior to any project planning or ground breaking. Parking areas need to have capture systems with sufficient design to contain vehicle fluids that may spill.
- Flashfloods or over-capacity influx of treated waste water or Bell Ditch irrigation water are issues that need to be considered. Currently, there is no hydrologic data for the Bell Ditch flow rates. Background data needs to be collected and assessed to determine temporal characteristics and magnitude of flow rates.
- Possible future recreational vehicle dump stations need to be considered.
- Potential impacts from new or reactivation of landslides from the west side of the river where the c.a. 1954, 1983, 1987, 1989 and 1995 slide areas are located need to be assessed. The effects from a major 'long run-out' type of landslide may extend across the river to the Museum/Research Center site. The USGS landslide division may need to complete a geo-hazard analysis before any project planning or ground breaking. A key component of the

landslide study will be the completion of a hydrogeologic characterization of near-shore groundwater conditions and responses from Idaho Power drawdowns.
- A follow up and hydrogeologic assessment is recommended to address the Brad Geisler hydrocarbon contamination.

Endangered Species

According to Weigel (2002), the USFWS has listed five species of snails that are endemic to the Snake River, from C.J. Strike Reservoir upstream to American Falls Dam, as endangered or threatened under the Endangered Species Act (ESA) 57 FR 59244. This area includes Monument properties. The snails are: Utah valvata (*Valvata utahensis*), Snake River physa (*Physa natricina*), Bliss Rapids snail (*Taylorconcha serpenticola*), Idaho springsnail (*Pyrgulopsis idahoensis*), and the Lanx (*Lanx sp.*). The decline of the aquatic mollusk species has been primarily attributed to changes in the river from free-flowing, cold water to impounded, slower, warmer water habitats (USFWS, 1995). Elements threatening or limiting the quality of habitat include: increasing water temperatures, decreasing water quality through lower dissolved oxygen and sedimentation, and pollutants (Weigel, 2002). Another variable is the population increase of non-native invasive aquatic species such as the New Zealand mudsnail (*Potamopyrgus antipodarum*).

Issues and recommendations include:
- Since this section of the Snake River, which includes Lower Salmon Falls Reservoir, is listed on EPA's 303d list for water quality parameters of concern for sediment and nutrients, and listed on USFWS for habitat of endangered species, the potential impacts from landslides are the number one natural resource issue for this aquatic system at the Monument. The Resources Management Plan describes landslides as the number one issue for impacts and destruction of fossil sites. Protection and preservation of fossil resources is the number one mandate in the Monument founding legislation. Further research needs to be implemented to fully describe landslide dynamics, with application of abating or stopping the causative agents.
- An inventory and monitoring program is needed to document the presence or absence of endangered aquatic species, as well as non-native invasive aquatic species and long-term trends.
- Long-term multi-parameter water quality monitoring is needed to document trends.
- Long-term landslide and erosion monitoring system is needed for the 1987, 1993, 1954, and 1991 landslides to determine effects on plant and animal populations, and fossil resources.
- Long-term reservoir water level fluctuations are needed to monitor and document reservoir management practices.

Dump Site

A dump site is located on the Monument that contained various containers and materials. It is located in Section 20, SE ¼, SE ¼ in a small ravine and it's dimensions are approximately 75 feet long by 30 feet wide. The area was cleaned up by seasonal staff in July 2001 and contained about two dozen agriculture chemical 5-gallon metal cans with a blue dusty powder on and around the cans, oil and gas filters, along with other farm related debris. It took eight pickup

truck and one trailer loads to remove the material. The upper area near a caliche pile (UTM E-667,668.8, N-4,740,529.4, NAD 83) had a concentration of oil and gas filters. A lower site (UTM E-667,678.1, N-4,740,536.5, NAD 83) had a concentration of the 5-gallon metal containers. A license plate dated 1968 was found when the site was revisited on December 24, 2002 by HAFO staff and seasonal staff that cleaned up the site in 2001.

Issues and recommendations include:

- Soil contamination may exist at this site but the possibility of effecting water quality is remote due to the high elevation and long distance to water bodies. It is recommended that a site scoping be performed by collecting soil samples to characterize the presence and concentration of chemicals. Further action will depend on results of the sampling.

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Appendix 1

PMIS Statements

Project Title: **Age Dating and Isotope Analysis of Landslide Water (USGS/NPS Partnership)**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02

PMIS Number: 36661	**Package Number:** HAFO-191 **Reference Number:** HAFO-N-204.004
Project Group: Unassigned	**Project Type:** Non-Facility
Project Contact Person: Neal Farmer - Groundwater Geologist	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

This project is recommended and discussed in HAFO's 1999 Interim Water Resources Scoping Report and was submitted under FY2000 and 2001 Unified Calls but was not funded.

ABSTRACT Through a renewed partnership between the NPS and USGS, a short-term (one year) water chemistry analysis during the 2002 irrigation season will provide a quick synoptic assessment of aquatic conditions. Specific sampling locations have been selected and matched with appropriate technologies to evaluate the spatial relationships of perched aquifer recharge areas (canals or farmland) that contribute water to landslides at Hagerman Fossil Beds National Monument. This information is 'ground-breaking' and it will provided the first data of its type, as well as a baseline, for future comparisons and analysis.

Investigation of isotopic and chemical parameters for various water sources and aquifer discharge points will be compared to determine specific sources of recharge to hillside springs located at existing and probable future landslide areas. Water samples will be collected and analyzed for isotopes of oxygen, hydrogen, nitrogen, age-dating constituents of sulfur hexafluoride, and nutrients. Baseline information learned from this project will allow quantification of environmental impacts from a recently proposed development of a 3,000 confined animal feed operation (CAFO) located just one mile from HAFO's west boundary. This information will aid in determining (1) remediation plans for landslide problems, (2) provide credible scientific data necessary to enable HAFO to protect its interests and (3) baseline nitrate isotope data (4) offers a unique opportunity for ground breaking research.

Justification:

DESCRIPTION OF THE PROBLEM

About 10 years following agricultural development of the plateau adjacent to the Horse Quarry at what is now Hagerman Fossil Beds National Monument water began seeping from numerous sites along the plateau escarpment. The springs and seeps are the result of leakage of irrigation water from unlined canals and/or infiltration of water applied to fields on the plateau. Over the years stability of the escarpment has deteriorated where discharge occurs and has resulted in [6] massive landslides covering an area of more than 30 football fields (' 1 million ft.2) in size and damage to other natural resources.

There is good evidence from long-term hydrographs and other earlier studies that several artifical perched aquifers now exist within the plateau, and they likely have multiple recharge source areas (Farmer, 1999; Riedel, 1992; Young, 1984). Tracking preferential ground water flow paths is a critical element to understanding the dynamic perched

aquifer systems responsible for these landslides. Differentiating between separate flow paths and recharge areas are necessary for planning and implementing canal lining treatments. If individual flow paths can be traced back to their origin then mitigative treatments can be appropriately and efficiently applied to abate recharge to the aquifers. For example, there is at least one (and likely two) ground water divides within the plateau. Canal lining treatments do not need to be applied on the 'other' side of a divide if that ground water is not flowing toward the monument.

It is important to note that within this study area there has only been crops since the initial development and land use change from sagebrush desert in 1970. There are no other variables such as industries, towns, sewage lagoons, injection wells, dairies, feedlots, etc. etc…, just cropland with the exception of about 6 houses in 25,000 acres. But, development is moving in and the time is now for collecting this type of baseline data because none exists, to show cause effect relationships from impacts in the future. The proposal has evolved into a well-defined course of action that will efficiently address the issues and goals of the project with research grade merit. Many professionals from the NPS and USGS have provided valuable resources in the development of this project noted in the 'Scientific Merit' section. This information is urgently needed, and nothing punctuates this more than a recent legal meeting on Feb. 7, 2001 where the park service has been requested to testify about the source areas for the perched aquifers.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

Using an equation that calculates distance to recharge area (average velocity * residence time) we will be able to more accurately identify the location of recharge areas that supply water to the springs and seeps. Results from small scale flourescent dye tracer tests (Farmer, 2000) have provided one side of the equation; average linear velocities. Results from this proposed project will provide the residence time variable for the other side of the equation, thereby enabling us to calculate the distance to recharge source areas. This will be accomplished by age dating and isotopic analysis, which have not been done on these systems, but have provided invaluable information about ground water flow paths in studies elsewhere as noted below in the figure (Plummer and others, 2000; Plummer and Friedman, 1999; Busenberg and Plummer, 1997 & 2000).

Cross section at locust grove, MD shows SF6 model ages (solid lines) and nitrate concentrations as mg/l nitrogen. (dashed lines) SF6 model ages are in agreement with ages obtained with other environmental tracers).

Discrimination between different recharge source areas will also be accomplished using nitrogen isotope fractionation. Enough fractionation should occur from canal water verses field applied water to provide good results. Using d15N and d18O of nitrate to identify nitrate sources and to determine whether certain biological transformation have occurred can be more effective than using d15N alone. This is because of the overlap between nitrate sources when relying on d15N alone (Table 1). For instance, it is easier to determine if denitrification has occurred using both isotopes. This is because as denitrification occurs, the d15N and d18O of the remaining nitrate becomes heavier, in a ratio of about 2:1 for d15N/d18O. This technique is also useful when nitrate has been produced by nitrification, as two of the oxygens are derived from H2O and one from

dissolved O2. d15N d18O Description 0 +23 fertilizer manufactured from atmospheric gas +15 +/- 5 -5....+15 animal waste +5 -5....+15 soil nitrate 0 +23 air up to +40 up to +20 NO3 produced by denitrification +5....+20 groundwater Table 1. Typical ranges of d15N and d18O of types of NO3.

Purpose and Objectives This is a one-year project that will renew and expand upon water monitoring efforts initiated by the USGS Water Resources Division in 1987. If the source to the water to the existing and potential landslide areas can be identified then remediation could be confined to a few options and cost-effective landslide remediation plans can be developed. The objectives of this project are: 1) Determine specific sources of water to springs and seeps along bluffs at the Monument. 2) Discriminate different sources of the water to the critical landslide areas. 3) Identify remediation options. 4) Start a baseline data base that will apply to broader regional implications for CAFO's.

Methods Recent advances in water-quality techniques, including age-dating and isotopic analysis of nitrate, will enable better identification for sources of water to the springs and seeps. Age dating will be conducted using a sulfur hexafluoride (SF6) technique described by Busenberg and Plummer (2000). The technique can identify the recharge age of young waters and will be used to help differentiate if the source of water to the springs and seeps is related to leaking canal water or the presumed-to-be-older applied irrigation water. Canal water is assumed to be younger than water applied to crops because the canal water is in contact with a fractured basalt flow verses water applied to crops that in theory would have to flow through about 150 feet of silty clay. The 'crop' water may take tens of years to reach the aquifers where the canal water may take months.

The scope of the project will include the following: A. Collect [24] water samples from [10] existing monitoring wells, [8] hillside springs, [1] irrigation canal, [2] storage ponds, [1] Snake River plus [1] replicate and [1] equipment blank. B. Analyze water for selected parameters including, nitrogen and oxygen isotopes of nitrate, sulfur hexafluoride for age-dating, isotopic ratios of oxygen (oxygen-18/oxygen-16) and hydrogen (deuterium/protium): 1) Purge well 2) Place tubing from pump in the bottom of 2.5L bottle 3) Fill bottle and allow it to overflow from the neck (about 2.5L) 4) Slowly remove tubing from the bottle while water is still flowing 5) Place loose plastic cone on mouth of bottle (do not leave any headspace) 6) Cap bottle (do not over-tighten) 7) Slightly loosen then retighten the cap a few times as ground water warms up to relieve pressure and prevent bottles from breaking 8) Keep bottles in the cooler and not in the sun (water expands when heated and breaks the bottles)

C. Identify unique ground-water ages and isotopic and chemical compositions of potential sources of seeps and springs.

The accuracy of the SF6 technique is within one month, which is sufficient for longer ground water flow paths. At some sites nitrate in water will be analyzed for both nitrogen-15 (N15) and oxygen-18 (O18) isotopes as described by Silva et al, 2000. This dual isotope approach will help determine if the nitrate in the water is more closely related to nitrate fertilizer (applied to crops in irrigation water) or to atmospheric or soil-derived nitrate (canal loss water), which is difficult to do using N-15 alone. Further

information on the SF6 can be found at http://water.usgs.gov/lab/sf6/ and on nitrate isotopes at http://wwwrcamnl.wr.usgs.gov/isoig/guidelines/nitrate/index.html.

Analysis of the isotopic ratios of oxygen and hydrogen will be used to help distinguish whether the source of water has been influenced by evaporation through the application of water on crops through sprinkler systems or essentially no evaporation from leaking canal water. One set of replicate samples and one set of equipment blank samples will be collected during the sampling period. Some sites may need preliminary sampling to determine concentrations of nitrate and dissolved organic carbon before nitrate isotopic sampling can be conducted.

On-site analyses will include water temperature, pH, specific conductance, and dissolved oxygen. USGS staff will collect water samples from the sites assisted by HAFO staff, following established USGS data collection, preservation, and shipping procedures. Water samples will be shipped to the USGS National Laboratory in Denver, Colorado, and the SF6 facility in Reston, Virginia for analyses. Data will be stored in the Idaho District USGS QWDATA database, and copies of data files will be transferred to HAFO computers. The HAFO staff will continue to collect monthly water level and flow measurements to integrate with the USGS water-quality data. In addition to USGS staff, technical assistance will be sought from the NPS-WRD in developing protocols and advising HAFO staff.

BUDGET, etc. Budget Itemized USGS cost projections researched by Dave Clark (USGS Boise Office, Jan. 22, 2001) for this proposal are as follows: Budget Category FY Personnel $13,100 Vehicle and Travel 2,200 Supplies, equipment and shipping 2,600 Laboratory Analyses 23,400 Total $41,300

Personnel GS 12- Hydrologist for assistance in project set up, initial fieldwork, and data analysis. GS-7 Hydrologic Technician for on-site water analyses and water sample collection, sample processing, and data management.

Vehicle and Travel Travel expenses during the sample collection trip and one trip to discuss the results with park managers when analyses are complete.

Supplies, equipment, and shipping meters, calibration solutions, probes, bottles, gloves, preservatives, filters, pumps or bailers, hoses, shipping containers, forms, FEDEX overnight and ground transportation of samples to laboratories.

Laboratory Analyses nitrogen-15/nitrogen-14 ratio and oxygen-18/oxygen-16 ratio of nitrate; sulfur hexafluoride and associated gas samples, and deuterium/protium ratio and oxygen-18/oxygen-16 ratio for samples from [10] wells, [8] springs, [1] canal, [2] storage ponds, [1] Snake River plus [1] replicate and [1] equipment blank analyses by the USGS National Laboratory in Denver, Colorado and the USGS SF6 Laboratory in Reston Virginia.

Park Contact: Neal Farmer & Bob Willhite (208-837-4793) USGS Contact: Deb Parlimen & Dave Clark (208-387-1316)

References: Farmer, C.N., 1999, A hydrostratigraphic model of the perched aquifer

systems located at Hagerman Fossil Beds National Monument, Idaho; University of Idaho Masters Thesis, 104 p.

Farmer, C.N., Larsen, I., 2000, Interim report on tracer tests at Hagerman Fossil Beds National Monument, Idaho, NPS report., 15p.

Silva, S.R., Kendall, C., Wilkison, D.H., Ziegler, A.C., Chang, C.C.Y., and Avanzino, R.J., 2000. A new method for collection of nitrate from fresh water and analysis of the nitrogen and oxygen isotope ratios. J. Hydrology. v. 228, 22-36 p.

Plummer, L.N. and Friedman, L.C., 1999, Tracing and dating young ground water, U.S.G.S. Fact Sheet-134-99, 4 p.

Busenberg, E., and Plummer, L.N., 1997, Use of sulfur hexafluoride as a dating tool and as a tracer of igneous and volcanic fluids in ground water. Geological Society of America, Salt Lake City, 1997, Abstracts and Programs, v. 29(6), A-78 p.

Plummer, L.N. and others, 2000, Age of irrigation water in ground water from the eastern snake river plain aquifer, south-central Idaho, Ground Water, Vol. 38, No. 2, 264-283 p.

Busenberg E., and Plummer, L.N., 2000, Dating young ground water with sulfur hexafluoride: Natural and anthropogenic sources of sulfur hexafluoride. Water Resources Research, v. 36(10), 3011-3030.

Riedel, J.L., 1992, Existing conditions of large landslides at Hagerman Fossil Beds National Monument, final report to the National Park Service; North Cascades National Park Geologist, Marblemount, Washington, 26 p.

Young, H.W., 1984, Evaluation of hydrologic processes affecting soil movement in the Hagerman fauna area, Hagerman, Idaho, U.S. Geological Survey, Water-Resources Investigations Report 84-4137, 16 p. National Park Service FY2002-FY2003 Servicewide Comprehensive Call Natural Resource Project Proposal Guidance

Natural Resources Project Ranking Criteria Rating Information

1. SIGNIFICANCE - The enabling legislation states that the Monument is "... to preserve and protect the outstanding fossil resources" which are world-class for the Pliocene epoch. The landslides are destroying fossil areas, are active, massive, and affect the terrain on both sides of the Smithsonian Institution Horse Quarry. Age dating and nitrogen isotope ratios are imperative and will aid in the understanding ground-water flow dynamics.

2. SEVERITY - Since 1979, six massive landslides (combined equivalent to over 30 football fields in size) caused by ground water seeps have destroyed fossils and other natural resources and present a safety hazard to staff, visitors and irrigation pump workers. A landslide in 1987 destroyed a million dollar pump station and endangered the lives of two workers. Lindsey McClelland (WASO) has described these landslides as one of the greatest natural resource problems within the National Park Service.

3. PROBLEM DEFINITION AND INFORMATION BASE - This funding source will provide support and insight into the water quality (nitrates and sulfur), age dating and preferential flow paths. A series of springs and seeps discharge water from bluffs on the Monument. The seeps and springs did not exist prior to the construction of a system of unlined canals and associated irrigated agriculture on the plateau to the west of the Monument. The cause and effect relationship between the initiation of irrigated agriculture on the plateau and ground water discharge at the seeps and springs is well defined and supported by substantial data. The major undefined problem is identifying the primary source of the water to the seeps and springs. Is the source the unlined canals, the irrigated fields or some combination? Determining the source will better aid in remediation of the problem. The USGS began collecting baseline water-level data in 1986, and the effort was renewed in 1992 with NRPP funding. Samples were collected for chemical analyses from some of the sites in 1993 prior to termination of the project in FY97 when funding ended.

4. FEASIBILITY - New methods and technologies for isotopes of nitrate and age dating of 'recent' ground water from sulfur hexafluoride ('Water Resources Research', Oct. 2000, vol. 36, No. 10) make it possible to determine the specific sources of water to the springs and seeps. The objectives are fairly simple consisting of collecting water samples at predefined target locations and analyzing them for nitrates and sulfur. Then use this data in combination with dye tracer tests to identify aquifer recharge source areas as well as provide insight and quantitative data about water quality and preferential flow paths. This project will renew a partnership between NPS and USGS established in 1992. Funding for that portion of the partnership ran out in the middle of FY97, and the cooperative effort was terminated.

5. PROBLEM RESOLUTION - Chemical signatures quantified in this study will aid in defining the ground-water flow dynamics, which are causing the landslides. Also, a large dairy operation is claiming that their operation will not impact HAFO's resources. This data will provide specific management prescriptions that will be used immediately for mitigation. No additional actions are anticipated other than follow-up water level monitoring by HAFO staff supported by ONPS-base funding.

6. TRANSFERABILITY - Results from this project will be interpreted and published in a report. An 'Interim' presentation of the entire project will be provided to NPS-WRD in 2002 and in 2003 it will be available to other parks or agencies, and on the web. Information gained from this project will benefit other geoscientists within the park service that are investigating residence times of ground water flow systems by providing insight and applied experience using new and better methods of analysis. 7. PROJECT SUPPORT - (In-Kind or 14% of project)

Fiscal Year Description Quantity Cost ($) FY02 GS-9 Physical Scientist 3 PP 4200 FY02 GS-11 Chief Ranger .5 PP 400 FY02 GS-11 Chief of Administration .25 PP 300 FY02 Field vehicles 200 miles 75 FY02 NPS Seasonal 1PP 800 Total 5,800

8. SCIENTIFIC MERIT - The value of the project lies in the results from age-dating and isotopic analysis through sound and proven scientific methods ('Water Resources Research Journal, 2000') which will provide identification of aquifer recharge areas and

delineation of preferential flows. Application of the data will be used for specific management prescriptions that will result in future resolution of natural resource threats from landslides and dairy operations. The project will also renew a previous scientific partnership between the USGS and NPS to address further mass wasting problems at HAFO. Water analyses provided by the USGS will be used to analyze and define complex ground-water systems causing slope failure and landslides at the Monument. Data will help define sources of hillside ground-water seeps and springs, and plans will be developed to reduce recharge to selected ground-water zones related to the seeps or springs. A report will be submitted to NPS-WRD, and at the end of the project the report will be published. A formal presentation will be made to WRD, and all of the information listed on the WEB page for other interested scientists. The NPS-WRD professionals will be integrated into the project as expert advisors to this project. Scientific contributors to this proposal are listed below:

Bob Willhite Chief Ranger NPS-HAFO Hagerman, ID Neal Farmer Ground Water Geologist NPS-HAFO Hagerman, ID Marsha Davis Geoscientist NPS-SSO Seattle, WA Larry Martin Hydrogeologist NPS-WRD Fort Collins, CO Derrill Cowing District Chief USGS Boise Deb Parlimen Hydrologist USGS Boise Dave Clark Hydrologist USGS Boise

Compliance codes: EXCL (CATEGORICAL EXCLUSION) Explanation: 516 DM2 APP. 2, 1.6

Related projects: HAFO-N-202.000 Document seeps and landslides HAFO-N-204.000 Monitor ground-water flow HAFO-N-602.000 Monitor use of agricultural chemicals HAFO-N-600.000 Monitor external activities most likely to affect monument resources and ecological processes HAFO-N-920.000 Natural resource training and professional development HAFO-N-960.000 Establish

Measurable Results:

Products Products will be a report describing the different elements of the project consisting of goals & objectives, sampling methods and techniques, results, conclusions and recommendations. Copies of the report will be deposited with the USGS, NPS-WRD, HAFO and SSO library. The information gained from the study will be integrated into the existing hydrostratigraphic model of the perched aquifer systems causing landslides and evaluated against other hydrologic data to see if the model needs to be adjusted accordingly. Then an attempt will be made to identify dominant recharge source areas so that canal lining treatments may be most efficiently applied. An added benefit of defining specific ground water flow paths will also provide new information about impacts from confined animal feed operations. Water quality data will be entered into EPA's STORET database.

Evaluation Typical for most field investigations, formal presentations will be provided at NPS-WRD, HAFO, USGS, and state professional meetings that will allow experts the opportunity to evaluate the study. An annual accomplishment report will be submitted to Kathy Jope (SSO).

Project Cost and Funding Information

Total Cost for Submission FY Request:	$41,300.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$41,300.00**
Eligible Funding Source(s):	USGS Water Quality Assessment and Monitoring Program Water Resources Division Competitive
Preferred Funding Source:	USGS Water Quality Assessment and Monitoring Program

Detailed Cost Estimate Information

Estimate By:	USGS&HAFO	**Date Of Estimate:**	03/14/2000	**Estimate Good Until:**	09/30/2001	**Class Of Estimate:**	A

Item	**Quantity**	**Unit**	**Unit Cost**	**Item Total Cost**
USGS Personnel [1] GS-12 Hydrologist for 4 PP @ $2130/PP = $8520	4.00	Each	$2,130.00	$8,520.00
USGS Vehicle and Travel Travel expenses during the sample collection trip to discuss the results with park managers when analyses are complete.	1.00	Lump	$2,200.00	$2,200.00
USGS Supplies, equipment and shipping (FY 2003) Meters, calibration solutions, probes, bottles, gloves, preservatives, filters, pumps and bailers, hoses, shipping containers, forms FEDEX, overnight and ground transportation of samples to labs. Supplies, equipment, and shipping: includes meters, probes, bottles, gloves, preservatives, filters, pumps or bailers, hoses, shipping containers, forms, FEDEX overnight and ground transportation of samples to laboratories.	1.00	Lump	$2,600.00	$2,600.00
USGS Laboratory Analysis nitrogen-15/nitrogen-14 ratio and oxygen-18/oxygen-16 ratio of nitrate; sulfur hexafluoride and associated gas samples, and deuterium/protium ratio and oxygen-18/oxygen-16 ratio for samples from [10] wells, [8] springs, [1] canal, [2] storage ponds, [1] Snake River plus [1] replicate and [1] equipment blank analyses by the USGS National Laboratory in Denver, Colorado and the USGS SF6 Laboratory in Reston Virginia.	1.00	Lump	$23,400.00	$23,400.00
USGS Personnel [1] GS-7 Hydrologic Technician for 4 PP @ $1145/PP = $4580.00	4.00	Each	$1,145.00	$4,580.00
Total Project Cost				$41,300.00

Project Priorities

Unit Priority:	1.00	**Unit Priority Band:** High Current
Regional Priority:	9999.00	
National Priority:	9999.00	**National Priority Band:** Future

Project Schedule

Planned Year: 2002	**Submission Year:** 2001
Target Start Date: 05/01/2002	**Target Completion Date:** 09/30/2002
Project Status: Waiting	**Project Submission Date:** 08/11/1998

Project Title: **GIS Mapping of Water Resources**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 1085	**Package Number:** HAFO-150 **Reference Number:** HAFO-N-201.000
Project Group: Unassigned	**Project Type:** Non-Facility
Project Contact Person: Neal Farmer-HAFO Physical Scientist	**Project Contact Phone:** 208-837-4793

Project Narratives
Description: Surface water resources will be surveyed, inventoried and mapped utilizing aerial photographs and conducting field reconnaisance. The resulting information will be recorded in GIS-compatible format for addition to the monument's GIS database. Related projects: HAFO-N-202.000 Document seeps and landslides HAFO-N-203.000 Monitor water

quality HAFO-N-204.000 Monitor ground-water flow HAFO-N-205.000 Delineate wetlands HAFO-N-206.000 Delineate floodplains HAFO-N-300.000 Survey and map vegetation HAFO-N-600.000 Monitor external activities most likely to affect monument resources and ecological processes HAFO-N-960.000 Establish natural resource database (GIS)

Justification:

The Monument has not been comprehensively surveyed to inventory and map surface-water resources. This information will be useful in other activities, such as, monitoring landscape changes, surveying and mapping vegetation, inventorying and monitoring wildlife, and visitor-use planning.

Measurable Results:

Results will be a GIS compatable 'Thematic' map delineating spatial distribution and associated attributes for HAFO's water resources.

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$5,000.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$5,000.00**
Eligible Funding Source(s):	GIS - Projects
Preferred Funding Source:	GIS - Projects

Detailed Cost Estimate Information

Estimate By:	Neal Farmer-HAFO Physical Scientist	**Date Of Estimate:**	02/15/2000	**Estimate Good Until:**	02/15/2002	**Class Of Estimate:**	A

Item	Quantity	Unit	Unit Cost	Item Total Cost
Air Photo Flight Air photo flight to generate false color infrared and true color images to identify water dischagre areas.	1.00	Each	$5,000.00	$5,000.00
Total Project Cost				$5,000.00

Project Schedule	
Planned Year: 2003	**Submission Year:** 2001
Target Start Date: 10/01/2002	**Target Completion Date:** 09/30/2003
Project Status: Waiting	**Project Submission Date:** 06/09/1998

Project Title: **Install Groundwater Tracer Test Well**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 2
PMIS Number: 49957	**Package Number:** HAFO-192 **Reference Number:** HAFO-N-204.003
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neal Farmer-HAFO Groundwater Geologist	**Project Contact Phone:** (208)837-4793

Project Narratives
Description:
METHODOLOGY - One groundwater tracer test injection well will be strategically placed to facilitate a large scale tracer test designed to tract preferential flow paths. It will also fill in a 'hole' in the existing monitor well grid system established by the USGS to deal with massive landslides at the fossil beds. EPA-approved fluorescent dye tracers will be injected to track subsurface flow paths back to canal leakage areas. Data synthesis will require some computer hardware and software upgrades. The project will be overseen by the park's groundwater geologist, Neal Farmer.
Justification:

SIGNIFICANCE - HAFO is a Threatened Natural National Landmark. The internationally significant, Smithsonian Institution Horse Quarry is imminently endangered. Zones of seepage are threatening, and at some locations already destroyed, world-class fossil sites, along with other significant resource destruction and risk to human life.

SEVERITY - Leakage from unlined irrigation canals and ponds adjacent to HAFO is creating unnatural aquifers that are saturating slopes and have caused six massive, destructive landslides (1979, 1983, 1987, 1989, 1991, and 1995). A large pump station was completely destroyed in the 1987 landslide and two workers nearly lost their lives. Lindsey McClelland (NPS-GRD) states, "The landslide problem at HAFO is the worst in the entire National Park Service." At present, the disturbed surface area is the size of 30 football fields with over 150 million cubic feet of fossil-bearing material translocated from its original position, losing critical scientific information regarding depositional environment.

PROBLEM DEFINITION AND INFORMATION BASE - A series of unnatural seeps dishcarge water from bluffs on the Monument. These seeps did not exist prior to 1969 construction of a large agricultural system of unlined canals and ponds on the plateau adjacent to the Monument. The park's enabling legislation states these facilities are "compatible with the purposes of the Monument." The Masters Thesis analysis revealed alarming information about water levels rising in the lowest aquifer in which there is only one well. This provides a new landslide risk which further threatens the Monument's most significant fossil site. Tracer tests provide definitive flow tracking information and need to be performed to support possible future mitigation actions.

The information base started prior to NPS management of the fossil beds. The BLM in 1984 identified 33 soil movement sites. In 1986, they drilled a number of wells down to the top of a basalt layer to observe groundwater levels and maintained measurements for one year. The area became a NPS unit in 1988. In 1991, a massive landslide occurred that showed the water was at the base of basalt rock, below the well depth for the 1986 wells. With 1992 NPS funding, the USGS added 6 more wells penetrating the basalt and resumed measurements until 1996. These existing wells provided useful information up to the limit of their design and construction. The cause and effect relationships were then analyzed in a Master's Thesis (Farmer, 1998).

FEASIBILITY - The project can be completed within the proposed one-year time frame and with the resources/costs projected.

Measurable Results:

PROBLEM RESOLUTION - This project will provide: 1) groundwater flow path tracking for identification of recharge areas from irrigation water and efficient mitigative applications; 2) provide critically needed analysis of the developing aquifer; 3) focus mitigation on the the greatest hazards to slope stability; 4) fill in an area that has no monitor wells; 5) permit mandated protection of fossils on these internationally significant sites; and 6) improve visitor/employee safety. The most important resource issue at HAFO revolves around the cessation of these landslides.

TRANSFERABILITY - Results will be available and beneficial nationally to other park units and agencies, and included on HAFO's web site. Lindsey McClelland (NPS-GRD)has been compiling and composing a document discussing and describing System-wide landslide and mass wasting issues; information from HAFO's landslide dynamics will be integrated into the project. Data will be shared with two other parks that are performing tracer studies.

Results from this project will be presented at a professional meeting by Neal Farmer. A formal presentation of the project will be provided to NPS-WRD in 2001 at the Water Resource Professionals Conference, Fort Collins, CO.

Goals - Service-wide goals (GPRA) are listed under 'Project Emphasis and Goals'.

COST-EFFECTIVENESS

In-kind Contribution. Total = $7,550

or 12% of the total project cost

There are no other known sources of funding.

1 Physical Scientist (GS-7) for 5 pay periods $6,500

1 Administrative Officer (GS-11) for 0.5 pay period $1,050

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$13,757.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$13,757.92**
Eligible Funding Source(s):	NRPP - Small Park Block Grants
Preferred Funding Source:	NRPP - Small Park Block Grants

Detailed Cost Estimate Information

Estimate By:	N. Farmer - HAFO (based on drillers bids)	**Date Of Estimate:**	02/07/2000	**Estimate Good Until:**	01/01/2002	**Class Of Estimate:**	A

Item	**Quantity**	**Unit**	**Unit Cost**	**Item Total Cost**
Silica Sand Pack A total of [10] bags (50#) of 'Colorado Silica Sand' @ $8.00/bag = $80.00 (from drillers bid)	10.00	Bags	$8.00	$80.00
Bentonite Seal A total of [160] linear feet of bentonite grout seal @ $2.00/ft. = $320.00 (from drillers bid)	160.00	Linear FT	$2.00	$320.00
Cement Grout Seal	10.00	Linear	$10.00	$100.00

A total of [10] linear feet of cement grout surface seal @ $10.00/ft. = $100.00 (from drillers bid)		FT		
Computer Upgrade Hardware and Software upgrade to handle data processing.	1.00	Lump	$200.00	$200.00
Administrative services [1] GS-11 admin services for 0.25 pay periods = $400.	0.25	Each	$400.00	$100.00
Misc. Supplies Miscellaneous supplies for logging drill core and tracer tests. Pencils, graph paper, field notebooks, hard hats, ear protection, gloves, sample bags-bottles-trays, screens, tools.	1.00	Lump	$500.00	$500.00
Gravel Pack A Total of [20] feet of washed gravel pack @ $6.35/ft. = $127.00 (from drillers bid)	20.00	Linear FT	$6.35	$127.00
Installation of materials Installation of construction materials for [1] wells @ $250.00/well = $250.00 (from drillers bid)	1.00	Each	$250.00	$250.00
Well Bailers	1.00	Each	$28.00	$28.00
Well Development [3] hours @ $200.00/hour = $600 (from drillers bid)	1.00	Each	$200.00	$200.00
Travel [200] miles x .32/mile = $64.00	200.00	Miles	$0.32	$64.00
Drill-Cutting Chip Trays [20] Drill-Cutting Chip Trays @ $10.55/each = $211.00	20.00	Each	$10.55	$211.00
Drill Borehole A total of [240] feet of 6" diameter borehole will be drilled @ $20.00/ft. = $4,800.00 (from drillers bid)	240.00	Linear FT	$20.00	$4,800.00
PVC Casing A total of [200] feet of 2" diameter Flush Threaded PVC SCH-40 casing @ $2.00/ft. = $400.00 (from drillers bid)	200.00	Linear FT	$2.00	$400.00
PVC Screen A total of [40] feet of 2" PVC SCH-40 Flush Threaded slotted screen @ $3.60/ft. = $144.00 (from drillers bid)	40.00	Linear FT	$3.60	$144.00
PVC End Caps [1] 2" PVC end caps @ $7.00/cap = $7.00 (from drillers bid)	1.00	Each	$7.00	$7.00
Sample Collection Containers [3] Sample Containers (25mmx150mm) @ $152.64/case = $458.00	3.00	Each	$152.64	$457.92
Flourescent Dye Tracer [50] gallons of Flourescene Dye @ $78.00/gal. = $3,900.00	50.00	Gal	$78.00	$3,900.00
Locking Stand Pipe A total of [1] locking stand pipes (8"x5') @ $150.00ea = $150 (from drillers	1.00	Each	$75.00	$75.00

bid)				
15% Contingency Allowance 15% Contingency Allowance for unforeseen drilling problems.	1.00	Lump	$1,794.00	$1,794.00
Total Project Cost				$13,757.92

Project Schedule	
Planned Year: 2002	**Submission Year:** 2001
Target Start Date: 04/01/2002	**Target Completion Date:** 09/30/2002
Project Status: Waiting	**Project Submission Date:** 07/29/1999

Project Title: Abate Canal Leakage	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 1082	**Package Number:** 9608-163 **Reference Number:** HAFO-N-001.005
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neil King	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

Through an Interagency Agreement with the Bureau of Reclamation, engineering and lining activities will be performed on those sections of canal exhibiting the highest rate of leakage. The Bureau of Reclamation will make recommendations to the NPS as to the most cost effective methods prior to construction and will be responsible for quality control.

Justification:

Unlined irrigation canals and ponds on the Bell Rapids property adjacent to the monument provide over 5,000 acre-feet of water to the perched aquifer system each year. Approximately ten percent of this recharge reached the cliffs within the monument annually, creating a situation conducive to mass wasting. By eliminating the source of water, hillside instability within the monument should lessen. The canal leakage continues to endanger the monument's fossil resources through its role in producing

major landslides.
Measurable Results:

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$0.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$516,500.00**
Eligible Funding Source(s):	NRPP - Natural Resource Management
Preferred Funding Source:	NRPP - Natural Resource Management

Project Schedule	
Planned Year: 1999	**Submission Year:** 1999
Target Start Date: 10/01/1998	**Target Completion Date:**
Project Status: Waiting	**Project Submission Date:** 06/09/1998

Project Title: **Collect & Analyze Surface Water Flow from Landslides**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 36531	**Package Number:** 9608-175 **Reference Number:** HAFO-N-202.000
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neil King	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

The occurence of landslides associated with unnatural seeps within the monument have been documented and monitored for a number of years. Specialists who have been studying the landslide process at Hagerman have concluded that additional landslides are imminent. The monument needs to continue documenting water flows to assist in predicting potential mass failure of slopes.

Justification:

Conduct monitoring of seeps and surface flows from the landslides to analyze for hydrologic trends. Consistent and recurring data collection is critical to establish cause/effect relations.

Measurable Results:

Project data will be entered into database, analyzed and processed for mitigative actions.

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$0.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$48,000.00**
Eligible Funding Source(s):	Water Resources Division Competitive
Preferred Funding Source:	Water Resources Division Competitive
Project Schedule	
Planned Year: 2000	**Submission Year:** 2000
Target Start Date: 10/01/1999	**Target Completion Date:**
Project Status: Waiting	**Project Submission Date:** 08/11/1998

Project Title: **Analyze & Quantify Reservoir Drawdown Effects from Idaho Power Operations**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 36721	**Package Number:** HAFO-181 **Reference Number:** HAFO-N-604-000
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neal Farmer - HAFO Physical Scientist	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

METHODOLOGY - A program will be implemented to analyze the effects of reservoir operation on the geologic formations that have already slumped into the Snake River, and those that are at current risk. The study will also evaluate the fossil sites that are impacted and implement mitigation measures, evaluate the ecosystem processes and species affected by the fluctuations. It will involve documenting impacts and integrating compatible data into HAFO's GIS system and analyzed using hydrology software called 'Spatial Analyst'. The project will be overseen by the park's Physical Scientist/hydrogeolgist, Neal Farmer and Bob Willhite, Chief of Natural Resource Management.

INFORMATION BASE - The flow of water through the reservoir along the edge of HAFO affects slope saturation and slumps; there are twenty-five slopes that have already slid into the reservoir, and many more are threatened. Also, affected are water quality and temperature; fish and other aquatic species; waterfowl and other water associated

bird species; native and non-native riparian plants, amphibians, and other species; and, in turn, upland species. There is currently water level variations of about two feet periodically during the year in the reservoir. With power de-regulation, Idaho Power is proposing increased production of electricity by fluctuating the reservoir daily up to five feet which will have significant impacts to visitor and recreationist safety. Information on the effects of the reservoir operation on monument resources will provide HAFO's only basis for protection to ensure that the NPS is able to meet its legislatively mandated responsibilities.

FEASIBILITY - The project can be completed within the two year time frame and with the resources listed.

Justification:

PROBLEM DEFINITION - Impacts from recently proposed Idaho Power Co. operations daily reservoir drawdowns will pose immediate threat to public recreationsists and staff from increasing mass slope failures.

SIGNIFICANCE OF THE RESOURCE - Fossils at HAFO are internationally famous and provide the greatest Pliocene age species diversity and abundance. Enabling legislation defined the primary purpose of HAFO is to "preserve... outstanding paleontological sites." The current RMP priority rating does not reflect the Idaho Power decision to drastically alter reservoir levels that will impact fossil resources.

SEVERITY OF RESOURCE THREAT - Imminent health and safety issues for park visitors, water recreationists, staff and researchers will be immediate. Irreversible impacts to fossils have already occurred from 44 slope failures because of current and past minor fluctuations.

Measurable Results:

PROBLEM RESOLUTION - Seven miles of shoreline will be mapped and evaluated. Anaylsis of data will produce a 'Hazard Map' for employee health and safety, visitors and research. Hazards will be marked to improve safety.

TRANSFERABILITY - The information will be made available to scientists and the WEB.

PROJECT SUPPORT - Total $10,980 or 27% of the project cost.

1 Physical Scientist for 5 pay periods @ $1500 each = $6500

1 GS-11 Chief of Resource Mgmt. for 2 pay periods @ $2240 each = $4480

COST EFFECTIVENESS - The project can be reasonably completed for the following:

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$32,000.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$58,000.00**

Eligible Funding Source(s):	Water Resources Division Competitive
Preferred Funding Source:	Water Resources Division Competitive

Detailed Cost Estimate Information							
Estimate By:	B. WILLHITE	**Date Of Estimate:**	03/09/2000	**Estimate Good Until:**	03/09/2002	**Class Of Estimate:**	A
Item				**Quantity**	**Unit**	**Unit Cost**	**Item Total Cost**
First year - GS-5 Seasonal Paleontolgists; 0.8 FTE Evaluate failed and threatened strata; field recon.; photo documentation; data entry; biological impact data collection; fossil salvage; hazard identification and marking.				2.00	Each	$9,250.00	$18,500.00
Photo documentation [ITEM DESCRIPTION]				1.00	Each	$1,000.00	$1,000.00
Hazard markers [ITEM DESCRIPTION]				50.00	Each	$10.00	$500.00
Second year - GS-5 Seasonals Paleontologists; 0.8 FTE [ITEM DESCRIPTION]				2.00	Each	$9,500.00	$19,000.00
Supplies for fossils [ITEM DESCRIPTION]				1.00	Each	$1,000.00	$1,000.00
Year #2 Same as in year #1 of the project except a shorter season for seasonals (0.5 FTE).				1.00	Lump	$18,000.00	$18,000.00
Total Project Cost							$58,000.00

Project Schedule	
Planned Year: 2001	**Submission Year:** 2000
Target Start Date: 01/01/2001	**Target Completion Date:** 09/30/2002
Project Status: Waiting	**Project Submission Date:** 08/11/1998

Project Title: **Collect & Analyze Water Quality Data**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 36622	**Package Number:** HAFO-174 **Reference Number:** HAFO-N-203.000
Project Group: Unassigned	**Project Type:** Non-Facility
Project Contact Person: Neal Farmer - HAFO Groundwater Geologist	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

A series of seeps discharge water from the bluffs. These seeps did not exist prior to the construction of a system of unlined irrigation canals and ponds on the plateau to the west of the monument. Within a zone extending 1000 feet to the east of the Horse Quarry, seepage volumes are in the range of 360 acre-feet per year. The USGS has been generating baseline chemical data from water samples collected at these seeps, and from monitoring wells, to create an interpretation, based on the distinct chemical signatures, of how the water is moving through the subsurface. Using the signatures of the water, source areas can be paired with seep locations or subsurface flow paths of similar unique chemical composition. From this, cost effective remedial measures can then be applied to site specific projects in the future, to reduce or eliminate the threat to the fossil resources from the seeps resulting from this subsurface flow.

Justification:

The USGS Water Resources Division, under an interagency agreement, will conduct sampling and chemical analysis for HAFO through April 1996. This project will continue the water sampling/chemical analysis efforts initiated by the USGS Water Resource Division. Technical assistance will be sought from the Water Resource Department in developing protocols and training staff. The goals of the water chemistry analysis protocol will be 1) to document the chemical composition of each seep and

monitor well sites, 2) tie source areas to seepage areas, 3) prepare/refine aquifer flownet maps, and 4) determine the influence of dewatering efforts on the individual chemical flowpaths. This will be an on-going activity requiring an increase in the monument's base funding level. By performing this function internally, HAFO will realize a nearly 50% reduction in the cost of performing this activity.

Measurable Results:

Results will be data collected on a quarterly basis and composed into a database. The data will be submitted to NPS Water Resources Division for incorporation into their database.

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$21,700.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$21,700.00**
Eligible Funding Source(s):	USGS Water Quality Assessment and Monitoring Program
Preferred Funding Source:	USGS Water Quality Assessment and Monitoring Program

Detailed Cost Estimate Information							
Estimate By:	HAFO	**Date Of Estimate:**	02/28/2001	**Estimate Good Until:**	09/30/2003	**Class Of Estimate:**	A
Item				**Quantity**	**Unit**	**Unit Cost**	**Item Total Cost**
water analysis [ITEM DESCRIPTION]				1.00	Lump	$21,700.00	$21,700.00
Total Project Cost							$21,700.00

Project Schedule	
Planned Year: 2003	**Submission Year:** 2001
Target Start Date: 05/01/2003	**Target Completion Date:** 09/30/2003
Project Status: Waiting	**Project Submission Date:** 08/11/1998

Project Title: **Inventory Agricultural Chemicals**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 36702	**Package Number:** HAFO-165 **Reference Number:** HAFO-N-602.000
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neal Farmer (Physical Scientist)	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

ABSTRACT - The purpose of this project is to provide an inventory and identify agricultural chemicals in key water bodies. The results will be information that will enable protection of visitors and evaluate impacts to Vital Sign species in riparian zones and wetlands. This project is recommended and discussed in HAFO's 1999 Interim Water Resources Scoping Report and is added in 'scope' from the RMP statement with the purpose of establishing an inventory of baseline information for agriculture chemicals.

METHODOLOGY - Use of agricultural chemicals will be qualitatively monitored through contacts with adjacent landowners and farm managers. Analyses for pesticides and fertilizer-derived nutrients will be included as a component of the water-quality report. Subsequent monitoring will be carried out by Monument staff as a base-funded program. Other benefits will include using the trends in the analyzed data to help define groundwater flow systems such as identifying aquifer recharge areas. Analysis for pesticides and fertilizer-derived nutrients will be included as a component of the water quality monitoring program. This will be carried out by park staff as a basefunded program. Other benefits will include using the trends in the analyzed data to help define groundwater flow systems such as identifying aquifer recharge areas.

Justification:

SIGNIFICANCE - Hagerman Fossil Beds National Monument was established by Congress to preserve the outstanding Pliocene fossil sites of the region. HAFO has several key surface water and groundwater bodies that are impacted from agricultural chemicals. Wetlands are receiving discharge from these streams, and hiking trails cross or parallel most of them. Also, drinking water needs to be analyzed for a supply well at HAFO's new property site. The importance of this project is to determine safety for people drinking well water, horses, and wild animals that are potentially drinking from these streams and impacts to Vital Sign species in these riparian zones and wetlands.

SEVERITY - Pesticides, herbicides, fungicides, nematocides, and fertilizers are applied to agricultural areas surrounding the monument. These chemicals have the potential to affect water quality in wetlands, surface and subsurface waters. A drinking water supply well located at HAFO's new property needs to be analyzed for ag-chemicals especially due to its old (ca. 1920) well construction and design that do not meet today's standards for well head protection.

PROBLEM DEFINITION AND INFORMATION BASE - A one-time 'snapshot' water analysis was performed by the USGS six years ago at three sites. Ag-chemcials were identified and many such as nitrates significantly exceeded recommended EPA water quality criteria (40 ppm vs. EPA's maximum of 10 ppm). This clearly shows excessive concentrations of ag-chemicals in groundwater drinking supplies and it is a good indicator that other chemical species are present in elevated concentrations. Groundwater discharge known to contain ag-chemicals flows by hiking trails used by the public and at one riparian location appears to have severely impacted native vegetation species. A quantitative water analysis needs to be performed to assess the impacts to visitors, park staff, horses, wetlands and riparian zones.

GPRA Goals met by this project: · Ia4. Water Quality: 85% of Park units have unimpaired water quality. · Ib5. Aquatic Resources: The NPS has completed an assessment of aquatic resource conditions in parks. · IIa2. Visitor Safety: The visitor accident/incident rate will be at or below 8.1 per 100,000 visitor days. · IVa1. Data Systems: 65% [25 of 38] of the major NPS data systems are integrated/interfaced

FEASIBILITY - The objectives are clear, methods and procedures are technically sound based on standards set by the Holms Research Lab. The project can be completed within the proposed one-year time frame and with the resources/costs projected.

Measurable Results:

PROBLEM RESOLUTION - This project will identify the presence or absence of agricultural chemicals in key water bodies at HAFO and fulfill one component of the Water Scoping Report and GPRA goals. It will provide a basis to progress into subsequent stages of Natural Resource Protection. Results will be a database containing analyses for ag-chemicals that will be included as a component of the water-quality monitoring program.

TRANSFERABILITY - Results will be available and beneficial nationally to other park units and agencies, and included on HAFO's web site. Results from this project will be combined with other hydrologic data and submitted to a professional journal by HAFO's

Physical Scientist. A formal presentation of the project will be provided to NPS-WRD in 2001 at the Water Resource Professionals Conference, Fort Collins, CO.

Goals - Service-wide goals (GPRA) are listed under 'Project Emphasis and Goals'. This project supports HAFO's Five-year Strategic Plan and the following General Managment Plan (GMP) goals.

1. "The causes and occurrences threatening Monument resources, such as landslides, will be determined and mitigated whenever possible."

2. "Identify and document paleontological resources, sites, and their geological setting, and protect from unnaturally accelerated erosion and other unnatural disturbance."

3. "The National Park Service and the private sector will work together to protect the Monument resources while allowing electrical and irrigation facilities to function as intended."

4. "Identify and mitigate impacts to monument resources by external activities."

5. "The Monument's natural resources and values will be protected."

6. "There will be a broad-based internal and external support for the Monument's research and resource management programs in terms of funding, staffing, equipment, and facilities.

7. "The National Park Service also will actively and aggressively encourage partnerships and outside assistance and advice in the design and conduct of resource management."

8. "The results of Monument research efforts will be published in scientific journals and popular media."

9. "Active resource management will be conducted at the Monument. The National Park Service will supervise all activities and will have the capability to conduct most aspects of these activities at some level."

COST EFFECTIVENESS - Costs are realistic and based on price listing from University of Idaho Analytical Sciences Laboratory, Holm Research Center, Moscow, Idaho, 83844; 208-885-7081.

PROJECT SUPPORT - (In-Kind or 40% of project) One GS-7 Physical Scientist for five pay periods $5,200 One GS-11 Admin. Services. for 0.5 pay periods $1,050 _____ Total In-Kind = $6,250

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$16,000.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$16,000.00**
Eligible Funding	USGS Water Quality Assessment and Monitoring Program NRPP - Small Park Block

Source(s):	Grants Water Resources Division Competitive
Preferred Funding Source:	USGS Water Quality Assessment and Monitoring Program

Detailed Cost Estimate Information							
Estimate By:	Neal Farmer (HAFO Physical Scientist)	**Date Of Estimate:**	03/10/2000	**Estimate Good Until:**	03/10/2001	**Class Of Estimate:**	A
Item				**Quantity**	**Unit**	**Unit Cost**	**Item Total Cost**
Nitrate Solution Kit [2] Double junction nitrate solution kits from Cole Parmer Cat. #P-27502-79 @ $63.00 ea = $126.00.				2.00	Each	$63.00	$126.00
Replacement Adjustors [2] Replacement ionic strength adjustors @ $26 ea = $52.00.				2.00	Each	$26.00	$52.00
Travel [500] miles @ $.32/mile = $160.00				1.00	Lump	$160.00	$160.00
Shipping [28] shippings @ $15.00 ea = $420.00				28.00	Each	$15.00	$420.00
Seasonal Hydrologic Assistant [1] hydrologic assistant @ $8,000/season = $8,000.00				1.00	Each	$8,000.00	$8,000.00
Clerical Services				1.00	Each	$421.00	$421.00
Nitrate Electrode [2] Nitrate ION specific probe from Cole Parmer Cat. #P-27502-31 @ $276ea = $552.00.				2.00	Each	$276.00	$552.00
Nitrogen & Phosphorus Pesticides Lab Analysis [6] EPA 507 water analysis for Nitrogen & Phosphorus Pesticides @ $191.00 ea = $1,146.00. Based on price listing from University of Idaho Analytical Sciences Laboratory, Holm Research Center, Moscow, Idaho, 83844; 208-885-7081.				7.00	Each	$191.00	$1,337.00
Chlorinated Pesticides Lab Analysis [6] EPA 508 water analysis for chlorinated pesticides @ $218.00 ea = $1,308.00. Based on price listing from University of Idaho Analytical Sciences Laboratory, Holm Research Center, Moscow, Idaho, 83844; 208-885-7081.				7.00	Each	$218.00	$1,526.00
Chlorinated Acids Lab Analysis [6] EPA 515.1 water analysis for chlorinated acids @ $234.00 ea = $1,404.00. Based on price listing from University of Idaho Analytical Sciences Laboratory, Holm Research Center, Moscow, Idaho, 83844; 208-885-7081.				7.00	Each	$234.00	$1,638.00
Carbamates/Carbomoyloximes Lab Analysis [6] EPA 531.1 water analysis for Carbomates/Carbamoyloximes @ $191.00 ea = $1,146.00. Based on price listing from University of Idaho Analytical Sciences Laboratory, Holm Research Center, Moscow, Idaho, 83844; 208-885-7081.				7.00	Each	$151.00	$1,057.00

Analysis Meter [1] ION specific analysis meter from Cole Parmer Cat.#P-59003-30 = $711.00.	1.00	Each	$711.00	$711.00
Total Project Cost				$16,000.00

Project Schedule	
Planned Year: 2000	**Submission Year:** 2000
Target Start Date: 01/01/2001	**Target Completion Date:** 09/30/2001
Project Status: Waiting	**Project Submission Date:** 08/11/1998

Project Title: Conduct Groundwater Tracer Tests	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 2
PMIS Number: 57325	**Package Number:** HAFO-207 **Reference Number:** HAFO-N-204.004
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neal Farmer - HAFO Physical Scientist	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

ABSTRACT - The purpose of this unique project is to track groundwater flow paths to provide information about dynamics causing landslides. This project is recommended and discussed in HAFO's 1999 Interim Water Resources Scoping Report # NPS/NRWRD/NRTR-00/98.

METHODOLOGY - An unprecedented and unique small-scale pilot project designed to inject fluorescent green dye into groundwater will track flow paths and provide a greater understanding of 'sand' aquifer parameters such as flow vectors of direction, velocity, conductivity and storage. This study will define problems from aquifers causing landslides and assist with formulation for more in-depth larger scale tests.

Nine shallow monitor wells will be installed by hand using a soil auger with a maximum depth capacity of 25 feet into the hillsides where groundwater is discharging. PVC pipe will be used for the well casing, and screens cut into the casing by hand using a hacksaw to reduce costs. Dye will be injected into one of the monitor wells and aquifer discharge locations as well as other wells will be monitored for presence of the green dye and concentrations. Samples will be collected in culture tubes and analyzed with a fluoremeter to determine concentrations. A qualitative analysis of samples to determine the presence of dye can be done at night using a 'UV' black light that causes the water/dye to fluoresce with a green glow. HAFO hydrologist, Neal Farmer, will oversee and coordinate the project with additional expertise from NPS-WRD, David Mott (Hydrologist-Buffalo National River) and Joe Meiman (Hydrologist-Mammoth Cave National Park).

Justification:

SIGNIFICANCE - The National Natural Landmark, Smithsonian Institution Horse Quarry is imminently endangered. Zones of seepage are threatening, and at some nearby locations already destroyed, world-class fossil sites, along with other significant resource destruction and risk to human life. Hagerman Fossil Beds National Monument was established by Congress to preserve the outstanding Pliocene fossil sites of the region.

SEVERITY - Lindsey McClelland (NPS-GRD) states, "The landslide problem at HAFO is the worst in the entire National Park Service." At present, the disturbed surface area is the size of 30 football fields with over 150 million cubic feet of fossil-bearing material translocated from its original position, losing critical scientific information regarding depositional environment. There is no other unit in the Park Service that has the magnitude of problem that HAFO has with landslides. In one area, three of the slides are starting to merge into a tremendous area of devastation. It has the potential of diverting the Snake River if it completely fails. To illustrate the reality of this resource threat, a 1994 landslide occurred near HAFO's boundary that completely blocked the Snake River until it overflowed the fill, cutting down to base level.

PROBLEM DEFINITION AND INFORMATION BASE - Unnatural leakage from unlined irrigation canals and ponds adjacent to HAFO is creating unnatural aquifers that are saturating slopes and have caused six massive, destructive landslides (1979, 1983, 1987, 1989, 1991, and 1995). A large pump station was completely destroyed in the 1987 landslide and two workers nearly lost their lives. The landslides are impacting fossils, multi-million dollar water diversion facilities (Bell Rapids Pumping Station was completely obliterated), natural and cultural resources. They are an extremely hazardous safety problem for visitors and employees. It is imperative to identify the groundwater flow dynamics from tracer tests to implement mitigation treatments. The following are reasons this project does not fall under the 'Water Resources Project Call': · Level 1 Water Quality Inventories - This project does not relate to level 1 criteria of temperature, pH, conductivity, total dissolved solids, dissolved oxygen and turbidity. · NPS-USGS Water Quality Assessment and Monitoring Partnership - This project does not meet the $42,500/project/year minimal requirement.

GPRA Goals met by this project: · Ia4. Water Quality: 85% of Park units have unimpaired water quality. · Ib5. Aquatic Resources: The NPS has completed an assessment of aquatic resource conditions in parks. · IIa2. Visitor Safety: The visitor accident/incident rate will be at or below 8.1 per 100,000 visitor days. · IVa1. Data Systems: 65% [25 of 38] of the major NPS data systems are integrated/interfaced

FEASIBILITY - The objectives are clearly defined and feasible based on pilot tracer tests that were done in 1997 and 1998 by Neal Farmer. These tests proved design viability but were limited by the scale of pilot test. The proposed tracer test would increase the scale and resulting benefits. This project is well defined, feasible, urgent, and critical to protect the resource.

Measurable Results:

PROBLEM RESOLUTION - Results will define critically needed aquifer flow information to identify target areas of the leaking canal system for lining and mitigation treatment. This will contribute the most important hydrologic data to NPS managers for

resolving the landslide issue.

TRANSFERABILITY - Results will be available and beneficial nationally to other park units and agencies, and included on HAFO's web site. Results from this project will be conbined with other hydrologic data and submitted to a professional journal by HAFO's Physical Scientist. A formal presentation of the project will be provided to NPS-WRD in 2001 at the Water Resource Professionals Conference, Fort Collins, CO. Information from this test will be shared with and directly usable to other park units that are currently conducting similar tests, thus solving multiple needs. The fluorometer will be used for subsequent studies, NPS-WRD, and assistance to other agencies.

Goals - Service-wide goals (GPRA) are listed under 'Project Emphasis and Goals'. This project supports HAFO's Five-year Strategic Plan and the following General Managment Plan (GMP) goals.

1. "The causes and occurrences threatening Monument resources, such as landslides, will be determined and mitigated whenever possible."

2. "Identify and document paleontological resources, sites, and their geological setting, and protect from unnaturally accelerated erosion and other unnatural disturbance."

3. "The National Park Service and the private sector will work together to protect the Monument resources while allowing electrical and irrigation facilities to function as intended."

4. "Identify and mitigate impacts to monument resources by external activities."

5. "The Monument's natural resources and values will be protected."

6. "There will be a broad-based internal and external support for the Monument's research and resource management programs in terms of funding, staffing, equipment, and facilities.

7. "The National Park Service also will actively and aggressively encourage partnerships and outside assistance and advice in the design and conduct of resource management."

8. "The results of Monument research efforts will be published in scientific journals and popular media."

9. "Active resource management will be conducted at the Monument. The National Park Service will supervise all activities and will have the capability to conduct most aspects of these activities at some level."

COST EFFECTIVENESS - Costs are realistic and HAFO Physical Scientist has previously performed this type of project. Costs will be held to a minimum due to manual installation using HAFO in-kind resources.

PROJECT SUPPORT - (In-Kind = 100% of project)

One GS-7 Physical Scientist for five pay periods $5,200

One GS-11 Admin. Services. for 0.5 pay periods $1,050 _____ Total In-Kind = $6,250

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$5,907.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$5,907.00**
Eligible Funding Source(s):	NRPP - Natural Resource Management USGS Research (NRPP) NRPP - Small Park Block Grants Water Resources Division Competitive
Preferred Funding Source:	NRPP - Small Park Block Grants

Detailed Cost Estimate Information							
Estimate By:	Neal Farmer - HAFO Physical Scientist	**Date Of Estimate:**	03/02/2000	**Estimate Good Until:**	03/02/2001	**Class Of Estimate:**	A
Item				**Quantity**	**Unit**	**Unit Cost**	**Item Total Cost**
Culture Sample Tubes [1] case (144/case) of Pyrex culture tubes w/ screw caps (25x150mm) @ $275.00/case = $ 275.00				1.00	Each	$275.00	$275.00
Travel 400 miles @ .32/mile = $128.00				1.00	Miles	$128.00	$128.00
Hydrologic Assistant, SCA [ITEM DESCRIPTION]				1.00	Each	$3,000.00	$3,000.00
Misc. Supplies Miscellaneous supplies for logging geology from auger cuttings and well completion. PVC primer-glue-couplings-end caps, pencils, graph paper, field notebooks, gloves, sample bags-trays, miscelaneous tools.				1.00	Lump	$200.00	$200.00
Hand Auger [1] hand auger kit = $1,000. Includes handle, [6] 4-foot long drill stem, [2] 4-inch auger bits, [1] carrying case.				1.00	Each	$1,200.00	$1,200.00
PVC Casing [250] feet of 2-inch diameter SCH-40 PVC pipe @ $1.00/ft. = $250.				250.00	Linear FT	$1.00	$250.00
Flourescent Dye [10] gallons of flourescent dye @ $69.00/gallon = $690.00				10.00	Gal	$69.00	$690.00
Hacksaws [2] hacksaws @ $10.00ea = $20.00				2.00	Each	$10.00	$20.00
Hacksaw Blades [12] replacement hacksaw blades @ $2.00 ea = $24.00				12.00	Each	$2.00	$24.00
Bentonite Seal [6] 40 pound bags @ $20.00/bag = $120.00				6.00	Bags	$20.00	$120.00

Total Project Cost	$5,907.00
Project Schedule	
Planned Year: 2001	**Submission Year:** 2001
Target Start Date: 10/01/2000	**Target Completion Date:** 03/30/2000
Project Status: Waiting	**Project Submission Date:** 02/15/2000

Project Title: Inventory Rare, Threatened And Sensitive Fauna - Species	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 1090	**Package Number:** 9608-153 **Reference Number:** HAFO-N-402.001
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neil King	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

Information on the range of listed and candidate mammals, birds, reptiles, amphibians, arthropods, and other species will be reviewed, and a listing of species with the potential to occur in the monument will be compiled. Information will also be included on species that are particularly sensitive, during some part of their life cycle, to existing or potential human activities within or outside of the monument. A systematic survey to document whether these rare species occur in the monument (seasonally or year-round) will then be designed and carried out. The inventory would be carried out as a graduate study.

Related projects:

HAFO-N-400.000 Inventory and Baseline Studies of Fauna Populations.

Justification:

Federally and state-listed and candidate fauna species, as well as sensitive species, that occur in the monument have not been delineated. This information is necessary to monitor the condition of these species, help ensure their survival, and meet the requirements of the Endangered Species Act and NPS policy.

Measurable Results:

At least one listed species will be identified and its habitat protected from this project.

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$0.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$50,000.00**
Eligible Funding Source(s):	Biological Resource Management Division - Competitive
Preferred Funding Source:	Biological Resource Management Division - Competitive

Detailed Cost Estimate Information

Estimate By:	HAFO	Date Of Estimate:	02/21/2001	Estimate Good Until:	02/21/2001	Class Of Estimate:	A
Item				**Quantity**	**Unit**	**Unit Cost**	**Item Total Cost**
Work [ITEM DESCRIPTION]				1.00	Acres	$50,000.00	$50,000.00
Total Project Cost							$50,000.00

Project Schedule	
Planned Year: 2002	**Submission Year:** 2002
Target Start Date: 10/01/2001	**Target Completion Date:**
Project Status: Waiting	**Project Submission Date:** 06/09/1998

Project Title: **Inventory Rare, Threatened, and Sensitive Plant Species**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 2
PMIS Number: 37033	**Package Number:** 9608-199 **Reference Number:** HAFO-N-303.001
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neil King	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

In conjunction with the inventory and mapping of plant species and communities, a systematic survey of listed, candidate, and sensitive non-vascular species will be carried out.

Justification:

A systematic survey of rare or sensitive plant species in the Monument has not been done. No listed or candidate species have been documented. Preliminary investigation indicates non-vascular species that have all but been eliminated elsewhere because of grazing pressures. This project is essential to identify and protect these non-vascular species. This greatly limits assessments for planning and management as this relatively new park proceeds with development projects.

Measurable Results:

At least two sensitive non-vascular plants will have their current range and potential habitat identified for management protection and expansion.

Project Cost and Funding Information	
Total Cost for Submission FY Request:	$0.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$40,000.00**
Eligible Funding Source(s):	NRPP - Natural Resource Management
Preferred Funding Source:	NRPP - Natural Resource Management
Project Schedule	
Planned Year: 2001	**Submission Year:** 2001
Target Start Date: 10/01/2000	**Target Completion Date:**
Project Status: Waiting	**Project Submission Date:** 08/12/1998

Project Title: **Survey Paleontology Sites and Prepare Base Map**	
Park/Unit: Hagerman Fossil Beds National Monument	
Project State(s): ID	**Congressional District(s):** 02
PMIS Number: 6861	**Package Number:** 9608-117 **Reference Number:** HAFO-N-004.000
Project Group: Unassigned	**Project Type:** Facility
Project Contact Person: Neil King	**Project Contact Phone:** 208-837-4793

Project Narratives

Description:

Monument staff will implement a fossil salvage program through a systematic search for exposed fossils. Documentation of each site must be made prior to stabilization and specimen collection A laser transit will be used to survey the location of each site using an existing grid of reference points. The location data will be recorded in GIS.

Justification:

The fossils at HAFO are internationally famous and provide one of the greatest deposits from the Pliocene epoch in the world for the number of specimens and diversity of species.

The destruction of fossil specimens occurs readily at HAFO through rapid erosional processes in the unconsolidated sediments. Significant specimens have become uncovered in a very short time; for example, the Monument's first complete camel skull was found in 1994 by a graduate student only three months after another project was completed just 20 yards away. The breakdown of the specimens from the weather extremes is irreversible. Also, scientific information is lost when fossils roll downhill from where they were originally deposited.

Staff would conduct a systematic inspection with special attention to areas where no park staff have yet traveled in their other duties. Once fossils are located, they would be documented and evaluated for condition. Fragile specimens must be treated in-the-ground for preservation before movement. Sometimes large blocks of earth containing the fossils have to be prepared before movement is possible. Surveying would have to be done prior to specimen removal.

Scientific information about extinction and ecosystems gained from studying the deposition of fossils extends beyond the boundaries of parks to universities, museums, and researchers literally throughout the world because of HAFO's resource significance.

Measurable Results:

At least 200 previously identified fossil sites will be located, evaluated, and mapped for protection of the resource.

Project Cost and Funding Information

Total Cost for Submission FY Request:	$0.00
Total Cost for Prior FY:	$0.00
Total Cost For Next FY:	$0.00
Total Project Cost:	**$96,000.00**
Eligible Funding Source(s):	NRPP - Natural Resource Management
Preferred Funding Source:	NRPP - Natural Resource Management

Project Schedule	
Planned Year: 1999	**Submission Year:** 1999
Target Start Date: 10/01/1998	**Target Completion Date:**
Project Status: Waiting	**Project Submission Date:** 01/15/1998