Aquatic Survey and Condition Assessment

Great Basin National Park
Final Accomplishment Report

By Gretchen M. Baker, 2005

PMIS # 83233

Great Basin National Park, Nevada
National Park Service
Department of the Interior

TABLE of CONTENTS

List of Tables

List of Figures

ABSTRACT
Over 425 perennial springs and seeps were located throughout Great Basin National Park in FY03-04 in the Aquatic Survey project. About 60% of these springs have a single springhead, while 40% are classified as spring complexes with multiple springheads. Baker Creek watershed contains the most springs, with 148, while eight of the park's 25 watersheds have no springs, largely due to underlying karst geology. About 10% of the springs are at elevations greater than 10,000 ft, with 61% between 8,000 and 10,000 ft and the remainder below 8,000 ft. Corresponding to the elevation gradient, 76% of springs have aspen-mixed conifer habitat around them, while 11% have pinyon/juniper, 9% have sagebrush, and the remainder have a variety of vegetation types. Roughly 23% of the springs have vegetation encroachment nearby, with the dominant vegetative community changing from aspen to white fir and from sagebrush to pinyon/juniper. Nearly 17% of the springs have some disturbance near them, with roads and trails as the most common type of disturbance. Seven percent of the springs have cultural features near them such as water troughs, fencing, or historic cabins. The study measured water chemistry and found the mean water temperature is 7.2° C (± 3.1° C within one standard deviation (s.d.)). The mean specific conductance is 86.0 (± 90.3) uS/cm, the mean dissolved oxygen is 6.0 (± 4.7) mg/L, and the mean pH is 6.8 (± 0.7). Approximately 87% of the springs have visible animal sign near them, including 12% with mollusks. This project has greatly expanded the park's understanding of location and baseline data of its water resources.

ACKNOWLEDGEMENTS
This project would not have been completed without funding from the National Park Service's Water Resources Division. Many thanks also to the field technicians have traversed rough ground, bushwhacked through mountain mahogany and dogwood thickets, and chased aspen stands high up on mountain sides to verify if a spring was present: Stephanie Leslie, Nancy Williams, Rob Colvin, Matt Proett, Missy Brickl, Heather Vice, Bryan Hamilton (2003); and Margaret Allan, Tana Ellis, Eric Scott, Cole Neill, Nadja Schaefer (2004).

INTRODUCTION

Great Basin National Park, located in the Great Basin desert, defies many people's expectations of a desert park. Located in one of the highest ranges in Nevada, the Snake Range intercepts passing storms and receives more than double the precipitation of the adjacent valley bottoms. At the inception of this project, 10 perennial streams, 6 lakes, and about 50 springs were documented in the park, although many more springs were suspected.

As populations throughout the West increase, water becomes ever more important, and the park needed to document all the water resources in the Park for five main reasons:

1. A landowner adjacent to the park boundary caused resource damage to a spring and wetland inside the park in 2001. Lack of baseline data hampered the Park from knowing how the resource had been impaired and to what extent it should be restored.
2. The Southern Nevada Water Authority (SNWA) and Vidler Water Company have applied for over 150,000 acre-feet/year of water rights in the valleys adjacent to the Park. According to Dave Prudic, hydrogeologist with the U.S. Geological Survey, pumping the regional aquifer at a rate sufficient to cause lowering of water levels in Snake Valley may reduce or eliminate spring discharge (pers. comm. 2002). If springs dry up in the park, they would potentially have a large impact on a variety of biota, including aquatic species, riparian birds, and animals that use the riparian corridors. In addition, lowering the ground water level of Rowland Spring, located along the eastern park boundary, could have substantial effects on water levels and the cave-forming process in Lehman Caves (McGlothlin *et al*, 2000).
3. Continued spring snail surveys are needed for the Park to abide by the signed Memorandum of Understanding for the conservation and recovery of the Great Basin spring snail to avoid its listing.
4. Four coal-fired power plants are proposed for construction that may affect the park by acid rain deposition into six lakes that are deemed sensitive (acid neutralizing capacity of ≤ 200 μequiv L^{-1}) to acidic deposition and precipitation, according to the classification criteria of the EPA's National Surface Water Survey. Continued monitoring of the lakes' pH levels is needed.
5. Eighteen species of rare and/or sensitive plant species and 15 animal species occur in or near Great Basin NP. Many use springs for water sources, food sources, or use the dense foliage associated with springs for forage, cover, nest sites and roost sites.

Study Area

The study area for this project encompasses the entire 77,000-acre Park, located in the south Snake Range. Preliminary GIS work divided the Park into 25 watersheds, varying in size from 100 to 12,000 acres within the park (Figure 1). In this area, ten perennial streams originate in the Park between 6,200 and 11,000 feet elevation and are fed by numerous springs along their courses. Six creeks flow east into Snake Valley and four drain west into Spring Valley. The streams average five miles in length within the park boundaries, ranging from 0.5 miles (Ridge Creek) to 15.2 miles (Baker Creek system). Also within the Park are six alpine lakes with an average surface area of two acres, many intermittent streams, and over 400 springs.

Although Great Basin National Park is located in the Great Basin desert, it is mostly a mountainous park. The valleys on either side of the park receive annual precipitation of approximately six inches, while near the park boundary the annual precipitation as measured at the visitor center is about 12 inches. The highest parts of the mountains receive several feet of precipitation, mainly in the form of snow. Snow pack makes up the largest part of the creek water, as it slowly melts and percolates through the ground and emerges as springs that feed the streams.

The southern part of the park has a large amount of karst geology, similar to many mountains in Nevada. These carbonate rocks allow the water to percolate into the ground without flowing on the surface, thus there are no perennial streams in the southern sections of the park. The northern areas consist of metamorphic rock, which allow the water to remain on the surface.

The headquarters area obtains its water from Cave Springs, a series of springs between the visitor center and Lower Lehman campground. Water is treated and piped to the visitor center, offices, and residential area. Sewage water is directed to two sewage lagoons to the east of the headquarters area. Separate water systems are developed for Baker Creek, Lehman Creek, and Wheeler Peak campgrounds. The new visitor center and housing in the town of Baker are on the city water and sewage system. The only other major water development in the park is a three-mile long pipeline along Snake Creek that bypasses a losing section of stream over karst geology. Water enters the pipeline at 7,600 ft and exits at 7,100 ft.

Study Objectives:

- Document the location and condition of each water source in Great Basin NP, especially unknown springs.
- Complete a preliminary search for aquatic organisms at each water source, including mollusks and amphibians.
- Conduct basic water chemistry measurements (temperature, dissolved oxygen, pH, conductivity, and flow) for all water sources.
- Conduct a basic vegetative survey at each water source to search for rare and sensitive plants as well as to estimate animal use of the water source.
- Create a database and maps of water sources that can be used in future planning for backcountry trail and road management, recreational developments, watershed restoration, water rights adjudication, and water quality monitoring.

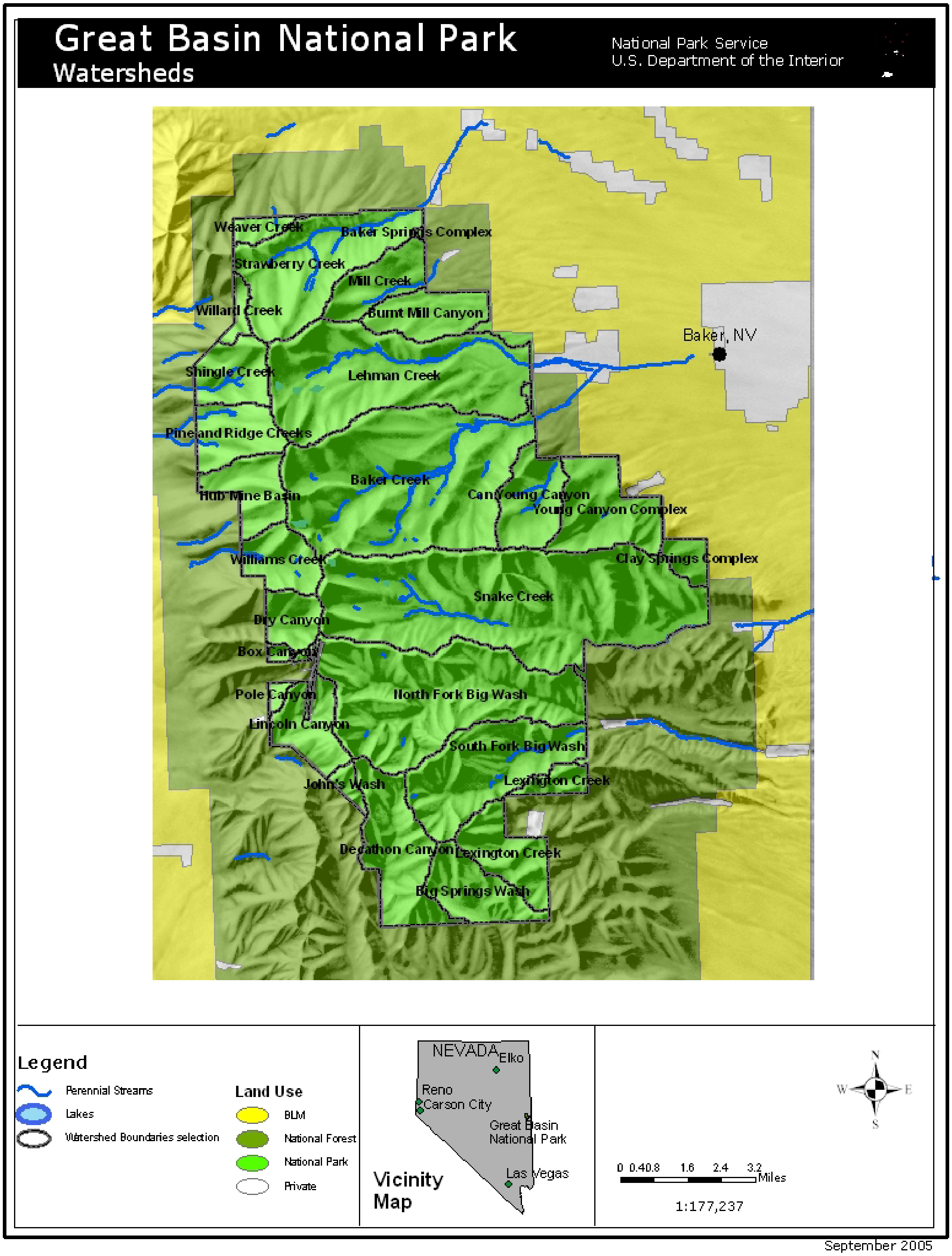

Figure 1. Great Basin National Park includes 25 watersheds.

METHODS

The following methodology was followed to conduct this study:

1. Prioritization of watersheds based on the amount of information needed and accessibility throughout the field season. Areas close to the park boundaries (Can Young, Young, Clay, Mill, Lehman and Burnt Mill watersheds) were the first priority due to the possibility of out-of-park influences such as water diversions and pumping. Second priority were alpine areas (Lincoln, Williams, Dry Canyon, Box Canyon, Johns Wash) where bighorn sheep use an unknown water source and the areas are only accessible in the middle of the summer. Third priority were watersheds that contain or will contain Bonneville cutthroat trout (Snake, Strawberry, South Fork Big Wash, Baker), in particular the upstream areas that have not been well documented.

2. Examination of late season aerial photos to find areas that most likely have water. Existing information from the National Wetland Inventory maps, fishery survey maps, spring and seep inventory and other pertinent information was synthesized and analyzed to identify data gaps.

3. Conduct field studies. Each season a crew of biologic/hydrologic technicians was hired to follow protocols to locate and survey springs. Photographs were taken with a digital camera from several locations, and the description of each site included location, spring type, area of discharge, vegetative community, aspect, slope, substrate and bedrock type. Basic water quality monitoring was conducted using YSI85 and pHTestr meters to measure temperature, dissolved oxygen, conductivity, and pH in accordance with the basic water quality parameters that the Water Resources Division wants measured in each park. The technicians also searched for aquatic organisms at each water source. Full details of the field methods are included in the *2004 Aquatic Survey Field Manual* (Baker 2004).

4. Production of high quality GIS layers for resource management and park. Data collected during the field surveys was imported into ARCGIS and made into a shapefile. The data can be sorted, summarized, and displayed in ArcGIS.

5. Placement of water quality data into an approved database that meets with national standards (including the Water Resources Division standards) and the Inventory and Monitoring database management plan. The data was transferred into the NPStoret database in December 2005, and submitted to and checked by Dean Tucker of the Water Resources Division of the NPS. It was subsequently uploaded to EPA's STORET database.

Collecting and handling physical, biological, and chemical parameters for this project followed protocols in the *Aquatic Resources Protocols Manual* of Great Basin National Park (2003) and the newly developed *Aquatic Inventory Field Manual* (2004). These manuals follow Water Resources Division (WRD) guidelines for field and laboratory protocols. In addition they include information about collecting sufficient metadata.

RESULTS and DISCUSSION

All study objectives were met for this project. All 25 of the park watersheds were thoroughly searched for water (Table 1), and all perennial water sources were documented with GPS units (NAD83) and descriptions to be able to easily find the water sources again. All data was entered into the newly developed Aquatics Database and subsequently transferred to ArcGIS for spatial analysis.

Table 1. Watershed size and number of perennial water sources

Watershed Abbreviation	Full Name	Size of watershed (acres)	Number of Perennial Springs	Perennial Stream Miles in Park	Number of Lakes
BAKE	Baker	10,934	148	15.2	1
BISP	Big Springs	1,984	0	0	0
BOXC	Box Canyon	156	0	0	0
BUMI	Burnt Mill	1,761	4	0	0
CAYO	Can Young	2,004	19	0	0
CLAY	Clay Springs	603	0	0	0
DECA	Decathon	3,241	1	0	0
DRYC	Dry Canyon	1,055	0	0	0
HUBM	Hub Mine	1,598	0	0	0
JOHN	Johns Wash	337	0	0	0
LEHM	Lehman	8,224	79	6.5	3
LEXI	Lexington	2,517	1	0	0
LINC	Lincoln	1,723	2	0	0
MILL	Mill	1,700	13	1.8	0
NFBW	North Fork Big Wash	8,310	6	0	0
PIRI	Pine/Ridge	1,714	15	1.2	0
POLE	Pole Canyon	143	0	0	0
SFBW	South Fork Big Wash	4483	12	4.3	0
SHIN	Shingle	1606	9	0.9	0
SNAK	Snake	13,021	39	11.6	2
STRA	Strawberry	4,820	59	5.3	0
WEAV	Weaver	488	2	0	0
WILL	Willard	375	0	0	0
WILM	Williams	1,486	11	0.6	0
YOUN	Young	2,817	7	0	0
Total		**77,100**	**427**	**47.4**	**6**

Geology is very important to spring location. The northern section of the park is largely underlain by metamorphic rock, which allows the water to be expressed in springs and streams, and most of the springs are located here (Figure 2). The southern section of the park is largely karst, so the water sinks and enters the carbonate aquifer (Figure 3). About 61% of the springs are within 50 m of a geologic contact, while 66% are within 50 m of a perennial stream. Altogether, 85% of the park's springs can be found within 50 m of a geologic contact or a perennial stream. Baker Creek watershed contains the most springs, (n=148), while eight of the park's 25 watersheds have no springs, largely due to underlying karst geology. About 10% of the springs are at elevations greater than 10,000 ft, with 61% between 8,000 and 10,000 ft and the remainder below 8,000 ft.

Most of the springs occur in relatively flat areas; 239 have a slope of 0-10°, 123 have a slope of 11-25°, 47 have a slope of 26-40°, 16 have a slope of >40°, and two were unrecorded. The primary aspect, or direction of flow, of the springs is east (n=153), followed by northeast (n=81), north (n=79), southeast (n=38), west (n=27) northwest (n=20), south (n=19), southwest (n=8), and not recorded (n=2). Since most of the park is located on the east side of the South Snake Range, these results are not unexpected.

Nearly 17% of the springs had some disturbance near them, with roads and trails as the most common type of disturbance. Considering the large number of springs that are disturbed in the West, this is a small proportion of springs that have been impacted. Nevertheless, with the protection of the surrounding land as a national park, reducing the amount of disturbance should be a park priority.

Vegetation around the springs is closely related to elevation. Since most of the springs are found above 8,000 feet, 76% of them have aspen-mixed conifer habitat around them, while 11% have pinyon/juniper, 9% have sagebrush, and the remainder have a variety of vegetation types. Roughly 23% of the springs have encroachment nearby, identified as white fir taking over aspen stands and pinyon/juniper moving into sagebrush next to the springs (Figure 5). This encroachment has the potential to reduce springflow, since white fir and pinyon/juniper use more water than aspens and sagebrush. The park plans to begin a thinning project near historical springs to remove the pinyon-juniper and try to bring back the water flow beginning in 2006. Vegetation in the springs is dominated by moss, watercress, and sedge. Wetlands had previously been identified in the park using remote sensing in 1996 and ground-truthing in 1996-97. Despite 400 identified wetland areas throughout the park (Figure 6), only 131 (31% of total) perennial springs are found in or within 50 m of these wetlands. Many of the wetlands may only be seasonally wet, and since this spring inventory project focused on perennial water sources, they would not have been included. In addition, many of the springs surveyed have little or no riparian area.

With more than 75% of the species in the Great Basin region strongly associated with riparian vegetation (U.S. General Accounting Office 1993), we expected to find wildlife sign at many springs, and we did at 87% of the springs. Signs include trails, scat, wallows, and live and dead animals. Of particular interest to the park are mollusks, due to the Memorandum of Understanding for springsnails. About 12% of the springs had mollusks present, primarily clams, but some with snails. Snails were collected from five springs in 2005 and sent to Dr. Robert Hershler at the Smithsonian Institute for identification. He identified *Pyrgulopsis kolobensis* springsnails from two locations in Snake Creek and *Valvata humeralis* snails from five locations. While looking for springs, the field crew discovered a new marmot population in the Strawberry Creek watershed up Windy Canyon. Since only one population had previously been known in the park, this was an ecologically important find.

Cultural features were documented at seven percent of the springs (Figure 6), and included old livestock watering troughs that had not been previously documented, old signs, and an array of historic litter. The cultural resources staff will be following up on these discoveries in addition to surveying selected springs for prehistoric evidence. Some of the cultural finds near springs are found in photos in a later section.

Water chemistry at the springs was generally in what is considered to be the normal range for this area. The mean water temperature for all park springs is 7.3° C (± 2.9° C within one standard deviation (s.d.)). The mean specific conductance is 91.5 (± 90.5) uS/cm, the mean dissolved oxygen is 6.2 (± 2.0) mg/L, and the mean pH is 6.8 (± 0.7) (Table 2). As expected, watersheds in the southern part of the park had springs high higher specific conductance and temperature, along with those that have pockets of carbonate rock like Weaver and Young Watersheds.

Table 2. Water quality by watershed.

WATERSHED	# Springs	Water Temp (C)	Specific Conduc-tance (uS/cm)	Dis-solved Oxyge n (mg/L)	pH
Baker	148	7.7± 3.0	67.6 ± 72.7	5.5 ± 1.9	6.7 ± 0.7
Burnt Mill	4	8.5 ± 1.4	115.3 ± 39.8	6.2 ± 1.9	6.9 ± 0.4
Can Young	19	5.7± 2.3	145.2 ± 102.2	6.3 ± 2.3	6.9 ± 0.3
Decathon	1	19.0	399.0	4.3	7.1
Lehman	79	7.6 ± 3.2	53.4 ± 42.7	6.9 ± 1.7	6.4 ± 0.6
Lexington	1	13.4	630.0	2.6	7.7
Lincoln	2	3.4 ± 0.4	321.7 ± 57.8	7.5 ± 1.4	7.9 ± 0.2
Mill	13	7.1 ± 2.3	66.4 ± 70.4	6.7 ± 1.8	6.8 ± 0.4
North Fork Big Wash	6	6.5 ± 3.4	259.9 ± 84.7	7.3 ± 2.6	7.8 ± 0.2
Pine/Ridge	15	6.4 ± 2.2	49.0 ± 26.6	6.8 ± 2.3	7.7 ± 1.0
South Fork Big Wash	12	7.2 ± 0.8	294.4 ± 75.1	7.0 ± 1.7	7.5 ± 1.1
Shingle	9	6.4 ± 1.9	53.1 ± 22.8	7.0 ± 1.6	7.5 ± 1.1
Snake	39	7.7 ± 3.5	88.5 ± 63.8	6.4 ± 2.1	6.8 ± 0.6
Strawberry	59	6.4 ± 2.0	117.2 ± 63.3	6.0 ± 2.1	6.9 ± 0.5
Weaver	2	9.6 ± 3.1	182.9 ± 3.8	4.8	7.0 ± 0.1
Williams	11	4.8 ± 1.6	31.0 ± 7.1	9.4 ± 1.6	7.0 ± 0.3
Young	7	10.5 ± 1.7	167.0 ± 155.0	7.2 ± 1.6	6.9 ± 0.3
OVERALL	427	7.3 ± 2.9	91.5 ± 90.5	6.2 ± 2.0	6.8 ± 0.7

Further examination of the water quality by geologic unit reveals some interesting items (Table 3). Springs are found in greatest number with an underlying gologic structure of glacial deposits (n=161), unconsolidated sediments (n=130), and Prospect Mountain Quartzite (n=51). Springs in glacial deposits have the lowest specific conductance with a mean of 44.1 and a standard deviation of 35.7 uS/cm. Also less than 100 uS/cm are springs in the McCoy Creek Group and Prospect Mountain Quartzite. Springs with conductance more than 300 uS/cm are

Table 3. Water quality by geologic group.

GEOLOGIC GROUP	Acres	% Park	# Springs	Elevation (m)	Water Temp (C)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/L)	pH
McCoy Creek Group (PRE-CAMB)	4394	5.7	26	2749 ± 153	6.5 ± 2.1	49.9 ± 25.2	7.0 ± 1.7	7.2 ± 1.7
Granitic Rock (JUR-TERT)	10731	13.9	35	2649 ± 241	7.7 ± 3.4	103.9 ± 88.2	5.2 ± 2.9	6.4 ± 2.0
Prospect Mountain Quartzite (CAMB)	19670	25.5	51	2638 ± 234	6.6 ± 2.5	65.1 ± 48.3	6.1 ± 2.1	5.9 ± 2.2
Unconsolidated Sediments (QUAT)	5947	7.7	130	2318 ± 140	8.7 ± 2.8	107.3 ± 87.8	5.3 ± 6.2	6.5 ± 1.4
Glacial Deposits (QUAT)	6138	8.0	161	2852 ± 211	6.1 ± 2.8	44.1 ± 35.7	6.4 ± 4.6	6.2 ± 1.8
Pole Canyon Limestone (CAMB)	8294	10.8	4	2597 ± 299	8.3 ± 1.3	359.7 ± 69.2	5.0 ± 2.5	7.5 ± 0.3
Pioche Shale (CAMB)	1832	2.4						
Eureka Quartzite & Pogonip Group (CAMB-ORD) incl House LS	8770	11.4	6	2843 ± 164	10.0 ± 4.7	376.8 ± 135.8	4.8±1.7	7.7 ± 0.3
Corset Spring, Johns Wash & Lincoln Peak Formations (CAMB)	6312	8.2	9	2709 ± 289	5.5 ± 2.0	273.9 ± 59.4	7.9 ± 1.1	7.9 ± 0.3
Notch Peak Limestone (CAMB)	1568	2.0	1	2848	4	202.5	9.8	7.7
Simonson, Levy, Laketown & Fish Haven Dolomites (ORD-DEV)	1931	2.5	1	2107	6.7	379	9.2	7.5
Landslide Debris (QUAT)	629	0.8	1	2390	8.5	252.7	8	8.5
Guilmette Formation (DEV)	301	0.4	0	n/a	n/a	n/a	n/a	n/a

located in Pole Canyon Limestone; Simonson, Levy, Laketown, & Fish Haven Dolomites; and Eureka Quartzite & Pogonip Group. Water temperature is highest for springs in this last group. pH is lowest in springs in the Prospect Mountain Quartzite (5.9 $\pm$ 2.2), and highest for springs in the Corset Spring, Johns Wash & Lincoln Peak Formations (7.9 $\pm$ 0.3), along with the one spring in Landslide Debris (8.5).

Water quantity is one of the hardest parameters to measure, since many springs do not have simple channels, but instead are diffuse, flowing out into a wide vegetated area. When possible, the spring was measured using the bottle method, but many times an ocular estimate was the most viable way of estimating the discharge, so several categories were created. Only 8 springs had discharge over 1 cfs; 25 between 0.1 and 1.0 cfs; 101 between 0.01 and 0.1 cfs; 209 between 0.001 and 0.01 cfs, 68 less than 0.001 cfs (generally a small seep with virtually no flow); and 16 were not recorded (Figure 5). It must be remembered that all of these measurements were done during drought years between April and November, so seasonality affected some of these measurements as well as the drier than normal period. The drought did help the project in that only perennial springs were studied, and in most cases the park staff knew that if the spring was running during the dry years, they would run anytime. Several springs that are listed on topographical maps were found to be dry (Figure 8), most likely due to the intense drought, but possibly also from encroachment.

One long-lasting document from this project is the Watershed Summaries report (to be submitted during the winter of 2005-06), which summarizes all aquatic information for each of the 25 watersheds within the park. The summary also includes a data portion, where all electronic data regarding aquatic resources is gathered in one spot. This data includes water chemistry, water discharge, macroinvertebrate surveys, physical habitat surveys, fish surveys, and historical records. This information will greatly assist future aquatics reports.

BUDGET

The budget provided adequate for hiring field crews for two seasons to complete the project, along with vehicles, equipment, aerial photos, and limited travel (Table 4).

Table 4: Budget for Aquatic Survey project

Item	2003	2004
Personnel, 4 GS-5 seasonals	$29,394.26	$34,884.47
Travel and Vehicle Costs (backcountry travel)	$366.84	$1,060.00
Vehicle Costs (for use of GSA vehicle)	$2,000.00	$1,000.00
Aerial Photos (flown by the USFS for the most up-to-date imagery)	$3,000.00	$0
Equipment Costs (YSI85 meter, pHtestrs, tape measures, compasses, ArcPad computer software, two Trimble XM units, two cameras, five Garmin Rino units, two Kestrels, six thermometers)	$25,738.90	$4,413.94
TOTAL	**$58,500**	**$41,358.41**

CONCLUSIONS

This project has allowed the park to develop a comprehensive map and database of its perennial water sources. This information will be used for a wide variety of projects ranging from fire planning to archeological surveys to trail construction.

Future needs include determining which springs are most at-risk due to water withdrawals, air deposition of contaminants, and other factors such as construction and maintenance of roads and trails. These springs, along with others determined to be of high priority, should be monitored on a regular basis to determine if conditions are changing and actions should be taken. In addition, many components of this study, such as wildlife and vegetation, were qualitative in nature. Quantitative surveys of these items would greatly aid in future monitoring to determine changes in community composition and abundance.

This study would not have been possible without the support of the Water Resources Division of the National Park Service, which provided funding and oversight of the project.

LITERATURE CITED

Baker, Gretchen. 2004. Aquatic inventory field manual. Great Basin National Park files. Baker, NV.

Baxter, Lee, 1994. Great Basin National Park Hydrologic Inventory. Bureau of Reclamation. Provo, UT.

McGlothin, Dan, Jennifer Back, Jeff Hughes, Bill Van Liew. 2000. Trip Report for Travel in the Southern Nevada Portion of the Colorado Groundwater Flow System and to Great Basin National Park, May 22-25, 2000. Water Resources Division, National Park Service.

Metcalf, Richard C., Glenn D. Merritt, Martin A. Stapanian, John R. Baker, Kit M. Peres, and James E. Pollard. 1989. Chemistry of Selected Lakes and Streams in Great Basin National Park, Nevada during Winter and Spring 1989. EPA.

Prudic, Dave. 2001. Personal Communication. Hydrogeologist, U.S. Geologic Survey. Carson City, NV.

Schenk, Gretchen, Neal Darby, and Bryan Hamilton. 2003. Aquatic Resources Protocols Manual. Great Basin National Park files. Baker, NV.

U.S. General Accounting Office. 1993. Livestock grazing on western riparian areas. Gaithersburg, MD. 44 pp.

Water Resources Division, NPS, 2000. Baseline Water Quality Data: Inventory and Analysis; Great Basin National Park.

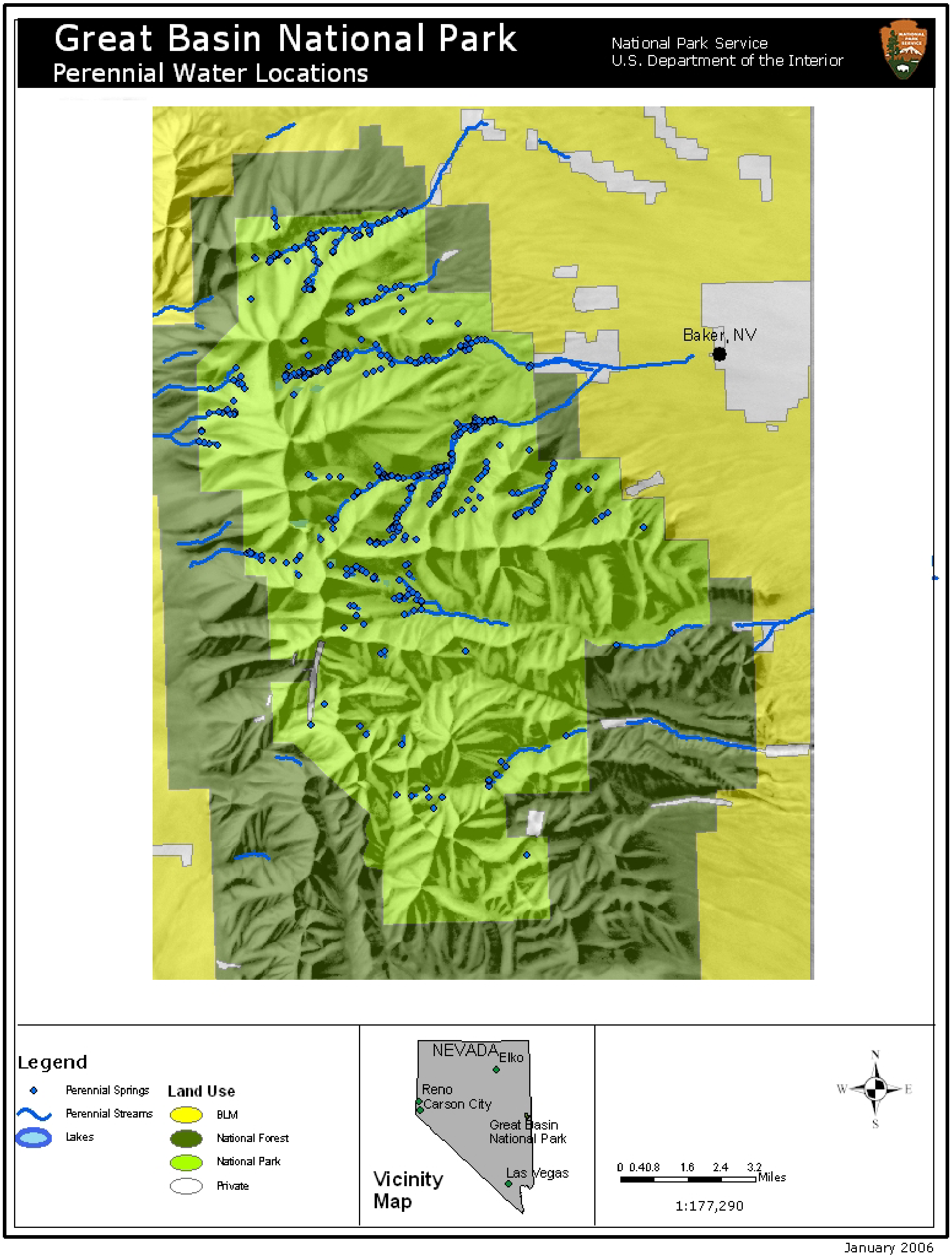

Figure 2. Perennial water sources in Great Basin National Park.

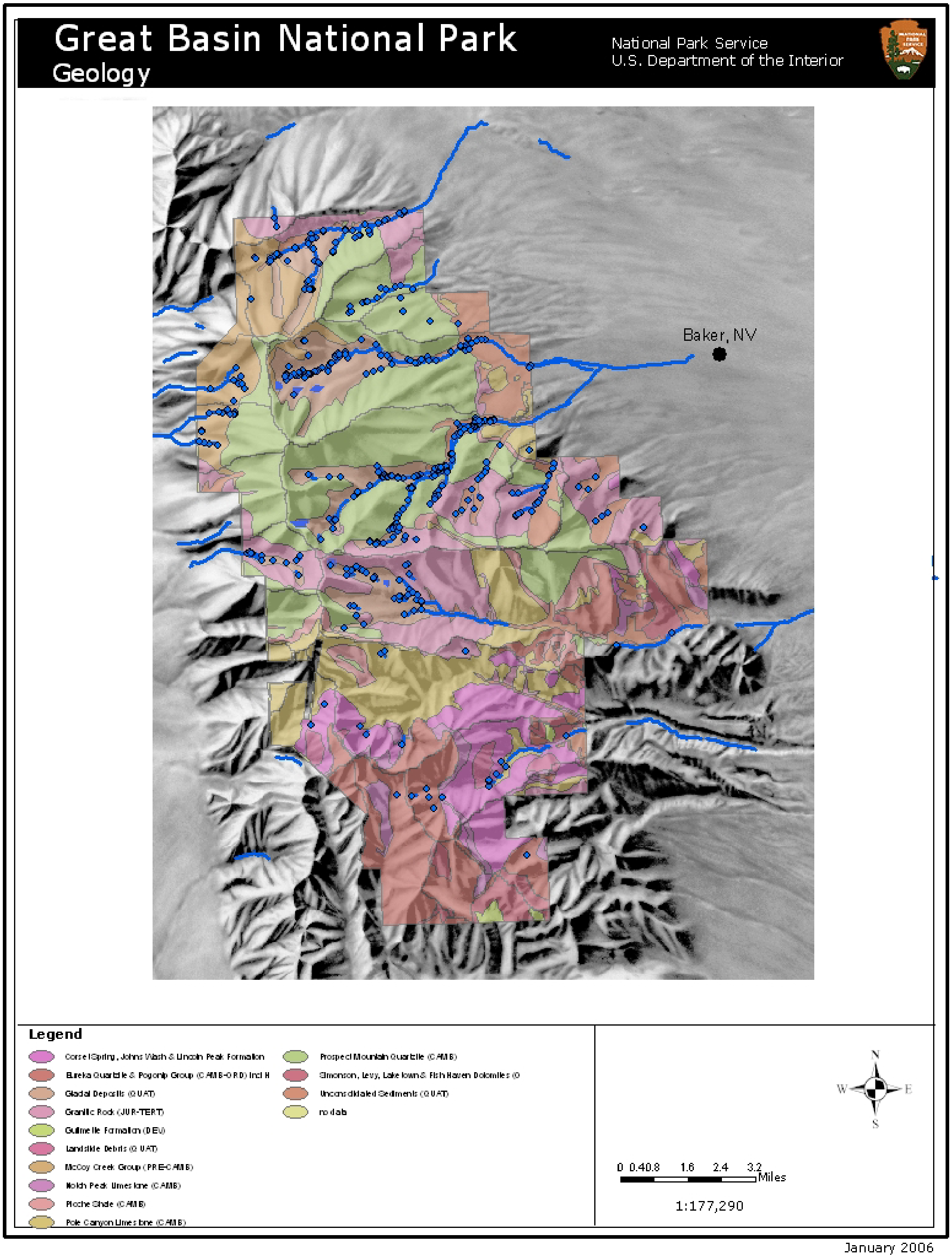

Figure 3. Geologic features of Great Basin National Park, with perennial water sources overlain.

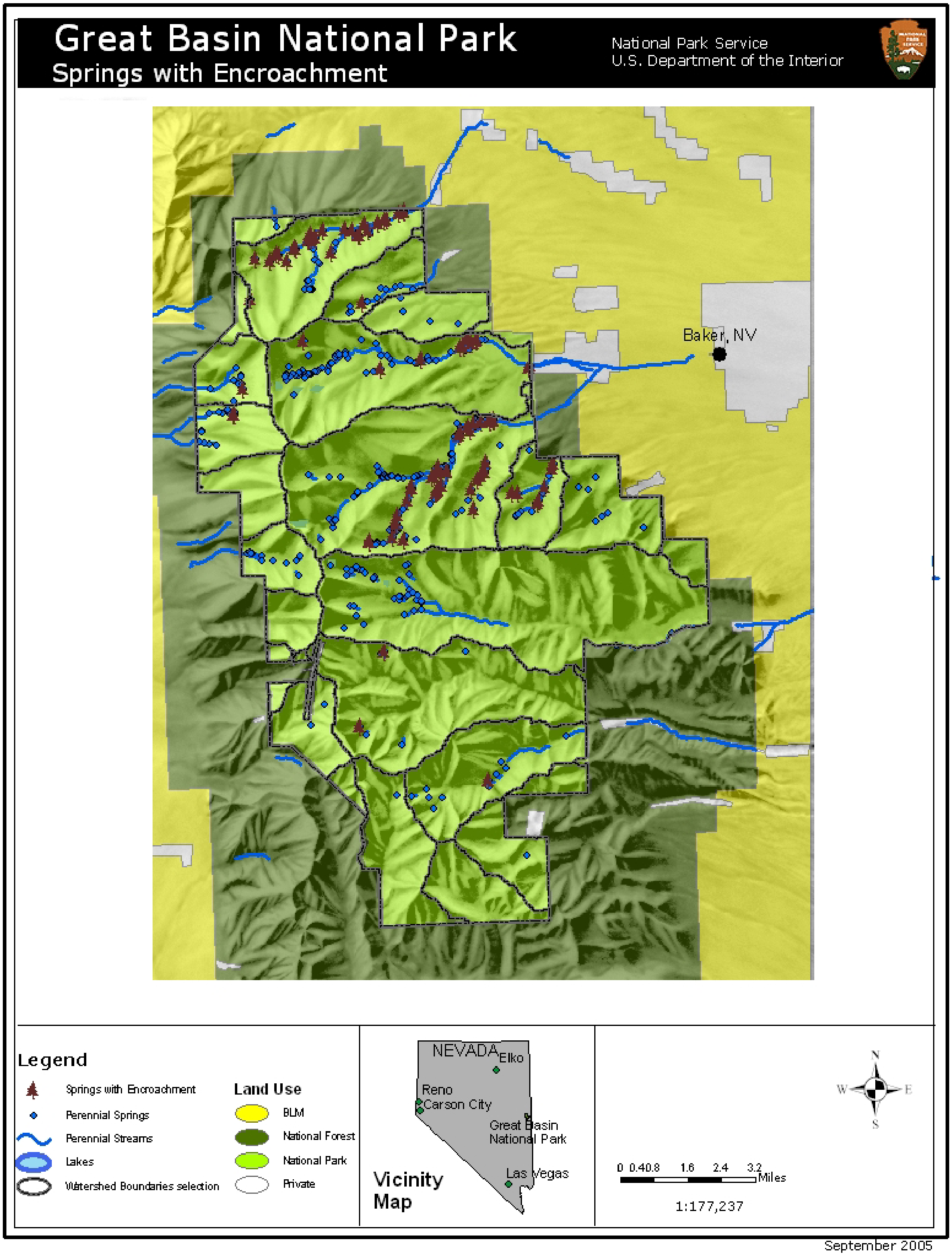

Figure 4. About 23% of the springs have vegetation encroachment near them, with pinyon/juniper taking over sagebrush stands and white fir invading aspen stands. These vegetation changes could have impacts on water flow.

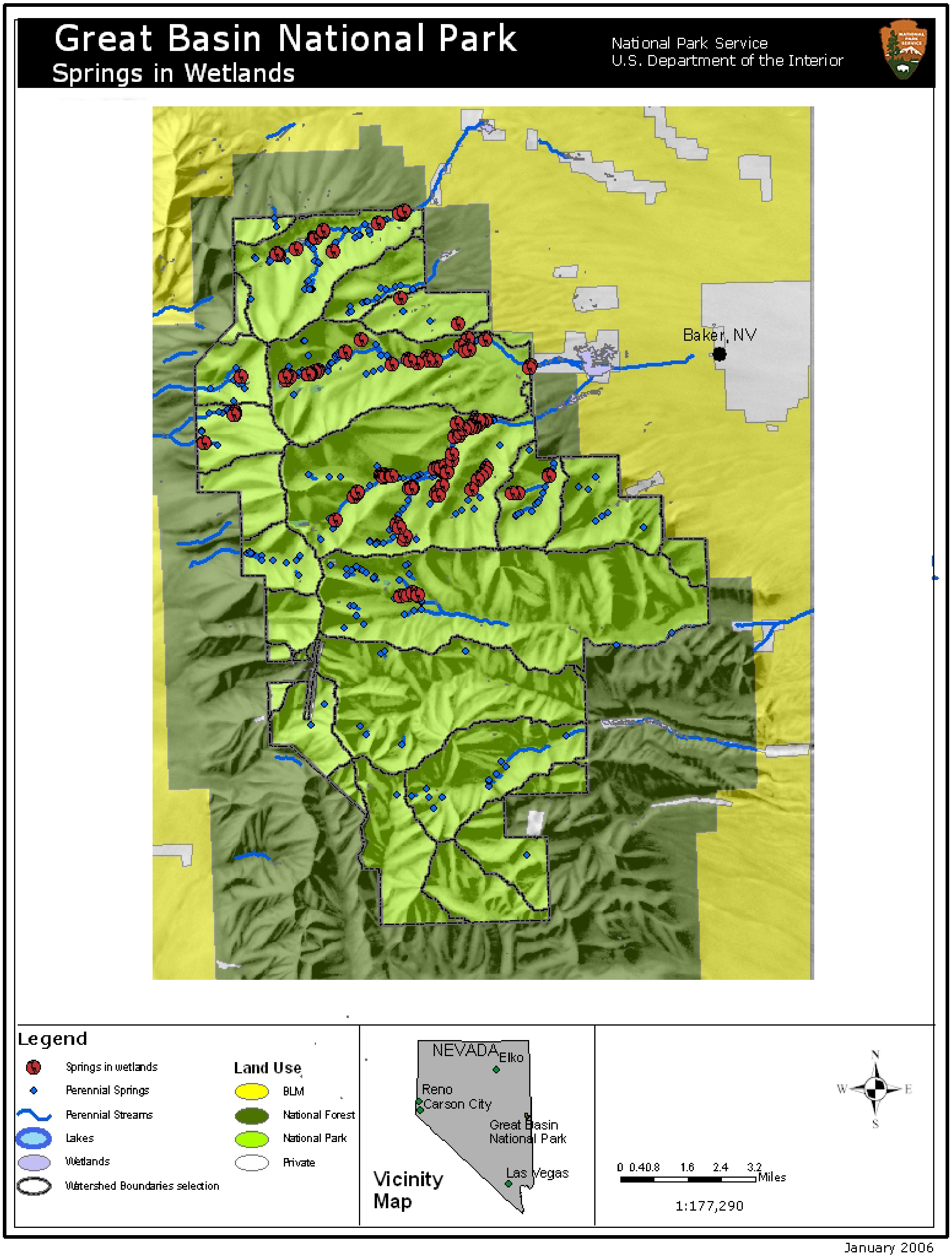

Figure 5. Surprisingly, only 131 (31%) of perennial springs are found in wetland areas. This is due to many wetlands drying up during droughts and the absence of riparian and wetland vegetation near many of the springs.

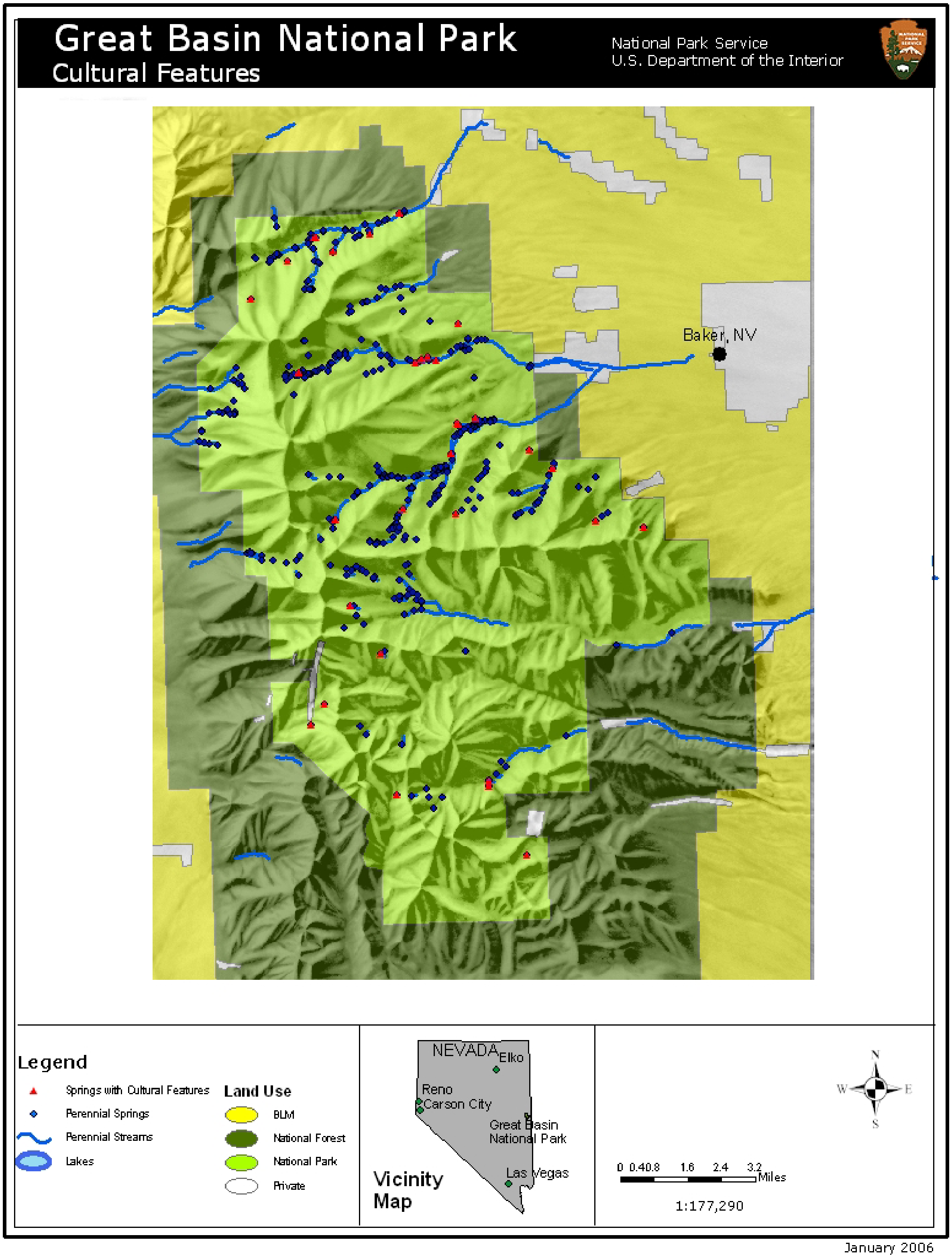

Figure 6. Locations of springs with cultural artifacts.

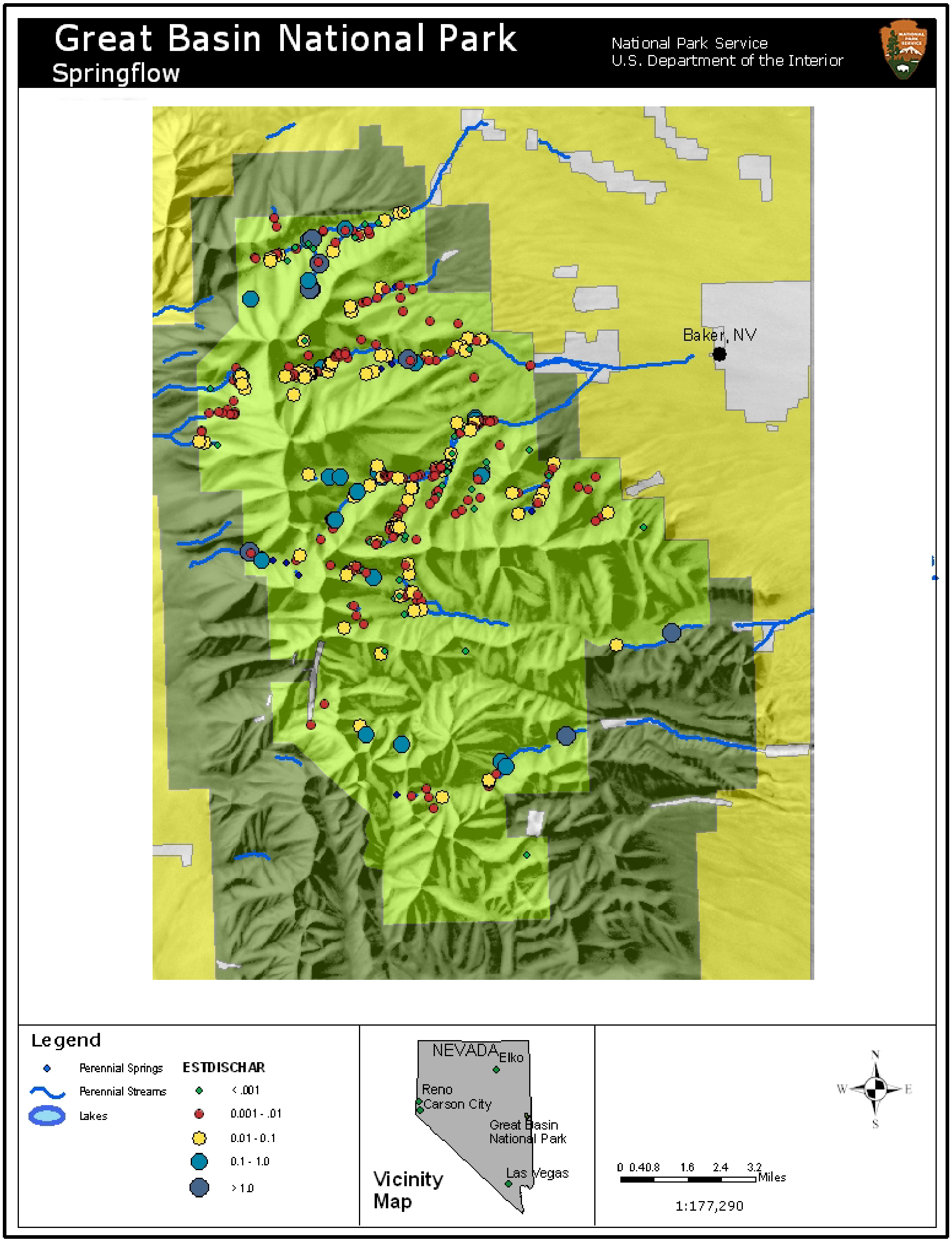

Figure 7. Springflow during 2003-2004 field seasons. Each spring was measured one time, so seasonality and dry/wet years can have large effects on the amount of springflow from each spring. 2003 and 2004 were drought years.

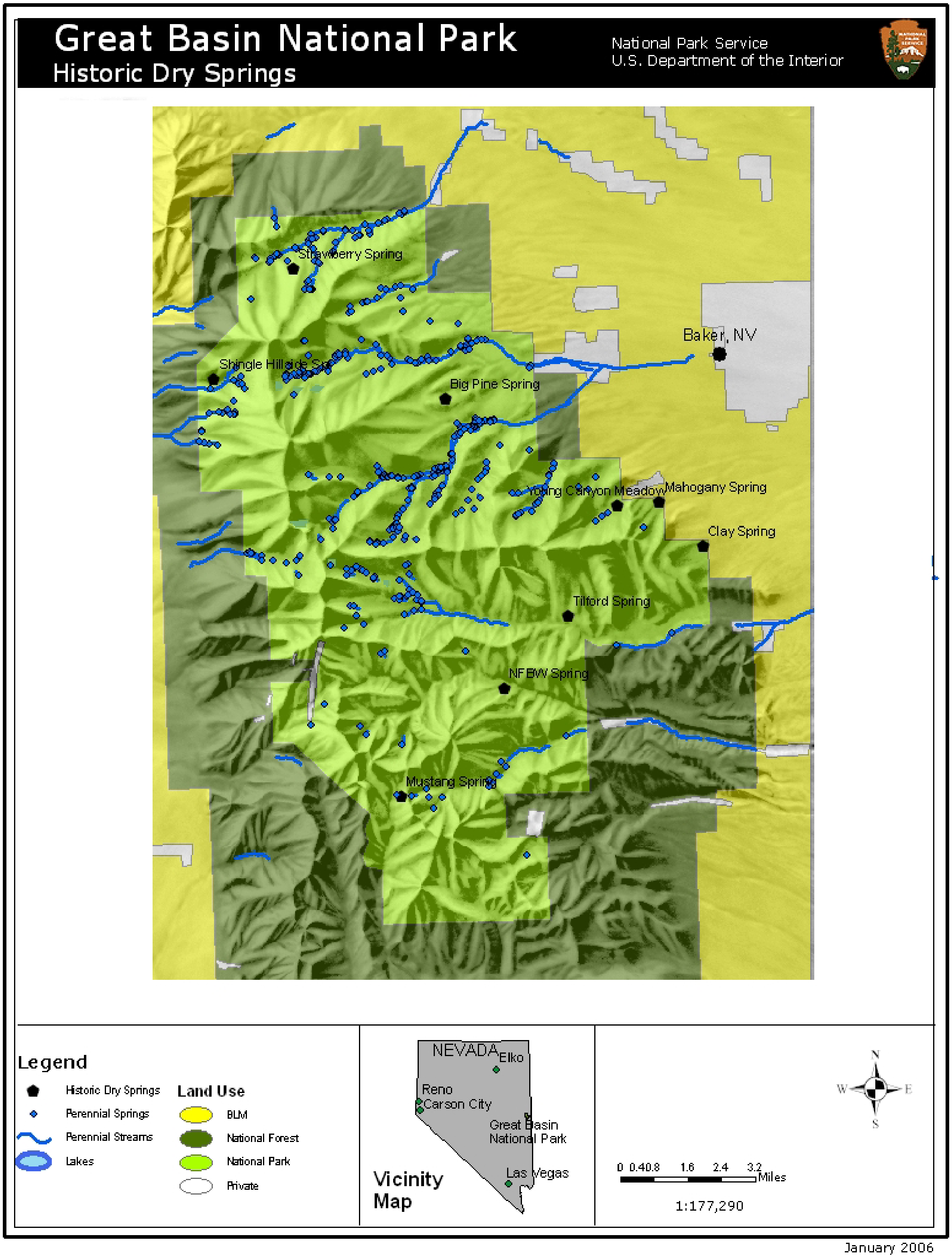

Figure 8. Several named springs dried up during the 2003-2004 drought years. These springs had previously been thought to be perennial springs.