FRIENDS OF THE RIO DE FLAG

October 18, 2011

Leah Schofield, Environmental Coordinator
Flagstaff Ranger District
Coconino National Forest
5075 N. Highway 89
Flagstaff, AZ 86004

Dear Ms. Schofield:

The Friends of the Rio de Flag wholeheartedly supports the desired condition of healthy, self-sustaining riparian vegetation for Maxwell and Big Leroux Springs included in the September 2011 proposed action of the Coconino National Forest's Wing Mountain Fuels Reduction and Forest Health Restoration Project. We particularly support the proposed action for Big Leroux Spring to "construct and maintain ungulate-deterrent fences to restore riparian vegetation [and] re-plumb and release excess water to create riparian area, including potential breeding habitat for northern leopard frog."

Friends of the Rio de Flag is a more than 150-member Flagstaff-based community group that promotes the Rio de Flag's natural stream system as a unique and valuable natural resource, an asset, and amenity to the City of Flagstaff and the surrounding community. The goal of the Friends of the Rio de Flag is to protect, restore, clean up and improve the Rio de Flag and its tributaries to maximize their beauty, educational, recreational, and natural resource values, including the riparian habitats they provide.

It may be a bit of a stretch to argue that Flagstaff would not exist if Leroux Springs had not served as an essential oasis for the early expeditions across the Colorado Plateau, but there is no doubt that without this abundant and reliable water source Fort Valley would never have developed its rich ranching and farming history. The restoration of spring health and riparian vegetation at Big Leroux Spring would not only return its services to the ecosystem but would recognize and honor its more than 150 years of service to the region's human development.

Enclosed are a "white paper" entitled "Big Leroux Spring" and a CD containing a collection of documents describing topics ranging from history to recent inventories of plants at Big Leroux Spring. Our specific recommendations are included in the white paper. Please accept these items as our organization's input in response to the September 2011 proposed action.

Many members of Friends of the Rio de Flag have a long-term interest in the Leroux Springs and may be interested in participating in the restoration process. Possible contributions of time and expertise may be available for the following tasks and others that may arise in the future:

- Monitoring (e.g., hydrology, photography, mapping, botanical surveys)
- Participating in or coordinating work projects
- Fence construction
- Site cleanup (especially old plastic pipe in the area)
- Invasive plant removal, including assistance with identification of potential funding sources and grant writing
- Public outreach and education, including signage

We look forward to continuing engagement in this process.

Sincerely,

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Encl.

Big Leroux Spring

by Stephen Monroe, Shannon Clark, and John Grahame

on behalf of the Friends of the Rio de Flag as input to the Wing Mountain Fuels Reduction and Forest Health Restoration Project

Submitted to:
Leah Schofield, Environmental Coordinator
Flagstaff Ranger District
Coconino National Forest
5075 N. Highway 89
Flagstaff, AZ 86004

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Introduction

Big and Little Leroux Springs flow near the base of the San Francisco Peaks and are the perennial surface headwaters of the Rio de Flag (see Figure 1). Since there are few other reliable water sources in the area, the springs were important to Native Americans and played a critical role as a source of water for early explorers and settlers in the Flagstaff region.

It was common in the early years to refer to all the springs and various seeps in the upper end of Fort Valley as the Leroux Springs; maps of the area did not designate the primary springs as Big and Little Leroux Springs until the 1930's. The proposed action addresses only Big Leroux Spring, described by historian Platt Cline as "the finest spring at the foot of the San Francisco Peaks." (P. Cline, "They Came to the Mountain," p. 18).

In 1927 the Coconino National Forest acquired the land on which Big Leroux Springs is located; however, the water rights did not transfer with the land. It was not until 1979 that the Forest Service filed a formal water rights claim for Big Leroux Spring for the amount of 0.19 acre feet per year. In 1986 the claim was modified to 16.1 acre feet per year for the purposes of "Irrigation, Stock & Wildlife Water, Domestic, and Firefighting." Water rights for Little Leroux Spring in the amount of 3,000 gallons per day have been held by the Southwestern Forest and Range Experiment Station, now the Rocky Mountain Research Station, since 1934 for the purpose of "Forest Nursery and Domestic Supply for Experiment Station." In recent years, need for water from the two springs has diminished, opening the opportunity for release of flow and ecological restoration of the site.

The February 2011 Coconino National Forest Draft Land Management Plan includes the following:

Management Approaches for Springs

- Continue working with partners and stakeholders, including tribes, to inventory, classify, and prioritize springs for restoration. Include consideration of rare and endemic species when evaluating springs for restoration.
- Work with partners and stakeholders to develop strategies for restoration of upland watersheds to improve spring flows.

Guidelines for Springs

- Structures that divert or alter spring flows should be minimized and/or modified to allow some flow from the spring's source and still maintain established water rights.
- Open vegetative conditions in the watershed's surrounding springs should be maintained where feasible to raise the water table.
- Access to springs should be limited to trails or entry points that minimize erosion, trampling, compaction, and inadvertent introduction of non-native and undesirable plants, animals, and disease.
- Fences constructed around springs should not cause harm to wildlife.

The September 2011 Wing Mountain Fuels Reduction and Forest Health Restoration Project Proposed Action includes a "desired condition of healthy, self-sustaining riparian vegetation for Big Leroux Spring. " It further proposes "replumbing and releasing excess water to create riparian area, including potential breeding habitat for northern leopard frog," and "construction and maintenance of ungulate-deterrent fences to restore riparian vegetation." These proposed actions are consistent with the Guidelines and Management Approaches cited above.

History

Discovery and Early Expeditions

Antoine Leroux, for whom the springs are named, was a companion of Kit Carson, a friend of Old Bill Williams, and the first American to thoroughly explore the San Francisco Mountain country. He guide several of the major expeditions through the region, including the first to visit the area, the 1851 expedition by Capt. Lorenzo Sitgreaves for the U.S. Army Corps of Topographical Engineers to survey a road from Zuni to the Colorado River (*Ibid*, p. 17).

The Sitgreaves expedition followed the Little Colorado River downstream as far as Grand Falls, which Sitgreaves named, then turned west toward San Francisco Mountain, as the Peaks were known at the time. Arriving at the Wupatki ruins and impressed by the beauty of the area, they expected to find water coming from the Peaks. They did not, and moved around the north and northwesterly sides of the mountain in search of it. On October 12th, on the verge of abandoning the expedition altogether, mule packmaster Juan de Díos fired his musket to alert the rest that he had encountered "a spring of delicious water" (L. Sitgreaves, "Report of an Expedition down the Zuni and Colorado Rivers in 1851," p. 11).

He had found Big Leroux Spring, later described by Lt. Edward F. Beale as "...one of transparent sparkling water, [that] bursts out of the side of the mountain and runs gurgling down for a quarter of a mile, where it loses itself in the valley." (E. Beale, *Wagon Road from Fort Defiance to the Colorado River*. p. 51). During the night the mules were stampeded by "the roaring of a panther, or other large animal, in uncomfortable proximity to the herd" (Sitgreaves, *op. cit.*, p. 11).

Accompanying the 1851 Sitgreaves expedition was Surgeon-Naturalist S. W. Woodhouse, who collected plant and animal specimens and kept a detailed journal. The expedition spent two days at Leroux Springs, where Woodhouse collected and named *Sciurus aberti*, the Abert's squirrel. He collected two other rodents at the spring. One he called red sand rat and named it *Geomys fulvus*. Reclassified later as *Thomomys bottae fulvus*, it is known today as the western or pygmy pocket gopher. The other was a mouse he had observed earlier at Zuni, the pocket mouse, *Perognathus penicillatus* (A. Wallace and R. Heavly, "From Texas to San Diego in 1851: The Overland Journal of Dr. S. W. Woodhouse, Surgeon-Naturalist of the Sitgreaves Expedition," p. 116).

Woodhouse also collected two amphibious species in the vicinity of Big Leroux Spring. A dark brown toad with prominent cranial crests was recognized as unique in 1858 by Charles F. Girard, who named it for Woodhouse, *Bufo woodhouseii* (Woodhouse's toad). Salamanders were also abundant near the spring. Today they are considered a subspecies of the tiger salamander (*A. tigtinum nebulosum*) (*Ibid.*, p. 116).

Woodhouse identified at least seventeen species of birds at the spring, but took few specimens. An exception was the hepatic tanager (*Piranga flava*), which turned out to be the first example collected in the United States. (*Ibid*., p. 116).

In 1853-54 Leroux was a guide for A.W. Whipple, who was in search of a railroad route to Los Angeles. It was Whipple who named the springs in Leroux's honor and first recorded its temperature - 48.4 degrees Fahrenheit (9.1 degrees Celcius). The Santa Fe railroad later followed the Whipple reconnaissance route from Winslow to Flagstaff (*Ibid.* p. 152). Other recorded expeditions that stopped at Leroux Springs were led by Lt. Edward Beale in 1857 (Beale Wagon Road), Lt. Joseph Ives in 1858, and Gen. William Palmer in 1867 and 1868. (S. Olberding, "Fort Valley Then and Now: A Look at an Arizona Settlement." p. 11-12).

Beale, who made four journeys through the area, had the highest regard for Leroux, and the Beale Road was carefully routed near Leroux Springs. Platt Cline wrote: "Leroux could be described as father, perhaps grandfather, of Flagstaff, because he was the first to become intimately acquainted with the area, and it was on his advice that the expeditions followed the general routing through here which they did." (Cline, *op. cit.*, p. 18).

The Beale Road began to attract wagon trains to Leroux Springs even before the road was completed. A journal from one of the first, the Rose-Bailey wagon train in 1858, was kept by

John Udell. Some days after visiting Leroux Springs the party was attacked by Mohave Indians, and Udell's journal caused a sensation when it was published in 1859. The group arrived at the springs on July 27th. San Francisco Mountain is described as being "perpetually covered with snow." On July 28, some of the men in the party went hunting and returned with "deer, antelope and turkeys enough for the whole company." Another group headed up-slope and returned to Big Leroux Springs "with snow enough for all to taste." On July 28! (J. Udell, "Journal of a Trip Across the Plains, Containing an Account of the Massacre of a Portion of His Party by the Mohave Indians in 1858," p. 31).

Settlement

It's not certain when the first "improvements" were made to Big Leroux Spring but Robert Coody, in his history of Fort Valley, speculates that Beale and his engineers may have been the ones to have "dug a basin into which the springs flowed, providing water for animals and men alike." Coody does supply us with a useful date: "On July 2nd, 1859, F. C. Engle, a member of the expedition, noted that the spring had been diverted down a trench for 1500 feet, and in spots it was dammed to form pools. This trench may have provided water to a station of the Central Overland Mail Company." Coody describes the mail station at Leroux Springs as "the first historic structure known to have existed in Fort Valley, although its exact location remains unknown." The Central Overland Mail Company was established in 1856 to carry mail and supplies by wagon or rider over the Beale Road (R. Coody, "Historic Fort Valley: Archaeological Survey and Historic Overview," p. 34).

Although there may have been a short-lived settlement in the early 1870's at Leroux Prairie, as Fort Valley was known prior to 1877, Coody marks the first reliable record of attempted settlement as occurring in May, 1878. The so-called Boston Party was drawn to northern Arizona by a description of the area in *The Marvelous Country* by Judge Samuel E. Cozzensas as a "jungle paradise with fertile ground for crops and trout crowding the streams and jumping into the air." The fifty settlers chose the southwestern end of Leroux Prairie near an unnamed spring to lay out their "town." They named it Agassiz, after Louis Agassiz, the geologist, but soon disbanded the settlement as unsuitable for farming (*Ibid.*, p. 38).

Diversion of water at Leroux Springs for domestic, agricultural, and livestock uses probably began more formally with the arrival of Mormon settlers of the Iverson-Blythe expedition in April, 1877. According to Coody, the group was instructed by John W. Young, a son of Brigham Young, to construct a small log cabin at Leroux Springs with the purpose of securing claim to the land. The cabin was built and occupied for about a year by C. L. Christenson and his wife. Young arrived in 1879 and evicted two squatters from the cabin. This cabin may be the one still standing near Little Leroux Spring (*Ibid.*, p. 39-40).

By the 1880's the railroad was making its way through northern Arizona. Young secured the Santa Fe grading and tie contract from Winslow to Flagstaff. His operation arrived in Flagstaff in 1881 and a tie-cutting operation was set up at Leroux Springs. Word of Apache attacks on Mormon settlements reached Fort Valley in the summer of 1881, and John Young and his brother William began the construction of a stockade in the middle of Fort Valley that he named Fort Moroni. The settlement became the headquarters of the Fort Moroni Cattle Company when Young switched to the cattle business, and the valley's population at the time may have approached 100 people. A vegetable garden was planted near Big Leroux Spring to take advantage of the rich soils and abundant water (Olberding, *op cit.*, p. 23-24).

Young left Fort Valley in 1884, perhaps after a visit from Arizona Territorial Governor Frederick A. Tritle, who was determined to rid Arizona of polygamy. Young never returned, and his fellow Latter Day Saints settlers also moved elsewhere. The Arizona Wool and Cattle Company, soon renamed the Arizona Cattle Company (ACC), took over the operation. The ACC hired a carpenter named John McLaws to fix up the fort's buildings and to build a two-room frame house near Big Leroux Spring (*Ibid.*, p. 26).

In 1886 former Chicago Fire Captain Ben B. Bullwinkle arrived with his wife and son to manage the ACC. Bullwinkle changed Fort Moroni's name to Fort Rickerson after Charles L. Rickerson, the ACC's treasurer and later president. A deed dated January 5, 1886, says that Samuel C. Church sold the northeast quarter of Section 14 where Big Leroux Spring is located to Bullwinkle and the ACC. The sale included all buildings, water troughs, fences, and corrals (*Ibid.*, p. 45).

Bullwinkle upgraded Fort Rickerson considerably, including improvements to a series of water troughs connected by iron pipes from Big Leroux Spring to the fort. The Flagstaff newspaper at the time, *The Arizona Champion*, reported that an immense dam was under construction at Leroux Spring, which "when finished, will have a capacity of 10,000,000 gallons of water" (Coody, *op. cit.*, p. 54). It is unclear how far the construction went on the dam, as there is no remaining evidence of such a large structure.

Homesteading

Homesteading of 160-acre parcels (¼ of a section) in the even-numbered sections in the Ft. Valley area officially began in 1891 when Normal Hall received the first recorded homestead patent in the southeast quarter of Section 14. A stream ran through Hall's land from Big Leroux Spring in the northeast quarter of the same section. The ACC was busy building pipelines from Big Leroux, so inevitably a dispute over the use of the water arose. In 1891 the ACC petitioned the Coconino County Board of Supervisors for permission to build a road through Hall's land for access to Big Leroux Spring at its source. Hall filed a petition requesting that a public road be built instead, providing access for everyone, but the board denied the request, ruling that a public road on private land would be unconstitutional (Olberding, *op. cit.*, p. 44).

Water was scarce at times in the growing city of Flagstaff. In 1881, Charles Veit and Frank Cavanaugh hauled water from Leroux Springs to Flagstaff in barrels on an oxen-pulled wagon. A white rag on a stick indicated a customer willing to pay a dollar for a barrel (Olberding, *op. cit.*, p. 6). Arthur "Al" Beasley, who arrived at Fort Valley in 1883 to cut railroad ties for John Young, also hauled water to Flagstaff, in addition to improving the road to town and raising grain for his sheep (Coody, *op. cit.*, p. 52).

The abundance and reliability of Leroux Springs water caused farming to gradually replace ranching in spite of the short growing season. By the early twentieth century homesteaders were plowing under the native grasses and planting crops. Root crops were preferred since they are not as susceptible to the frosts and high winds. Potatoes, in particular, were grown successfully for several decades. Charles Corey's 150-acre farm was just below Big Leroux Spring; he built a large barn, raised hogs, and grew oats and potatoes until at least 1945. (Olberding, *op. cit.*, p. 46).

In 1930, Rufous B. Roundtree and his family began to farm part of the land between Big Leroux Springs and the treeline in Section 23. At the time of purchase, his farm included a well, a frame house, hay barn, garage, cellar, and storeroom. Roundtree was active with the Farm Bureau for many years, and his farm was considered exemplary for his use of weed spraying, terracing, and crop rotation. He grew potatoes, oats, alfalfa, peas, and wheat. He was able to produce five hundred pounds of potatoes on eight acres (*Ibid.*, p. 47).

Coconino NF land status records show that Bullwinkle's 40-acre land parcel containing Big Leroux Spring, in the SW ¼ of the NE ¼ of Section 14, was exchanged by George and Betty Wilson to the USFS in 1927. However, the water rights did not transfer with the land. Water rights to Big Leroux Spring were appropriated and tied to ownership with the SE ¼ of Section 14 (present-day Hotshot Headquarters). Ownership of this parcel apparently was highly valued as it was owned by many prominent and familiar names in Flagstaff history, including Timothy A. Riordan (Arizona Lumber and Timber Co. co-owner) in 1891, Saginaw/Manistee Lumber Co. in 1899, W.H. (Buck) Taylor in 1927, Dr. Charles Sechrist (Flagstaff Hospital founder) in 1933, and Albert C. Grasmoen (Arizona Snowbowl owner) in 1948. Grasmoen exchanged the 160-acre parcel and improvements, which he called the Ski and Spur Ranch, to the U.S. Forest Service (USFS) in 1971 (appraised value- $308,763, $1500/acre). The USFS formally claimed the water rights to Big Leroux Springs in a 1979 filing.

Water

Big and Little Leroux Springs Hydrology

Big and Little Leroux Springs are located in volcanic terrain near the base of the San Francisco Peaks about 10 miles northwest of Flagstaff. The two springs are located in small side canyons adjacent to the 100-acre Leroux Prairie. At least four springs are found in this area, the largest of which is Big Leroux Spring. In 2004 these springs drew the attention of Flagstaff hydrologist Stephen Monroe as potential restoration sites. Conversations with Coconino NF and Rocky Mountain Research Station staff led to the recognition that insufficient spring flow data existed to support a decision to restore the sites. A volunteer effort began at that time with the objective of compiling a long-term record of spring discharge for Big and Little Leroux Springs. Big and Little Leroux Springs were visited 74 times at approximately monthly intervals during the years

2004 through 2011. Over this period the springs were visited at least four times during each month of the year. During each site visit discharge, water, air temperature, and depth to water in the Big Leroux spring box and in the Little Leroux standpipe were measured.

Prior to 2004, relatively few discharge measurements documenting the flow of Big and Little Leroux Springs are available (Table 1). A measurement made in 1949 is the oldest known quantification of Big Leroux spring flow (Arizona Department of Water Resources). In a 1969 Forest Service Research Note E.C. Martin used spring flow data collected from Little Leroux Spring during 1947-1950 and 1963-1966 to examine the relationship between spring flow and precipitation (E. Martin, 1969. "The Relation of Precipitation to Flow From Little Leroux Spring on the San Francisco Peaks, Arizona." Forest Service Research Note RM-129). These data are not available. In the report Martin states occasional discharge measurements were also made at Big Leroux Spring. The measurements also are not presented, but flow of 40,000 gallons per day was estimated. A few discharge measurements describing flow at Big and Little Leroux Springs were made in 1987 and are available from the State of Arizona Water Rights Records.

Virtually all precipitation that falls on the San Francisco Peaks infiltrates through porous or unconsolidated volcanic sediments, sublimates, or moves to the atmosphere through evapostranspiration. There are no perennial streams on the mountain, and surface runoff only occurs during snowmelt runoff periods or following convective summer monsoon rainstorms. Infiltration at higher elevations recharges regional aquifers and local aquifers in the Inner Basin and on the flanks of the mountain.

Precipitation patterns on the San Francisco Peaks follow altitudinal and directional gradients, with greater amounts of precipitation falling at higher elevations and on the north and west sides of the mountain. Long-term precipition data (1909 to present) are available from the Fort Valley Cooperative Weather Station (COOP ID 023160), located at 7,347 feet above sea level in Fort Valley. Other precipition data from the Natural Resources Conservation Service Snowslide Canyon SNOTEL station (site number 927) on the San Franciso Peaks (9,730 ft. above sea level) are available for the period 1997 to present.

Big Leroux Spring emerges from the southwest base of the San Francisco Peaks near the toe of the younger andesite of the Agassiz Peak lava flow at approximately 7,680 feet above sea level. The spring discharges on a southeast facing slope, about 100 feet above the floor of a small forested canyon. The slope is composed of volcanic boulders and unconsolidated sediments, and bedrock outcrops are present on the slope above the spring. The spring is surrounded by a barbed wire fence. It is unknown when the fence was installed, but it is probably for the purpose of excluding cattle. The fence is in poor condition and does not have an access gate. The existing spring development at Big Leroux Spring consists of a concrete spring box and a valve box with valves on both the main two-inch delivery pipe to the Hotshot Headquarters and a two-inch drain pipe with outlet. The drain outlet is equipped with an internal screen to prevent rodents and insects from entering the drain pipe.

Little Leroux Spring emerges from the southwest base of the San Francisco Peaks near the toe of the older andesite of the San Francisco Mountain lava flow at approximately 7,600 feet above sea level. The spring is in the bottom of a shallow drainage below a slope with massive volcanic exposures. During 2004-2011 there was no evidence of surface flow at the spring and no wetland obligate plant species are present at the site. A small concrete diversion structure exists in the drainage bottom. A valve box is located near the diversion structure, from which an approximately 150-foot length of two-inch pipe transfers water to the 200,000 gallon storage tank. Sections of the pipe are variously composed of steel and black plastic. About 75 feet up the drainage from the diversion structure is a four-foot tall by two-inch diameter steel standpipe. The reason this pipe was installed is unknown; however, water is present below ground-surface in the pipe and in effect it functions as a piezometer. Approximately 50 feet further up the drainage a small dam composed of basalt cobbles and boulders crosses the bottom of the drainage.

Flow Measurement Methods

For most small springs, the most accurate way to measured discharge is the volumetric method (S. Rantz and others, 1982). At Big Leroux Spring normal valve configuration with all flow diverted is: open delivery valve and closed drain valve. Volumetric measurements of spring discharge were made by reversing this configuration, so the delivery valve was completely closed and the drain valve was completely open. Before changing the valves a two-inch diameter by four-foot long PVC pipe was attached to the drain outlet, making it possible to fit a bucket under the drain pipe and capture all flow (Figure 3). Also, before the valve configuration was changed the distance from the top edge of the spring box to the water surface was measured (Figure 4). In supply status the water level in the spring box is often 0.5 to 1.0 feet above the top of the outlet pipe due to resistance in the downstream plumbing system. When the valves are reversed and all water flows through the drain pipe, the water level in the spring box drops to near the top of the outlet pipe. Water level below the top edge of the spring box was measured every five to ten minutes until stable, usually taking about half an hour. Discharge was measured by filling a plastic bucket of known volume from the drain pipe. Total time to completely fill the bucket was measured to the tenth of a second and this measurement was repeated ten times during each site visit. The ten measurements were averaged and converted to gallons per minute. If the flow rate was high and the bucket filled in less than five seconds, a larger bucket was used. After each discharge measurement was completed the water level below the top of the spring box was measured again to document system equilibrium during measurement.

Little Leroux Spring flow was measured volumetrically at the point where the pipe from the diversion enters the storage tank (Figure 5). All flow is easily captured at this location. Discharge was measured by holding a container of known volume below the pipe outlet. Total time to completely fill the container was measured to the tenth of a second. This measurement was repeated five to ten times during each site visit. The ten measurements were averaged and converted to gallons per minute. During each measurement an appropriate-sized container was used to ensure fill time was greater than five seconds. When flow was too low to measure, drips were estimated. Depth to water in the steel standpipe was measured using a steel tape and conventional methods. During each visit the distance from the measuring point (top of pipe) to the water was measured twice and during some visits the distance from the measuring point to the bottom of the well was determined.

Summary of Flow Measurement Data

Seventy-four measurements of discharge from Big Leroux Spring were made during the period June 2004 to October 2011 (Table 2). They range from a low of 6.6 gallons per minute on December 12, 2005 to a high of 37.0 gallons per minute on May 1, 2005 (Figure 6). Spring flow varies seasonally as well as year to year and is responsive to winter precipitation amounts (Figure 7). For example, in 2004 the average spring flow following the dry 2003-2004 winter was 9.8 gallons per minute and the annual average spring flow following the wet 2004-2005 winter was 24.1 gallons per minute. Generally, higher rates of spring flow occur during the months January to May and spring flows typically decrease during the months June through December. During the period spring flow was measured, low (less than 10 gallons per minute) and high (greater than 20 gallons per minute) spring flow rates were observed during nearly every month of the year (Table 3). Average measured spring flow for the entire period from June 2004 to October 2011 was 16.2 gallons per minute and average annual flow was 15.5 gallons per minute. Average measured flows during the high use period of April to September ranged from 9.8 gallons per minute to 26.0 gallons per minute and averaged 16.1 gallons per minute. Big Leroux Springs water temperature is very consistent, ranging from a low of 6.0C to a high of 10.2C, and an average of 8.1C.

During the period June 2004 to October 2011 flow at Little Leroux Spring was measured or documented 73 times (Table 4). The highest flow measured during this period was 30.1 gallons per minute on March 13, 2005. Flow from Little Leroux Spring has steadily decreased since that time and there was no flow at the spring on March 5, 2011. There were twelve days during 2009 and 2010 when flow was a slow drip and discharge was estimated.

Diversion and Water Systems

The construction date of the original Big Leroux Spring box and pipeline is unknown, but the condition of the concrete and pipe looks to be of 1920's or 1930's vintage. The spring box was improved and the pipeline replaced in 1972 shortly after the USFS acquired the Hotshot Headquarters site (the former Ski and Spur Ranch). The construction date of the earthen stock pond located SE of the main Hotshot building is also unknown, but is visible in photos taken in the 1940's. There are remnants of an old water line in the embankment that indicate water from Big Leroux Springs was used to supply water to it.

The Ft. Valley Experimental Station was established in 1908 at the west end of Fort Valley. The location was chosen in part because of the presence of Leroux Springs. In 1934 a water right was filed by the USFS for 3,000 gallons per day produced by Little Leroux Spring. The Civilian Conservation Corp soon constructed a 200,000-gallon concrete water tank just below the spring and a 2.5-mile pipe line to supply water to the Experiment Station site and to the Leroux Nursery located just below Little Leroux Spring. This water line was placed through the middle of the 160-acre homestead but was independent of the Big Leroux water system. A well has been drilled on-site to supply the Station's potable water needs.

The USFS acquired the Hotshot Headquarters parcel in 1971. A 500-foot water line was constructed the following year to tie the two water systems together and commingle the two water sources. Little Leroux Spring has less flow (currently approximately 120 gallons per day) and is not as reliable as Big Leroux; joining the systems provided the mutual benefit of a reliable water source for the Experiment Station and a storage tank for the Hotshot Headquarters' domestic and firefighting water needs. See Figure 2 for a schematic of the water system.

Big Leroux Spring is located at an elevation of 7,680 feet. Water flows by gravity towards the Hotshot Headquarters located at an elevation of 7,480 feet. A water line tees off the main line to supply a small domestic water tank for the Hotshot buildings. The water continues past the Hotshot facilities and tees into the water line between the large water tank at Little Leroux Spring and the Fort Valley Experiment Station. This water line is used as both the inlet and outlet of the large water tank. The Little Leroux water tank is at elevation 7590 feet. Because of these various elevation differences and the common inlet/outlet pipe into this large storage tank, water used at the Hotshot facilities can come from either directly from Big Leroux Springs or from the large storage tank, depending on the water demand (Figure 2).

Water from Big and Little Leroux Springs discharges into the large water tank from separate pipes. The excess flow from Big Leroux Springs keeps the large water tank topped off and then flows through an overflow pipe to the stock pond located SE of the Hotshot Headquarters. This year-round flow of water from the springs to the large water tank and then to the stock pond keeps the pipes from freezing in winter.

Water use by USFS facilities at the Flagstaff Hotshot Headquarters and Fort Valley Experiment Station has not been consistently metered, but evaluation of records kept during the 1980s and information provided by experts familiar with the system indicate that water use ranges from 200 to 500 gallons per day, with most of the demand occurring during the months April through October.

The Hotshot Headquarters are occupied from April to September each year; measured flows averaged 16.1 gallons per minute (23,232 gallons per day) during these months. This is a conservative number to use for comparison purposes to determine if excess spring flow is available for surface diversion.

The 20-person Hotshot crew is normally on-site 5 days per week when they are not dispatched to a wildfire. They are typically gone from the site approximately 50% of their 26-week season and no water usage occurs during this time. No overnight lodging occurs at the site when the crew is back. A portion of the spring flow is used to keep a 1,100 gallon water tank topped off with treated water for domestic use in the main Hotshot building. Untreated water is supplied to a few yard faucets for other intermittent uses such as lawn watering in May and June and vehicle washing.

Estimated usage amounts are as follows:

- Domestic use: 20 people x 25 gallons per person per day = 500 gallons per day.
- Other use: 5 gallons per minute x 4 hours per day x 60 minutes per hour = 1,200 gallons per day (assume this occurs 30 days per season)

The domestic water tank is equipped with a control system that automatically refills the tank when the top ¼ of the volume is consumed. A typical refilling cycle is approximately 300 gallons and flows into the tank at a rate of 40 gallons per minute. This equates to 7.5 minutes of flow from the spring needed to top off the tank. On average, the tank is topped off every two days when the crew is on-site.

The 2,600 feet of two-inch water pipe between Big Leroux Spring and the domestic water tank has a capacity of 450 gallons, which means approximately 2/3 of this capacity is used each time the tank is refilled. Even though the 40 gallons per minute filling rate of the water tank exceeds the 10 gallons per minute spring output, this section of water line is never drained because of the storage capacity of the water line.

On the highest water demand day when the Hotshots are on-site, they use about 7% of the daily output of Big Leroux Springs [(500 + 1,200 gallons per day)/ 23,232 gallons per day = 7%]. On a six-month seasonal basis, their overall usage is estimated at 68,500 gallons while the spring will produce a minimum of 4.2 million gallons during that time. The cistern at Little Leroux Spring holds 200,000 gallons.

Big Leroux Spring Restoration

Re-plumbing for surface flow diversion

Spring-supported wetlands and riparian areas are important point sources of biodiversity and often function as keystone ecosystems, providing the only available water and habitat in the landscape for many plant and animal species. The waters of the Leroux Springs and water from nearly all of the springs on the San Francisco Peaks have been diverted for decades, resulting in a nearly complete loss of these unique and valuable ecosystems.

Since 1857, when Lt. Beale saw the waters of Big Leroux Spring flow until "…it loses itself in the valley," there have been many changes to the small canyon through which the spring water flowed. Today it is unknown how far downstream water will flow on the surface though it is unlikely it will reach the valley except during the wettest of years.

Any modification of the Big Leroux spring box plumbing should accommodate the following conditions:

- Maintain adequate flow for use at the Flagstaff Hotshot Headquarters.
- Provide an easy way to measure the main flow and the diverted flow for monitoring purposes.
- Keep the 200,000-gallon water tank at Little Leroux Spring topped off for future use by the Fort Valley Experimental Forest Station and as a water source for domestic and fire protection purposes (i.e. refilling engines) at the Hotshot Headquarters.
- Allow a reduced portion of the overflow from the Little Leroux water tank to continue flowing into the stock pond at the Hotshot Headquarters site.

Our measurements and calculations show that even at the minimum flow rate there is sufficient water flowing from Big Leroux Spring to satisfy the current water usage as well as the proposed diversion for surface flow just below the spring box. A four gallon per minute diversion is a good starting point; it would allow a substantial portion of the spring's output to flow on the surface while still allowing enough diverted water to provide for USFS facilities at the Flagstaff Hotshot Headquarters and Fort Valley Experimental Forest Station.

The plumbing can be easily modified to increase or decrease this amount as the need arises. The potable water system at the Hotshot Headquarters should not experience any change; it will continue to operate exactly as it does today. The one obvious change will be a decreased but still adequate amount of water delivered to the stock pond, which is used almost exclusively by wildlife. Diverting some of the flow at the spring box is effectively relocating this wildlife water usage to an additional location, with the added benefit of restoring a riparian zone below the spring.

The existing development at Big Leroux Spring consists of a concrete spring box and a valve box with valves on the main two-inch delivery pipe to the Hotshot Headquarters and a two-inch drain pipe with above-ground outlet. The spring box and valve box lids have locks to prevent unauthorized entry. The drain outlet is equipped with an internal screen to prevent rodents and insects from entering the drain pipe (see Figures 8 and 9).

The valves allow the main delivery line to be shut off for periodic maintenance of the spring box or the downstream pipelines. The drain valve can be opened to divert the spring flow onto the slope instead of letting it back up inside the spring box when the main valve is closed. This arrangement also allows the spring flow to be easily measured by placing a bucket of known capacity under the drain outlet and noting how long it takes to fill the bucket.

Diverting a suitable portion of the spring flow for riparian restoration can be done simply by fully opening the drain valve and allowing a portion of spring output to flow down the hill.

Measurements taken on October 10, 2011, with the main valve closed and the drain valve open, showed the overall spring flow to be 9.2 gallons per minute. The main valve was then opened and the flow allowed to stabilize. The flow coming out of the drain outlet was measured at 4.0

gallons per minute, which is 44% of the overall flow. Figure 10 shows what a four gallon per minute flow from the drain outlet looks like, about the same flow as a typical garden hose.

The tee fitting just above the valves splits the flow in a way that insures the main delivery pipeline to the Hotshot Headquarters receives a bigger share of the spring flow. If the spring flow increases, the flow will be split in the same proportions (56% to the main delivery pipeline, 44% to the drain outlet).

If a portion of the Big Leroux Spring flow is released at the spring box, the volume of water reaching the earthen stock pond will be reduced proportionally. The amount of water reaching the pond may not be the same as it is now, but a significant amount will still reach the pond (an estimated 2,000-3,000 gallons per day). Several measurements taken between October 2-10, 2011 shows substantial variation in the flow discharging into the stock pond - 4.6, 8.2, 4.1, 2.5, 5.2, and 6.0 gallons per minute. The spring output remained constant at 9.1-9.2 gallons per minute and there was no one at the Hotshot Headquarters during this time.

Northern Leopard Frog

The Northern Leopard Frog (NLF) is listed as a sensitive species. USFWS just completed a 12-month status review of NLF and found that listing as a threatened or endangered species is not warranted at this time. However, a status review is only conducted when current information suggests that listing may be warranted. NLF populations in the west are declining, and it is important to take steps to improve habitats before a species is warranted for listing rather than after. (Courtney Frost, *pers. comm.*)

Coconino National Forest Management Plan Wildlife and Fish Management Goals from the Coconino National Forest Plan and the Forest Service Manual include:

1. Manage habitat to maintain viable populations of wildlife and fish species and improve habitat for selected species.
2. Cooperate with the AGFD to at least achieve management goals and objectives specified in the AZ Wildlife and Fisheries Comprehensive Management Plan, and on proposals for reintroduction of extirpated species into suitable habitat... Support the AGFD in meeting its objectives for the state.
3. Improve habitat for listed threatened, endangered, or sensitive species of plant and animals and other species as they become T or E. Work toward recovery and delisting species.

The Wing Mountain proposed action with respect to Big Leroux Spring and NLF is consistent with the management goals cited above.

Arizona Game and Fish Department's Comprehensive Wildlife Conservation Strategy: 2005-2015 (a.k.a. State Wildlife Action Plan [SWAP]) includes the following management priorities for NLF:

- Protect and restore riparian areas.
- Remove artificial stream barriers where appropriate.
- Manage watersheds to maintain hydrological integrity and incorporate wildlife values.
- Manage upland watersheds to retain vegetation as a buffer against drought effects.
- Encourage proper functioning riparian areas and aquatic habitats as buffers against drought effects.
- Manage watersheds to maintain hydrological integrity and incorporate wildlife values.
- Protect sensitive habitats from excessive grazing.
- Revegetate disturbed areas with native plants.
- Develop and implement livestock and big game management guidelines that minimize habitat degradation while maintaining stock ponds where appropriate.

The management priorities cited above are also consistent with the Wing Mountain proposed action with respect to Big Leroux Spring and NLF.

Short-term Monitoring

USEPA suggests:

> Before actively altering a restoration site, determine whether passive restoration (i.e., simply reducing or eliminating the sources of degradation and allowing recovery time) will be enough to allow the site to naturally regenerate. …. With wetlands that have been drained or otherwise had their natural hydrology altered, restoring the original hydrological regime may be enough to let time reestablish the native plant community, with its associated habitat value. It is important to note that, while passive restoration relies on natural processes, it is still necessary to analyze the site's recovery needs and determine whether time and natural processes can meet them ("Principals for the Ecological Restoration of Aquatic Resources" Online guidance, USEPA).

We recommend an adaptive approach to the restoration of Big Leroux Spring. Decisions about implementation of physical changes to the site such as re-vegetation measures intended to establish an appropriate self-sustaining wetland and riparian vegetation community, and earthwork channel modifications for the purpose of creating leopard frog habitat should be knowledge-based, using information gained through collection of data describing hydrologic, physical, and ecologic change at the site for a minimum period of two to three years following release of spring flow.

We propose the USFS consider the following components for inclusion in a short-term monitoring program for Big Leroux Spring:

- Measure discharge from Big and Little Leroux Springs. Discharge should be directly measured at monthly intervals. If the right equipment can be found at a reasonable cost and will operate reliably in freezing conditions it may be feasible to add direct-reading flow meters to the piping to make this task easier. It will be interesting to see if the spring flow changes in response to the proposed forest restoration treatments in the area.

- Measure water use by USFS facilities at the Flagstaff Hotshot Headquarters and Fort Valley Experimental Forest Station through installation of a flow meter at a convenient location near the Flagstaff Hotshot Headquarters.
- Monitor groundwater levels at key points down-gradient from Big Leroux Spring through the installation of three piezometers. Water levels in the piezometers should be measured at monthly intervals.
- Visually document site conditions by taking photographs from existing photopoints and at additional points selected to include the reach from the spring source to where the channel downstream of Big Leroux Springs enters the valley. Photographs should be taken monthly.
- Develop a high-resolution base map for the site to document location of major features. This map would be used during repeat visits to document the extent of wetted perimeter, any pool formation and water depths, and the changing locations of dominant plant communities during the initial response to flow restoration.
- Identify all plant species growing in the reach from the spring source to where the channel downstream of Big Leroux Springs enters the valley. Plant surveys should be completed twice each year, once during the spring-time growing season and again during late summer, following monsoon rains. Indicate locations of plant species and communities on site map.
- Accurately delineate surface flow and wetted soil boundaries on the site map at monthly intervals.

These monitoring activities are low-impact, require relatively little investment in equipment, and can be done by volunteers or USFS staff. Protocol describing methods for all of these monitoring activities are readily available.

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Figures

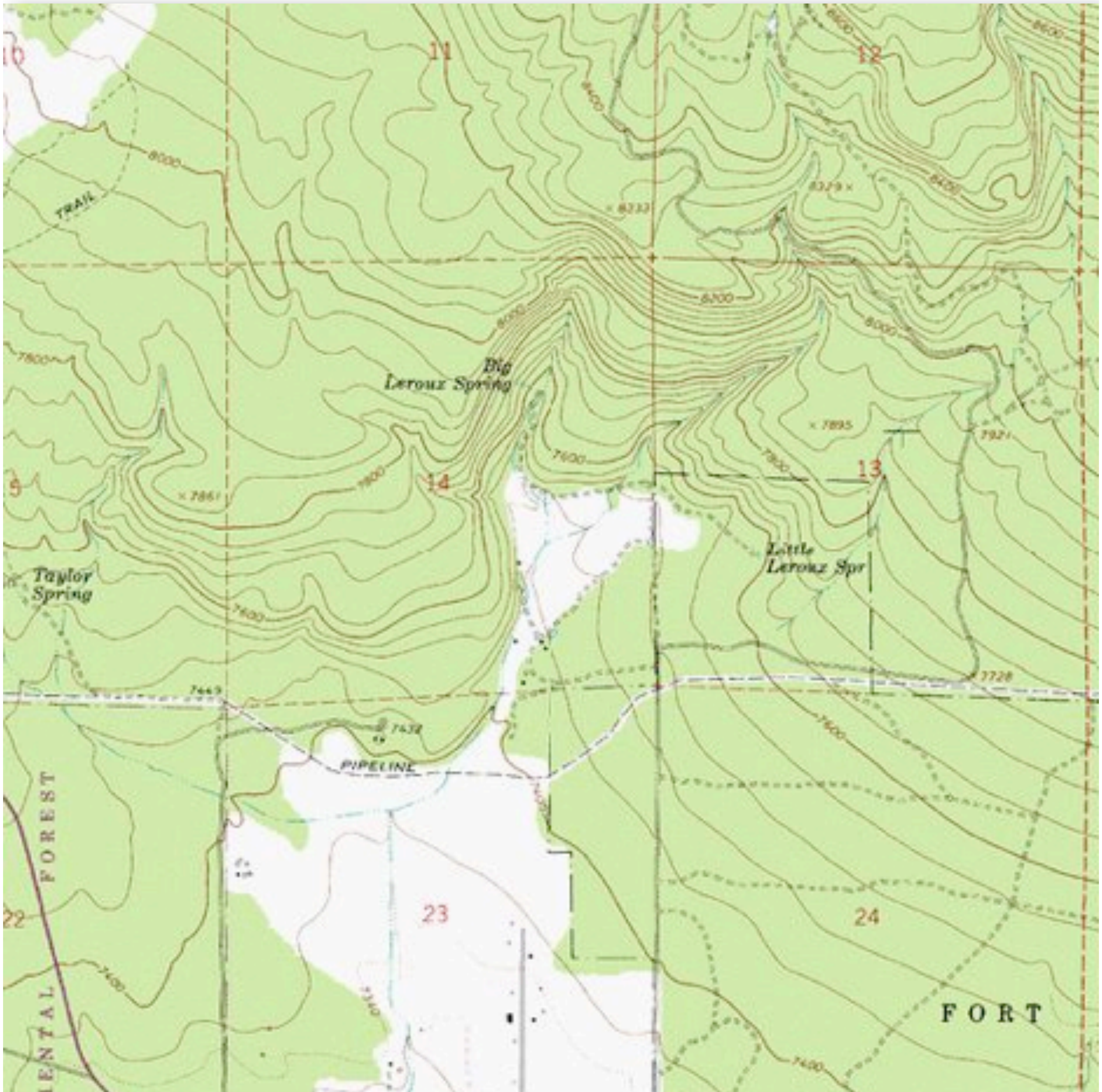

Figure 1. Map showing location of Big and Little Leroux Springs.

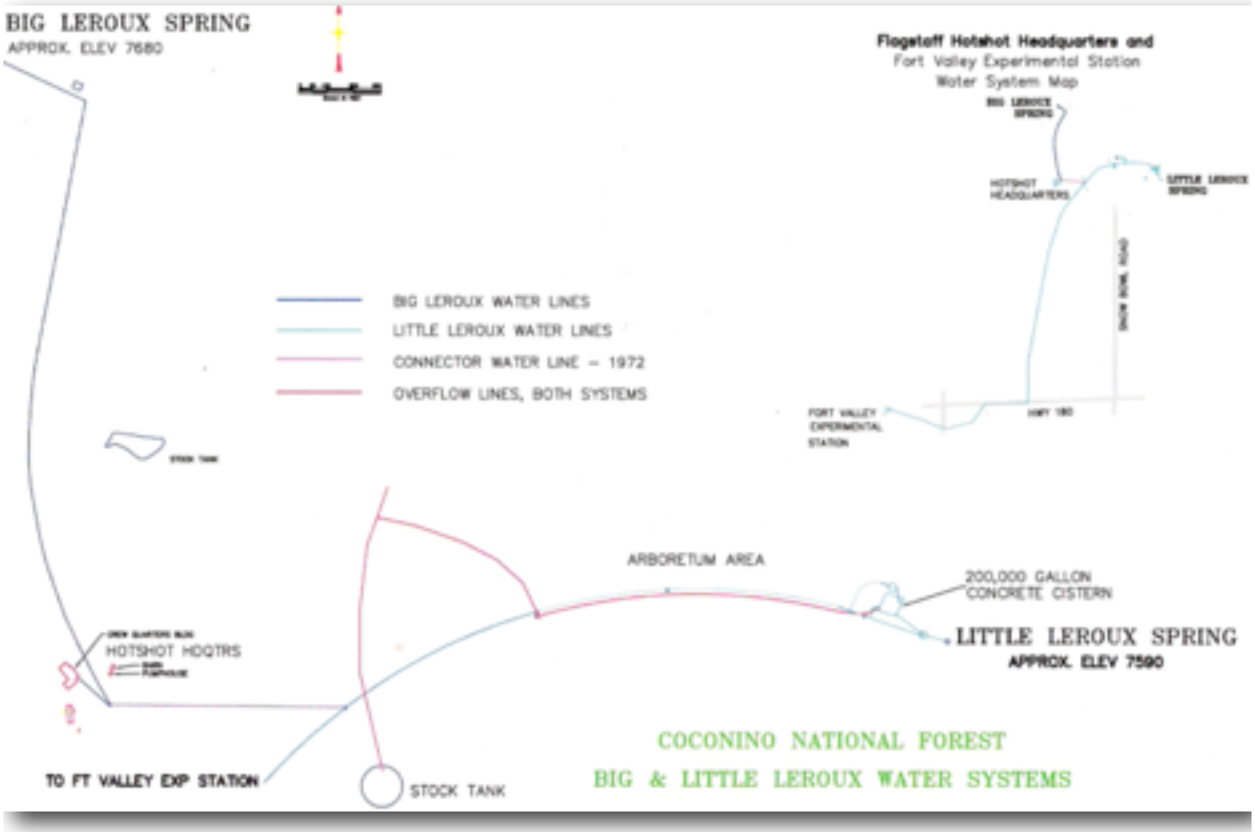

Figure 2. Leroux Springs Water System Schematic

Figure 3. PVC extension attached to Big Leroux Spring drain pipe for the purpose measuring spring flow with a bucket.

Figure 4. Measuring from top of Big Leroux Spring box to water surface.

Figure 5. Pipe from Little Leroux Spring diversion to 200,000 gallon storage tank. This is the point where spring flow measurements are made

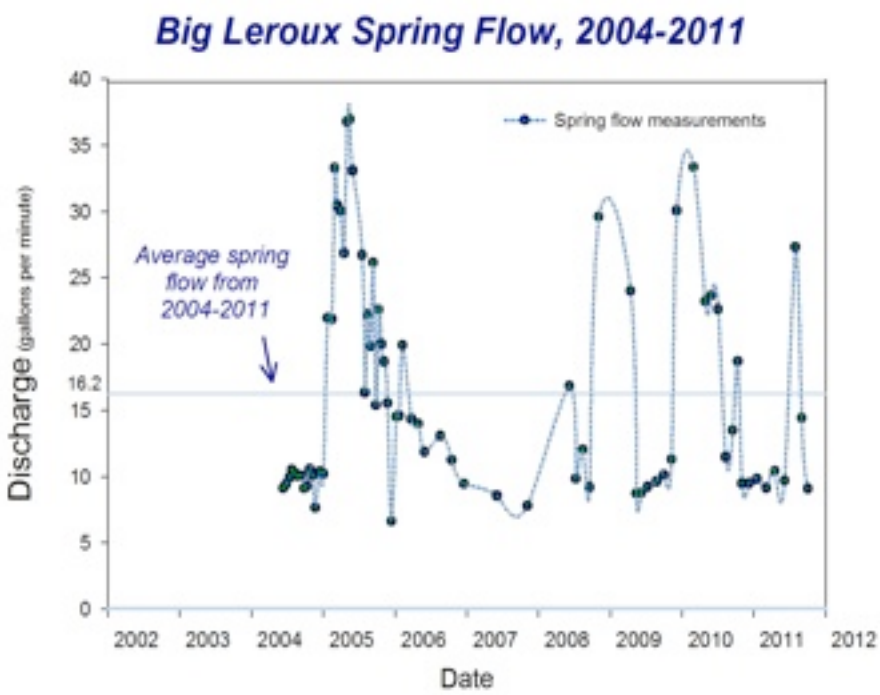

Figure 6. Graph showing measured flow at Big Leroux Springs during the period 2004-2011.

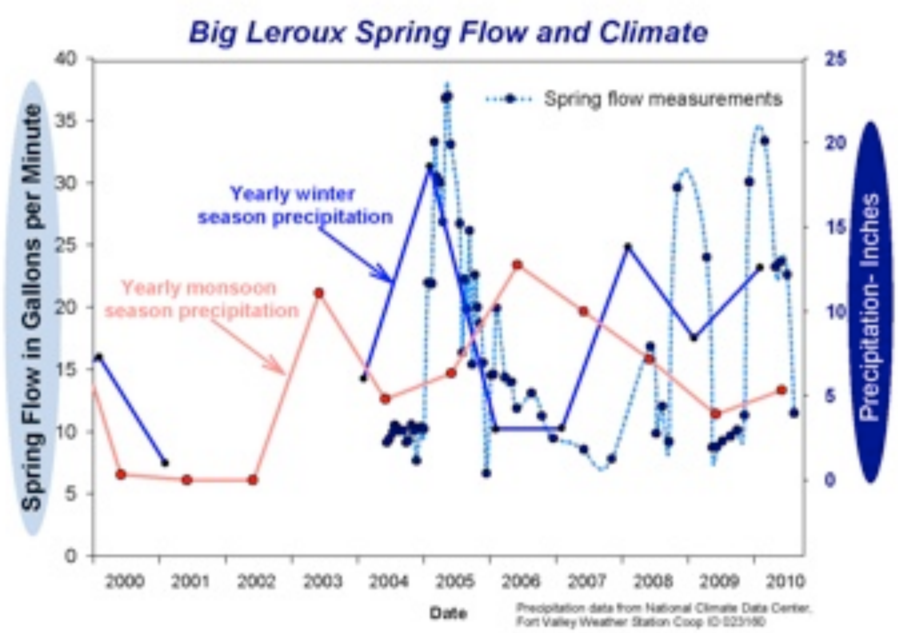

Figure 7. Graph showing measured flow and climate at Big Leroux Springs during the period 2004-2011.

Figure 8. Big Leroux Spring box (at right), valve box just below, and drain outlet
With PVC extension attached.

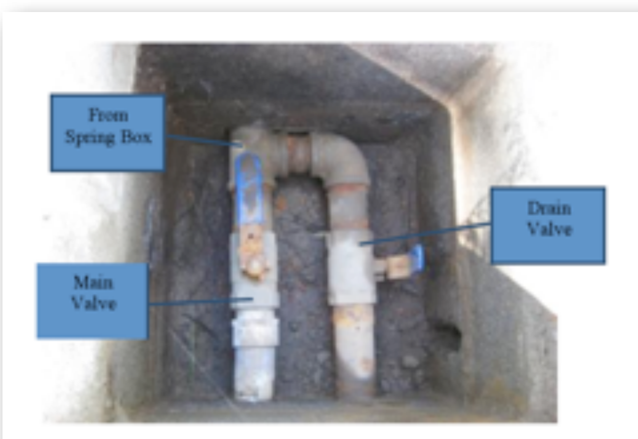

Figure 9. Valve box details showing the normal positions of the main valve open and drain valve closed.

Figure 10. Big Leroux Spring drain outlet with four gallons per minutes flow.

Table 1. Historic Big and Little Leroux Springs Discharge Measurements.

Big Leroux Spring				Little Leroux Spring		
Date	**Discharge (gallons per minute)**	**Source**		**Date**	**Discharge (gallons per minute)**	**Source**
09/26/49	25.0	ADWR		02/02/87	1.3	State water rights record number 36-10292
02/02/87	15.0	State water rights record number 36-10292		03/19/87	4.8	State water rights record number 36-10292
03/19/87	15.8	State water rights record number 36-10292		03/26/87	3.2	State water rights record number 36-10292
03/26/87	19.8	State water rights record number 36-10292		04/14/87	6.5	State water rights record number 36-10292
04/14/87	15.0	State water rights record number 36-10292		04/24/87	4.0	State water rights record number 36-10292
04/24/87	30.0	State water rights record number 36-10292		04/28/87	4.0	State water rights record number 36-10292
04/28/87	30.0	State water rights record number 36-10292		05/12/87	2.0	State water rights record number 36-10292
05/12/87	30.0	State water rights record number 36-10292				

Table 2. Big Leroux Spring Discharge and Temperature Measurements 2004-2011.

Date	Discharge (gallons per minute)	Water Temperature (C)		Date	Discharge (gallons per minute)	Water Temperature (C)
06/10/04	9.1	-		03/24/06	14.4	8.8
06/24/04	9.4	-		04/29/06	14.0	8.6
07/12/04	9.9	-		05/29/06	11.9	-
07/23/04	10.5	-		08/18/06	13.1	8.3
08/03/04	10.3	-		10/15/06	11.3	8.3
08/21/04	10.0	-		12/16/06	9.5	8.4
09/09/04	10.1	-		06/03/07	8.6	8.3
09/24/04	9.1	-		11/05/07	7.8	8.3
10/07/04	9.3	-		06/06/08	16.8	8.2
10/23/04	10.6	-		07/08/08	9.9	8.3
11/07/04	10.1	-		08/12/08	12.0	8.3
11/21/04	7.7	-		09/16/08	9.2	8.4
12/12/04	10.4	8.0		11/02/08	29.6	8.3
12/31/04	10.2	6.0		04/12/09	24.0	8.4
01/21/05	22.0	7.0		05/12/09	8.7	8.3
02/12/05	21.9	7.0		06/07/09	8.8	8.4
02/27/05	33.3	6.0		07/09/09	9.3	8.6
03/13/05	30.5	7.0		08/23/09	9.6	8.5
03/30/05	30.0	-		09/29/09	10.1	8.5
04/15/05	26.9	-		11/07/09	11.3	8.5
05/01/05	36.8	-		12/04/09	30.1	8.4
05/15/05	37.0	8.0		02/27/10	33.4	8.4
05/29/05	33.1	6.0		04/27/10	23.2	8.1
07/17/05	26.7	7.0		05/28/10	23.7	8.2
07/31/05	16.4	8.5		07/02/10	22.6	8.2
08/14/05	22.2	8.8		08/09/10	11.5	8.5
08/27/05	19.8	8.6		09/14/10	13.5	8.6
09/10/05	26.2	8.5		10/10/10	18.7	8.4
09/25/05	15.4	8.5		10/31/10	9.5	8.3
10/09/05	22.6	8.4		12/05/10	9.5	8.3
10/22/05	20.0	8.4		01/15/11	9.8	8.3
11/05/05	18.7	5.3		03/05/11	9.2	8.2
11/23/05	15.6	8.3		04/17/11	10.4	10.2
12/12/05	6.6	8.3		06/05/11	9.7	8.3
01/06/06	14.5	8.2		07/30/11	27.3	8.4
01/21/06	14.6	8.0		08/31/11	14.4	-
02/06/06	19.9	8.4		10/02/11	9.1	-

Table 3. Big Leroux Spring Discharge – lowest and highest measurements by month, and average of monthly measurements during the period 2004-2011.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low	9.8	19.9	9.2	10.4	8.7	8.6	9.2	9.6	9.1	9.1	7.7	6.6
High	22.0	33.4	30.5	26.8	37.0	16.8	27.3	22.2	26.2	22.6	29.6	30.1
Average	15.2	27.1	21.0	19.7	25.2	13.9	16.6	13.7	13.4	13.9	14.4	12.7

Table 4. Little Leroux Spring Discharge and Temperature Measurements 2004-2011.

Date	Discharge (gallons per minute)	Water Temperature (C)		Date	Discharge (gallons per minute)	Water Temperature (C)
06/10/04	0.06	-		03/24/06	0.14	3.4
06/24/04	0.10	-		04/29/06	0.12	9.2
07/12/04	0.08	-		05/29/06	0.08	-
07/23/04	0.10	-		08/18/06	0.10	16.8
08/03/04	0.11	-		10/15/06	0.15	7.8
08/21/04	0.24	-		11/17/06	0.09	4.9
09/09/04	0.13	-		12/16/08	0.09	2.2
09/24/04	0.16	-		06/03/07	0.01	16.8
10/07/04	0.12	-		11/05/07	0.02	9.3
10/23/04	0.16	-		06/06/08	0.01	11.9
11/07/04	0.25	-		07/08/08	0.01	19.4
11/21/04	0.22	-		08/12/08	0.01	18.3
12/12/04	0.28	0.5		09/16/08	0.004	15.8
12/31/04	2.3	5.0		11/02/08	0.002	5.5
01/21/05	6.4	-		04/12/09	0.002	5.4
02/12/05	10.6	5.0		05/12/09	0.002e	-
02/27/05	11.9	7.0		06/07/09	0.002e	-
03/13/05	30.1	6.0		07/09/09	0.002e	-
03/30/05	17.7	-		08/23/09	0.002e	-
04/15/05	10.6	-		09/29/09	0.002e	-
05/01/05	11.1	-		11/07/09	0.002e	-
05/15/05	8.2	8.0		12/04/09	0.002e	-
05/29/05	6.2	8.0		02/27/10	0.002e	-
07/17/05	2.8	10.0		04/27/10	0.002e	-
07/31/05	2.6	10.1		05/28/10	0.002e	-
08/14/05	2.7	10.0		07/02/10	0.002e	-
08/27/05	1.9	10.9		08/09/10	0.002e	-
09/10/05	1.6	10.8		10/19/10	0.002	-
09/25/05	1.4	10.4		10/31/10	0.003	-
10/09/05	1.1	10.1		12/05/10	0.004	-
10/22/05	0.79	9.6		01/15/11	0.01	-
11/05/05	0.52	7.9		03/05/11	0.0	-
11/23/05	0.44	6.0		04/17/11	0.04	-
12/12/05	0.07	4.9		06/05/11	0.03	-
01/06/06	0.21	3.9		07/30/11	0.04	-
01/21/06	0.18	2.3		08/31/11	0.08	-
02/06/06	0.15	3.5		10/02/11	0.08	-

e indicates estimated flow