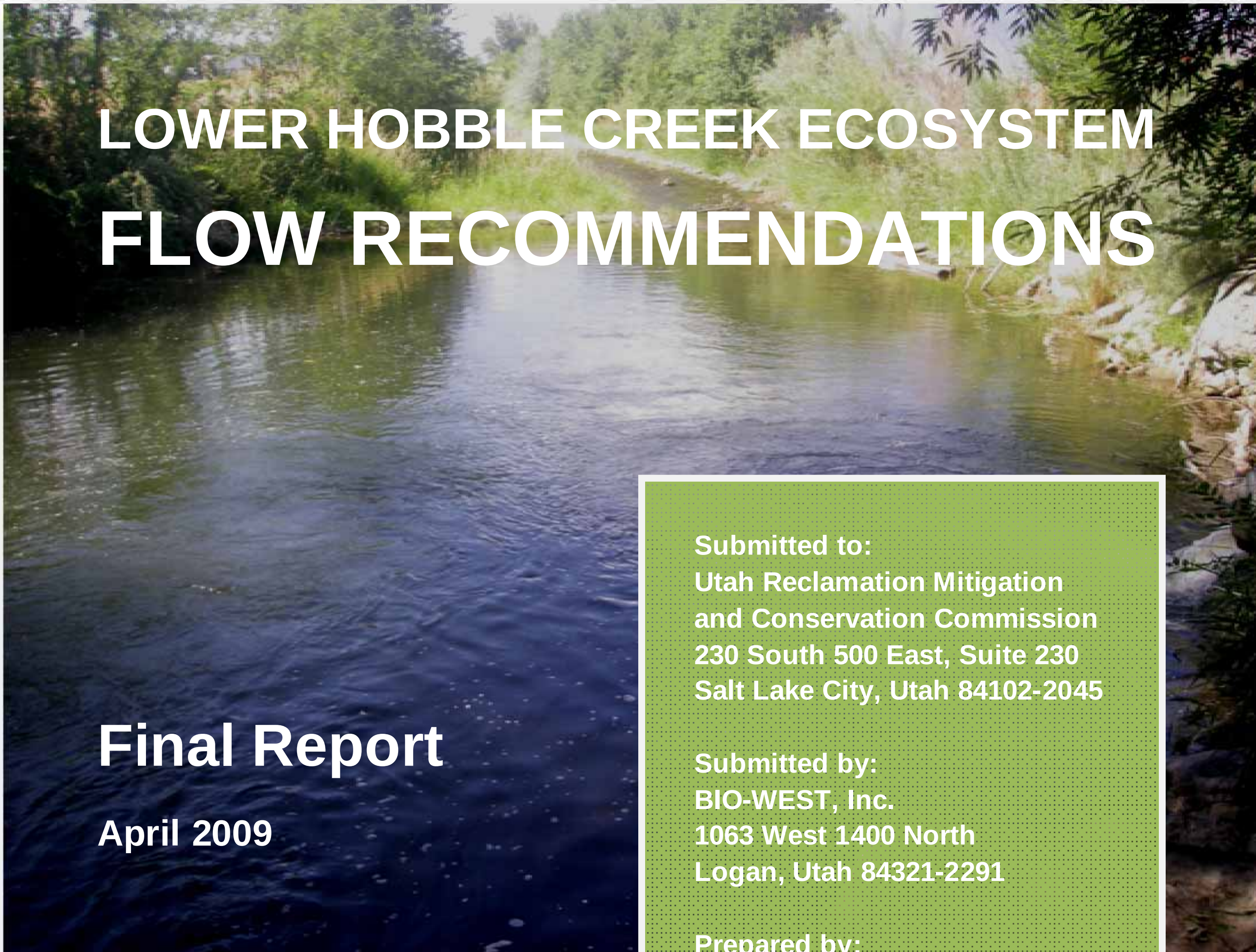

LOWER HOBBLE CREEK ECOSYSTEM
FLOW RECOMMENDATIONS

Final Report

April 2009

Submitted to:
Utah Reclamation Mitigation
and Conservation Commission
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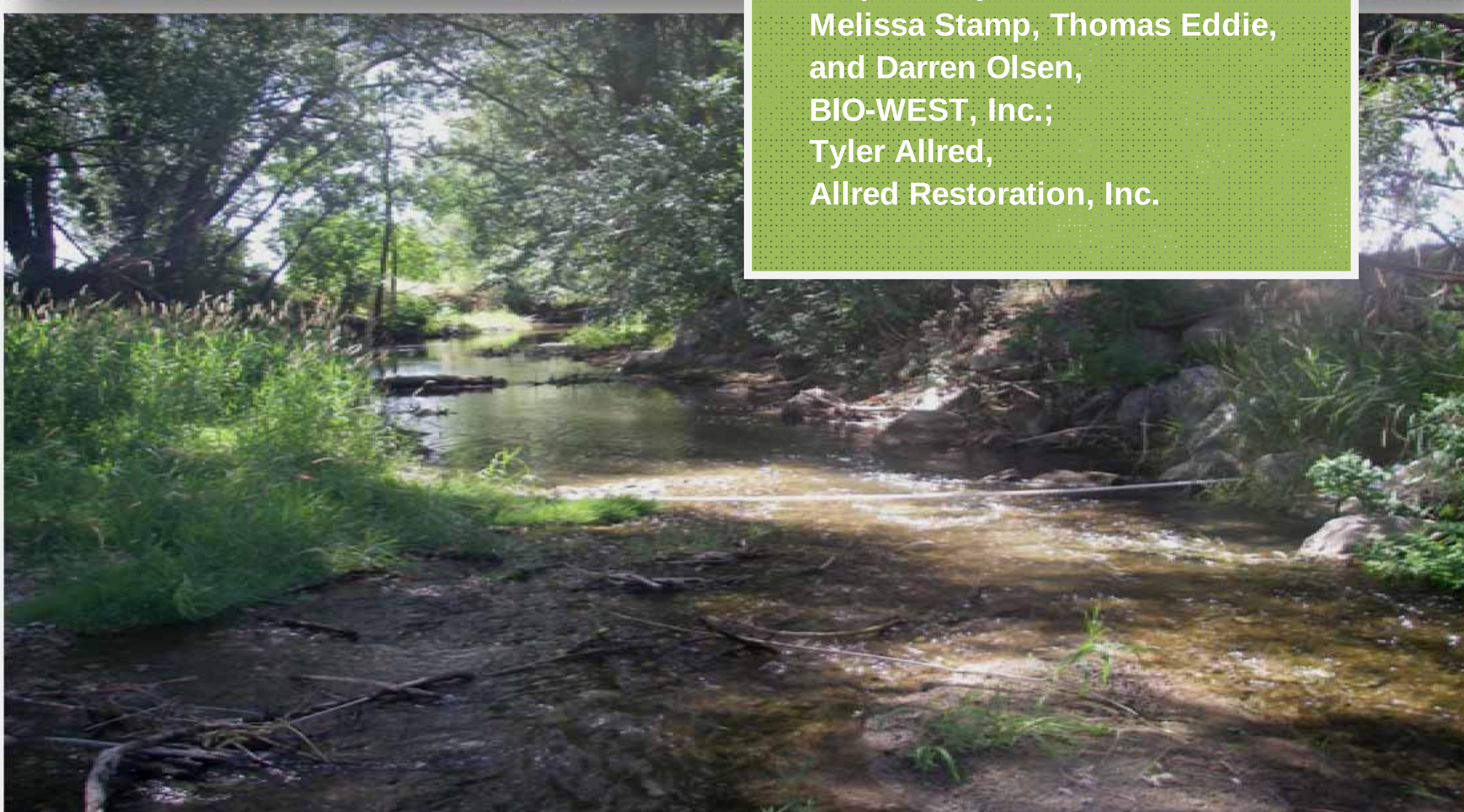

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SECTION 1. INTRODUCTION

This report describes the process and products of developing a suite of year-round instream flow recommendations for lower Hobble Creek in Utah County, Utah. This project was undertaken by the Utah Reclamation Mitigation and Conservation Commission (the Commission) as a component of the June Sucker Recovery Implementation Program (JSRIP) 2008 Work Plan (JSRIP 2008). The Commission is a Federal agency established by the Central Utah Project Completion Act (CUPCA [Titles II through VI of Public Law 102-575]). The Commission is responsible for mitigating impacts of the Bonneville Unit of the Central Utah Project (CUP) on fish, wildlife, and related recreation resources. The Commission is required to include in its fish and wildlife mitigation plans measures that it determines will ". . . restore, maintain, or enhance the biological productivity and diversity of natural ecosystems within the State and have substantial potential for providing fish, wildlife, and recreation mitigation and conservation opportunities," and ". . . be based on, and supported by, the best available scientific knowledge".[1] The JSRIP is a multi-agency cooperative program established to coordinate and implement recovery actions for June sucker (*Chasmistes liorus*), an endangered fish native to Utah Lake that historically used tributaries such as Hobble Creek for spawning (JSRIP 2002). The JSRIP attempts to balance June sucker recovery needs with the need to provide for ongoing water development for human needs within the Utah Lake basin.

The Commission recently completed a report describing ecosystem flow recommendations for the lower Provo River (Stamp et al. 2008). The framework developed for the Provo River recommendations has been applied here to lower Hobble Creek.

Purpose and Need

The guiding principle for this study is that the recommended flow regime for lower Hobble Creek should protect the entire riverine ecosystem year-round. The flow regime(s) should be scientifically derived, ecologically defensible and hydrologically feasible. A critical aspect of this effort is the need to provide habitat for June sucker spawning and recruitment. The June sucker was listed as an endangered species in 1986, and is native only to Utah Lake.

Historically, June sucker most likely had significant spawning populations in multiple tributaries to Utah Lake but currently is known to primarily use the lower Provo River for spawning. The June Sucker Recovery Plan (USFWS 1999) lists establishment of a second spawning run in a tributary to Utah Lake other than Provo River as a requirement for long-term protection and eventual recovery of the June sucker. Efforts are being implemented by the JSRIP and other entities to establish Hobble Creek as this second spawning tributary. These efforts include reconstruction and restoration of the lower Hobble Creek channel where it enters Utah Lake (DOI 2008), and delivery of supplemental flows to lower Hobble Creek.

The Utah Lake Drainage Basin Water Delivery System (ULS) is the final component of the Bonneville Unit of the CUP. When operational and under full water delivery conditions, the ULS

[1] From CUPCA, Sections 301(g)(4)(A) and (B)

project will, among other things, deliver between 4,000 to approximately 12,000 acre-feet of water per year to lower Hobble Creek to supplement stream flows and assist in June sucker recovery (CUWCD 2004a). Guidance is needed regarding desired daily and seasonal flow rates and patterns for delivery of the water. Establishment and implementation of flow recommendations will also be important to help maximize the benefits of the recently completed channel restoration work at the mouth of Hobble Creek. Construction of the new channel and floodplain was completed in November 2008.

Utah Lake Drainage Basin Water Delivery System (ULS) Supplemental Flows

When operational and under full water delivery conditions, the ULS will deliver water to Hobble Creek at the Mapleton-Springville Lateral Pipeline on the east side of Springville City (Figure 1.1) and will supplement flows within lower Hobble Creek. Of the 12,000 acre-feet, approximately 4,000 acre-feet will be generated by water returned to the U.S. Department of the Interior (DOI) from water conservation projects completed under Section 207 of CUPCA. This 4,000 acre-feet will be available for release to Hobble Creek every year (CUWCD 2004a). The additional 8,000 acre-feet will be available when transbasin CUP water is being delivered to Utah Lake for exchange to Jordanelle Reservoir. During naturally high runoff years when Utah Lake is above compromise level, this portion of Hobble Creek supplemental water would typically not be available for delivery to the creek (CUWCD 2004a). The 8,000 acre-feet of CUP water will build up over time and may not be fully available until up to 10 years after all ULS distribution facilities are constructed and operational. The facility that will deliver supplemental flows to Hobble Creek is being designed to have a 125 cubic feet per second (cfs) maximum release rate (CUWCD 2003). The ULS is currently in the design and initial construction phases, and it is anticipated that the infrastructure will be in place to begin supplemental flow deliveries to Hobble Creek no sooner than 2011.

Study Area

The headwaters of Hobble Creek originate in the Wasatch Mountains of Utah at an elevation of approximately 9,000 ft. The creek begins as two separate forks, Right Fork Hobble Creek and Left Fork Hobble Creek, that merge to form Hobble Creek proper about 3 miles east of Springville City (Figure 1.1). The total drainage area of Hobble Creek at its outlet to Utah Lake is approximately 114 square miles. The majority of the watershed area (approximately 108 square miles) is located in the mountains upstream of the canyon mouth. Lower Hobble Creek, defined as the portion of the creek between the Mapleton-Springville Lateral and Utah Lake, flows west to northwest for approximately 7 miles through Springville City (Figure 1.1).

Much of the upper watershed lies within the Uinta National Forest, although the corridor along Left Fork Hobble Creek is privately owned and contains some residential and agricultural development. Springville City’s Hobble Creek Golf Course is located just downstream from the Left Fork and Right Fork confluence. The lower watershed is primarily in private ownership, and land use is a mix of agricultural, residential, and commercial uses. The population of Springville City has grown very rapidly in recent years, and areas that previously were in agricultural use are becoming developed for residential and commercial purposes.

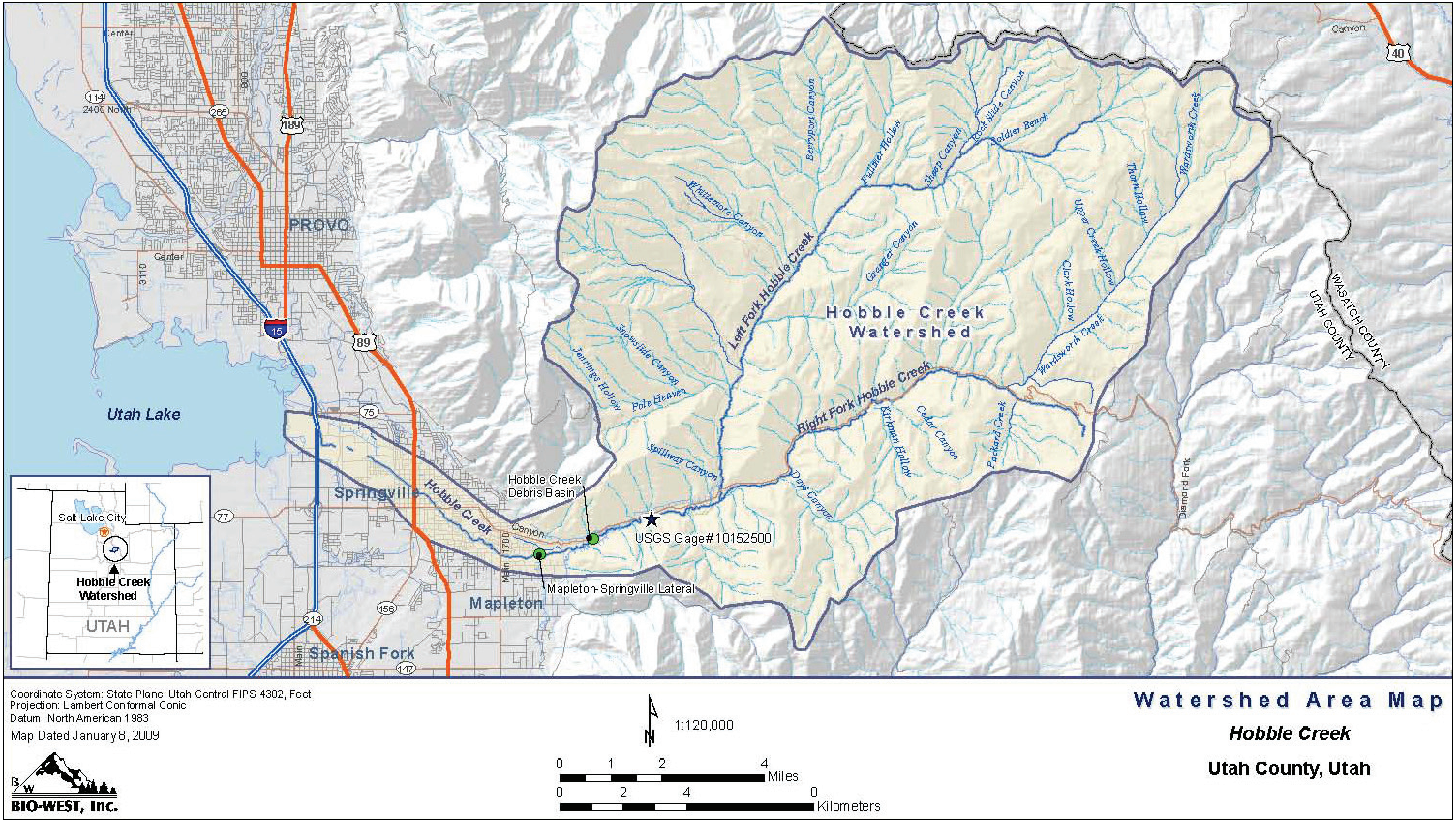

Figure 1.1. Location and watershed area map.

The Springville area contains many naturally occurring springs. Most were developed for irrigation and municipal/industrial uses. As part of early agricultural development in the valley, subsurface drains were installed to control the water table near Utah Lake. This drainage system affects the areas on the south side of Hobble Creek west of 400 West in Springville.

SECTION 2. EXISTING CONDITIONS

Hydrology

A new U.S. Geological Survey (USGS) streamflow gage (#10153100) was installed on lower Hobble Creek near 1500 West in November 2008 (Figure 2.1). Data collected at this gage will be highly valuable in the future; however, at this time the stage-discharge rating relation is still being developed for the gage and data are too limited to describe the hydrology of lower Hobble Creek. Therefore, hydrologic information must be inferred from flow data collected at a discontinued USGS gage (#10152500) that operated in Hobble Creek Canyon approximately 8.9 miles above Utah Lake from 1908−1916 and 1945−1974 (Figure 1.1). Data from this gage were analyzed to provide an indication of the natural hydrologic conditions of lower Hobble Creek. Springville City diverts water for municipal uses from underground springs in a tributary canyon to Left Fork Hobble Creek (FERC 2002); therefore, the hydrology of Hobble Creek at the gage is not entirely natural. Upstream from the gage, flows in Hobble Creek and its tributaries are affected by flow withdrawals for hydroelectric and irrigation purposes. However, the gage is located downstream from the return points for most of the upper watershed irrigation uses, and is below the Hobble Creek Hydroelectric Plant where water diverted for power generation returns to the creek. Therefore, these upstream power and irrigation uses do not substantially alter the hydrology at the gage, and the gage data provide a reasonable estimate of natural conditions.

Data from the discontinued gage indicate that, as with most streams that drain Utah's Wasatch Mountains, Hobble Creek's hydrology is characterized by a distinct springtime peak typical of snowmelt-driven systems (Figure 2.2). Flows on Hobble Creek typically peak at the end of April or in May (Table 2.1), with May having the greatest average monthly flow (Figure 2.3). Flows on Hobble Creek vary greatly depending on yearly climatic conditions. In dry years, springtime peaks are essentially nonexistent (Figure 2.2). In wet years with heavy snowpack, flows typically peak later in the year and have a magnitude that exceeds average conditions.

Table 2.1. Peak flow data (U.S. Geologic Survey Gage #10152500).

PEAK FLOW CHARACTERISTIC	HOBBLE CREEK
Average date of peak	April 29
Range of dates of peak	February 1 – June 15
Magnitude of 2-year flood[a]	265 cubic feet per second (cfs)
Magnitude of 10-year flood[a]	633 cubic feet per second (cfs)
Magnitude of 100-year flood[a]	1,052 cubic feet per second (cfs)
Years of peak flow data	43

[a] Flood recurrence intervals calculated using Log-Pearson Type III analysis of instantaneous peak flow data. A 2-year flood has a 50 percent chance of occurring in any given year; a 10-year flood has a 10 percent chance of occurring in a given year; a 100-year flood has a 1 percent chance of occurring in a given year.

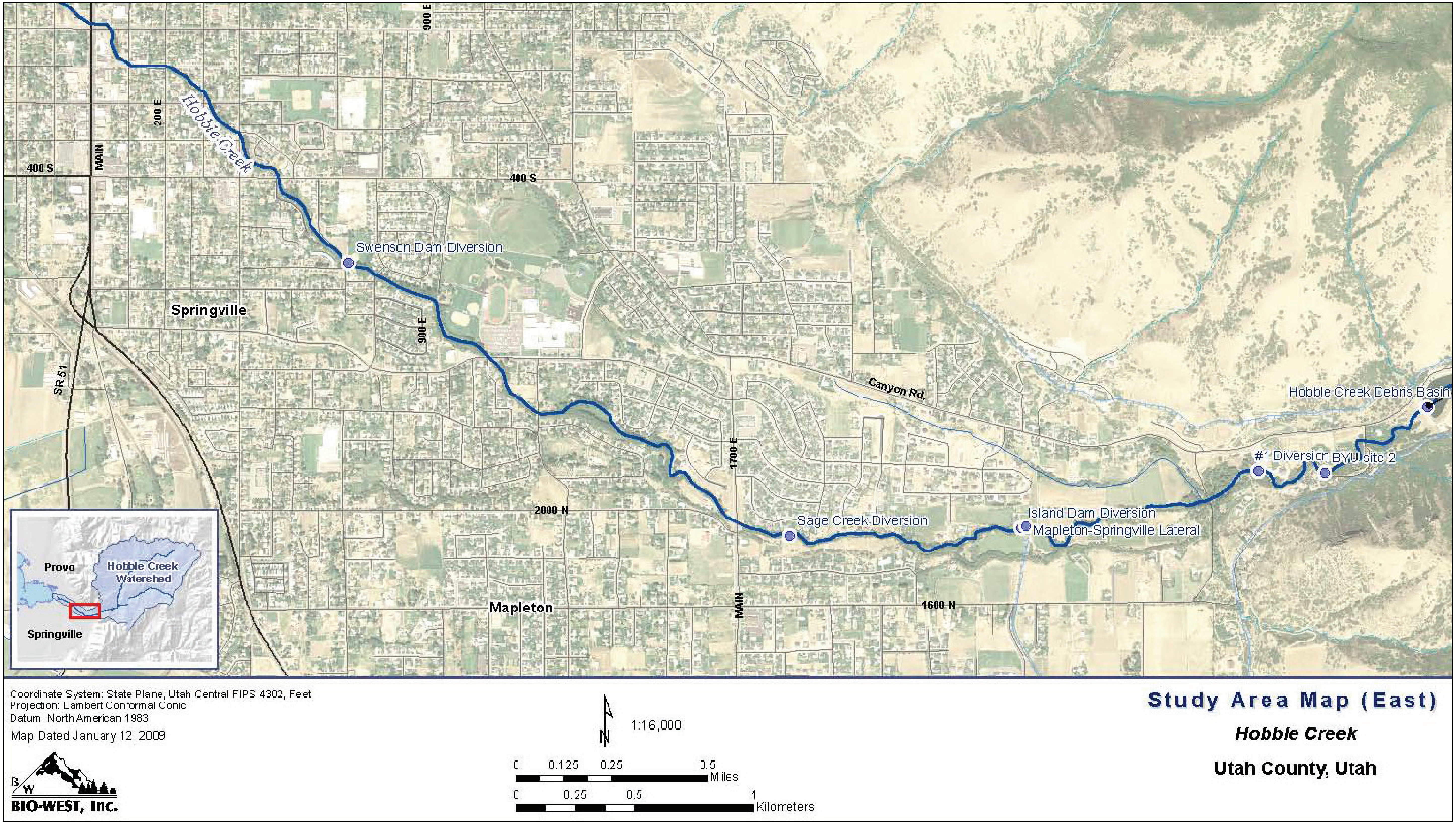

Figure 2.1. Study area map (east part).

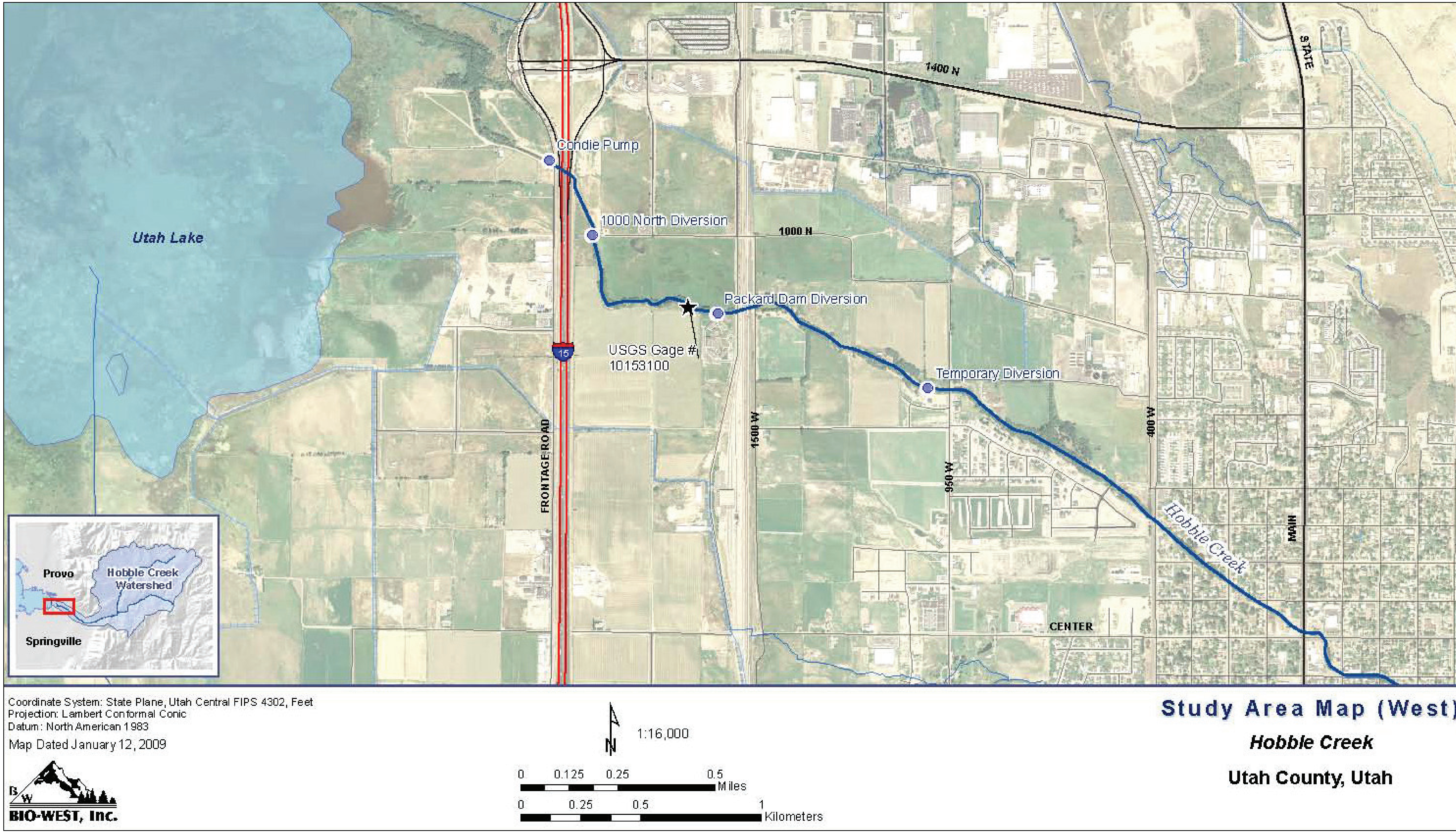

Figure 2.1. Study area map (west part).

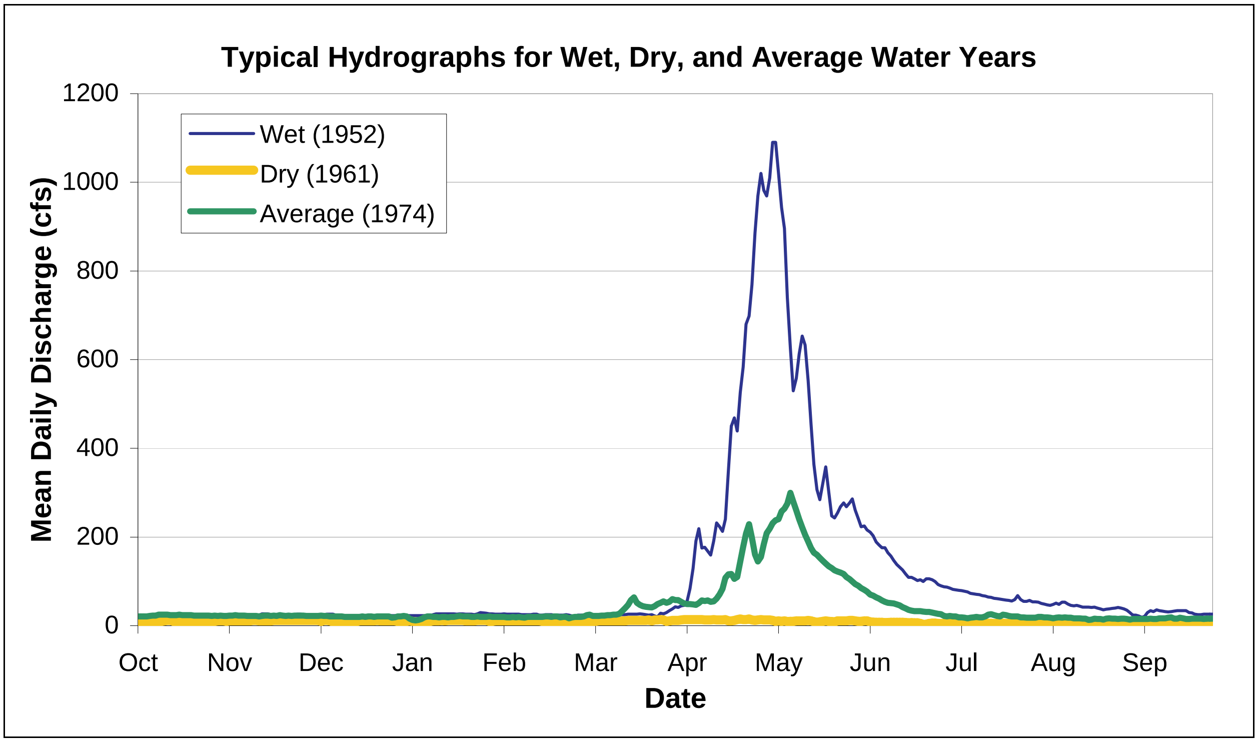

Figure 2.2. **Typical Hobble Creek hydrographs (data from USGS gage located 8.9 miles above Utah Lake).**

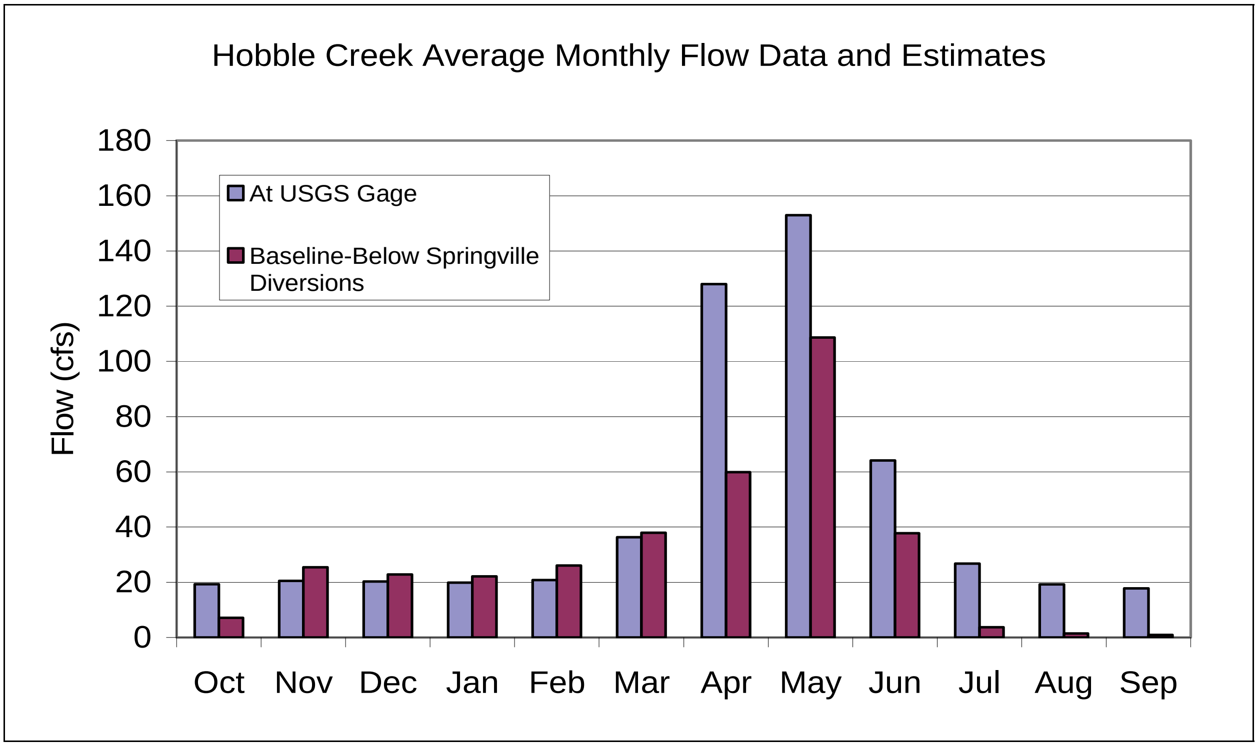

Figure 2.3. **Monthly flows at USGS gage #10152500 and below Springville diversions to 400 West. Note: values are averaged over a 40- to 50-year data period, and flow in a given year can vary considerably from this average.**

The majority of irrigation diversions on Hobble Creek occur downstream from the discontinued USGS gage (Figure 2.1). Streamflow and sediment transport are also affected by the Hobble Creek debris basin, located near the canyon mouth about 1.5 miles downstream from the gage location. The debris basin has a 120 acre-foot storage capacity and traps some of the sediment entering from upstream. Accurate, continuous records of flow withdrawals from the Springville City area diversions are not available. As part of analysis work related to the ULS, the Central Utah Water Conservancy District (CUWCD) developed estimates of diversion amounts and average monthly streamflow within Springville City (CUWCD 2004a). These estimates account for diversions by the Springville and Mapleton Irrigation companies between the USGS gage and 400 West Street in Springville City; however, they do not account for the diversions or return flows that occur between 400 West Street and Utah Lake. The total diversion capacity of the agricultural diversions upstream of 400 West is 60 cfs (CUWCD 2003). To generate the data plotted in Figure 2.3, the CUWCD used a “worst case” scenario that assumed 36 cfs would be diverted in April and the full 60 cfs would be diverted from May through October (CUWCD 2003). As evident in Figure 2.3, the diversions above 400 West Street are estimated to substantially reduce average flows in Hobble Creek during the April through October irrigation season.

Additional flow is removed from Hobble Creek at four diversion points below 400 West Street (Figure 1.2) (Stamp et al. 2003). No reliable records are available to estimate the diversion amounts that occur at these locations. In addition, no estimates are available to quantify the inputs to Hobble Creek from agricultural return flows, surface water runoff, or springtime discharge that may occur within this area. Prior to development of the Springville valley, inputs from natural springs would likely have added to flows in the lower parts of Hobble Creek. These natural inputs have been reduced by development of the springs for irrigation and municipal/industrial uses, and by the installation of subsurface drainage systems on agricultural lands near Utah Lake. It is likely that some amount of return flow to the creek does occur, but it is also apparent that under existing conditions very little flow typically reaches the lowest portion of Hobble Creek during the summer irrigation season.

The Utah Division of Water Quality (DWQ) operates a water quality sampling station on Hobble Creek at I-15 (STORET # 4996100). Since 1982 the DWQ has conducted sampling at the site, including measuring or estimating stream flow, a total of 146 times. Flows of 0 cubic feet per second (cfs) have been recorded 10 times during this record period between June and October, with August and September being the most common months with no flow.

Various occasional field measurements of discharge on lower Hobble Creek have been made as part of this study and previous studies on Hobble Creek (Stamp et al. 2003, Brown 2008). The results of these measurements are summarized in Table 2.2.

Although these miscellaneous discharge measurements do not provide a complete representation of existing flow patterns on lower Hobble Creek, they do provide some further insight into existing flow conditions, and confirm the patterns described above. Flows on lower Hobble Creek during the spring season are highly variable depending on the water year. In 2003, which was a drought year, flow measured in early May was only 8.3 cfs, while in 2006, a wet year, flow was measured at 461.7 cfs in early May (Table 2.2). Although data are limited, it also

Table 2.2. Summary of miscellaneous discharge measurements on lower Hobble Creek.

DATE	APPROXIMATE LOCATION	MEASURED DISCHARGE (CUBIC FEET PER SECOND)	REFERENCE
Measurements made during springtime			
5/17/06	900 East (BYU Site 3)	304.5	Brown 2008
5/19/06	900 East (BYU Site 3)	240.7	Brown 2008
5/24/06	900 East (BYU Site 3)	155.2	Brown 2008
5/30/06	900 East (BYU Site 3)	103.2	Brown 2008
6/1/06	900 East (BYU Site 3)	80.6	Brown 2008
4/27/06	100 South 200 East	457.0	Brown 2008
5/26/06	200 West 100 North (BYU Site 4)	134.9	Brown 2008
6/1/06	200 West 100 North (BYU Site 4)	76.3	Brown 2008
4/13/03	1500 West (downstream side)	37.5	Stamp et al. 2003
5/5/03	1500 West (downstream side)	8.3	Stamp et al. 2003
6/20/08	1000 North	19.4	measured for this study
4/27/06	Frontage Road	512.0	Brown 2008
5/2/06	Frontage Road	461.7	Brown 2008
5/30/06	570 feet below Frontage Road	93.6	Brown 2008
Measurements made during non-irrigation season base-flow period			
12/5/02	1,200 feet below Frontage Road	18.0	Stamp et al. 2003
10/15/08	Below Packard Dam	19.8	measured for this study
Measurements made during summer irrigation season			
7/7/08	Below Packard Dam	0.59	measured for this study
8/4/08	Below Packard Dam	6.71	measured for this study
9/3/08	Below Packard Dam	3.85	measured for this study
9/12/07	1000 North	0.24	measured for this study

appears that flows are similar in the lower and upper parts of the creek during high runoff periods. Brown (2008) measured a flow of 473.1 cfs at the Hobble Creek Golf Course (in Hobble Creek Canyon) on May 3, and a similar flow (461.7 cfs) at the Frontage Road about 9 miles downstream on May 2. These field measurements on the lower creek also provide additional evidence that flows become very low during the summer irrigation season, and that they vary depending on irrigation patterns (Table 2.2). Base flows measured during periods when no apparent irrigation was taking place (on 12/5/02, 6/20/08, and 10/15/08) were consistently about 19 cfs (Table 2.2).

Geomorphology and Riparian Vegetation

Utah Lake to Interstate-15

Hobble Creek enters Utah Lake at Provo Bay, an area of the Utah Lake shoreline characterized by extensive wetland habitat. Reconstruction and relocation of the portion of Hobble Creek between I-15 and Provo Bay was completed in November 2008. Prior to project completion, the Hobble Creek stream channel below I-15 was an artificially straightened, dredged channel that had been installed for flood control purposes. Its connection to Provo Bay had been altered by reduced flows, debris accumulations, and channelization, and debris blockages created barriers to fish migration. The old channel had a trapezoidal cross-sectional form entrenched between narrow, tall levees (Stamp et al. 2003, DOI 2008).

The new Hobble Creek channel meanders gently, supporting a diversity of aquatic habitat including a deltaic river-lake transitional zone, pool and riffle areas, and depositional point bar features (DOI 2008) (Figure 2.4). The channel is inset within an excavated 200 to 250 foot-wide floodplain and is designed to flood over bank with an average frequency of once every 2 years. Stream channel width is 45 feet, with a depth of approximately 2.0 to 3.5 feet. Average slope of the new stream channel is approximately 0.2 percent. The total length of the main channel between I-15 and Utah Lake is approximately 0.5 river mile. Figure 2.5 illustrates a cross section of the new stream channel and floodplain wetlands. Because of the low streambed gradient in this reach, bed material consists primarily of sand and silt, with the exception of several patches where cobble-sized material was placed as part of the restoration design.

Because construction was only recently completed, riparian vegetation within this reach of Hobble Creek is currently limited. Approximately 120 native cottonwood and willow trees and 450 willow and dogwood shrubs were planted within the project area. A seed mix including native wetland and upland species was applied throughout the project area. With time, it is anticipated that this restored reach of Hobble Creek will support a diverse native riparian community, with regular overbank flooding promoting natural recruitment of new cottonwood and willow seedlings.

Interstate-15 to 400 West Street

In this reach, Hobble Creek consists of a trapezoidal-shaped channel between tall levees. This reach has a total length of approximately 2.1 river miles. The levees limit the ability of the creek to meander, and sinuosity is low (Figure 2.2). Review of historical air photos indicates that at least one meander bend was straightened between 1946 and 1958 (Stamp et al. 2003); prior agricultural development likely entailed straightening and re-alignment of other sections of the creek as well. In-stream habitat consists primarily of riffles and runs, while well-developed pools are relatively rare. Stream channel plan form is single-threaded with the exception of an area of channel located immediately upstream from the 1500 West crossing. This area was artificially widened after the 1983 floods to help capture sediment and logs and reduce debris problems during floods. Sediment deposition has created a mid-channel island in this location, and the channel divides into two threads before recombining into a single channel and flowing under 1500 West and the railroad.

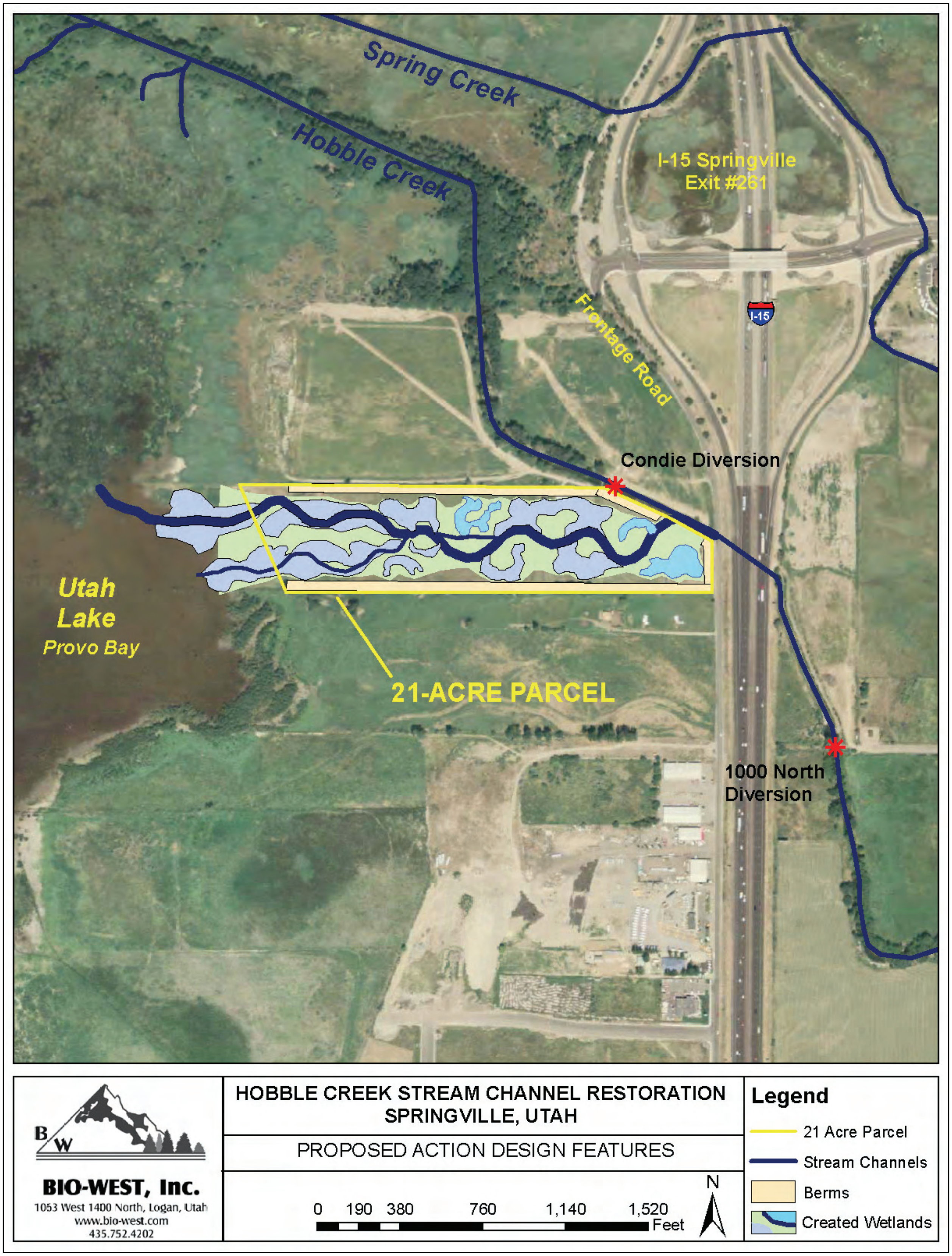

Figure 2.4. Plan view of Hobble Creek restoration design (DOI 2008).

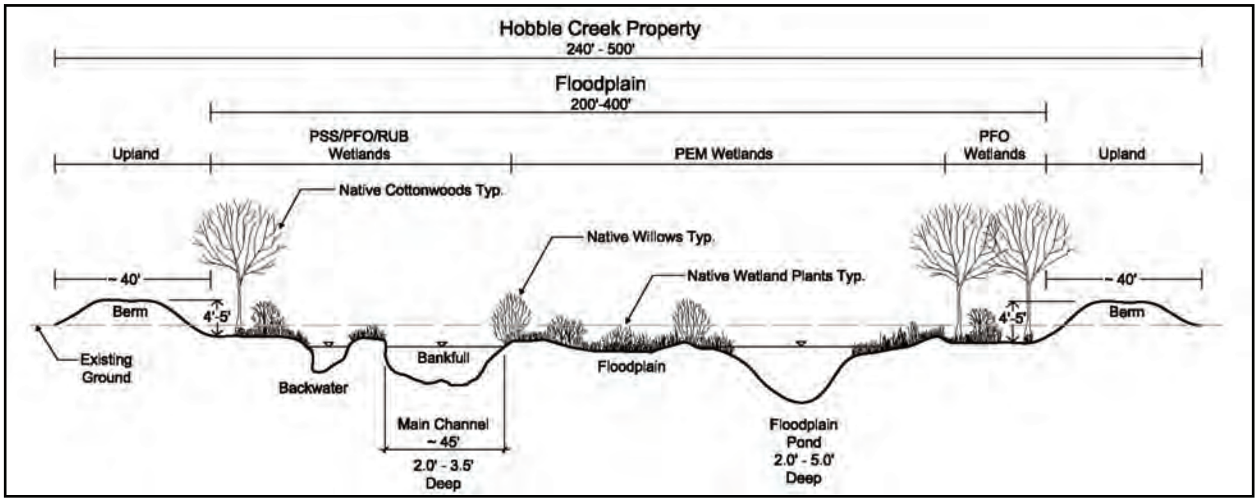

Figure 2.5. Cross section of Hobble Creek restoration design (DOI 2008).

The channel in this reach is typically about 30 to 40 feet wide at low flow and about 60 to 75 feet wide between the tops of the levees. The levees are generally about three to five feet higher than the adjacent agricultural fields (Figure 2.6). Average channel slope varies from about 0.2 percent in the downstream portion of the reach to 0.7 percent in the upstream portion of the reach (Stamp et al. 2002). The streambed profile is interrupted by irrigation diversions at 1000 North and at Packard Dam, each of which creates a vertical bed elevation drop of about four feet. These structures flatten the local slope and cause deposition of fine sediment both upstream and downstream. Streambed substrate consists of sand and silt in the vicinity of these diversions and the 1500 West debris basin. In the remaining portions of the reach, bed material typically consists of gravel and cobble particles that are occasionally algae-coated or partially embedded with fines (Stamp et al. 2002).

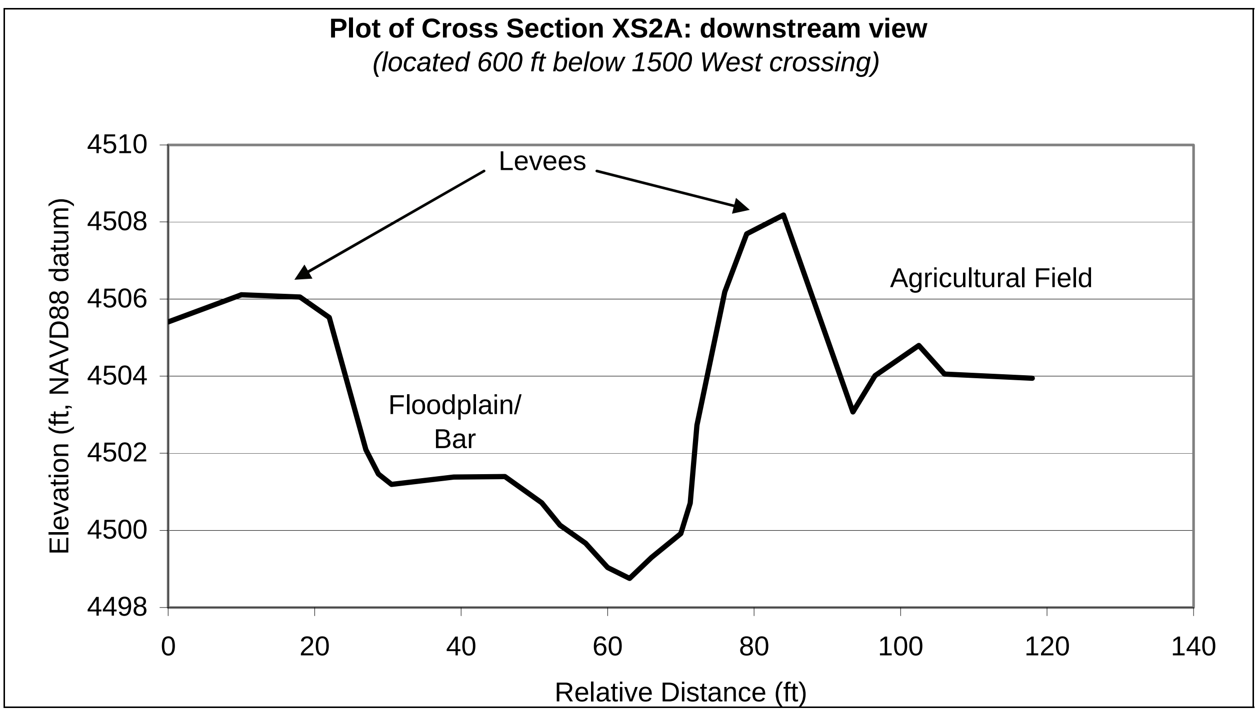

Figure 2.6. Plot of lower Hobble Creek cross section near 1500 West.

Within this reach, the levees are typically well-vegetated with willows, cottonwoods, and Russian Olives. However, the lateral extent of riparian vegetation is limited because the levees prevent the stream from being connected to a broad, well-developed floodplain. The total width of riparian vegetation typically extends about 20 to 35 feet beyond the streambank on both sides of the channel. One relatively large stand of mature cottonwood trees is present beyond the levee on the north side of Hobble Creek upstream of 950 West; this stand is likely a relict from a previous channel or floodplain location prior to levee construction. A second stand of mature cottonwoods had been present beyond the levees on the south side of the creek in this area as well. However, that stand of trees was converted to a housing subdivision between 2002 and 2006.

400 West Street to 1700 East Street

This reach extends for a length of approximately 3.2 river miles and is the most urbanized reach of Hobble Creek. Numerous roads cross the stream in this reach and development constricts channel width. In many sections, the streambanks have been stabilized with vertical concrete walls or rip rap. As with the downstream reaches, the channel in this reach has been confined between levees and portions have been straightened, resulting in low sinuosity. Channel width is generally narrower in this reach, ranging from approximately 10 to 15 feet at low flow to about 25 feet at high flow (Stamp et al. 2002, CUWCD 2004b). Pool habitat is infrequent, and average channel slope is 1.1 percent. The irrigation diversion at Swenson Dam (near 700 East) alters the bed profile and creates a backwater when boards are in place (CUWCD 2004b). Streambed material typically consists of cobble-sized material, often coated with algae. Riparian vegetation is limited to a narrow width along the channel banks; areas of broad floodplain are lacking.

1700 East to Mapleton-Springville Lateral

This upper reach of lower Hobble Creek remains less urbanized than the reach from 400 West to 1700 East. Stream length in this reach is approximately 0.84 river mile. However, land use in this area has been shifting from agricultural to residential, and several new housing subdivisions have been constructed in the downstream half of this reach within the last seven years. As with the downstream reaches, the channel is confined between levees and access to broad floodplain areas is lacking. On the north side of the creek, many of the new homes have been built within 65 feet of the Hobble Creek channel centerline, limiting future opportunities to widen the levees to restore habitat. As with the downstream reaches, riparian width is limited to the streambank and levee area, and extends from about 20 feet to about 40 feet from the streambank on both sides of the channel. Channel gradient averages 1.4 percent in this reach, and channel width and substrate composition generally remain similar to the reach between 400 West and 1700 East (Stamp et al. 2002). The Sage Creek and Island Dam Diversions withdraw water from Hobble Creek in this reach. These structures locally alter the streambed profile and create backwater effects when boards are in place (CUWCD 2004b, Stamp et al. 2002). Two areas of bank instability were noted in this reach during studies associated with ULS planning (Appendix A of CUWCD 2004b).

Water Quality

Hobble Creek is listed as a class 2B, 3A, 4 stream by the Utah Division of Water Quality. The corresponding designated beneficial uses are secondary contact recreation (2B), cold water fishery (3A), and irrigation (4). Hobble Creek is not currently on the Utah 303(d) list as being impaired or requiring a Total Maximum Daily Load (TMDL) analysis for any constituents.

Overall, according to State data, Hobble Creek water quality meets all State standards under current flow conditions. According to the description of baseline conditions in the ULS Final Environmental Impact Statement, dissolved oxygen (DO), total dissolved solids (TDS), pH, nitrate plus nitrite, ammonia, and selenium meet State standards on a monthly basis (CUWCD 2004a). According to the state of Utah's 2006 305b report, Hobble Creek is indicated as supporting its assessed beneficial use classes with some tributaries not assessed (UDEQ 2006). However, Utah Lake is listed as impaired on the Utah 303(d) list for total phosphorus and total dissolved solids.

There are indications that total phosphorus (TP) and temperature may be problematic in Hobble Creek under current conditions during certain times of the year. Based on review of data collected since 1999 at the water quality station on Hobble Creek at I-15 (STORET site #4996100), average TP concentration is 0.06 milligrams per liter (mg/L), which slightly exceeds the Utah indicator value of 0.05 mg/L. Recent data also indicate temperatures can exceed 20°C, which is the State cold water fishery standard. This temperature increase typically occurs during summer days when air temperatures are high and flow in the channel is low. For example, water temperature in Hobble Creek was 23.63°C on August 7, 2001. Flow on this day was only 3.5 cfs (EPA 2008). Additional temperature data were collected specifically for this project to quantify the relationship between flow and water temperature, as described in Section 3 of this report.

Fisheries

General

Hobble Creek contains populations of brown trout; headwater portions of the creek contain Bonneville cutthroat trout and rainbow trout (CUWCD 2004b). Carp have been observed in the portions of Hobble Creek below I-15 (Stamp et al. 2002). Mountain sucker (*Catostomus platyrhynchus*) and sculpin (*Cottus* spp.) have also been found in Hobble Creek (CUWCD 2004b).

June Sucker

As discussed above, June sucker are not currently known to use Hobble Creek for spawning, although it is believed that lower Hobble Creek was used historically. Recent tracking studies and monitoring efforts have found adult June sucker staging in Provo Bay near the mouth of Hobble Creek during the springtime spawning period (Buelow 2006, UDWR 2008). The recently completed channel realignment project at the mouth of Hobble Creek removed access barriers to the creek, and it is hoped that June sucker will utilize the new channel for spawning and rearing beginning in 2009.

Because June sucker have not been observed in Hobble Creek for at least the last several decades, no Hobble Creek-specific fisheries monitoring data are available to help determine the relationship between flow and June sucker spawning success. However, information has been collected on the lower Provo River and on other rivers where similar sucker species spawn. Based on this information, the linkages between streamflow patterns and the specific life history requirements of June sucker are discussed below.

Spawning

It is believed that river flow is a primary factor influencing the cue for June sucker to initiate the spawning migration (USFWS 1999). However, a congener species, the cui-ui (*Chasmistes cujus*), is believed to be cued by water temperature in addition to flow characteristics (Scoppettone et al. 1983, Sigler et al. 1985, Scoppettone et al. 1986). Peak migrations for cui-ui occur in river temperatures varying from 9°C to 17°C and mean daily temperatures from 12°C to 15°C (Scoppettone et al. 1986). Hatching success is highest at temperatures lower than 17°C (Coleman et al. 1987). In addition to the apparent importance of temperature, Scoppettone et al. (2000) suggest that "sufficient fresh turbid flow" is also required to stimulate migration of that species. However, it remains unclear how readily the spawning requirements for cui-ui translate to the requirements for June sucker. To date, existing monitoring data collected on the lower Provo River, where June sucker spawning regularly occurs, have not been sufficient to conclusively determine a relationship between runoff patterns and spawning behavior (Stamp et al. 2008). The inability to safely and consistently sample fish during high flow periods has made it difficult to relate spawning preferences to flow conditions. Therefore, it remains unclear precisely which factor (i.e., turbidity, temperature, flow volume) is the most critical in attracting June sucker up river to spawn. Results of monitoring planned for 2008 using a stationary antenna should provide new insights into this relationship.

In a natural setting, temperature and the associated flow pattern of inflow streams may influence spawning events. However, refuge populations of June sucker have spawned in lake shore environments. A population of stocked June sucker in Camp Creek Reservoir has been spawning and recruiting with such success that the reservoir can not support the recruitment (Webber and Thompson 2008). The common factor seems to be use of a gravel/cobble substrate as the spawning bed. It may be that as long as the water temperature is within the optimum range of 12−17 °C (Keleher et al. 1998) and a suitable substrate for spawning is present, then spawning will occur independent of water velocity.

Radant et al. (1987) developed habitat suitability index (HSI) curves for preferred water depth and velocity for June sucker spawning. These curves indicate that June sucker spawn in areas with an average depth of 1.67 feet (ft) and average velocity of 1.2 feet per second (ft/s). Preferred substrate was described as ranging in size from 100–200 millimeters (mm). However, this substrate curve has been updated based on the observations of June sucker spawning over larger substrates in Red Butte Reservoir. These sources suggested that June sucker use larger substrates in addition to those identified in the Radant et al. (1987) curves. The larger substrates are also predominant in the section of Provo River where June sucker spawn. The presence of low velocity pools that provide resting habitat adjacent to spawning areas may also be important for spawning success.

Larvae

Modde and Muirhead (1990) suggested that emergent June sucker larvae on the Provo River drifted downstream, primarily at night and shortly after hatching; these results were supported by studies during the spawning seasons in 1996 (Crowl and Thomas 1997) and 1997 (Keleher et al. 1998). Keleher et al. (1998) also determined that when Provo River flows are below 400 cfs, changes in flow have a more dramatic effect on velocity, and possibly drift rates of larvae, than when flows are above 400 cfs. However, Wilson and Thompson (2001) found that neutrally buoyant beads were able to drift at sufficient speed when flows were 300 cfs to move from the spawning areas to the lake during one night (approximately 5 hours) and presumably avoid the high predation risk. At 100 cfs the researchers found that beads drifted only 30 meters (m) in approximately 30 hours, suggesting that this flow would not allow efficient transport to the lake. A study by Ellsworth et al. (forthcoming) suggests that recruitment failure may be related to larvae not being able to reach the higher zooplankton densities within the lake before they deplete their yolk reserves. While these studies are specific to the lower Provo River and not to Hobble Creek, they suggest that streamflow and velocity patterns are important determinants of how effectively larvae are able to drift and reach suitable rearing habitats with cover from predators.

Water Temperature Requirements

According to Kindschi et al. (2005), a laboratory evaluation of chronic lethal temperatures on 8-inch fish indicated that the LC50 (temperature at which there was 50% survival for 60 days) occurred between 27.9° C (actual mortality was 18.7%) and 29.7° C (actual mortality was 61.3%). Water temperatures that provided maximum weight gain and feed efficiency in these 8-inch fish was 21.9° C and 21.6° C, respectively. Although this study focused on a single life stage and was a laboratory-based study that did not account for interaction effects of other factors, the information nonetheless provides valuable guidance for managing water temperatures in lower Hobble Creek. In another study Shirley (1983) reported that June sucker eggs hatch faster at 21.1° C (4 days) than at 10.6° C (10 days).

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SECTION 3. FLOW RECOMMENDATIONS FRAMEWORK AND DATA

Lower Hobble Creek Instream Flow Recommendations Framework

The ideal approach to instream flow recommendations would take into account all the types of riverine processes and ecological functions supported or affected by streamflows. This idealized approach is promoted by several of the Instream Flow Council's Policy Statements (Annear et al. 2004):

> ***IFC Riverine Components Statement:*** Instream flow studies must evaluate flow needs and opportunities in terms of hydrology, geomorphology, biology, water quality, and connectivity.
>
> ***IFC Riverine Resource Stewardship Policy Statement:*** All streams and rivers should have instream flows that maintain or restore, to the greatest extent possible, ecological functions and processes similar to those exhibited in their natural or unaltered state.
>
> ***IFC Flow Variability Statement:*** Instream flow prescriptions should provide inter- and intraannual variable flow patterns that mimic the natural hydrograph (magnitude, frequency, duration, timing, rate of change) to maintain or restore processes that sustain natural riverine characteristics.

The idea of a comprehensive framework that includes all riverine components is also suggested in the principles of effective instream flow science outlined in a recent National Research Council report (NRC 2005). This idea is further supported by the resolution passed by the American Fisheries Society at their 2008 annual meeting (American Fisheries Society 2008). Additional discussion of the idea of developing ecologically based comprehensive flow recommendations, as well as a complete description of available methods for determining instream flows can be found in Stamp et al. 2008.

On lower Hobble Creek, protection of certain individual ecological functions is of higher priority than other functions. For example, protection of flow-dependent ecological functions for the endangered June sucker is of high priority because establishment of a spawning run on Hobble Creek is a recovery goal for the JSRIP. Table 3.1 identifies some of the important flow regime components that support the June sucker life cycle. Additional Hobble Creek factors that affect the ecological functions important for June sucker independent of flows are also identified. In Table 3.2 we incorporate some of the priorities on lower Hobble Creek with a more complete list of riverine components to generate a specific lower Hobble Creek instream flow recommendation framework.

Table 3.1. June sucker life history stages supported by instream flows.

JUNE SUCKER LIFE HISTORY STAGE	DESCRIPTION	SUPPORTING DATA/RESEARCH	TYPE OF FLOW REQUIRED	OTHER FACTORS
Spawning: Attraction Flows	June sucker may cue their timing of spawn on water temperature/ turbidity/flow conditions associated with springtime snowmelt runoff.	June Sucker Recovery Plan-USFWS 1999; Scoppettone et al. 1983, 1986, 2000; but it is uncertain whether the main spawning cue is water temperature, turbidity, flow magnitude, or some combination thereof.	flows patterned/timed to coincide with natural springtime snowmelt runoff	Existing diversion structures may prevent June sucker from accessing portions of Hobble Creek upstream of 1000 North.
Spawning: Flushing of Spawning Substrate	June sucker spawn in coarse gravel to small cobble-sized substrate and do not spawn in finer material.	Radant et al. 1987, Sigler and Sigler 1996	regularly occurring flows of sufficient magnitude/duration to flush accumulated fine sediment/algae and maintain clean, loose spawning substrate	Existing diversion structures may prevent June sucker from accessing portions of Hobble Creek upstream of 1000 North.
Spawning: Hydraulic Habitat	June sucker spawn in moderate-velocity riffles/runs 1 to 3 feet deep with gravel/cobble substrate adjacent to lower-velocity resting areas.	Radant et al. 1987, Shirley 1983	flows during the spawning period that maximize spawning habitat in terms of depth/velocity	Existing diversion structures may prevent June sucker from accessing portions of Hobble Creek upstream of 1000 North; levees and channelization above I-15 limit spawning/ staging habitat regardless of flow.
Larval Drift	June sucker larvae emerge from spawning beds and drift downstream during the night.	Modde and Muirhead 1990, Crowl and Thomas 1997, Keleher et al. 1998, Wilson and Thompson 2001, Ellsworth et al. forthcoming.	flows adequate to transport June sucker larvae from spawning to rearing habitats	Predation by non-native fish, which are common in Utah Lake/Provo Bay, may limit reproductive success regardless of flows.
Juvenile and Adult Life Stages	June sucker adults and juveniles live in Utah Lake and congregate at the mouths of tributaries during pre- and post-spawning periods; Hobble Creek is a significant tributary to the lake and influences the water level (and associated refuge habitat availability) and water quality of Provo Bay.	Buelow 2006 (tracking study); Crowl and Thomas 1997; UDWR 2005; information regarding use of main part of lake remains limited	flows adequate to provide appropriate Utah Lake levels, temperature, nutrient, and water chemistry conditions that maximize habitat at Provo Bay mouth during congregation periods	Predation by non-native fish, which are common in Utah Lake/Provo Bay, may limit recruitment success regardless of flows.

Table 3.2. Ecological functions supported by instream flows and their relative priority on lower Hobble Creek under existing (January 2009) conditions [a].

CATEGORY	ECOLOGICAL FUNCTION	PURPOSE/ISSUES	GENERAL TYPE OF FLOW REQUIRED	LOWER HOBBLE CREEK CONSIDERATIONS/ RELATIVE PRIORITY
Water Quality	maintenance of water temperature below harmful/lethal levels	When summertime flows become too low temperatures can exceed lethal levels.	adequate summertime base flow	high priority
Water Quality	nutrient cycling	High, overbank flows that inundate the floodplain provide lateral connectivity between the channel and floodplain, and allow for nutrient cycling.	high-magnitude, low-frequency flood flows	high priority below I-15; low priority above I-15 where levees and channelization limit floodplain inundation regardless of flows
Biology: Aquatic	spawning: attraction flows	Springtime-spawning species may cue their timing of spawn on water temperature/chemistry conditions associated with springtime snowmelt runoff.	flows patterned/ timed to coincide with natural springtime snowmelt runoff and/or appropriate early springtime flow patterns	high priority Additional research is needed to identify specific components of flows that cue spawning on Hobble Creek.
Biology: Aquatic	spawning: flushing of gravels/ cleansing of substrate	Adequate flows are needed to flush accumulated fine sediment/algae and maintain clean, loose spawning gravels.	regularly occurring flows of sufficient magnitude/ duration to flush fine sediments	high priority downstream from 1000 North; lower priority upstream of 1000 North because existing diversion structures may prevent spawning access
Biology: Aquatic	hydraulic habitat availability	Flows affect the availability of habitats with different depths/velocities required by various aquatic species and life stages.	flow regime that provides an appropriate mix of hydraulic habitats during critical life stage periods	medium priority Levees and channelization limit availability of low-depth/velocity habitat at high flows.
Biology: Riparian	cottonwood/willow recruitment	Seed-based recruitment of native woody riparian species requires a specific combination of flows and fluvial surfaces.	flows that inundate an appropriate germination surface during the seed dispersal window and then decline slowly enough for root growth to keep up	high priority below I-15; low priority above I-15 where levees and channelization limit floodplain inundation regardless of flows.

Table 3.2. (cont.)

CATEGORY	ECOLOGICAL FUNCTION	PURPOSE/ISSUES	GENERAL TYPE OF FLOW REQUIRED	LOWER HOBBLE CREEK CONSIDERATIONS/ RELATIVE PRIORITY
Biology: Riparian	prevention of vegetation encroachment/ channel narrowing	Low flow or dry conditions during the summer growing season allow vegetation to encroach into the active channel and can lead to channel narrowing.	adequate summertime base flow	medium priority
Geo-morphology	channel maintenance	Moderate-magnitude (bankfull) floods are needed to maintain channel capacity and form (pools/riffles) and transport sediment.	regularly occurring flows of sufficient duration/ magnitude to fully mobilize the streambed and transport the incoming sediment load	medium priority Sediment trapping by Hobble Creek Debris Basin and other diversions alter sediment transport/ channel maintenance regardless of flows.
Geo-morphology	channel complexity creation/ maintenance	Large, overbank floods create and maintain complex habitat such as side channels and backwaters.	occasional large, overbank flood flows	high priority below I-15; low priority above I-15 where levees and channelization limit floodplain inundation regardless of flows.
Hydrology	inter- and intra-annual flow variability	Native plants and aquatic species are adapted to natural flow variability at short- and long-term time scales.	mimicry of natural inter- and intra-annual flow variability (duration, magnitude, rise and fall rates, etc.)	high priority

[a] The priorities listed in this table reflect the existing leveed condition of lower Hobble Creek above I-15 and are not meant to imply that certain functions are unimportant in natural systems.

Instream Flow Determination Methods/Data for Lower Hobble Creek Riverine Components

Various existing data sets and analyses completed specifically for this study were used to develop instream flow recommendations for lower Hobble Creek. These data and analyses are described below.

Hydrologic Data

As discussed under Existing Conditions, available hydrologic data for Hobble Creek include data from the discontinued USGS gage, the periodic field discharge measurements summarized in Table 2.2, and monthly flow estimates developed by the CUWCD accounting for water diversions in Springville above 400 West. In addition to these data sources, as part of this study, a dimensionless flow duration technique, which has been useful in other river systems for determining a natural range of variability for periods of low streamflow, was used. Additional details of this technique can be found in Stamp et al. 2008. For this study, an analysis of Hobble Creek springtime runoff patterns was completed using data from the discontinued USGS gage.

Dimensionless Flow Duration Analysis

This analysis approach begins with the selection of a group of gaged streams with climatic, geologic, and physiographic characteristics similar to the stream of interest, in this case lower Hobble Creek. These streams are termed “reference” streams because they are used as a reference for natural streamflow distribution. Streams are selected that have limited human alteration of naturally variable temporal patterns of streamflow (e.g., streams without excessive alteration of the watershed, streams without large dams, streams with limited diversion capacity).

The following seven streams were selected for use as reference streams:

- Bear River near the Utah-Wyoming state line
- Hobble Creek near Springville, Utah
- North Fork Provo River near Kamas, Utah
- Payson Creek above Diversions near Payson, Utah
- Spanish Fork above Thistle, Utah
- Weber River near Coleville, Utah
- Yellowstone River near Altonah, Utah

Although all these streams have some level of hydrologic alteration, they represent the natural distribution of streamflow in this area reasonably well. Note that Hobble Creek at the discontinued USGS gage (#10152500) was included as one of the reference sites.

Streamflow data from the selected group of reference streams can be plotted to create a standard flow duration relation, as shown in Figure 3.1. Notice that streams of different size are distributed vertically along the y-axis (discharge). Although the curves appear to have similar shapes, the vertical distribution makes it impossible to use the data from one stream to guide flow recommendations on another stream, unless they happen to be of exactly the same discharge volume. In order to use these data to guide flow recommendations, a way must be found to remove the effect of stream size on the data, which would allow basins of different sizes to plot in the same space. This can be accomplished by dividing each of the measured discharges for the period of record by the mean flow for the same period, which produces the plots shown in Figure 3.2. The result is a dimensionless variable that we will call “dimensionless discharge.” It is dimensionless because the units of discharge cancel out when dividing by the mean discharge. Notice that the plots that were previously distributed along the y-axis are now grouped much more closely. The new plots are quite useful for determining a natural range of discharge for other streams in the area.

Because this technique is new to most people, a quick example may provide some helpful insight. In a way, the dimensionless discharge units can be thought of in terms of multiples of the mean flow. For example, on Hobble Creek, which has a mean flow of approximately 45.7 cfs, the flow on a given day may be 22.8 cfs, which becomes a dimensionless discharge of 0.50 (22.8 cfs / 45.7 cfs = 0.5), or 0.5 times the mean flow. In the springtime, during the runoff period, the discharge may be 228 cfs, which becomes a dimensionless discharge of 5 (228 cfs / 45.7 cfs = 5), or five times the mean flow. Dimensionless discharges, like those shown in Figure 3.2, can be

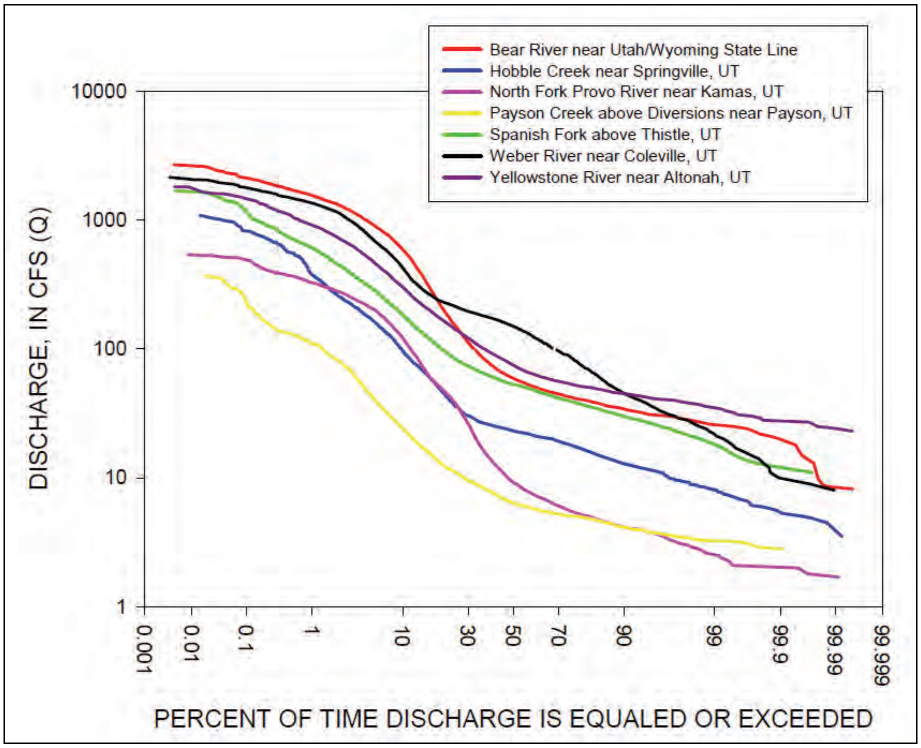

Figure 3.1. **Standard flow duration relations for seven Utah reference streams.**

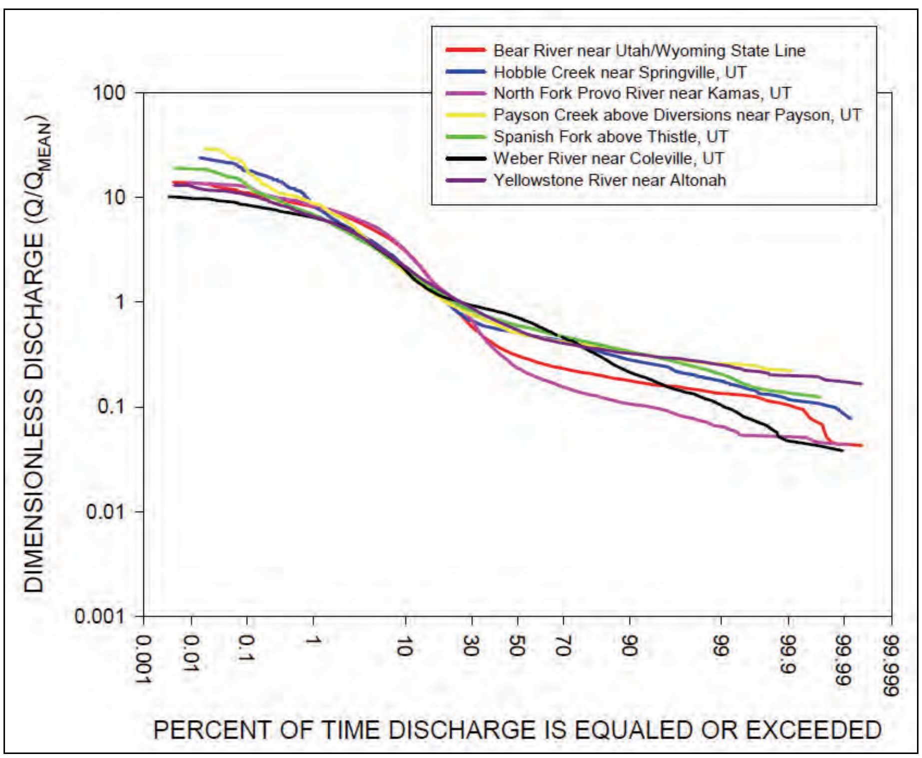

Figure 3.2. **Dimensionless flow duration relations for seven Utah streams.**

scaled for any similar stream by multiplying the values by the mean discharge for the new stream. This simple procedure can be applied to any stream with similar characteristics.

In order to determine a more appropriate range of streamflow during different seasons for Hobble Creek, gage data from the reference streams were analyzed to produce dimensionless flow duration curves for each month. Figure 3.3 provides an example of one of these monthly curves (July) for the Utah reference streams. For comparison purposes, the estimated average July flow on Hobble Creek below the Springville diversions (3.7 cfs) is also plotted as a dimensionless value. This value plots well below the reference streams, indicating that flows are substantially lower in July than would be expected in a less-altered system. These low flows occur during the warmest times of the year, when temperatures in the river are hovering at or above lethal levels for many organisms and oxygen levels are extremely low. The biological implications of these low flows are potentially profound.

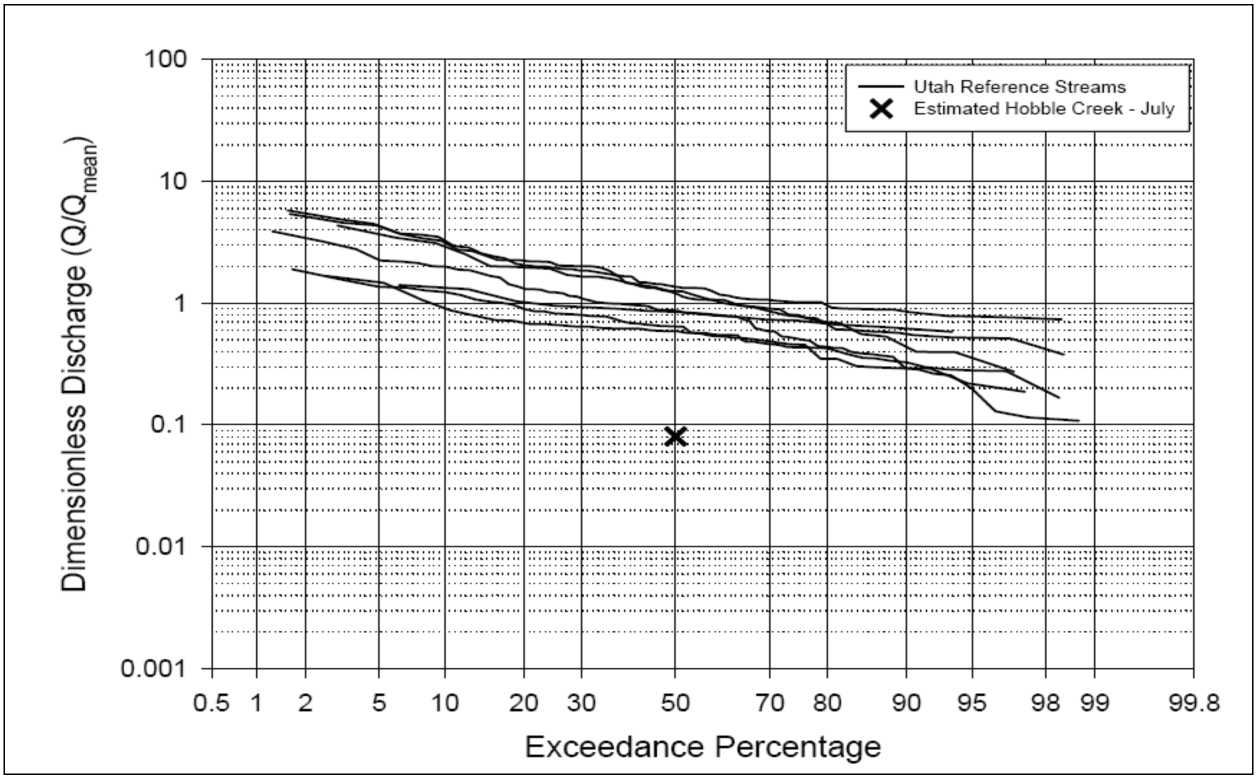

Figure 3.3. Monthly (July) dimensionless flow duration relations for seven Utah reference streams. Estimated average July flow for Hobble Creek below Springville diversions is shown as an X on the plot.

The table of monthly dimensionless discharges can then be scaled for any similar Utah stream by multiplying by the mean discharge. Such a scaling was completed for lower Hobble Creek, which resulted in the values shown in Table 3.3. Monthly discharge values were computed for water years ranging from a low of the 10th percentile to a high of the 90th percentile. In addition to the 20th, 50th, and 80th percentile water year values generated from the dimensionless analysis of all seven Utah reference streams, the comparable values specific to the Hobble Creek gage are also listed in Table 3.4.

Table 3.3. Calculated natural average monthly flows for lower Hobble Creek based on median dimensionless values for seven Utah reference streams.

MONTH	WATER YEAR PERCENTILE								
	10	20	30	40	50	60	70	80	90
January	12.3	14.0	15.5	18.2	18.7	18.9	19.0	19.2	20.5
February	12.1	13.6	15.9	16.2	17.8	17.8	18.4	19.4	20.3
March	13.2	14.6	17.6	18.6	19.4	19.9	21.0	21.0	21.4
April	15.2	20.5	25.4	35.0	42.2	53.1	73.8	88.9	110.5
May	42.4	71.4	88.2	112.1	132.2	147.3	159.4	184.4	234.4
June	31.5	39.7	49.9	79.2	118.1	129.6	146.1	183.0	229.2
July	18.6	27.7	32.2	35.5	38.5	43.7	48.4	59.3	86.0
August	11.1	14.1	16.3	19.3	20.9	24.5	29.1	38.0	40.1
September	10.7	12.4	15.8	17.8	19.3	21.5	24.9	26.3	31.5
October	11.5	14.8	16.9	19.0	20.2	22.3	22.6	23.4	26.3
November	12.6	15.6	17.4	19.4	21.2	22.6	24.1	24.8	25.7
December	12.7	16.0	17.2	18.0	18.7	20.5	20.9	21.4	22.9

Table 3.4. Monthly flows for lower Hobble Creek for 20th, 50th, and 80th percentile water years based on median Utah reference stream values and based on data from the discontinued USGS gage on Hobble Creek (#10152500).

MONTH	WATER YEAR PERCENTILE					
	20		50		80	
	UT Median	Hobble Ck gage	UT Median	Hobble Ck gage	UT Median	Hobble Ck gage
January	14.0 cfs	15.1 cfs	18.7 cfs	19.4 cfs	19.2 cfs	23.3 cfs
February	13.6 cfs	15.9 cfs	17.8 cfs	21.2 cfs	19.4 cfs	24.8 cfs
March	14.6 cfs	20.1 cfs	19.4 cfs	25.5 cfs	21.0 cfs	38.9 cfs
April	20.5 cfs	41.7 cfs	42.2 cfs	97.8 cfs	88.9 cfs	168.8 cfs
May	71.4 cfs	68.9 cfs	132.2 cfs	132.2 cfs	184.4 cfs	184.4 cfs
June	39.7 cfs	35.4 cfs	118.1 cfs	59.5 cfs	183.0 cfs	74.6 cfs
July	27.7 cfs	14.8 cfs	38.5 cfs	25.9 cfs	59.3 cfs	30.6 cfs
August	14.1 cfs	12.6 cfs	20.9 cfs	19.5 cfs	38.0 cfs	22.4 cfs
September	12.4 cfs	12.0 cfs	19.3 cfs	17.9 cfs	26.3 cfs	21.5 cfs
October	14.8 cfs	12.6 cfs	20.2 cfs	19.8 cfs	23.4 cfs	23.3 cfs
November	15.6 cfs	14.7 cfs	21.2 cfs	21.2 cfs	24.8 cfs	24.8 cfs
December	16.0 cfs	16.1 cfs	18.7 cfs	20.5 cfs	21.4 cfs	24.5 cfs

For the most part, the values generated by the group of Utah reference streams are similar to those generated from the Hobble Creek gage data (Table 3.4). However, some differences are apparent. The Hobble Creek gage values are higher in the winter and early spring, most likely because Hobble Creek has a lower elevation watershed with a snowpack that melts off relatively early. For this same reason, the Hobble Creek values are lower than the Utah reference values for June and July. The Hobble Creek August and September values are also slightly lower, while the values for October through December are quite similar to the Utah reference values.

Springtime Runoff Analysis

As discussed above, records of daily diversion amounts for diversions on lower Hobble Creek are not available. Therefore, it is difficult to know how the existing flow regime differs from natural conditions during the springtime June sucker spawning period. The CUWCD estimates below the Springville diversions (to 400 West) indicate that monthly flows in April, May, and June are reduced relative to flows at the discontinued USGS gage upstream (Figure 2.3). However, it is unclear how the diversion structures on lower Hobble Creek are actually typically operated during high flow periods. Most of the diversion structures are simple concrete sill/wing wall structures that are operated by placing wooden boards into slots to raise the water level to the degree needed to divert flow into an adjacent pipe or ditch. During high flow periods when sediment and woody debris are being transported by the creek, these boards are susceptible to damage and some irrigators may opt to delay flow withdrawals until runoff recedes.

Regardless of the extent to which the lower Hobble Creek diversions affect springtime flows, it is helpful to try to identify the springtime flow patterns that would occur naturally as a basis for developing springtime flow recommendations. Because flows during the springtime runoff period are highly variable day-to-day, analysis of monthly average flows such as the CUWCD estimates (2003) or of the values generated from the dimensionless analysis (Tables 3.3 and 3.4) are not helpful in determining appropriate daily springtime values. Instead, we relied on the available daily and instantaneous peak flow records for April through July at the discontinued USGS gage for our analysis.

To identify an initial set of hydrographs, percentile statistics (20^{th}, 50^{th}, 80^{th}, and 90^{th} percentile water years) were generated for each calendar day using the record of daily flows at the USGS gage. These statistics provide an indication of the types of flow patterns that would occur under dry, moderate, and wet-year conditions. Plots of these hydrographs are shown in Figure 3.4 for the springtime runoff period from March 1 through July 31. Because these plots are based on calculated daily statistics rather than actual flows that occurred on consecutive days in a given year, they may show some unusual day-to-day patterns as a relict of the analysis method. To evaluate this, the percentile plots were compared to various actual gaged hydrographs for dry, moderate, and wet-year conditions. These plots are included as Appendix A. Based on these comparisons, the statistical plots (Figure 3.4) do not generally appear to be unreasonable or unrealistic; however, the actual recorded hydrographs for moderate and wet years tend to have somewhat higher peak magnitudes, slightly shorter overall runoff duration, and somewhat steeper rise and fall rates. Dry-year hydrographs appear to be rather variable, with somewhat lower peaks and shorter runoff duration than the 20^{th} percentile plot shown in Figure 3.4.

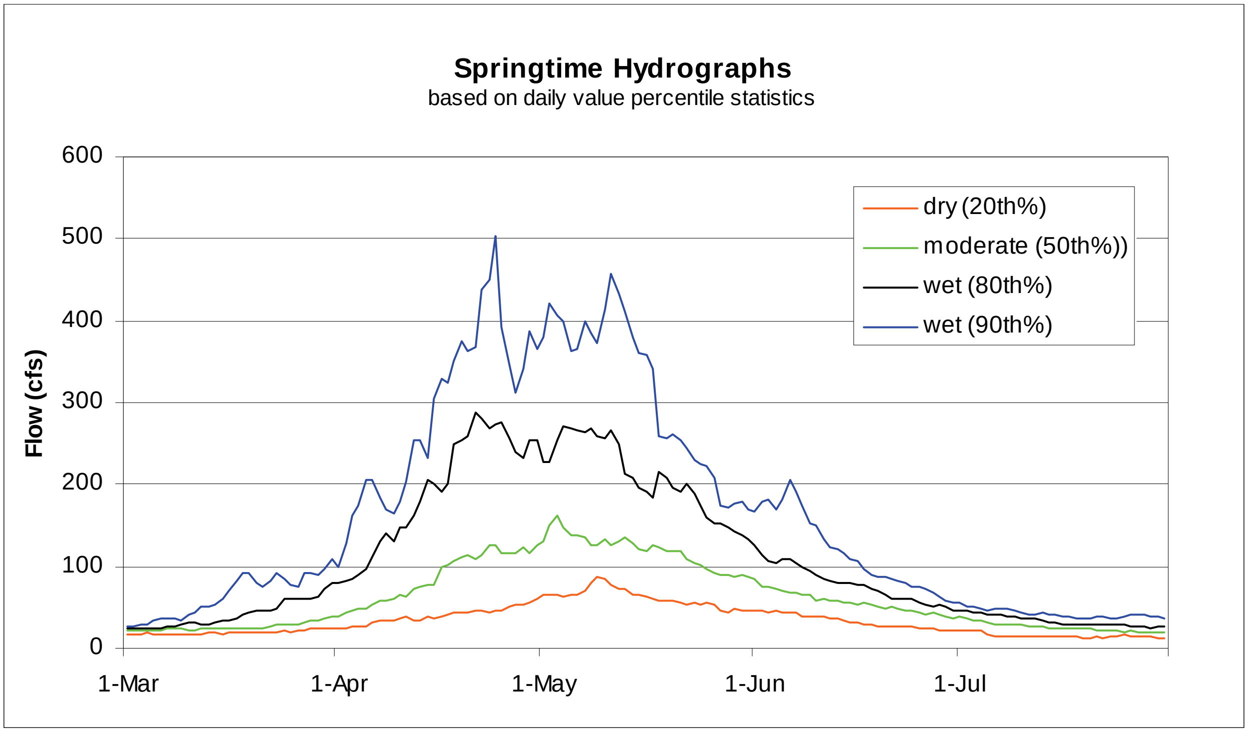

Figure 3.4. Springtime hydrograph plots based on daily percentile statistics at Hobble Creek USGS gage #10152500.

Geomorphic/Hydraulic Data

Several existing data sets are available to help determine the flows needed to support geomorphic processes on lower Hobble Creek.

Sediment Transport Data

As part of studies completed for ULS environmental documents, the WinXSPRO software program (Parker equation) was used to model bedload transport on Hobble Creek at a riffle cross section 1,000 feet downstream from the Mapleton-Springville Lateral. Results indicate that initial mobilization of the bed material occurs at about 95 cfs and that between 145 and 210 cfs, bedload transport rates increase rapidly (CUWCD 2004b). Channel slope at this cross section is 1.1 percent, and the median bed material particle size is 51 mm.

Bedload transport was field-measured at several locations on Hobble Creek during spring 2006 by Brown (2008). Although data are somewhat limited for the lower reaches of Hobble Creek, multiple samples were taken at a sampling site located near 900 East in Springville (Figure 2.1). Based on these samples, it appears that during the 2006 springtime runoff, significant sediment transport was initiated at about 100 cfs, and that transport rates increased rapidly at flows above about 240 cfs (Brown 2008). In 2006, bedload particle sizes of up to about 25 mm were captured at Site 3, and the maximum streamflow measured during bedload sampling at the site was 304.5 cfs (Brown 2008). However, spring season 2008 bedload sampling by Brigham Young University (BYU) at 950 West and 1600 West did not collect any measurable amount of sediment. Maximum flow measured during these sampling efforts was 200 cfs (R. Hotchkiss 2008, pers. comm.).

Results of HEC-RAS hydraulic model calculations performed for the design of the Hobble Creek restoration project predict that particles between 20 and 30 mm would be mobile at flows equal to the 2-year recurrence interval flood of 265 cfs. These results are applicable to the steeper riffle sections constructed at the eastern end of the restoration project.

As part of conceptual habitat enhancement studies (Stamp et al. 2003), BIO-WEST surveyed channel cross sections on Hobble Creek below 1500 West (previous street name 700 East) and above 950 West (previous street name 1150 East). Modeled (WinXSPRO) shear stress results at the 950 West cross section predict that flows of about 140 cfs would be adequate to mobilize medium-sized gravel (20 to 30 mm diameter), flows of about 490 cfs would be adequate to mobilize large-sized gravel (50 mm diameter) and flows of about 950 cfs would be adequate to mobilize cobble material ≥64mm diameter.

Although these available data sets and analyses are not comprehensive, they suggest that flows greater than 200 cfs are important for sediment transport on lower Hobble Creek. Flows of this magnitude appear capable of mobilizing medium-sized gravel particles in riffle habitats, which suggests they would be adequate to flush spawning substrates and maintain them free of fine sediments. However, no specific “flushing flow” study has been completed on lower Hobble Creek, and it is not yet known which specific riffle habitats will be accessible to and used by spawning June sucker. In the future, once fish monitoring data indicate where spawning occurs, additional sediment transport modeling or sampling efforts would be recommended to more definitively establish flushing flow magnitudes for the relevant locations along the channel.

Particle Size Data

Streambed surface particle size data were collected at several locations on lower Hobble Creek by Brown (2008); these data are summarized in Figure 3.5. These data suggest that substrate particles of the size preferred by June sucker for spawning (100 to 200 mm) are rare or absent in the lowest reaches of Hobble Creek, but become more common in the upstream reaches of the Study Area. As part of the Hobble Creek restoration project, cobble substrate material in this size range was placed in several riffle locations within the reconstructed channel (DOI 2008). Again, it will be important to monitor actual June sucker spawning habits in the future to better identify the actual substrate and hydraulic characteristics of the locations they are observed to spawn in Hobble Creek. This will, in turn, allow the relationship of these spawning habitats to streamflow to be more accurately described.

Channel Geometry/Hydraulic Data

As part of conceptual habitat enhancement studies (Stamp et al. 2003), BIO-WEST surveyed channel cross sections on Hobble Creek below 1500 West (previous street name 700 East) and above 950 West (previous street name 1150 East). Hydraulic analysis of the 950 West cross section using WinXSPRO predicts that flows between 35 and 141 cfs would provide appropriate spawning depths (1 to 3 feet) and velocities (0.2 to 3 feet/second) for June sucker (Stamp et al. 2003). Similar WinXSPRO analysis of the cross section below 1500 West predicts that flows between 37 to 319 cfs provide the preferred spawning depths and velocities.

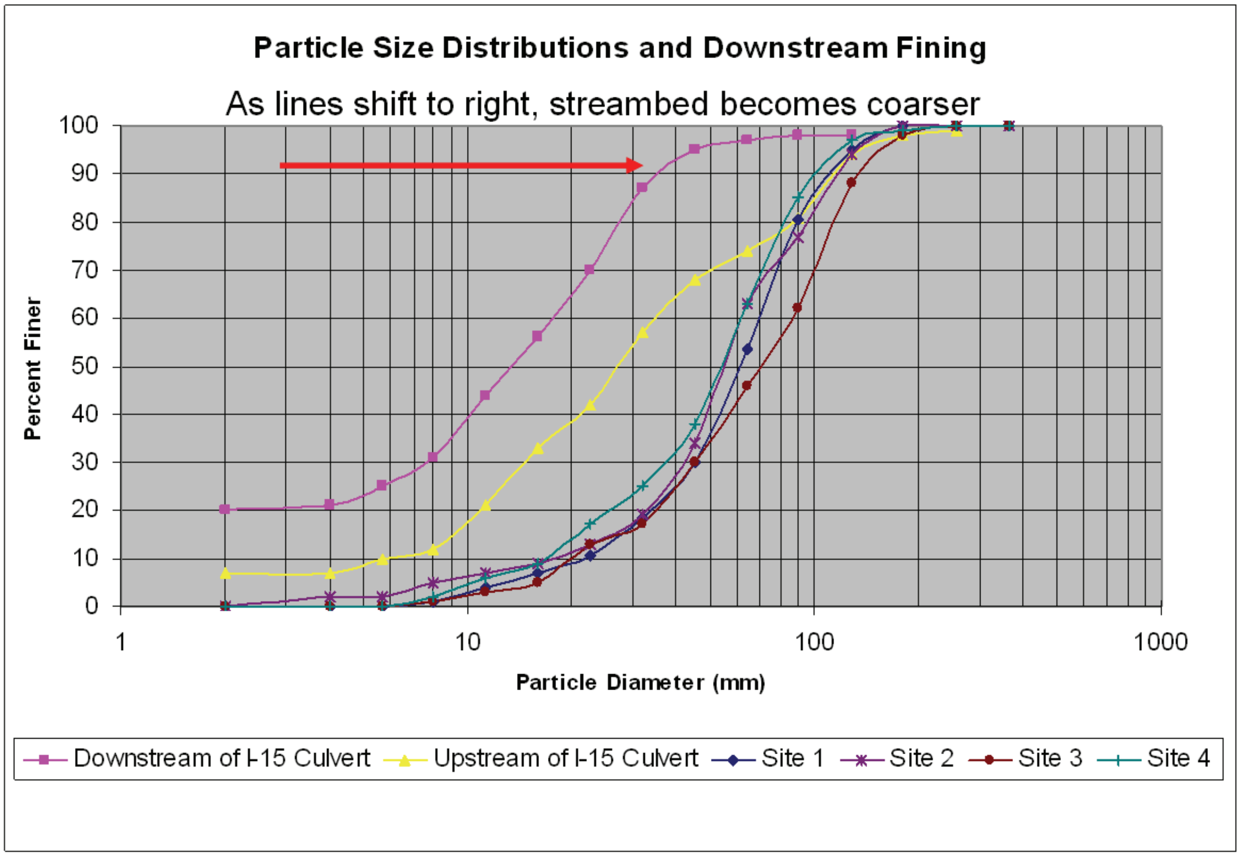

Figure 3.5. Hobble Creek streambed particle size distributions. Figure from Brown (2008). Site 4 is located at 200 West; Site 3 is located at 900 East; Sites 1 and 2 are upstream of the Mapleton-Springville Lateral.

As part of field surveys and analyses completed for ULS environmental documents, estimates of bankfull discharge were made at several cross sections (CUWCD 2004b). In this report, the term "bankfull discharge" refers to the flow that just begins to overtop alluvial bank features or deposits such as point bars; on lower Hobble Creek, these banks are typically much lower than the artificial levees that line much of the channel. Flows much greater than what we refer to here as bankfull discharge would be needed to overtop the levees on Hobble Creek. Reported bankfull estimates were 140 to 150 cfs for the upstream portion of the Study Area (CUWCD 2004b). Similar values are obtained when the WinXSPRO results at the 950 West and 1500 West cross sections are examined. At 950 West, the wetted width reaches the break in slope at the right bank at a discharge of about 146 cfs (Figure 3.6). At 1500 West, the floodplain/bar surface is fully inundated at flows of about 162 cfs. Within the newly constructed Hobble Creek restoration project, the channel was designed to overtop its banks beginning at flows of about 200 cfs. Although a comprehensive analysis of bankfull discharge or effective discharge has not been completed for Hobble Creek, the available data suggest that flows in the range of 140 to 200 cfs are important for maintenance of the bankfull channel.

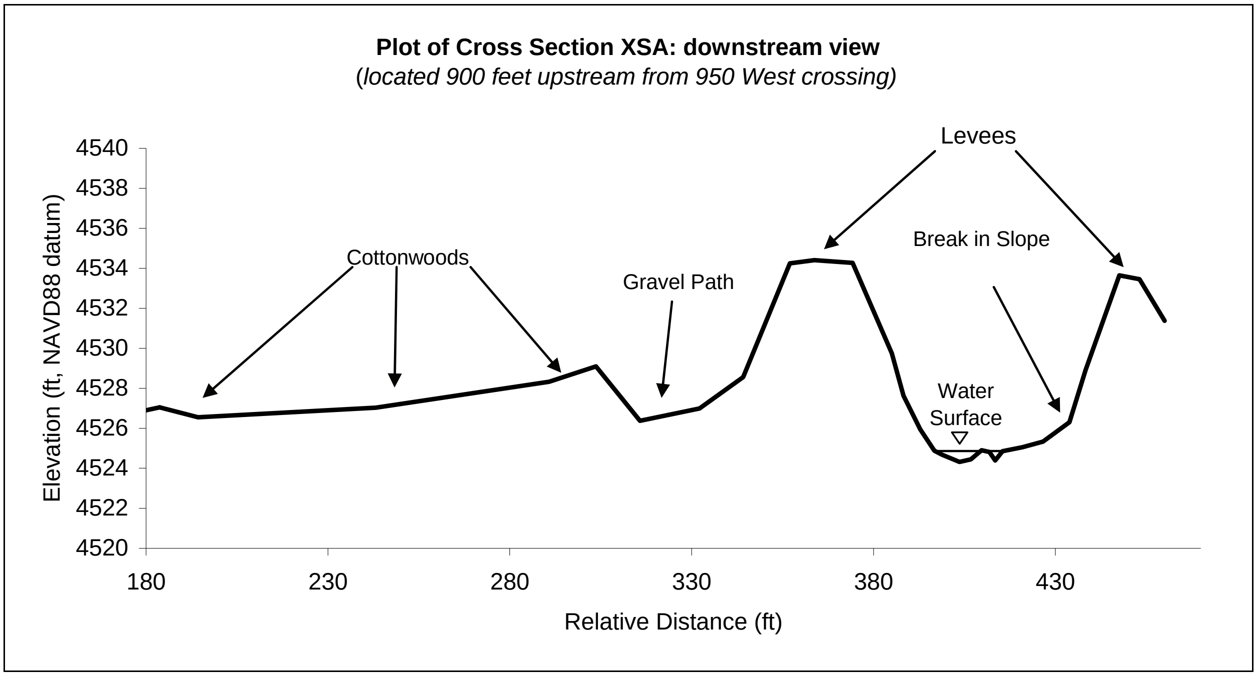

Figure 3.6. Plot of lower Hobble Creek cross section near 950 West.

Another geomorphic and hydraulic consideration involves base flows to limit vegetation encroachment by grasses, sedges, or woody shrubs. WinXSPRO results at the 950 West and 1500 West cross sections predict that flows of about 18.8 to 23.5 cfs fully inundate the low flow channel and would be adequate to prevent excessive vegetation growth during the summer growing season.

Biological Data

In general, available biological data for lower Hobble Creek are limited. Now that the Hobble Creek restoration project is complete and lower Hobble Creek has been re-connected to Utah Lake, it is hoped that June sucker will swim up Hobble Creek during the spawning period beginning in spring 2009. Future fisheries monitoring efforts should provide valuable biological information regarding June sucker spawning habitat requirements/preferences in Hobble Creek as well as larval drift patterns and rearing habitat use.

As described in Table 3.1, one biological flow component important for June sucker has to do with larval drift. Brown (2008) completed a drift bead study on lower Hobble Creek in 2006. Beads were deployed on July 17, 2006, at the 1600 West bridge, and nets were used to collect the beads at three sites west of I-15 in the pre-restoration lower Hobble Creek channel. Flow was not measured during the study, but was estimated at 40 cfs (Brown 2008). Beads were captured and observed at the first net site, located near what is now the entrance to the Hobble Creek restoration project. No beads were observed or collected at the net sites located farther downstream in the old outlet channel (Brown 2008). Observations indicated that the beads, although intended to be neutrally buoyant, tended to sink to the streambed, limiting the ability of the beads to accurately simulate larval drift. In addition, the fact that streamflow was only estimated rather than field measured limits the conclusions that can be drawn about drift effectiveness relative to flow. Nevertheless, the study results tend to suggest that flows of approximately 40 cfs are effective at transporting beads through the I-15 culvert. We recommend that June sucker larval monitoring be completed on Hobble Creek to better assess this relationship, and to assess transport of larvae into and within the newly restored lower channel.

Water Quality Data

As discussed in the Existing Conditions section, available water quality data indicate that water temperatures occasionally exceed the 20 degree cold water fishery standard (DWQ 2005) during low-flow periods in summer. As part of this study, additional data were collected and an empirical analysis of the relationship between flow and temperature was undertaken to help identify a minimum flow that would be protective of the temperature standard. In addition, we reviewed existing temperature data to determine if water temperatures ever reach the chronic level lethal to June sucker (approximately 28 degrees C for 60 days; Kindschi et al. 2005).

Initial Analysis

Periodic, non-continuous, water temperature and streamflow data collected on Hobble Creek by the Utah Division of Water Quality between 1982 and 2006 were obtained and analyzed. After initial review of the complete data set, a subset of the data containing only July and August flows less than 25 cfs were analyzed in greater detail. This is the time period and flow conditions when temperature exceedances are most common.

As evident in Figure 3.7, temperatures very rarely approach the 28 degree C chronic lethal level. Therefore, avoidance of temperatures lethal to June sucker will not be a driving factor in recommending minimum base flows.

Maintaining water temperature below the 20 degree C fishery standard is a greater concern. Once flows drop below about 11 cfs, water temperatures above 20 degrees C become quite common (Figure 3.7). At flows greater than about 11 cfs, temperatures rarely exceed 20 degrees C.

Data Collection Methods

BIO-WEST installed one HOBO U22 Water Temp Pro v2 (U22) and one HOBO U20 Water Level Logger (U20) in the lower reach of Hobble Creek. The U22 was deployed on July 7, 2008, below the I-15 culvert, and recorded temperature data every minute through July 25, 2008. The U20 was deployed on July 7, 2008, below Packard Dam, and recorded both temperature and pressure (stage) data every minute through July 18, 2008. The data was collected and then converted to hourly and daily averages. The hourly averages were calculated such that for a given hour data point, the minute data from said hour through said hour plus 59 minutes were averaged (e.g., data point 12:00 is the average of minute data for 12:00 through 12:59). The daily average data points are averages from 12:00 midnight through 11:59 p.m. Daily averages for days with incomplete data sets were not included as these tended to skew the results.

Data loggers were re-deployed in September and collected data from September 4, 2008, through October 14, 2008. These data were downloaded and plotted but were not analyzed in detail because air temperatures were relatively cool during this period and recorded water temperatures during this period did not exceed 20 degrees C.

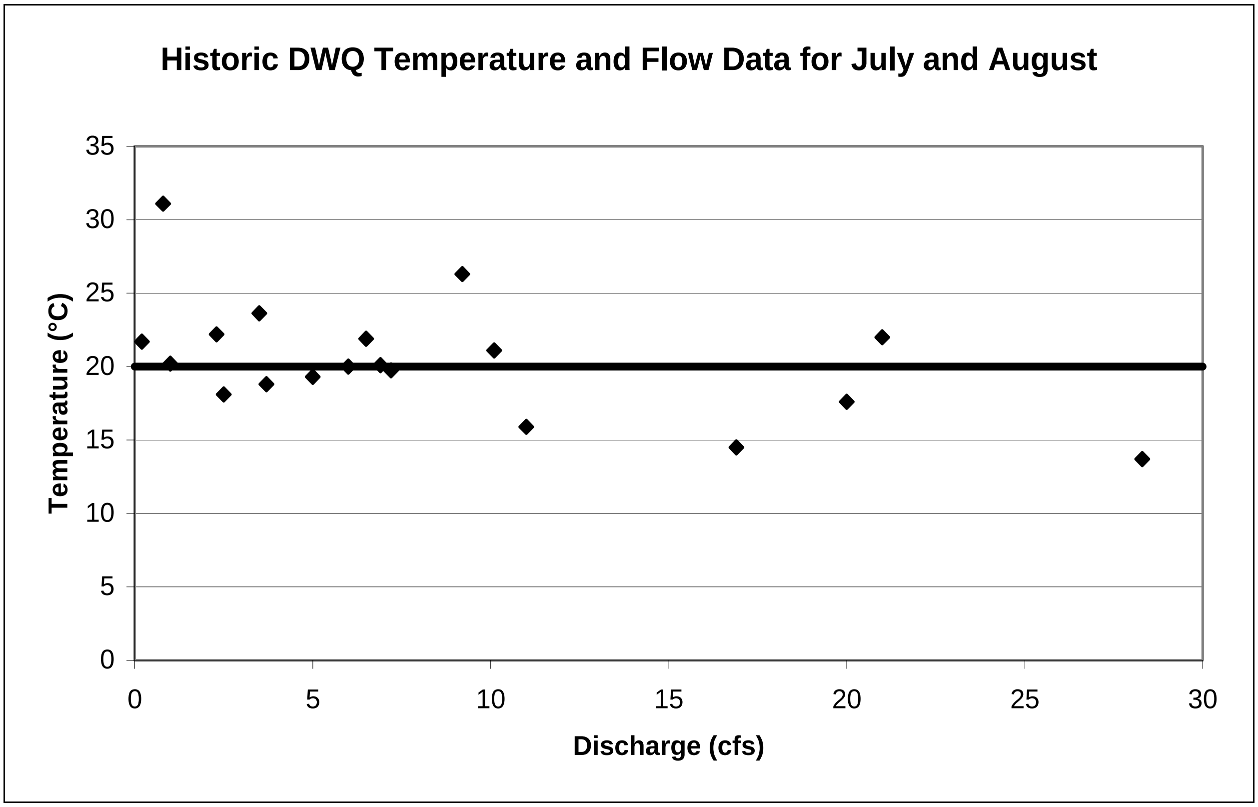

Figure 3.7. Plot of July and August water temperature data collected by the Utah Division of Water Quality (DWQ) on lower Hobble Creek. Thick black line indicates cold water fishery standard of 20 degrees C.

In-stream flow data was collected during four site visits to the station below Packard Dam using a Marsh-McBirney velocity meter and top-set rod calibrated to record at 0.6 depth from water surface. Water level was also recorded during for each discharge measurement and used to create a stage-discharge rating curve.

Temperature Analysis Results

Temperatures above 20 degrees C were observed almost continuously at the station below the I-15 culvert (Figures 3.8 and 3.9). Temperatures were 20 degrees C or greater 91 percent of the time. During lower flow events, average hourly temperatures approached, and in several instances, exceeded 25 degrees C. However, these events would last approximately three to five hours and did not approach the maximum temperature threshold of the June sucker. The maximum temperature recorded below the I-15 Culvert was 26 degrees C (Figures 3.8 and 3.9). Temperatures greater than or equal to 20 degrees C occurred 35% of the time during the sample period at the station below Packard Dam. The maximum temperature recorded below Packard Dam was 22.3 degrees C. Based on recorded water level (stage) data, flow rates during the sample period are estimated to have been between about 0.6 and 2 cfs for the Packard Dam site, and between 0.6 and 7 cfs for the I-15 site. More data over a greater range of flows would be needed to establish a more definitive relationship between discharge and temperature. The available data do suggest however, that flows in this range are not adequate to provide average hourly temperatures below 20 degrees C. When also considering the DWQ data set, the threshold

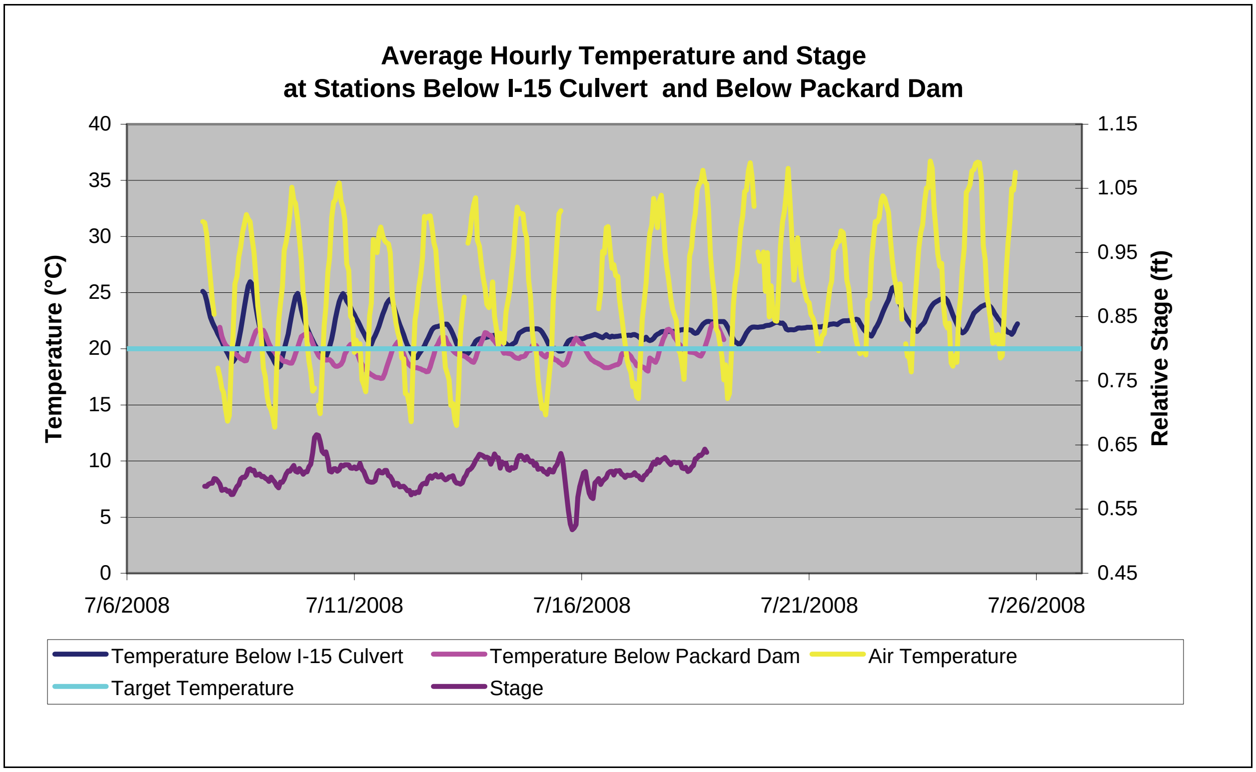

Figure 3.8. **Hourly temperature and water level (stage) data at Hobble Creek temperature monitoring sites.**

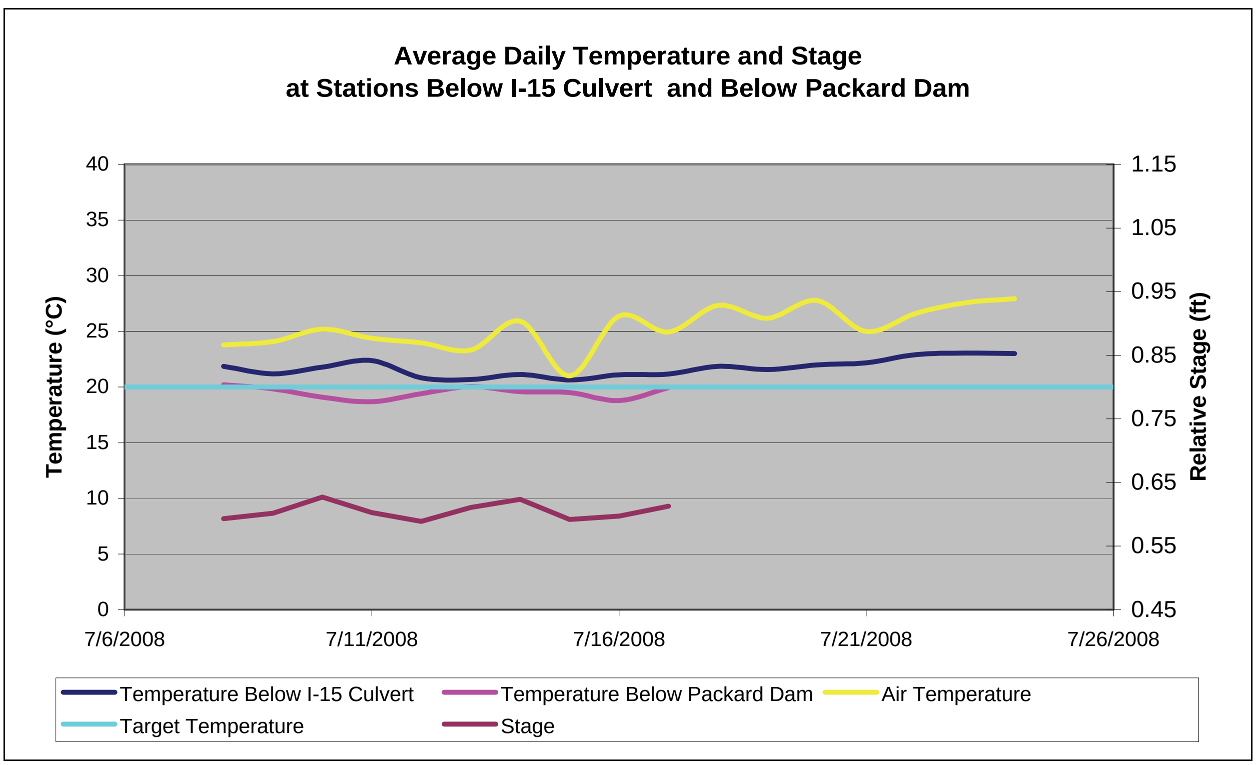

Figure 3.9. **Average daily temperature and water level (stage) data at Hobble Creek temperature monitoring sites.**

appears to be approximately 11 cfs. Now that the new USGS gage near Packard Dam is operational, it would be useful to re-deploy the temperature loggers during summer 2009 to obtain a more comprehensive data set and further refine this estimate of the flow needed to maintain water temperature quality. The Packard Dam site has a vegetative canopy that shades the stream which may have influenced the temperature data. Data collected at this site show lower water temperatures and less hourly variability than the downstream I-15 site, which is less shaded (Figure 3.8).

Summary

The methods and analysis results used to develop lower Hobble Creek flow recommendations are summarized in Tables 3.5 and 3.6.

Table 3.5. Instream flow determination methods for lower Hobble Creek.

TYPE OF FLOW	QUANTIFICATION METHOD(S)	DATA SETS/ ANALYSIS TOOLS	IMPORTANCE FACTOR
Base Flows to Maintain Water Temperature	dimensionless flow duration curve approach; empirical temperature vs. flow evaluation	DWQ cold water fishery standard; DWQ and BIO-WEST temperature data; lab study of June sucker temperature requirements	June Sucker Habitat = low, given June sucker do not use Hobble Creek during the warm low-flow months Hobble Creek Ecosystem = high, given potential impacts to aquatic biota
Base Flows to Limit Vegetation Encroachment	visual evaluation of cross section plots	BIO-WEST cross sections from 2002-2003 and WinXSPRO analysis results	June Sucker Habitat = medium, given potential impact to spawning habitat Hobble Creek Ecosystem = medium, given potential impacts to channel capacity and aquatic habitat
Base Flows for Aquatic Habitat	data not currently available to quantify this type of flow	data not currently available; monitoring of June sucker use of Hobble Creek is recommended to help determine flows that provide appropriate hydraulic habitat	June Sucker Habitat = unknown; however, probably high during the spawn and larval drift period Hobble Creek Ecosystem = high, given potential impacts to aquatic biota
Spawning Attraction Flows	mimicry of natural hydrograph	cui-ui research; analysis of USGS springtime hydrograph patterns as representation of “natural” hydrologic conditions	June Sucker Habitat = unconfirmed; limited information suggests June sucker may respond to increasing springtime flows Hobble Creek Ecosystem = unknown
Spawning Gravel Flushing Flows	empirical/test flow method; sediment transport modeling	Brown (2008) bedload study data; USGS gage data as representation of “natural” hydrology; WinXSPRO and Parker transport modeling (CUWCD 2004b)	June Sucker Habitat = high during most years given need to maintain clean gravel/cobble spawning substrate Hobble Creek Ecosystem = high during most years given need to reduce embeddedness, flush pollutants that periodically build up, and scour algae and aquatic macrophytes

Table 3.5. (cont.)

TYPE OF FLOW	QUANTIFICATION METHOD(S)	DATA SETS/ ANALYSIS TOOLS	IMPORTANCE FACTOR
Spawning Habitat Flows (Depth and Velocity)	hydraulic modeling (comparison of June sucker spawning depth/velocity preferences with WinXSPRO results)	BIO-WEST cross sections from 2002-2003 and WinXSPRO analysis results (Stamp et al. 2003)	June Sucker Habitat = high during most years to provide adequate spawning habitat Hobble Creek Ecosystem = unknown
Flows to Promote Effective Larval Transport	field experiment	drift bead study (Brown 2008); drift monitoring of actual June sucker larvae is recommended to obtain more accurate results	June Sucker Habitat = high, given available rearing habitat Hobble Creek Ecosystem = low
Channel Maintenance Flows	empirical/test flow method; sediment transport modeling	Brown (2008) bedload sampling data; estimates of bankfull discharge (CUWCD 2004b); BIO-WEST cross sections and WinXSPRO analysis results	June Sucker Habitat = high, given flushing flow needs Hobble Creek Ecosystem = high under natural conditions
Inter- and Intra-annual Flow Variability	dimensionless flow-duration curve approach	dimensionless flow-duration curve analysis	June Sucker Habitat = low, given June sucker do not use the Hobble Creek during the low-flow months Hobble Creek Ecosystem = high under natural conditions
Channel Complexity Creation/ Maintenance Flows	floodplain inundation method; empirical/test flow method; sediment transport modeling	BIO-WEST HEC-RAS model for designed restored channel; Brown (2008) bedload sampling data	June Sucker Habitat = high once restoration of river-lake interface is complete; out-of-bank flows will be important to create and maintain rearing habitat Hobble Creek Ecosystem = high under natural conditions
Overbank Flows to Promote Nutrient Cycling	same data and methods as channel complexity creation/maintenance flows		
Riparian Recruitment Flows	same data and methods as channel complexity creation/maintenance flows		

Table 3.6. Summary of results considered in determining lower Hobble Creek flow recommendations.

TYPE OF FLOW	QUANTIFICATION METHOD(S)	RESULT
Base Flows to Maintain Water Temperature	empirical temperature vs. flow evaluation	<11 cfs = frequent temperature problems
Base Flows to Limit Vegetation Encroachment	visual evaluation of cross section plots	18 to 24 cfs
Base Flows for Aquatic Habitat	dimensionless flow duration curve approach	See Table 3.3 and Table 3.4.
Spawning Attraction Flows for June Sucker	analysis of natural hydrograph patterns	target hydrographs for dry, moderate, and wet water years (see Section 4 below)
Spawning Gravel Flushing Flows	empirical/test flow method; sediment transport modeling	flows greater than 200 cfs for a multi-day duration
Spawning Habitat Flows for June Sucker (Depth and Velocity)	hydraulic modeling (WinXSPRO)	35 to 141 cfs (950 W cross section) 37 to 319 cfs (1500 W cross section)
Flows to Promote Effective Larval Transport	drift bead study (Brown 2008)	the estimated flow of 40 cfs was not adequate to transport the drift beads to Utah Lake but did transport beads under I-15
Channel Maintenance Flows	empirical/test flow method; sediment transport modeling; visual field estimates of bankfull	140 to 200 cfs
Inter- and Intra-annual Flow Variability during Non-Runoff Periods	dimensionless flow duration curve approach	See Table 3.3 and Table 3.4.
Channel Complexity Creation/ Maintenance Flows	floodplain inundation evaluation; empirical/test flow method; sediment transport modeling; WinXSPRO results	flows > 200 cfs begin to inundate restored floodplain medium gravel (20-30mm) is mobile at flows of about 265 cfs cobble (≥64mm) mobile at flows of about 950 cfs at 950 W cross section

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SECTION 4. LOWER HOBBLE CREEK INSTREAM FLOW RECOMMENDATIONS

No legally binding minimum instream flow requirements have been established to date on lower Hobble Creek. The ULS project is still in the construction phase, and supplemental flows are not yet being delivered to Hobble Creek. Therefore, at this time no formal working group has been established to guide the operations of the supplemental flow deliveries. It is anticipated that such a working group will form in the future so that flow deliveries can be managed to maximize ecosystem benefits.

This report is intended to assist the parties involved in these operational decisions. The following flow recommendations are intended to be adaptive. Studies on Hobble Creek, Provo River, and Utah Lake are ongoing, and as more is learned about the associations between streamflow and specific ecological functions, with emphasis on June sucker needs, recommendations may be adjusted. Also, if additional restoration activities that change the physical conditions of Hobble Creek upstream of I-15 are implemented, flow recommendations may need to be updated.

Base-Flow Guidelines

Base-flow guidelines to protect the lower Hobble Creek riverine ecosystem were developed for dry-, moderate-, and wet-year conditions (Figure 4.1). Guidelines were developed separately for winter, summer, and autumn base-flow seasons. Base-flow guidelines were not developed for the spring season (April–June); instead, the natural springtime runoff hydrograph examples (see below) should be used to guide supplemental flow-release decisions during this time period.

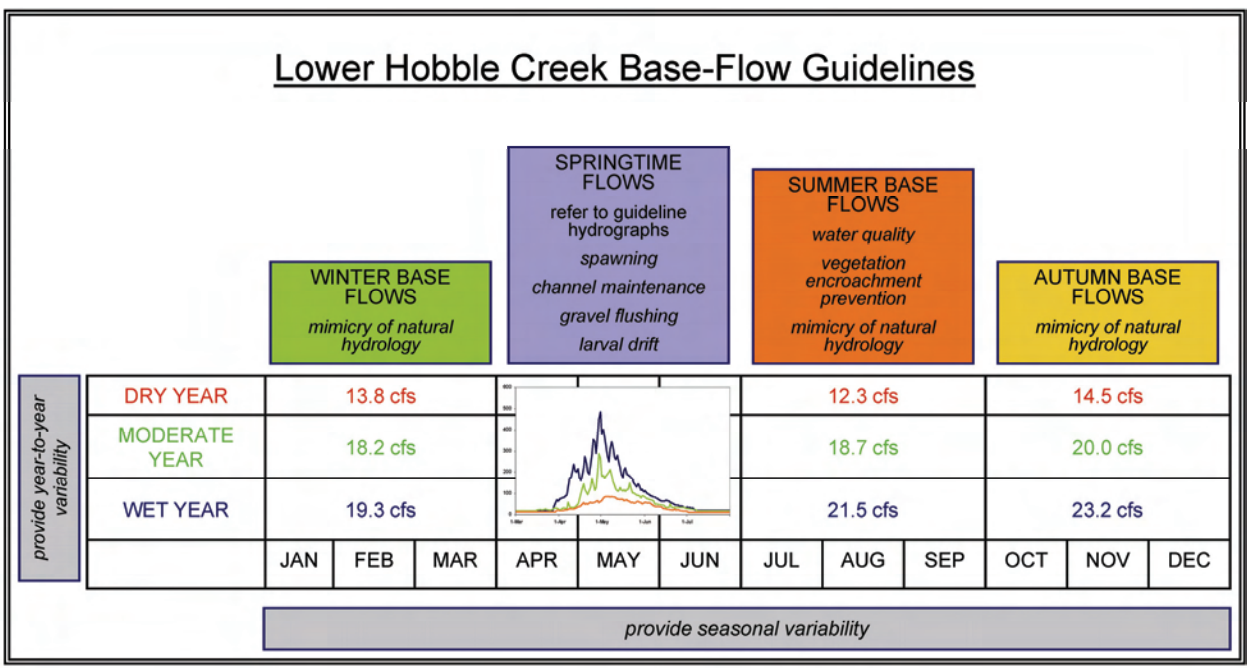

Figure 4.1. Lower Hobble Creek base-flow guidelines.

Winter Base Flows

Winter base flows apply from January through March and were quantified by averaging the January and February values determined from the dimensionless curve analysis (Table 3.4). The 20th, 50th, and 80th water year percentile values were used to determine guidelines for dry, moderate, and wet years, respectively. March flows were not included in the calculation because they are commonly influenced by early snowmelt runoff inputs and do not reflect a purely "base-flow" condition. However, the recommended winter base-flow values (Figure 4.1) should be used to guide minimum flow conditions throughout the full January–March period. These winter base-flow guidelines mimic natural hydrologic conditions and are assumed to support winter aquatic ecosystem needs. Because irrigation diversions are not active during these months, the existing winter flows on lower Hobble Creek most likely already meet the base-flow guidelines. At this time, it is not anticipated that supplemental flow deliveries will be needed during the winter season. However, once several years of data have been collected at the new USGS gage, the recorded wintertime flow data should be examined to confirm that flows are within the recommended range.

Summer Base Flows

Summer base flows apply from July through September (Figure 4.1). The dry- and moderate-year recommendations of 12.3 and 18.7 cfs, respectively, were calculated by averaging the August and September 20th and 50th percentile values from the analysis of daily flow data recorded at the discontinued Hobble Creek USGS gage (Table 3.4). The Hobble Creek summertime flow values are slightly lower than the values derived from the Utah dimensionless curves (Table 3.4), and therefore were used to guide the recommendations. This approach avoids a recommendation for a flow higher than what would naturally occur on Hobble Creek. The wet-year summer base-flow recommendation of 21.5 cfs matches the September 80th percentile value from the Hobble Creek gage analysis (Table 3.4). The July (dry- and moderate-year) and July−August (wet-year) values were not included in these calculations because they are commonly influenced by the falling limb of the snowmelt runoff period and do not reflect a purely "base-flow" condition.

Based on the limited temperature data available, these summer recommendations are adequate to protect water temperature even in dry years (Table 3.6). The moderate and wet-year recommendations are also competent to limit riparian vegetation encroachment, based on the limited hydraulic geometry information available (Table 3.6). Because the recommended summer flows mimic natural hydrologic conditions, it is assumed that they are also protective of aquatic habitat needs in terms of flow depths and velocities. However, it is important to keep in mind that the existing straightened, channelized, and leveed condition of Hobble Creek upstream of I-15 limits the availability of pool habitat and other low velocity/backwater habitat regardless of flows.

Summer base flows on lower Hobble Creek are currently affected by water diversions for irrigation. Available monthly flow estimates (Figure 2.3) and field measurements of flow made during the summer (Table 2.2) suggest that delivery of supplemental flows will be needed to meet these summer base-flow guidelines during most years.

Autumn Base Flows

The autumn base-flow guidelines apply from October through December (Figure 4.1). The averages of the 20th, 50th, and 80th percentile values for October, November, and December (Table 3.4) were used to calculate recommended values for dry-, moderate-, and wet-year conditions, respectively. The dry-year value of 14.5 cfs was derived from the Hobble Creek gage analysis, because it is lower than the respective value derived from the Utah reference stream analysis. The moderate- and wet-year autumn recommendations were derived from the Utah reference stream analysis (Table 3.4) because those values are lower than the Hobble Creek gage analysis results. However, differences in the autumn results for these two separate analyses are very minor, and recommendations derived from either analysis would be quite similar.

Some irrigation withdrawals on lower Hobble Creek may continue through the month of October; therefore, supplemental flow deliveries may be needed to meet the proposed autumn base-flow guidelines in certain years. However, field measurements of discharge on lower Hobble Creek in October and December were 19.8 and 18.0 cfs (Table 2.2), suggesting that existing flows come close to matching the moderate-year recommendation of 20.0 cfs, at least in some years (Figure 4.1).

A Note Regarding Variability

The base-flow recommendations presented in Figure 4.1 are intended to serve as flow release guidelines. The intent is not to hold flows perfectly constant (i.e., “flat-lined”) at the recommended value throughout each season. Short-term (i.e., 1–3 day) variations within 10−20% of the recommended values are appropriate and would more closely match natural hydrologic patterns than would perfectly constant conditions. However, during the summer season in dry years, dropping flows below 11 cfs should be avoided due to water temperature concerns. It is also important to note that the proposed base-flow guidelines are not the same as minimum instream-flow requirements in the traditional sense. Under minimum instream-flow requirements, any flows greater than the recommended minimum value (even flows much greater than the recommended minimum) would “meet” the requirement. Under the proposed base-flow guidelines (Figure 4.1), releasing flows substantially greater than the recommended values for extended periods of time would not mimic natural hydrology and would not meet the guideline objectives. Base flows that exceed the natural range of values can negatively affect aquatic habitat diversity, riparian vegetation, and sediment-transport processes. These negative effects can occur when base flows are too high relative to the channel size, sediment supply, annual peak flow magnitude, and sediment size of the stream. Releasing excessive base flows also runs counter to the objective of mimicking natural hydrology.

Although the current problem on lower Hobble Creek is that summer base flows are too low and “excessive” releases are unlikely to be an issue, it is nevertheless important to emphasize that the proposed base-flow guidelines are not simply minimum requirements. Depending on where irrigation demands on Hobble Creek must be met, “excessive” flows could be an issue in the reaches of the Study Area closest to the Mapleton-Springville Lateral. For example, if the Swenson Dam diversion (Figure 2.1) was removing 20 cfs from the stream, the total flow in the reach between Mapleton-Springville Lateral and Swenson Dam would need to be 38.7 cfs in order to ensure that the recommended base flow of 18.7 cfs would reach the lower portions of Hobble Creek. Flows of 38.7 cfs are above the natural range of variability for summer base flows. To avoid this potential issue, options to deliver irrigation water via pipe or canal conveyance systems other than Hobble Creek should be explored.

Once supplemental flow deliveries on lower Hobble Creek are operational, we recommend that base-flow patterns (as recorded at the new USGS gage on lower Hobble Creek) be periodically evaluated to ensure that year-to-year variability is being achieved. For example, over a 10-year period, some water years should mimic the wet-year base-flow guidelines, others the moderate-year base-flow guidelines, and others the dry-year base-flow guidelines. If only the dry-year guidelines were being met year after year, the intent of these comprehensive flow recommendations would not be achieved. Therefore, if year-to-year variability is found to be lacking after such an evaluation in the future, operational practices for supplemental flow deliveries may need to be revisited at that time.

March and July Considerations

As discussed previously, “natural” average monthly March and July flow values are commonly influenced by the rising and receding limb of the snowmelt runoff period and are higher than purely “base-flow” conditions. Therefore, in March and July, the base-flow guidelines listed in Figure 4.1 should be applied as “minimum” values. Exceeding the recommended winter and summer base-flow values during March and July in order to match natural snowmelt patterns is appropriate and encouraged. It is also important to note that the springtime runoff hydrograph examples (see below) extend into July and should take precedence over the July base-flow value. However, July was included in the summer base-flow recommendations to ensure protection of water temperature conditions.

Springtime Runoff Hydrographs

As discussed in Section 3 above, at this time it is not well understood to what extent existing springtime flows on lower Hobble Creek diverge from natural runoff patterns. Irrigation diversions most likely reduce peak flow magnitudes during dry years and some moderate years, but may not be active during flood flow conditions due to concerns about damaging withdrawal structures. Based on data collected during spring 2006, a relatively wet water year, flows near I-15 were similar to flows in Hobble Creek Canyon during the runoff period (Table 2.2) (Brown 2008). Therefore, delivery of supplemental flows during the springtime will likely only be needed during certain years. Another relevant consideration is that the facility that will deliver supplemental flows to Hobble Creek is being designed to have a 125 cfs maximum release rate (CUWCD 2003). It is unlikely that the full 125 cfs capacity will be entirely dedicated or available to provide environmental flows to Hobble Creek. Even if it were fully available, 125 cfs is less than the estimated 2-year recurrence interval flood (Table 2.1). Therefore, the majority of the lower Hobble Creek springtime runoff volume will typically come naturally from the upstream watershed, and its timing and volume will largely be dictated by the natural runoff patterns in a given year.

Nevertheless, there will be years when it is determined that springtime supplemental releases would be beneficial for lower Hobble Creek ecosystem functions or for specific June sucker recovery objectives. Therefore, examples of natural springtime hydrograph patterns for dry,

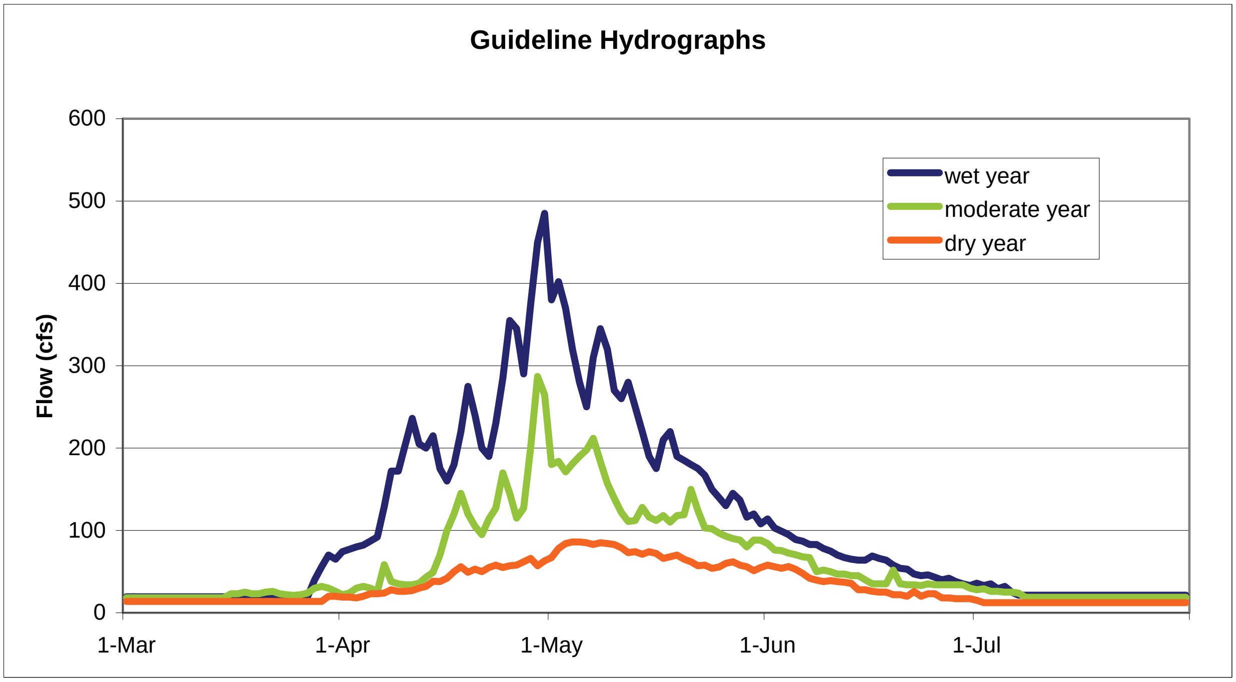

Figure 4.2. Guideline hydrographs for the springtime runoff period.

moderate, and wet years are provided in Figure 4.2. These hydrographs can be used to help guide decisions regarding the timing and magnitude of supplemental deliveries during the spring season. The plots shown in Figure 4.2 were generated by modifying the plots (Figure 3.4) derived from percentile statistics at the discontinued USGS gage.

Wet-Year Guidelines

The wet-year hydrograph guideline was developed by modifying portions of the 80th and 90th percentile plots based on comparisons with gaged wet-year runoff hydrographs for individual water years (Appendix A). The total volume of water (33,576 acre-feet) under the wet-year guideline curve matches the volume under the 80th percentile plot for the March 1−July 31 time frame. The guideline wet-year peak-flow magnitude of 485 cfs will ensure that gravel-sized streambed material is thoroughly mobilized. It is expected that the wet-year guideline hydrograph would support ecological functions including June sucker spawning, larval drift, gravel flushing, overbank flows, riparian recruitment, and channel maintenance.

Moderate-Year Guidelines

The moderate-year guideline hydrograph (Figure 4.2) was derived from the 50th percentile plot shown in Figure 3.4. The plot was modified to include a higher peak flow magnitude that would initiate bedload sediment transport. Specifically, the guideline hydrograph includes flows greater than 200 cfs for a duration of 4 days, and flows greater than 260 cfs for 2 days. In addition to mobilizing medium-sized gravel material, these peak flows are estimated to be adequate to inundate the restored floodplain west of I-15 (Table 3.6). The tails of 50th percentile plot were also adjusted to match the March and July base-flow values, and the rising and falling limbs were steepened. These modifications better match observed springtime hydrographs at the USGS gage during average-volume water years (Appendix A). Although the shape of the curve differs, the total volume of water (19,014 acre-feet) under the moderate-year guideline curve matches the volume of water under the 50th percentile plot for the March 1−July 31 time frame. Based on available analyses, the resulting moderate-year guideline hydrograph would be expected to support ecological functions including June sucker spawning, larval drift, gravel flushing, channel maintenance, and partially support overbank flow and riparian recruitment functions.

Dry-Year Guidelines

The dry-year guideline hydrograph (Figure 4.2) was derived from the 20th percentile plot shown in Figure 3.4. The “tails” of the hydrograph in March and July were modified slightly to better match the winter and summer dry-year base-flow recommendations and observed dry-year hydrograph patterns. Although the shape of the curve differs, the total volume of water (10,271 acre-feet) under the dry-year guideline curve matches the volume of water under the 20th percentile plot for the March 1−July 31 time frame. Dry-year runoff patterns are highly variable, and it is natural for a springtime peak to be essentially absent in some years on Hobble Creek (Figure 2.2). Flows of the peak magnitude shown in the dry-year guideline (87 cfs) are generally not adequate to support sediment transport, channel maintenance, or gravel flushing functions (Table 3.6). However, flows in this range may be important for spawning habitat or larval drift functions. We recommend that biological monitoring be conducted to better understand June sucker use of lower Hobble Creek habitats, and to help determine whether delivery of supplemental flows during years that lack a natural springtime peak would be beneficial for recruitment success. It may be the case that in some years, it would be more beneficial to “bank” water during the spring season and instead use it to provide supplemental flows during the summer or the following springtime.

At this time, these guideline hydrographs should be considered preliminary. We anticipate that the timing, magnitude, and volume of the hydrographs may be modified in the future as the constraints and opportunities associated with supplemental flow delivery become better understood. Adjustments may also be made as additional, more detailed biological information becomes available regarding June sucker habitat use on lower Hobble Creek. Once supplemental flow deliveries are operational, we recommend that springtime flow patterns (as recorded at the new USGS gage on lower Hobble Creek) be periodically evaluated to ensure that year-to-year variability is being achieved. For example, over a 10-year period, some water years should mimic the wet-year guideline hydrograph, others the moderate-year hydrograph, and others the dry-year hydrograph. If year-to-year variability is lacking, operational practices may need to be revisited.

Operational Considerations

Because daily discharge data describing flow conditions on lower Hobble Creek below the irrigation diversions are not available, it is difficult to estimate the volume of supplemental water that would be needed to meet the guidelines described above. One approach could be to simply base supplemental delivery rates on the rates at which flows are being diverted at irrigation structures. This approach would essentially “replace” the natural flows entering from the canyon upstream. The ideal version of this approach would involve using pipes and ditch conveyance facilities other than the Hobble Creek channel to deliver supplemental water from Mapleton-Springville Lateral directly to irrigators. This method would allow flows in lower Hobble Creek to be “run of the river” and accurately mimic natural hydrologic patterns. As discussed above, this approach would also avoid the need to deliver “excessive” flows to the upper sections of lower Hobble Creek in order to ensure adequate flows pass by the various diversion structures and reach Utah Lake.

We completed several preliminary estimates of supplemental flow volumes that would need to be delivered to achieve the base-flow and springtime runoff guidelines. If supplemental flows were used to replace water diverted at a constant rate of 60 cfs (the estimated total diversion capacity of the Springville diversions above 400 West) for the entire month of May, approximately 3,690 acre feet of water would be needed. If supplemental flows were used to provide 11 cfs through all of July and August to maintain water temperatures, approximately 1,350 acre feet of water would be needed. As a rough estimate of the annual amount of water that would be needed to meet the moderate-year flow recommendations, we calculated the difference between the recommendations and the CUWCD’s baseline monthly flow estimates (Figure 2.3) for the April through October period, when supplemental flows would be needed. Based on this calculation, a total of approximately 8,200 acre feet of supplemental water would be needed.

These values are intended to simply provide some approximate estimates of the water volumes that may be needed to achieve specified ecological functions. Better data on irrigation diversion rates and existing flows would be needed to accurately determine how much supplemental water would be needed to meet the proposed recommendations.

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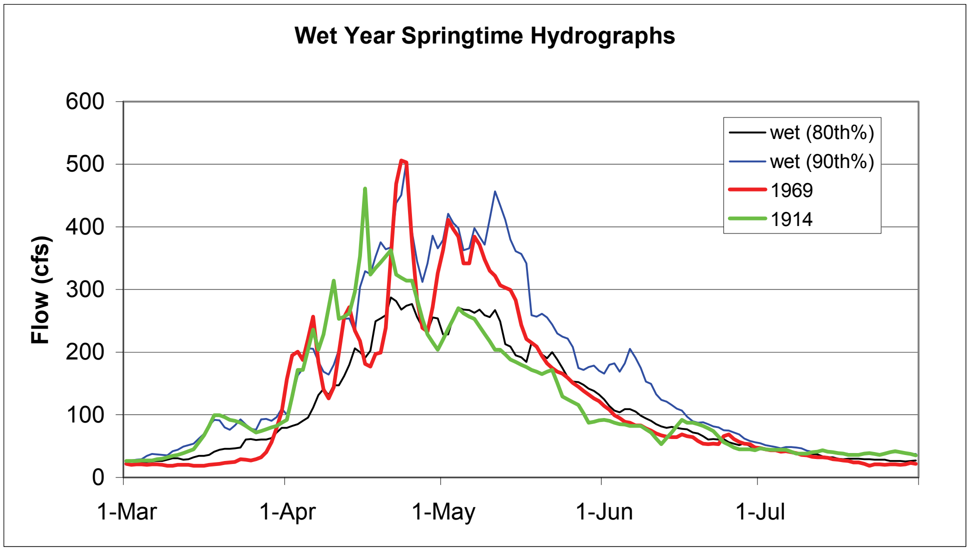
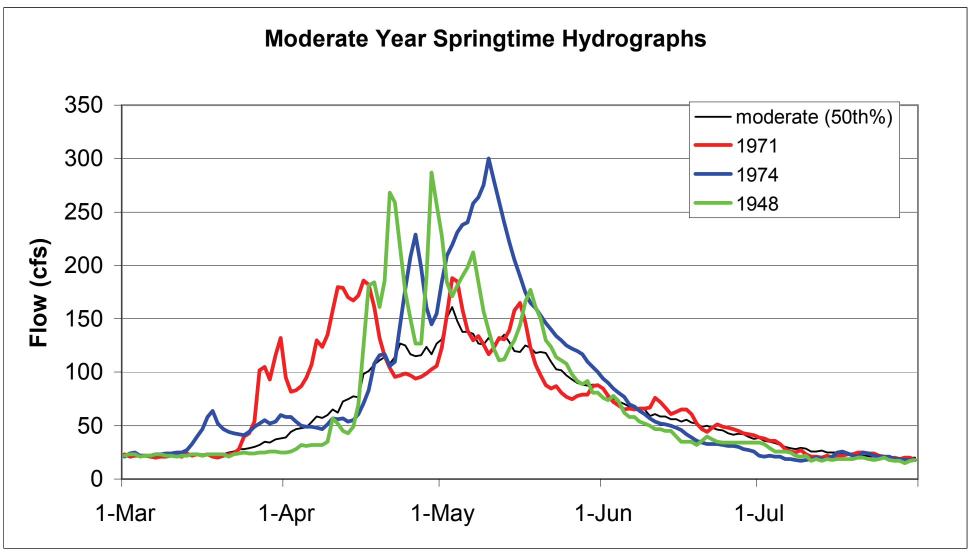
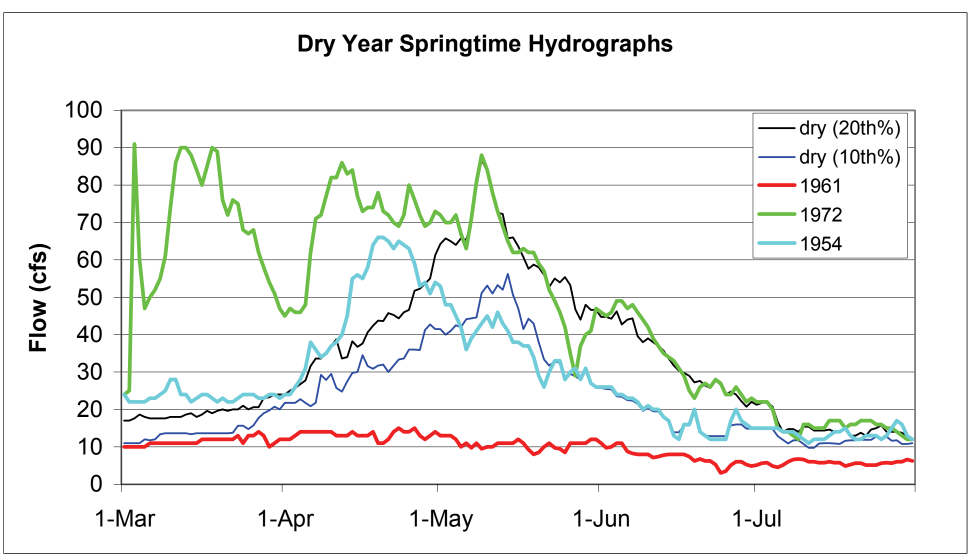
APPENDIX A: SPRINGTIME HYDROGRAPH PLOTS COMPARING STATISTICALLY DERIVED VALUES WITH FLOWS RECORDED AT USGS GAGE #10152500 DURING SPECIFIC WATER YEARS


Wet Year Springtime Hydrographs
Flow (cfs)
600
500
400
300
200
100
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
wet (80th%)
wet (90th%)
1969
1914


Moderate Year Springtime Hydrographs
Flow (cfs)
350
300
250
200
150
100
50
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
moderate (50th%)
1971
1974
1948


Dry Year Springtime Hydrographs
Flow (cfs)
100
90
80
70
60
50
40
30
20
10
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
dry (20th%)
dry (10th%)
1961
1972
1954