The Middle Provo River – An introduction for the fisherman

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Research Paper

High Country Fly Fishers

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Dave Whiteman, High Country Fly Fishers

INTRODUCTION

This document introduces fishermen to Utah's Middle Provo River, the portion of the Provo River in Utah's Heber Valley between the Jordanelle and Deer Creek Reservoirs. The Provo River was once a completely free-flowing stream, arising in the Uinta Mountains and flowing through north central Utah to Utah Lake. Great changes to the river, however, came with the advent of the Central Utah Project (CUP) – a project designed to divert a large share of Utah's portion of the Colorado River westward from northeastern Utah through inter-basin diversions and reservoirs into the Bonneville Basin and its large Wasatch Front population centers. Here, we briefly summarize the resultant changes to the Provo River, including the building and operation of the Jordanelle dam that collects water from the Provo River watershed and provides the water that now feeds the Middle Provo River. The focus then shifts to the Middle Provo River, its reconstruction and reclamation after the dam was built, its hydrological features, its fishery, water quality, and the resident macroinvertebrates that are the main source of food for the fish. The report concludes with a summary of potential future challenges to this productive Blue-Ribbon fishery.

HISTORY OF THE CENTRAL COLORADO PROJECT AND THE JORDANELLE RESERVOIR

Central Utah Project

The Colorado River Basin is the largest source of water in the Rocky Mountain West and provides needed water to many western states and Mexico (**Figure 1**). The water in the basin is shared among the upper and lower basin states through the Colorado River Compact of 1922 and subsequent agreements between the states and the federal government. The CUP designated the Bureau of Reclamation (BoR) and the Central Utah Water Conservancy District (CUWCD) to construct a network of reservoirs, aqueducts, tunnels, canals, pipelines, pumping plants and other conveyance facilities to carry Colorado River water westward for multiple uses in Utah (**Figure 2**). The Jordanelle Reservoir, constructed as part of the CUP, provides the water for the Middle Provo River tailwater fishery.

Figure 1 The Colorado River Basin consists of an upper and lower basin. From U.S. Geological Survey (USGS.).

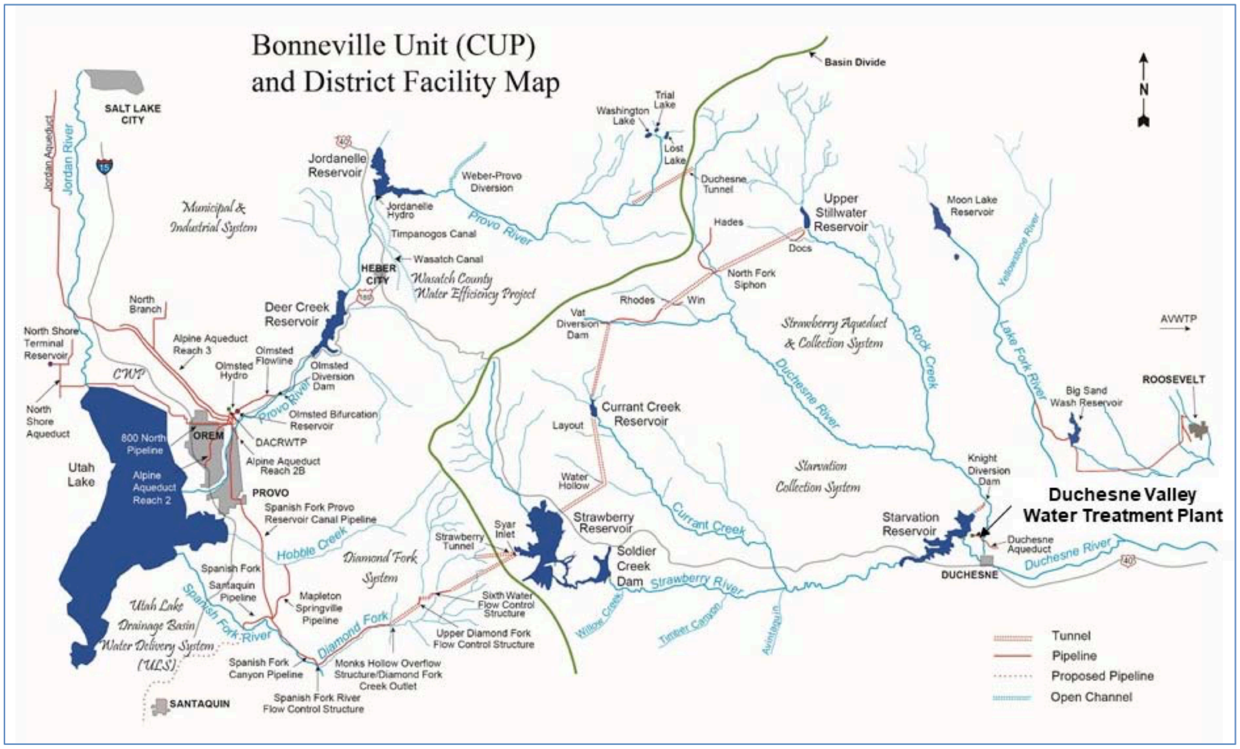

Figure 2 Bonneville unit of the CUP. The green line indicates the boundary between the Colorado River Basin (right) and the Bonneville Basin (left). From CUP Completion Act Office and CUWCD (2019).

The Jordanelle Reservoir

The Jordanelle Reservoir, constructed by BoR between 1987 and 1993 as part of the Central Utah Project, provides the water for the Middle Provo River. The reservoir was built to provide municipal, industrial, and agricultural water. Secondary purposes include recreation, fish and wildlife, flood control and power. The reservoir waters flooded two small towns and required the relocation of State Highway 40. It was first filled in 1996. Power from the dam comes from water channeled through two turbines at the foot of the dam with rated power outputs of 13 MW. This power is provided to Heber Light and Power, with power lines running both south and north from the dam.

When at full pool with a surface elevation of 6166.4 ft MSL, the reservoir's surface area is approximately 3024 acres with a depth of about 280 feet. The east arm of the reservoir receives water from the Upper Provo River, which carries supplemental water diverted from the Weber River and from the Colorado River Basin’s Duchesne River. The reservoir also receives water from the Ross Creek drainage north of the reservoir and the McHenry Creek drainage west of the reservoir.

The balance between inflows and outflows from the reservoir causes reservoir surface elevation fluctuations, illustrated in **Figure 3** for the years 2019-2024. The inflows to the reservoir were sufficient in 2019, 2020 and 2023 to bring the reservoir up to the "full pool" level by early June, but the low snowpack and below normal precipitation in 2021 and 2022 were unable to recharge the reservoir fully. The inflow to the dam's penstock that supplies water to the Middle Provo River at the foot of the dam comes from a set of six 7.5-ft-high inlets or gates that are located at different elevations on a partially submerged tower that rises from the floor of the reservoir near the dam (**Figure 4**). The elevations of these inlets are shown in **Figure 3**. The ultimate destination of water released from the reservoir is human use along the Wasatch Front, so the main concern is to release water having low levels of nutrients for later processing by downstream water treatment plants. Fortunately, suspended sediments and nutrients such as phosphorus settle out in the reservoir, so that the water discharged from the reservoir is relatively low in these water quality variables. Additional goals are to select water having suitable dissolved oxygen contents and temperatures. CUWCD has determined that both phosphorous levels and dissolved oxygen content can be controlled by selecting water based solely on temperature – a more easily measured quantity in the water column. The selection of draw depths and gate openings varies with season as the reservoir's vertical water temperature profiles evolve. This selection typically results in outflow water temperatures in an optimal range for the fishery.

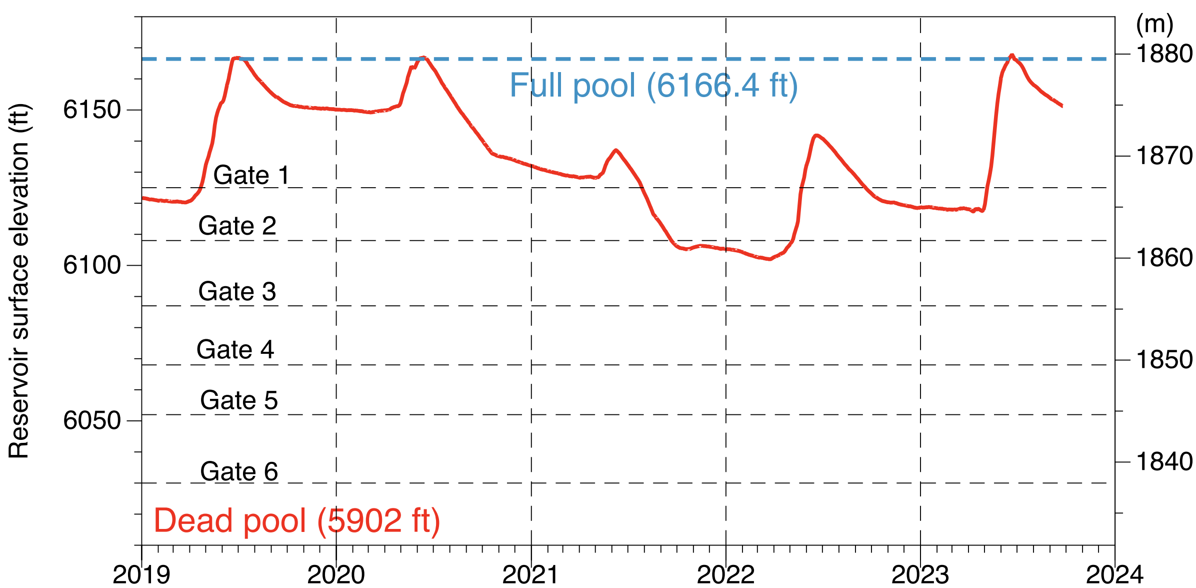

Figure 3 Jordanelle Reservoir surface elevation during the years 2019-2023. Also shown are the elevations of the 6 inlet gates used to blend the reservoir water for discharge downstream. The surface water elevations are still well above the lowest level ("dead pool") necessary to allow discharge from the dam. Data from CUWCD.

Figure 4 Photo of the Jordanelle dam looking east. In the far distance is the SLOW tower that feeds the dam penstock through one or more of the tower's inlet gates located at different levels in the water.

In drought years the reservoir's surface elevation often falls below one or more of the inlets, rendering them unusable. If the surface elevation falls below all six of the gates it is still possible for water to be discharged from the reservoir through an emergency outlet near the reservoir's base. This is possible so long as the surface elevation does not fall below the dead pool elevation. If this level were approached the water quality (low outflows, high temperatures, suspended particulates, elevated nutrients, etc.) would become unsuitable for the tailwater trout fishery below the dam. BoR modeling before the reservoir was built indicated that it is not beyond the realm of possibility that an extended multi-year drought could result in such a catastrophe.

The water storage volume and surface area of the reservoir are directly related to the reservoir's surface elevation (**Figure 5**). For example, the horizontal dashed line in the figure shows that water storage volume would fall to 50% when the surface elevation falls to 6103 ft. This elevation level was nearly reached in the spring of 2022 after two years of extreme drought, as seen earlier in **Figure 3**.

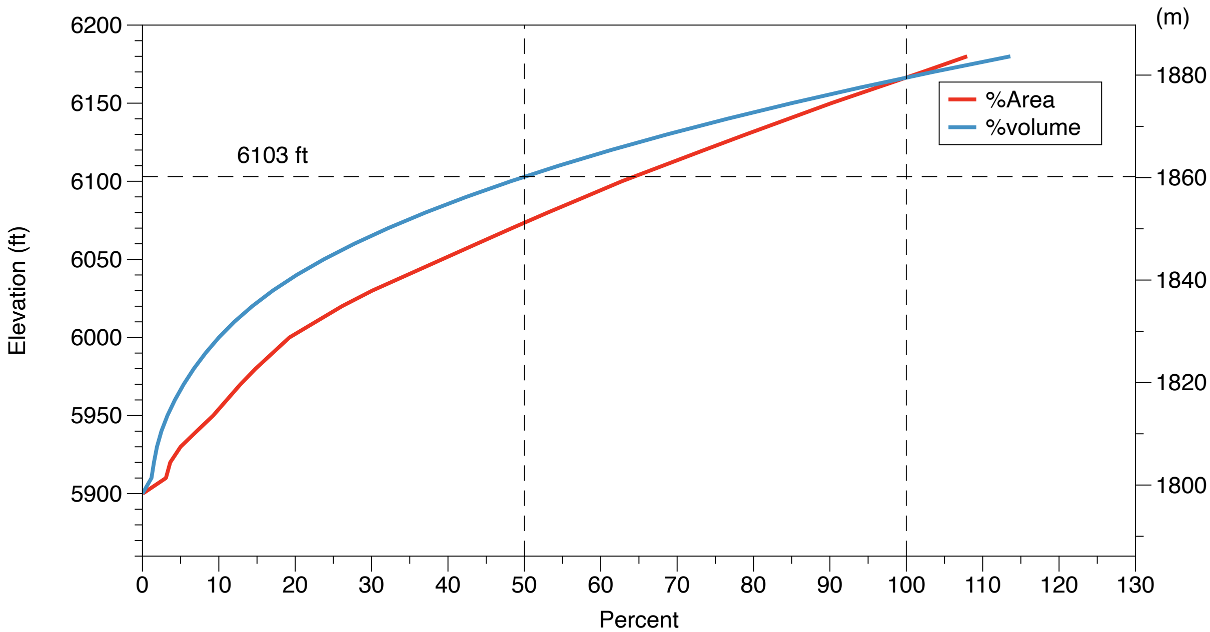

Figure 5 Relationship between reservoir surface elevation and the reservoir's fractional volume and surface area. Data from CUWCD.

The varying inflows and outflows during the years 2019-2024 that govern the reservoir's volume and surface are shown in **Figure 6**. Inflows to the reservoir from the Upper Provo River, as measured at the Hailstone gage (USGS 10155000), typically reach a peak in late spring but show much variation from day to day and week to week depending on precipitation, withdrawals above the reservoir, and on the rate of melting of the snowpack and its dependence on air temperature, solar radiation and winds. In addition to the Upper Provo River inflow there are also rainfall, groundwater, overland transport and tributary inflows into the reservoir from its own drainage basin. Years 2019 through 2022 were drought years, with an especially severe drought in the summer of 2021. In contrast, an unusually heavy winter snowpack provided water to the reservoir in 2023. Peak inflows reached over 2000 cubic feet per second (cfs) in 2019, 2020, and 2022 and over 3000 cfs in 2023. In the 2021 drought year peak inflows barely reached over 1000 cfs.

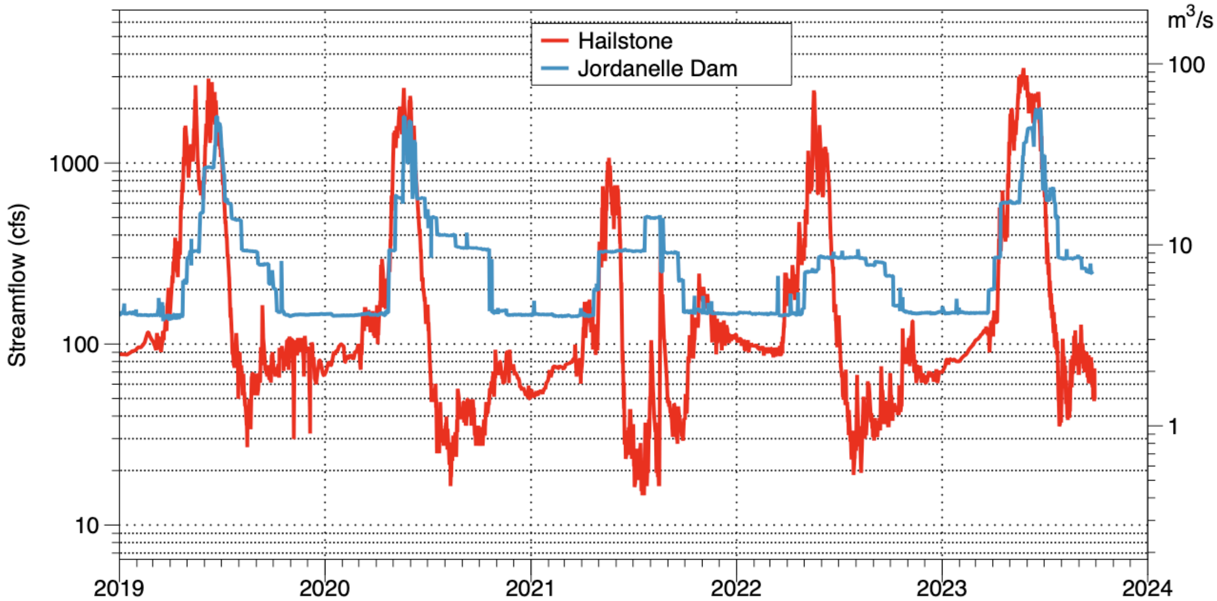

Figure 6 Upper Provo River streamflow entering the Jordanelle Reservoir at the USGS Hailstone gauge (red) compared to water releases from the Jordanelle Reservoir (blue) during the period 2019-2024. Note the logarithmic scale. Data from USGS and CUWCD.

The early season runoff is stored in the reservoir and later released to the river to meet summer water demands downstream. Outflows depend on the water supply in the reservoir and the need to provide water to water rights holders downstream. The outflows are measured at the foot of the dam by CUWCD.

Several features of the inflow-outflow curves of importance to fishing are worth mentioning. First, year-around outflows from the dam are never below 125 cfs, a requirement for the dam operator to protect the fishery. If the dam were not present, the flow in the river would be similar to the red curve. The river would be "blown-out" in the spring and the occasional extremely low flows (and associated high water temperatures) in summer would be detrimental to trout. The required minimum flow in winter protects the long-term health of the fishery.

More detailed temporal information on the dam release rates of importance for fishing trip planning, is shown in **Figure 7**. The discharge from the dam is often stepped up rapidly in early May as irrigation and other demands increase. Anglers will note that sudden stepwise changes in flows disrupt the fishing for a few days as fish seek new lies. In years with a water surplus (e.g., 2023), the release can start as early as late March. By late-May or early-June the release rates can reach up to 2000 cfs, producing challenging fishing and wading situations. These short-term high flows have the long-term effect of invigorating the macro-invertebrate taxa and improving the fishing as changes occur to the river channel. High release rates generally subside by early July. Water allocations downstream are cut in drought years. Discharge reached only 300-500 cfs in 2021 and 300 cfs in 2022. The annual total releases from the dam in acre-feet, as determined by integrating the areas under the curves, are shown in the legend. The high-water year of 2023 had nearly twice the annual release volume of the 2022 drought year and release rates over 600 cfs lasted from mid-April to late-July.

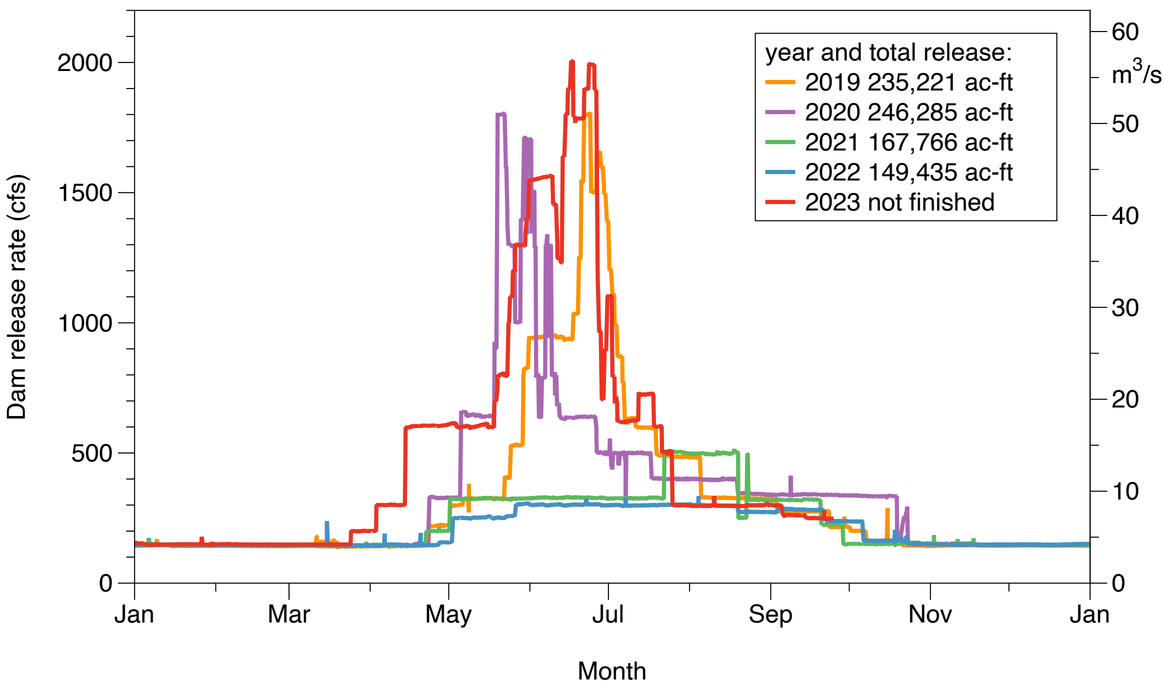

Figure 7 Release rate from the Jordanelle Reservoir as a function of time for 2019-2023. Shown in the legend is the annual total releases in acre-feet. Data from CUWCD.

MIDDLE PROVO WATERSHED

Geology

Utah's Provo River watershed (**Figure 8** upper sub-figure) in north-central Utah drains the Uinta Mountains. The Middle Provo runs through the Heber Valley between the Jordanelle and Deer Creek Reservoirs. The Heber Valley geology (**Figure 8** lower sub-figure) includes a valley floor region of Quaternary fill surrounded by areas of tufa, limestone, sedimentary rocks, and intrusive and volcanic rocks. Several major faults are present in the center and on the western side of the valley. Cold and thermal springs are found in the Snake Creek drainage.

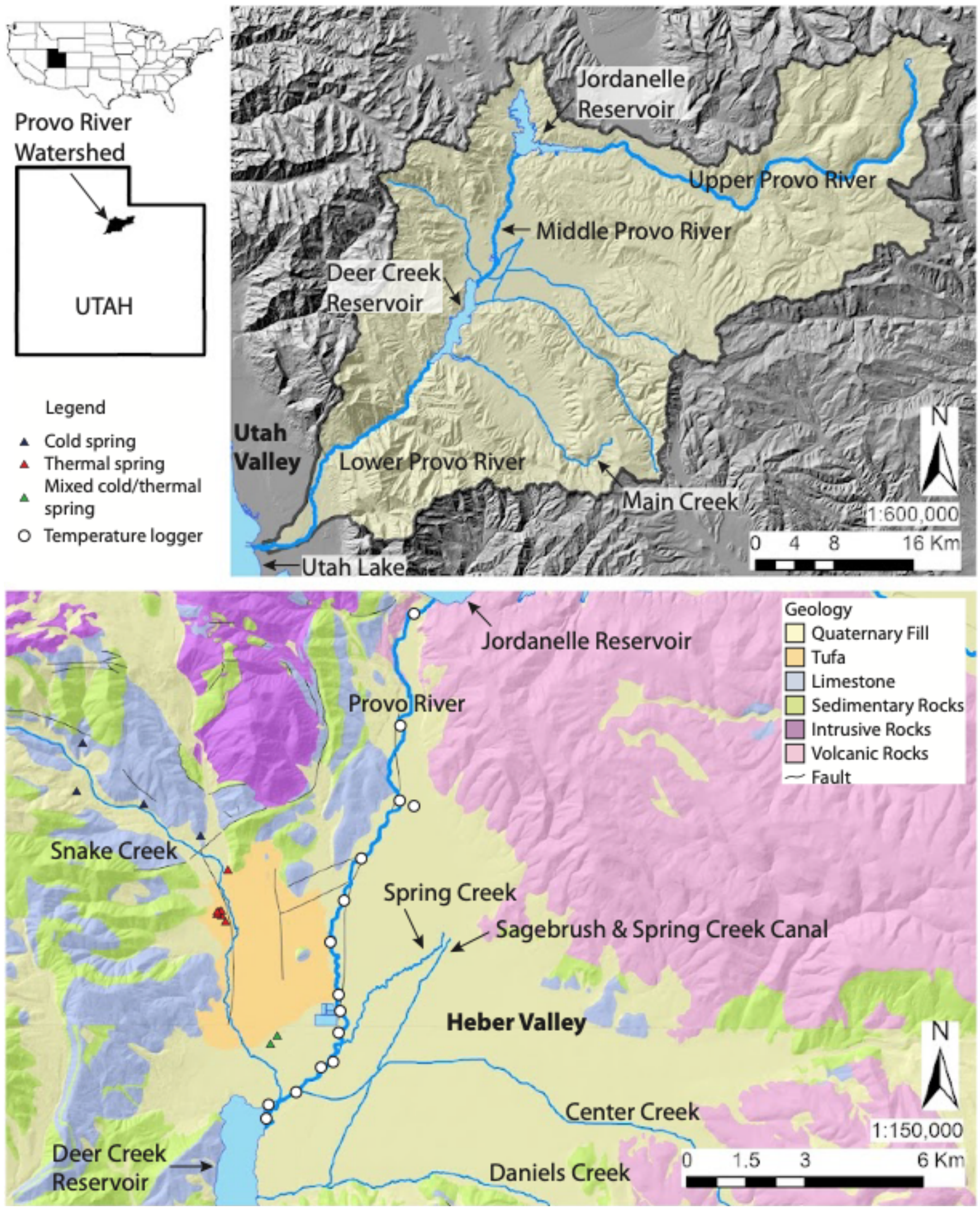

Figure 8 Location of the Provo River watershed in the U.S. and Utah (upper sub-figure) and the Middle Provo River between the Jordanelle and Deer Creek Reservoirs (lower sub-figure), indicating earthquake fault lines, rock types, tributaries and springs. Tufa deposits arise from thermal springs. Adapted from Goodsell et al. (2017), with permission.

Quaternary fill deposits run along the entire length of the river. These permeable deposits affect groundwater distribution (**Figure 9**). Water sinking into the deposits in the upper river and on both sidewalls provides inputs to the groundwater, which re-emerges into the river farther downstream (Lowe and Butler, 2003), providing an estimated 10% of the flow into Deer Creek Reservoir (Goodsell et al, 2017).

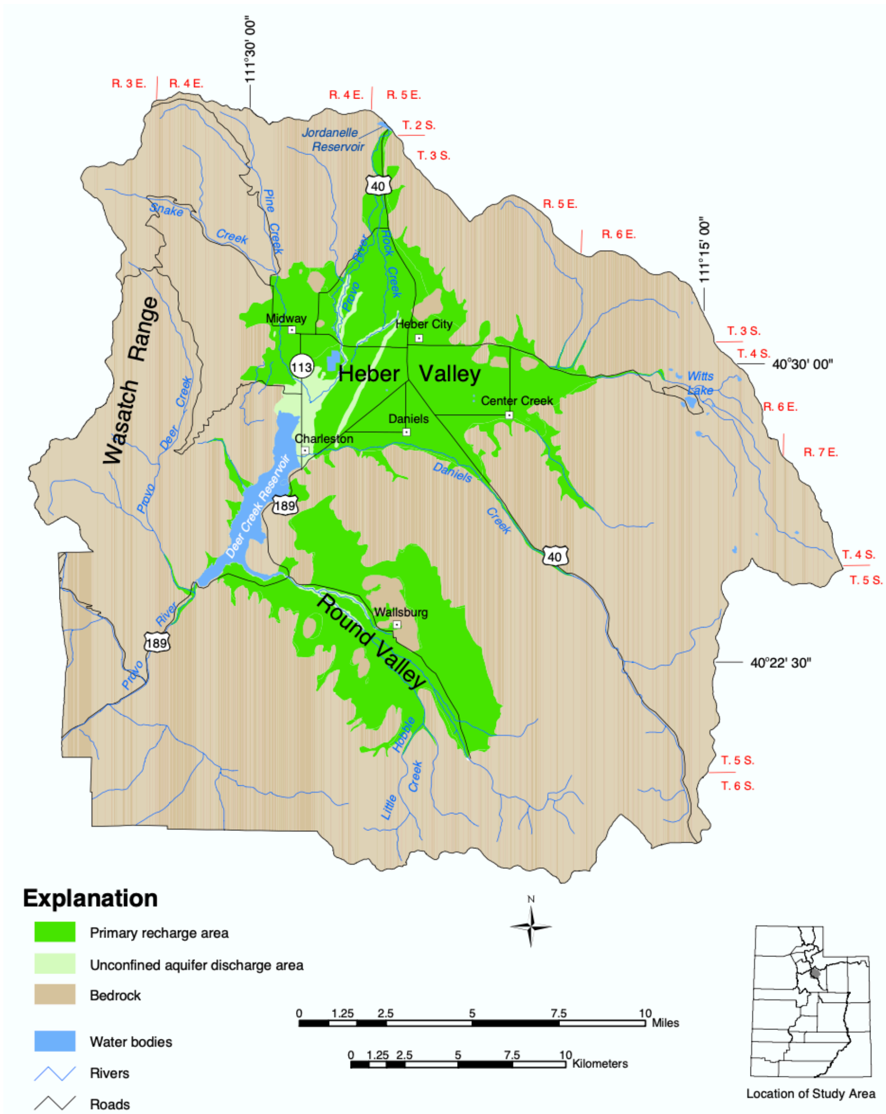

Figure 9 Map of the Heber Valley indicating the distribution of groundwater recharge and discharge areas. The Provo River is recharged by groundwater primarily below the Heber-Midway highway, which crosses the Legacy bridge. Water for recharge comes largely from agricultural irrigation within the valley. From Lowe and Butler (2003).

The fill deposits also make up the riverbed or river substrate. Sediment is trapped above the river in the Jordanelle Reservoir so that there is little suspended sediment or in-stream quantities of sand and gravel released from the dam. The angler will find boulders and cobbles in the upper river below the dam. Cobbles are present along the entire river, but gravel, sand and the suspended sediment load increase with distance down-river (hereafter called *river distance*). Bank erosion and sand and gravel bar development occurs episodically with short-term heavy water releases from the dam, especially in the lower river. The substrate is one factor affecting macro-invertebrate numbers and diversity.

Climate and meteorology

Heber City and its surroundings enjoy a climate with warm summers and cool winters (**Figure 10**). In an average year, monthly mean minimum temperatures fall below 32°F in November through March and monthly mean maximum temperatures are above 80°F in June, July and August. Daily maxima often exceed 90° during July and August.

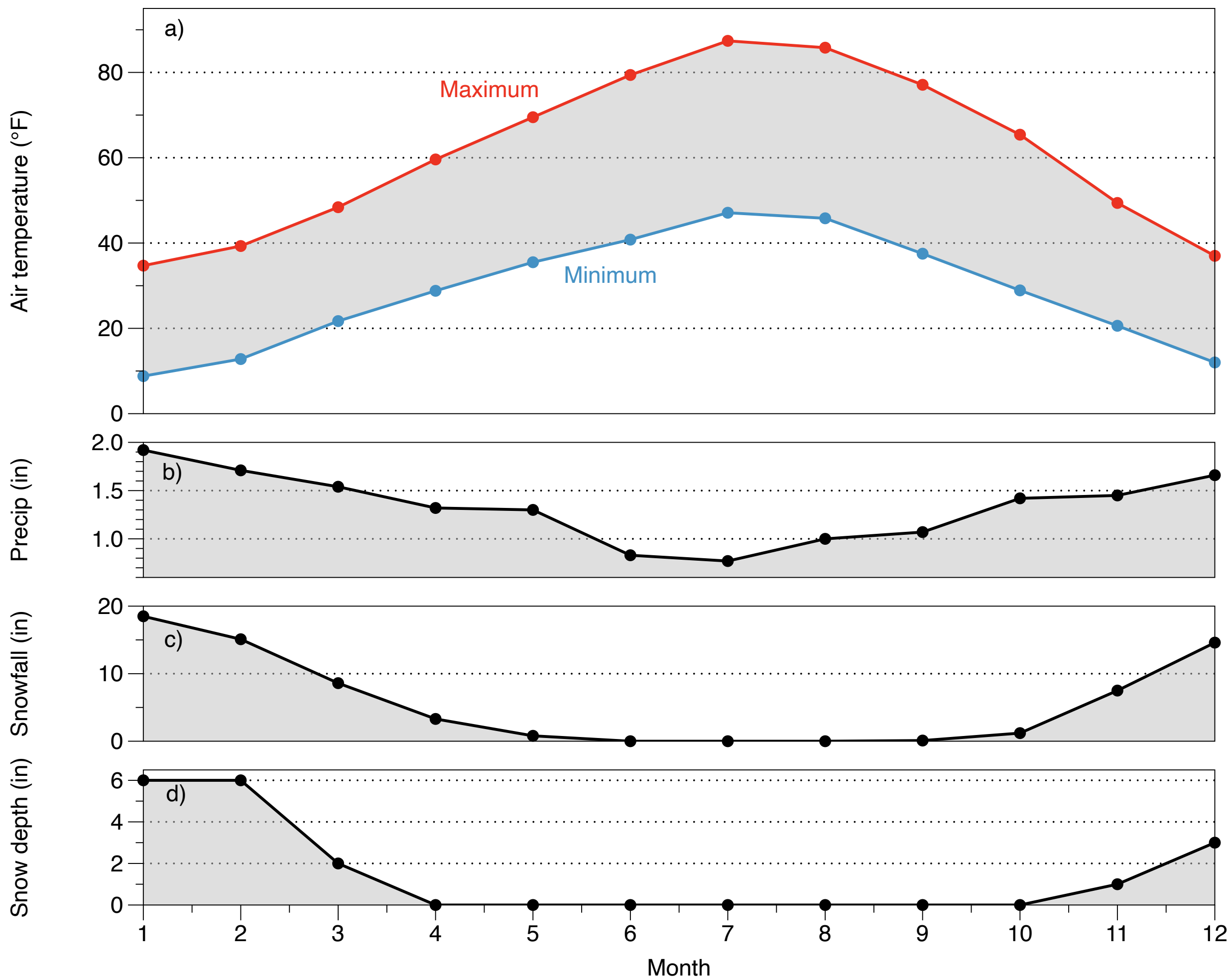

Figure 10 Mean monthly a) minimum and maximum temperatures, b) precipitation, c) total snowfall and d) snow depth for Heber City, Utah. Data from Western Region Climate Center.

The Heber Valley is in the rain shadow or lee of the Wasatch Mountains, receiving less precipitation than locations on the windward (west) side of the mountains. Heber City receives, in an average year, 15.99" of precipitation. Monthly mean precipitation is highest in the fall and winter and lowest in the summer. Mean monthly total snowfall exceeds 5" during the months November through March, with a mean annual snowfall total of 69.9".

Of special interest to fishermen are wind measurements on the river. A weather station on the riverbank just below the Trestle Bridge was operated as part of a special National Science Foundation-supported research program called iUtah in the years 2014 through 2018. Winds at this site tend to be bi-directional (**Figure 11**), blowing either up or down the NE-SW oriented river at this site. Winds blowing from the northeast are generally weak and come from a broad range of directions. Winds from the southwest come from a narrow range of directions and are much stronger. Southwest winds are typically up-valley daytime winds that are often accelerated by the channeling of winds aloft along the valley direction after the basin temperature inversion is destroyed by ground heating and convection late in the morning. Northeast winds are predominantly nighttime down-valley and down-slope winds that are protected from the stronger winds aloft by the basin temperature inversion. The inversion forms nearly every night year-around when not disturbed by traveling storm systems and is even present during the entire day in winter when the ground is snow-covered. The fly fisherman will have fewer "wind knots" by fishing in the morning before the late morning break-in of stronger winds. On the other hand, a dry fly fisherman will sometimes welcome an up-valley flow when casting up-stream, as this can increase casting distance. Mean monthly wind speeds are highest in the spring and lowest in winter (**Figure 12**).

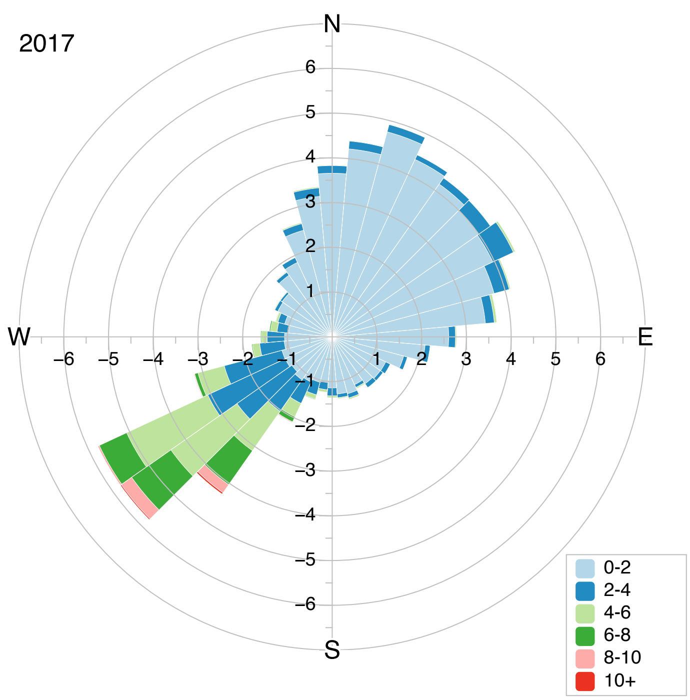

Figure 11 Wind rose for 2017 for the Charleston weather station near the Trestle Bridge. Wind speeds in m/s (1 m/s = 2.2 mph) are indicated by the colors in the legend. The rings indicate the relative frequency of winds in the thirty-six 10-degree direction segments. All segments have relative frequencies below 7%. Within each of the segments the relative frequencies of the different wind speed classes are stacked. Data from iUtah.

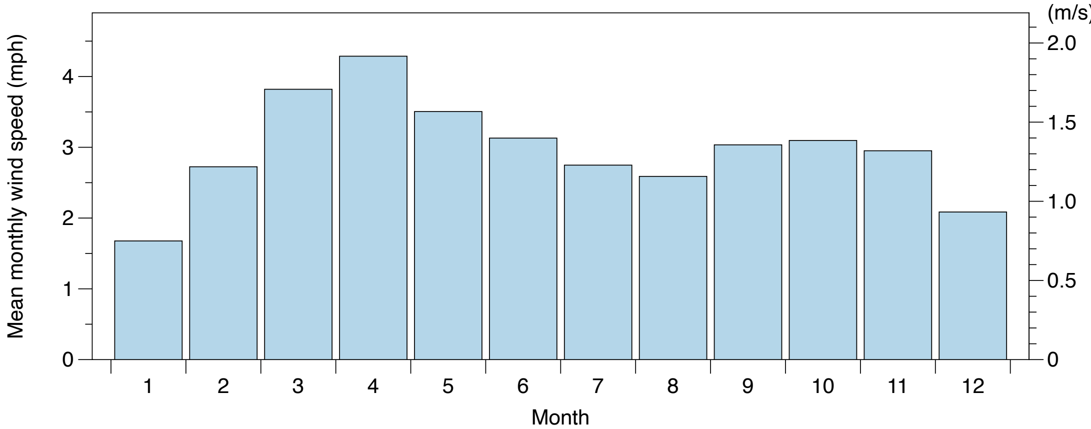

Figure 12 Mean monthly wind speeds at the Charleston weather station. Data from iUtah.

THE RECONSTRUCTED MIDDLE PROVO RIVER

In the years before the Jordanelle dam became operational in 1997 the section of the Provo River now called the Middle Provo was largely channelized, with levees on both sides of the river to limit flooding (**Figure 13**). Because of occasional low flows in late summer, fall and winter the food production for trout in the channelized stream was limited and the habitat was severely restricted. Following the construction of the Jordanelle dam, the Utah Reclamation, Mitigation and Conservancy Commission (the Mitigation Commission) was established in 1994 to design, fund and implement projects to mitigate the adverse effects of CUP dams and reservoirs on fish, wildlife and related recreation resources. The Mitigation Commission established a Provo River Restoration Project (PRRP) in 1999 that removed the levees and attempted to re-create the river's pre-channelized course to improve aquatic and riparian habitat for the new tailwater fishery, with marshes, side channels and some shallow lake environments adjacent to the streambed (**Figure 14**). The existing levees were set back to create a near-natural floodplain and to allow the river to change course naturally. The project was substantially completed in 2008. A minimum streamflow restriction was established to aid the fishery below the dam. The cool water temperatures and improved streamside habitat increased the macroinvertebrate food production in the river, benefitting the fishery. The Middle Provo River should thus be considered an artificial river channel, with bends, pools, and riffles that were constructed with fish habitat in mind. Further, PRRP constructed 7 parking lots with restroom facilities and trash receptacles so that fishermen could easily access the stream. The parking lot locations, the names that fishermen use to indicate river reaches and other features are shown in the *Provo River Fishing Map* in **Appendices A1-A3**. The map was produced by *Streamlinemaps* and can be purchased at local fishing stores. With the increase in the numbers of fishermen in recent years, the parking lots are often full. Trails run along the river for fishermen and other recreationists, but to conserve the undeveloped nature of the fishery these are not regularly maintained. A public access corridor between 800 and 2200 ft in width runs along the river, bounded by fence lines (**Figure 15**). Private land abuts this corridor, and anglers cannot trespass on this private land without permission.

Figure 13 The pre-Jordanelle channelization of the river. From Provo River Restoration Project.

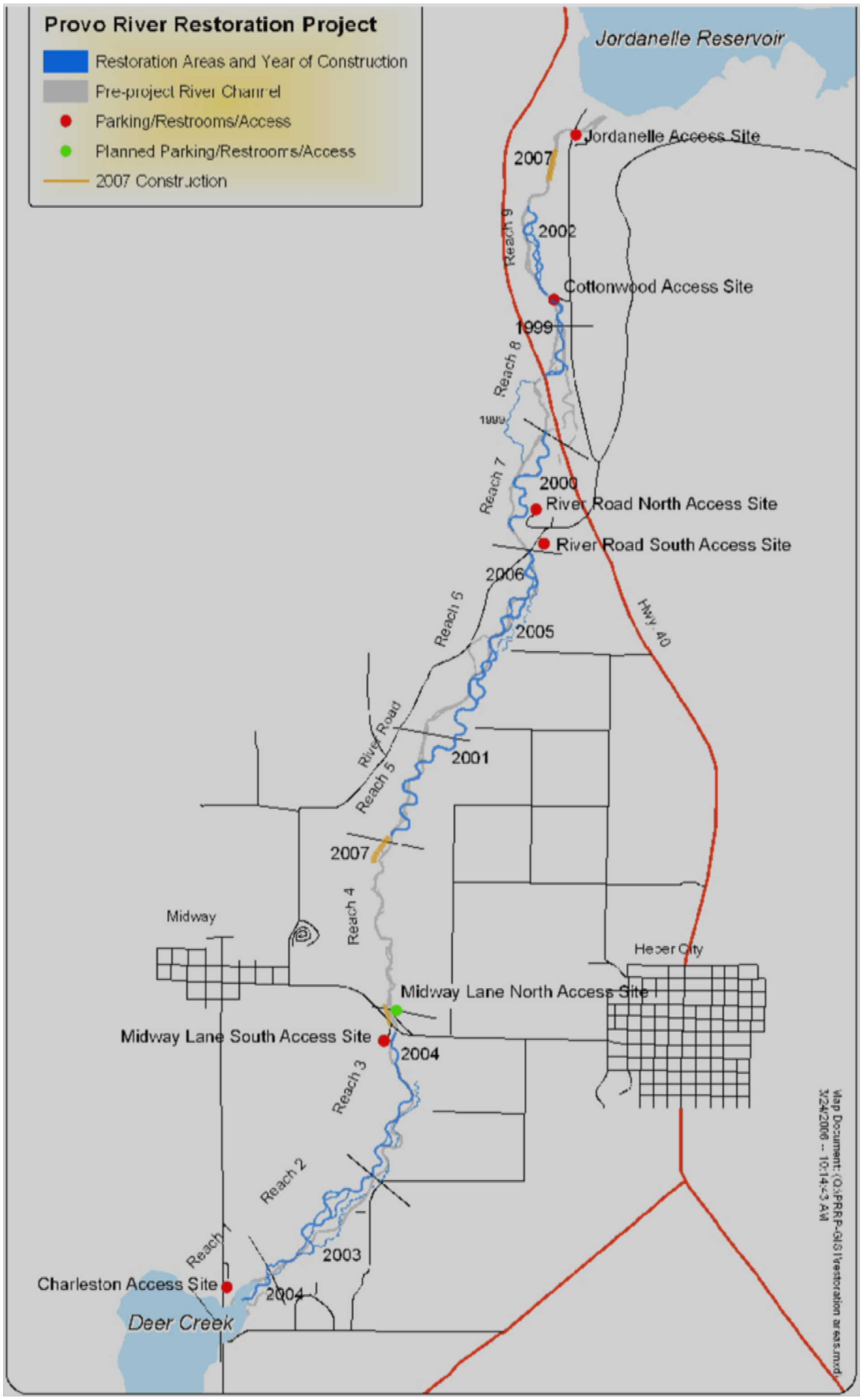

Figure 14 Changes in the river channel as part of the Provo River Restoration Project. Shown are the reaches that were restored during different years. From the Mitigation Commission.

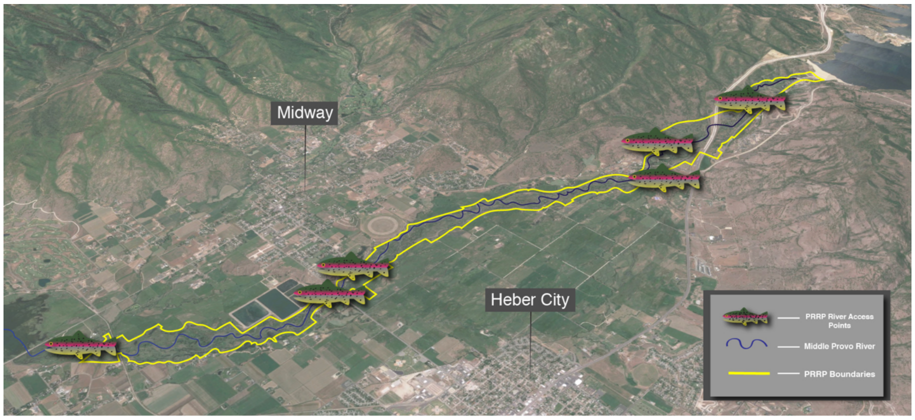

Figure 15 Public corridor along the Middle Provo River. From The Daily Universe, BYU.

THE RIVER'S SLOPE AND MAJOR INFRASTRUCTURE FEATURES

The river has a slope of 44 ft per mile above the Legacy Bridge and 28 ft per mile below the Legacy bridge (**Figure 16**). The slope is sufficient to produce turbulent water flowing around boulders and cobbles in the upper river, increasing the dissolved oxygen content that is so critical to macro-invertebrate and trout health.

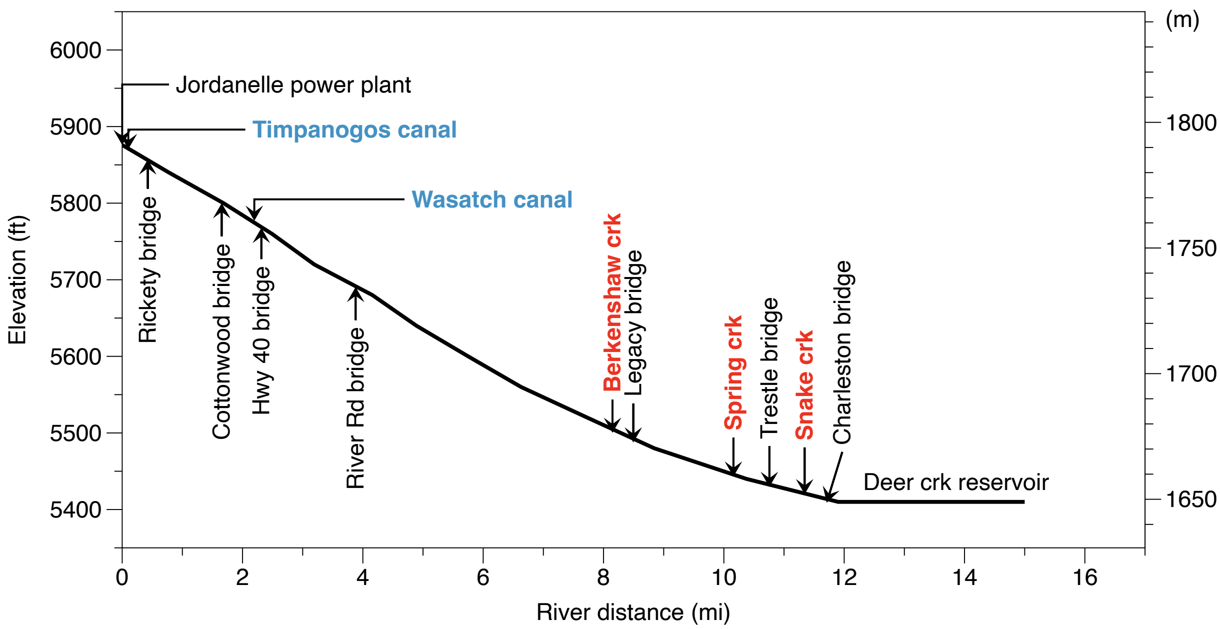

Figure 16 Topographic section along the Middle Provo River between the Jordanelle and Deer Creek reservoirs. Black text indicates the Jordanelle dam powerplant and bridge locations, blue text indicates irrigation diversions and red text indicates tributaries. Elevation data from the Heber City 2020 and Charleston 2020 USGS quadrangles.

HYDROLOGY

Tributaries and water diversions

Some water from the upper Middle Provo River is diverted into a network of irrigation ditches to support agricultural activities in the Heber Valley (**Figure 17**). Additionally, the lower river receives water from several tributaries as it flows south toward Deer Valley Reservoir. The river also experiences losses and gains in volume due to groundwater inputs and outputs. As we will see in an accompanying report, Middle Provo water temperatures are affected by these inputs and outputs, which generally have different temperatures than the main river.

During the irrigation season some water is diverted into the Timpanogos Canal at the foot of the dam. This water feeds irrigation ditches to farms and ranches in the upper eastern portion of the Heber Valley. The Middle Provo is further diverted into the Wasatch Canal 2.6 miles farther downstream, providing irrigation water to the lower east side of the Heber Valley, including a flow into Rock Creek. Excess water in Rock Creek feeds Spring Creek and returns to the Middle Provo 10.2 river miles downstream from the dam (0.6 miles above the Trestle Bridge).

Two tributaries enter the Middle Provo from the west. The minor Berkenshaw Creek tributary enters 8.1 miles below the dam, 0.3 miles above the Legacy Bridge. The major Snake Creek tributary enters the Middle Provo 11.3 mi below the dam, 0.4 miles above the Charleston Bridge. Snake Creek carries high nutrient loads from hot springs and grazing operations on the west side of the valley and is usually choked with vegetation (macrophytes) in the growing season. The tributaries and irrigation ditches come across private lands and are not fishable. They, nonetheless, have effects on Middle Provo discharge and water temperatures.

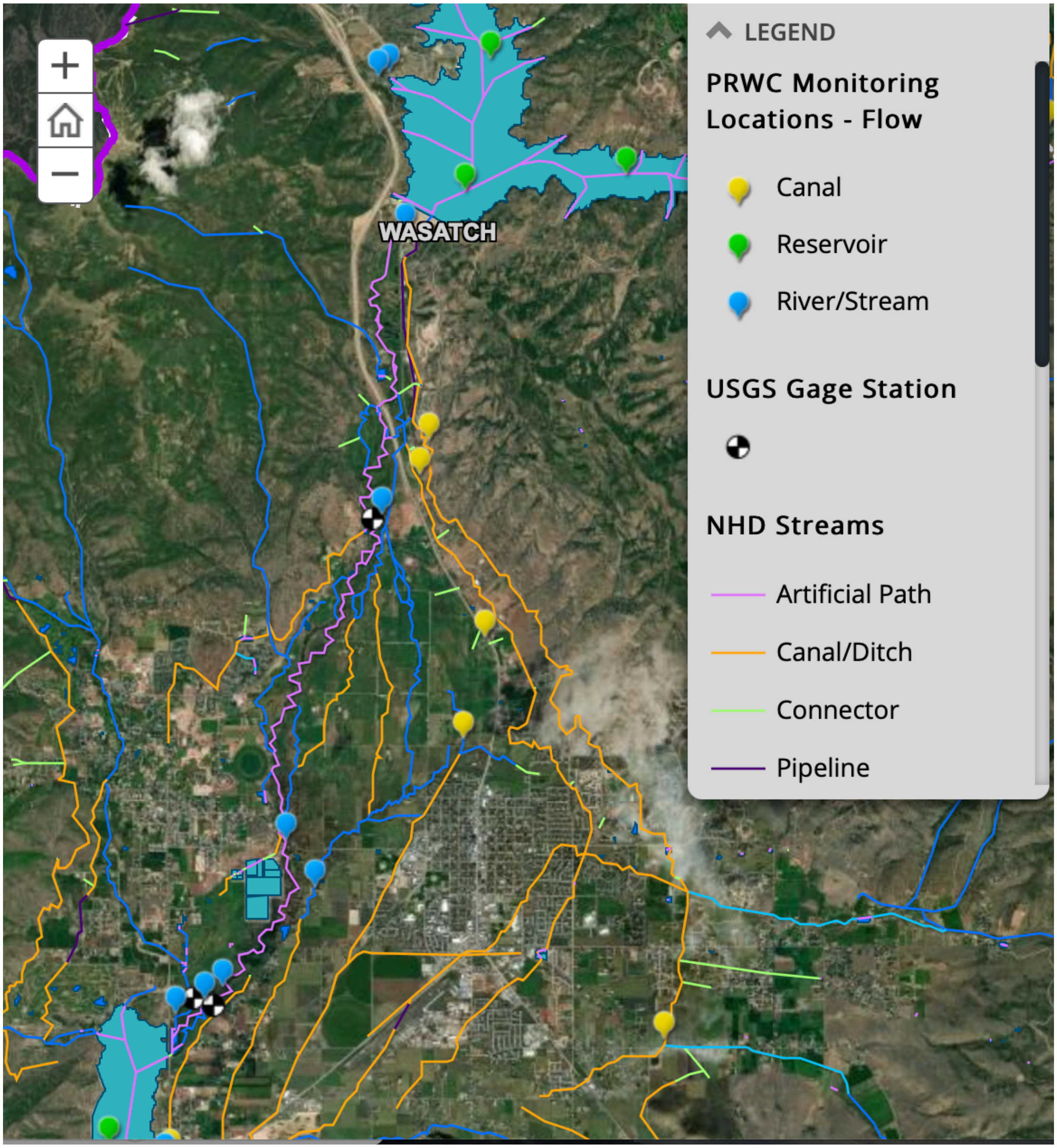

Figure 17 Irrigation diversions (canals and ditches) and their connectors in the Heber Valley. The purple line indicates the present (artificial) course of the Middle Provo River. From SWCA Environmental Consultants (2024).

Main channel gage sites

In addition to the CUWCD discharge measurements at the dam shown in **Figures 6 and 7**, discharge measurements are taken at two USGS river gages in the main river below the dam.

A gage (USGS 10155200) under the River Road Bridge utilizes a concrete weir that stretches across the river from bank to bank. Measurements here are used by CUWCD to verify that flow (i.e., discharge) is always above the 125 cfs minimum. The discharge across the weir is determined from a statistical relationship between discharge and the depth of the water pouring over the weir (i.e., the stage). This relationship is shown in **Figure 18**.

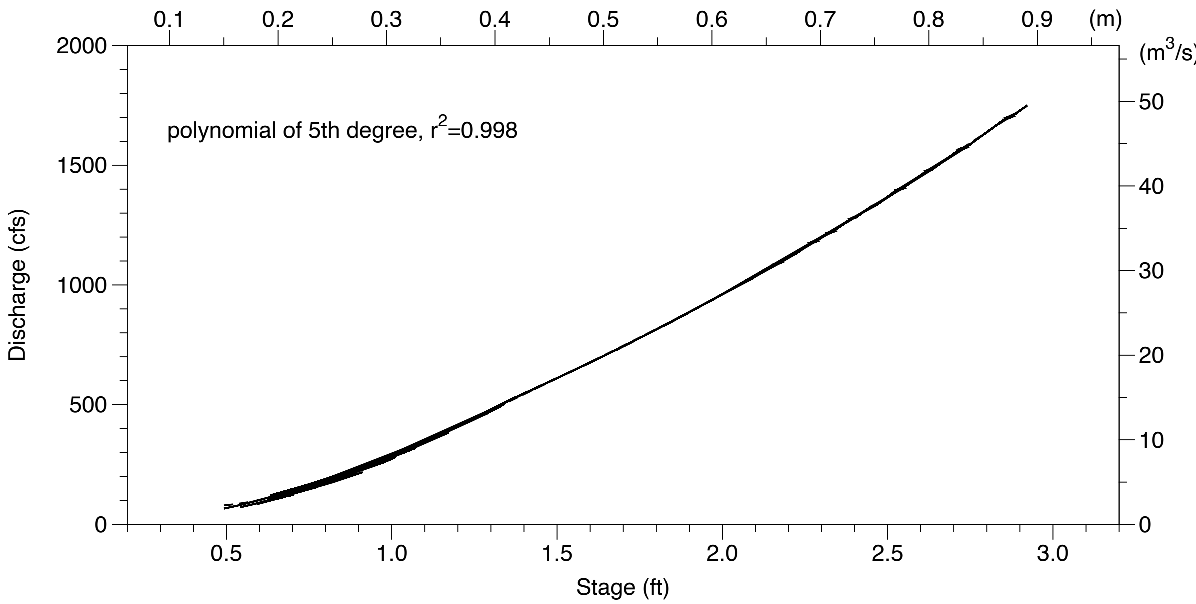

Figure 18 Discharge as a function of stage at the River Road gage. Data from USGS

One can compute the mean flow velocity coming across the weir by simply dividing the discharge by the vertical area of the flow crossing the weir. These computations show that the mean flow velocity increases with discharge (**Figure 19**). When the flow in the river becomes deeper it also becomes faster – an increasing hazard to the wading fisherman. Because the cobbles on the Middle Provo streambed are typically covered by slippery algae, a good rule of thumb is to wade only when the stream velocity is less than a typical walking speed of about 2.5 - 3 mph. Use a wading staff and cross the stream where the river is wide and shallow. Streamflow at the River Road gage and its recent history can be obtained from the USGS gage (see link above). When utilizing this site, choose to plot discharge. Sudden changes in discharge from the dam have adverse effects on fishing that last up to several days as the fish seek new lies. These changes in discharge are unpredictable and the angler should refer to this website when planning a trip.

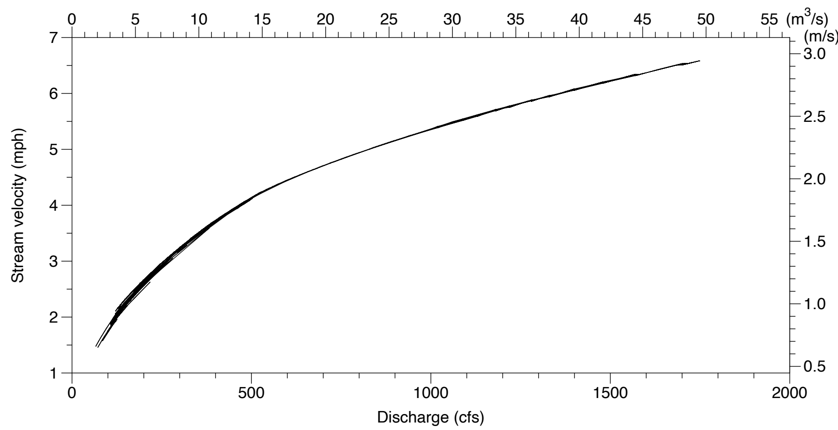

Figure 19 Stream velocity as a function of discharge at the River Road Bridge. Data from USGS.

The information in **Figure 19** can be used to estimate how long it will take water leaving the Jordanelle Reservoir to reach Deer Creek Reservoir, a river distance of about 12 miles. At 2 mph it would take 6 hours; at 4 mph it would take 3 hours; and at 6 mph it would take only 2 hours.

A second USGS gaging station (USGS 10155500) named Charleston is located 10.7 miles down-river from the dam a stone's throw south of Trestle Bridge. In this report we will call this the Trestle gage to distinguish it from the Charleston Bridge site that is farther down-river at the upper end of Deer Creek Reservoir. A well-equipped weather station located 100 ft south of the Trestle gaging station collected weather data over the years 2014-2018 as part of a National Science Foundation research program. Data from this BYU-owned station is available on the web for those years and the station is presently being rehabilitated and brought back on-line as funding allows for the instruments to be calibrated and/or replaced.

Discharge measurements in the main channel, tributaries and irrigation diversions

Discharge measurements at the dam and USGS sites in the main channel from 2019-2024 are shown in **Figure 20** along with discharge measurements from the tributaries and irrigation diversions. A logarithmic portrayal visually separates the higher flows in the main river (upper three curves) from the lower flows in the tributaries and in the irrigation season diversions (lower curves).

River Road gage flows are lower year-around than the flows from the dam. During the irrigation season this is caused by irrigation diversions into the Timpanogos and Wasatch Canals between the dam and the River Road gage. In the non-irrigation season, this flow difference is likely caused primarily by the year-around flow into

Rock Ditch (a secondary diversion from the upper Wasatch Canal) above the River Road gage.

The flows at the Trestle gage are sometimes higher than the discharge from the dam! The Spring Creek tributary and groundwater inflows contribute to this enhanced flow. Spring Creek is a year-around tributary that is enhanced during the irrigation season; its record is shorter than the other records and is also quite noisy.

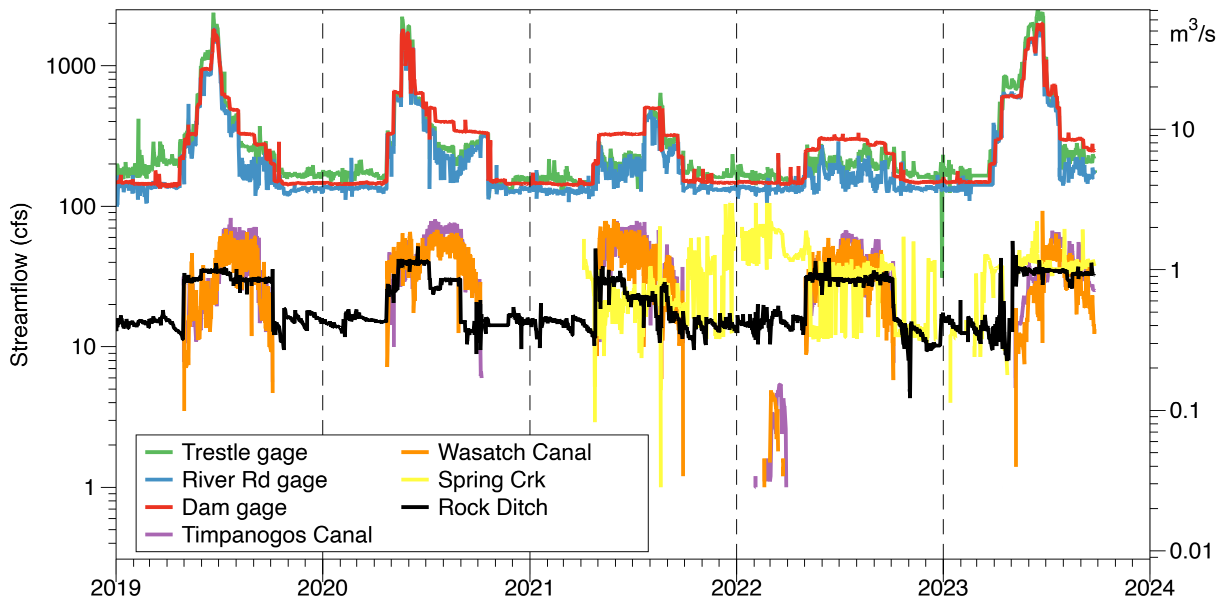

Figure 20 2019-2024 discharge measurements at the three streamflow gages on the Middle Provo River (Dam, River Road and Trestle), the Spring Creek tributary, and the three (Timpanogos, Wasatch and Rock) irrigation diversions. Data from CUWCD and USGS.

An additional tributary, Snake Creek, enters the river below the Trestle gage. Its flow (**Figure 21**) is measured at a separate gage (USGS 10156000) above its confluence with the Middle Provo. This tributary adds a 25-45 cfs contribution to the Middle Provo flow entering Deer Creek Reservoir, higher in winter than in summer. In the high-water year of 2023 a spring and early-summer peak reached nearly 95 cfs. Snake Creek water quality is lower than that in the main channel of the Middle Provo River. Its flow through areas containing thermal springs and cattle operations increases the arsenic and nutrient levels in the water. Nonetheless, the lower quarter mile of Snake Creek bounded at its upper end by a high fence and private land, does contain fish.

A third minor tributary to the river, Berkenshaw Creek, enters the river through an irrigation ditch just above the Legacy Bridge. Its flow temporarily ended in the fall of 2023 as the ditch underwent repairs. No discharge data are collected on this creek.

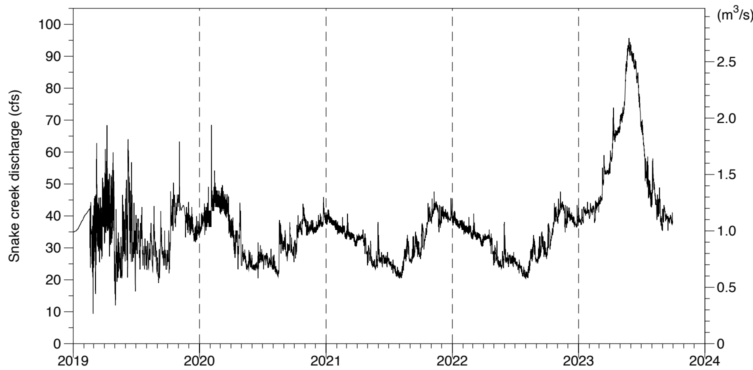

Figure 21 Snake Creek discharge during the years 2019-2024. Data from USGS.

THE FISHERY

The Middle Provo River is a self-sustaining, blue ribbon, tailwater brown trout fishery. It is the most heavily fished stream fishery in Utah. While brown trout are the main trout species in the river (**Figure 22**), mountain whitefish, rainbow trout and a few Bonneville cutthroat trout are also found there. The small to moderate-sized river has a variety of hydrological features (runs, riffles, pools, etc.) and riparian zones. The shallow river is not navigable, so that fishermen either fish from the shore or wade.

Figure 22 Middle Provo River brown trout. Photo from www.jeremyallanflyfishing.com, used with permission.

Fishing regulations differ along the river. Fishermen above the Legacy Bridge that connects Heber City to Midway, Utah, can use only artificial flies and lures and can keep two fish under 15". Below the Legacy Bridge, fishermen follow general Utah regulations. Bait is allowed and the daily limit is four trout of any size. Fly fishermen are prevalent along the entire river and catch-and-release is practiced by most fishermen.

Fish sampling is conducted occasionally by the Utah Division of Wildlife Resources (DWR) at sites at and above the Legacy Bridge, including at their Johnson Mill, 2400 N and Cottonwood Bridge sampling sites. The fish population varies from year to year, but there are generally between 2000 and 3500 brown trout per mile at or above 6" in size. (This can be compared to the astonishing 22,000 trout per mile in a 6-mile stretch of the Green River below the Flaming Gorge dam). This equates to about 1800 pounds of fish per mile. A survey in 2019 found that 20% of the fish were above 15" and 3% were above 18". For reference, the sizes are above Idaho's definition of "trophy waters" and the number of pounds per mile exceeds Wyoming's standard for Blue Ribbon fisheries. Further, the relative weight to length ratios indicates that the brown trout are in good condition in a healthy population.

Brown trout spawn in the fall, with some larger trout swimming up-river from the Deer Creek reservoir to spawn. Fall anglers need to be careful when wading to keep from disturbing the redds where fish have laid their eggs. The redds, where stream sediments have been disturbed by the fish, are sometimes difficult to recognize.

The Middle Provo fishery is heavily used by fishermen from the cities along the Wasatch Front (the west side of the Wasatch Mountains), from the surrounding communities on the east side and by visiting anglers who usually stay in Park City or Heber City, Utah. Almost 70% of the Utah population lives within a 1-hour drive of the Middle Provo. A recent survey showed that 61% of the anglers are from Utah; 39% are out of state. A third of the anglers are fishing with local guide services. Guided clients often fish within easy walking distance of the stream and the guides often have preferred locations where neophyte fisherman have higher probabilities of success. The fishing pressure is generally high in the Middle Provo at locations that are easy to access, especially on weekends and good weather periods, but there is less pressure in parts of the stream that are farther from the parking lots.

WATER QUALITY

Nutrient levels in the water increase downstream from the dam as the river receives runoff from agricultural and human activities in the rapidly urbanizing Heber Basin. The nutrient levels are closely monitored each year by the Provo River Watershed Council (PRWC) from water samples collected by CUWCD and the Utah Division of Water Quality (UDAQ). Detailed recent reports on Middle Provo water quality have been prepared by SWCA Environmental Consultants (2023; 2024). High levels of nutrients increase algae and macrophytes (aquatic plants) in the river. The nutrient levels are highest in the lowest section of the Middle Provo just above Deer Creek Reservoir. Weed beds in the Snake Creek tributary, which enters the river 0.7 miles above Deer Creek Reservoir, are indicators of excessive nutrient levels (eutrophication). Individual macro-invertebrate species have different tolerances to nutrient levels, so that the types and diversity of species are an indicator of water quality.

Water quality is monitored episodically at several sites in the river by various state and federal agencies and reports are issued occasionally. Here we report a special study intended to ascertain how the water quality varies with downstream distance using water quality samples obtained by Wasatch High School students as part of Wasatch High's Center for Advanced Professional Studies (CAPS) program under the direction of retired entomologist Dr. Roger Gold. Water quality data were obtained from 12 water samples that were collected during the fall semester of 2023 at selected sites (1-8 and 11-14 in **Figure 23**) where the students also collected macroinvertebrates. Site coordinates are provided in **Table 1**. These samples, taken on selected dates in the period from 26 September to 1 November, were analyzed at the Brigham Young University (BYU) Environmental Analytical Laboratory, following BYU's sampling and analysis protocols. Ion concentrations in the samples (both filtered and unfiltered) were obtained using an analysis technique called Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES). Additional analyses were made of pH and electrical conductivity. Grab sample ion concentrations, where possible, are compared to one-hour average regulations established by the state of Utah. For many of the ions, regulations that have been established for additional averaging times (24-hr, annual, etc.).

Figure 23 Macro-invertebrate and water sampling sites in the Middle Provo River. Base map from USGS.

Table 1. GPS coordinates and river distance from the dam of macro-invertebrate/water sampling sites.

Site	Latitude (°N)	Longitude (°E)	River distance (mi)
01	40.59504	-111.42676	0.210
02	40.58654	-111.43241	1.010
03	40.57740	-111.42921	1.904
04	40.56854	-111.43169	2.562
05	40.56028	-111.43399	3.324
06	40.55162	-111.43274	4.100
07	40.54343	-111.43765	4.817
08	40.53604	-111.44236	5.645
09	40.52979	-111.44698	6.306
10	40.52191	-111.45285	7.084
11	40.51202	-111.45067	8.023
12	40.50190	-111.44809	8.784
13	40.49490	-111.45399	9.604
14	40.48836	-111.45966	10.259
15	40.48246	-111.46704	11.093

pH, water conductivity and nitrates

The river's pH, water conductivity and nitrate content are shown as a function of river distance in **Figure 24**.

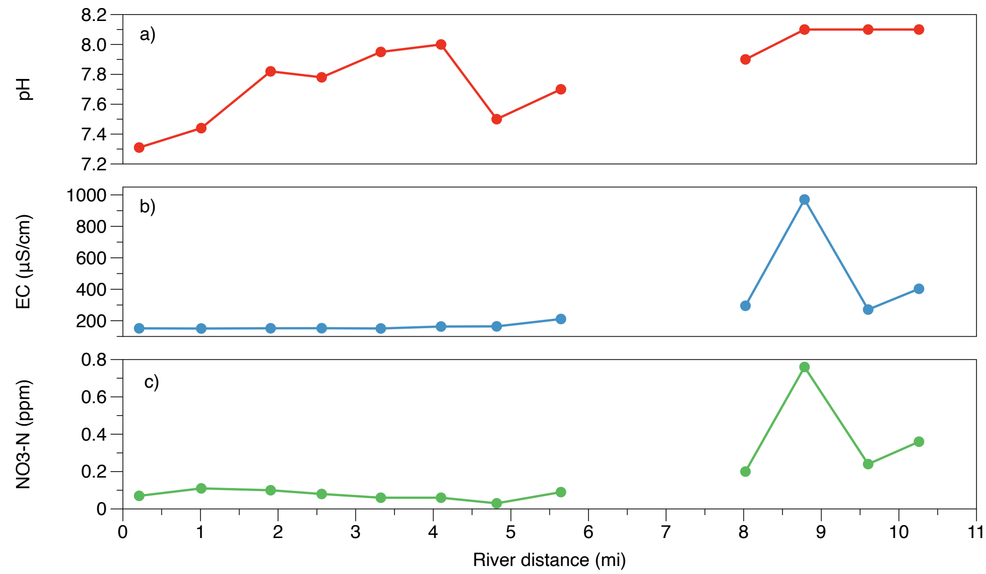

Figure 24 a) pH values, b) conductivity, and c) nitrate content as a function of river distance. Dots indicate macro-invertebrate sites numbered from 1 through 14. Data are missing from sites 9, 10 and 15. Water samples collected by CAPS students.

A pH of 7 is neutral – neither acidic or basic. To meet the state standard (3A) for cold water fisheries the pH must be between 6.5 and 9.0. Values below 7 are acidic, while values above 7 are basic. The pH of the river water (**Figure 24a**), while slightly basic and generally increasing with downstream distance, is in a healthy range for macroinvertebrates and fish.

Electrical conductivity (**Figure 24b**) measures water's ability to pass an electrical current. Because dissolved salts and other inorganic chemicals conduct electrical current, conductivity increases as salinity increases. Human disturbance tends to increase the dissolved solids entering waters, resulting in increased conductivity. In the Middle Provo, electrical conductivity begins to increase about 5 miles down-river, with a large spike between 8 and 9 miles downstream in the vicinity of the Jordanelle wastewater treatment plant.

Nitrate nitrogen is the amount of nitrogen in the nitrate ion. State water quality regulations for cold water fisheries require that nitrate nitrogen not exceed 4 mg/L. The amount of nitrate is given by multiplying the nitrate nitrogen concentration by 4.43. Nitrate nitrogen may be caused by the seepage of water through soil containing nitrate-bearing minerals or as the result of using certain fertilizers in the soil. Nitrates are also a product of the decomposition of animal and human wastes. Thus, the presence of nitrates in a water supply indicates possible water pollution. The increase of nitrate nitrogen concentrations with river distance parallels the increase of electrical conductivity (**Figure 24c**). Concentrations start to increase between 5 and 6 miles down-river, with a pronounced peak between 8 and 9 miles down-river and a fall-off farther down-river.

Nitrates and phosphates are nutrients that are essential for plant growth. Low levels of nutrients are good for a stream, as they support the growth of stream vegetation (macrophytes) and algae on which macroinvertebrates browse. The overabundance of nutrients (eutrophication), on the other hand, can lead to the overgrowth of algae. Algae blooms can spread, turn the water green, block sunlight and some varieties of algae can even release toxins. When algae and other organic matter dies, they are decomposed by bacteria, consuming the oxygen dissolved in the water that is needed by fish and other aquatic life.

Ion concentrations

The BYU laboratory analysis of water samples provides information to determine how ionic concentrations of various metals and non-metals vary with river distance. **Figure 25** plots ionic concentrations in parts per million (ppm) for several ions that reach relatively high concentrations. These include calcium, potassium, magnesium, sodium, sulfur, silicon and strontium. None of these ions are regulated in cold water fishery waters by the state of Utah. Concentrations in ppm are numerically nearly identical to concentrations expressed in milligrams per liter. The results for high concentration ions parallel those obtained for electrical conductivity and nitrate nitrogen. Relatively low concentrations occur in the upper river. Concentrations, however, begin to rise 5-6 miles down-river. Concentrations then peak at 8 to 9 miles down-river and then decrease farther down-river, but with concentrations still higher than found in the upper river. High concentrations of nitrate-nitrogen are evidence of pollution from septic tank fields, cesspools, water treatment facilities, golf courses, parks, gardens, or naturally occurring sources of nitrogen. Nitrates are highly soluble and can travel through groundwater. Well waters can be tested to determine if nitrates are present in groundwater.

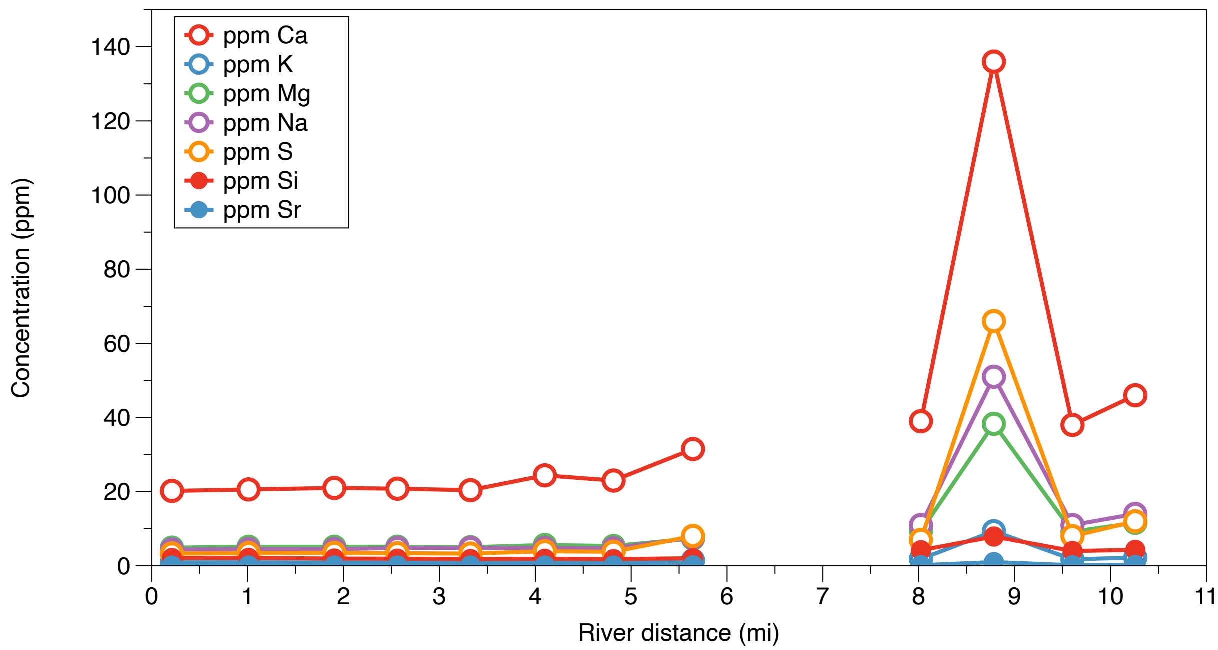

Figure 22 Concentrations above 0.3 ppm in filtered Middle Provo River water as a function of river distance. Water samples collected by CAPS students.

The variation with river distance of ions with concentrations below 0.30 ppm is shown in **Figure 26**. Ionic concentrations of cadmium, cobalt, chromium, copper, nickel, lead and titanium were below detection limits. Concentrations of other ions (aluminum, arsenic, iron, manganese, molybdenum, phosphorus, selenium and zinc) generally decreased with down-stream distance. Exceptions include boron, barium, and vanadium. Historical mining operations in the Jordanelle Reservoir drainage may be responsible for the higher concentrations of some of these elements entering the upper river. The state has established maximum ppm concentrations in cold water fisheries of aluminum (0.75), arsenic (0.34), iron (1), phosphorus (0.05), selenium (0.0184) and zinc (0.12). None of the ionic concentrations in the water samples exceeded these standards. Concentrations of nutrients have been found to be higher, however, during the high flows of the irrigation season.

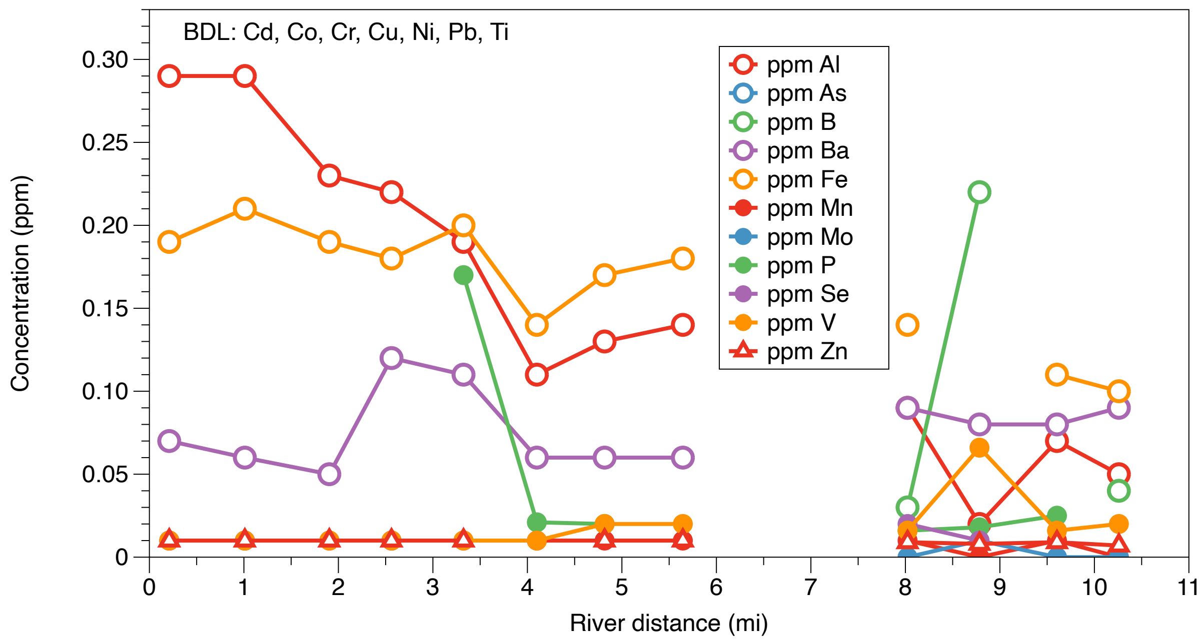

Figure 26 Concentrations below 0.3 ppm for ions in filtered Middle Provo River water as a function of river distance. Ion concentrations that were below detection level (BDL) are listed in the upper left portion of the figure. Water samples collected by CAPS students.

Dissolved oxygen concentrations

Dissolved oxygen (DO) is the amount of gaseous oxygen dissolved in water. Dissolved oxygen is an important measure of water quality as it is a direct indicator of a stream's ability to support aquatic life, including macroinvertebrates and fish. All aquatic animals need dissolved oxygen to breathe. Dissolved oxygen content in water decreases when excess organic materials like large algal blooms are consumed by microorganisms. State regulations require that DO concentrations be above 8.0 for early life stages of aquatic organisms and above 4.0 for all other life stages.

Water bodies receive oxygen from the atmosphere and from aquatic plants. Water exiting the dam is relatively low in dissolved oxygen since it comes from the depths of the reservoir (**Figure 27**). The swift moving stream in the steep upper river cascades around boulders and cobbles and produces riffles that mix oxygen into the stream, increasing the dissolved oxygen content. Oxygen solubility is a function of water temperature – the lower the temperature the higher the solubility. Thus, there is a distinct annual variation in dissolved oxygen content, with higher values in winter and lower values in summer.

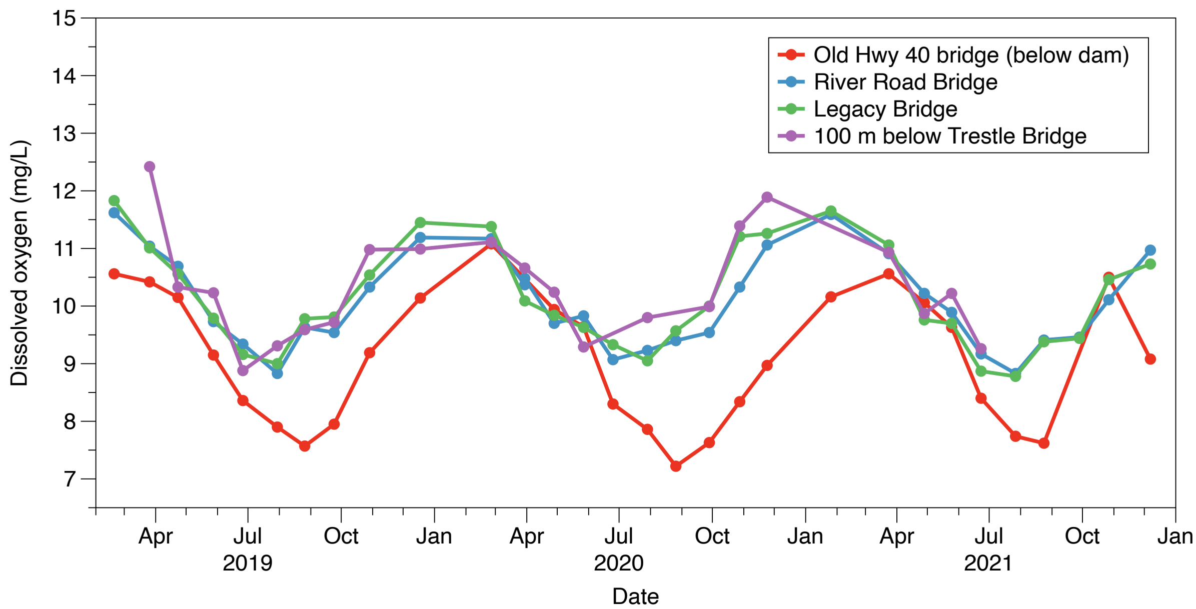

Figure 27 Dissolved oxygen concentration observed at 4 sites in the Middle Provo River at sampling intervals of about once per month. From DWQ?

Water Temperatures

As previously mentioned, CUWCD selects the released water temperature by blending reservoir water from different depths in the Jordanelle Reservoir through inlet gates located at different elevations within the reservoir. The gates can be partially opened to blend water from different levels having different water temperatures. In winter, reservoir water temperatures are nearly constant with depth throughout the gate elevation range. In summer, water temperatures increase with elevation (i.e., a *thermocline* forms) through the gate elevation range and temperature differences between the lower and upper gates can reach over 30°F. Thus, in summer, water must be pulled from the lower elevation gates where water temperatures are cooler.

Water discharged from the dam undergoes regular diurnal (i.e., day-night) and annual temperature changes (**Figure 28**). Summer temperatures around 51°F, with a 1-4°F day-night oscillation. In mid-October water temperatures start to decrease linearly to the winter value of 37°F, reaching this value by early January and remaining steady until late March. In late March they begin a slow rise followed by a sudden jump to the summer values sometime during the period from early June to early July. These temperatures are quite suitable for the trout population.

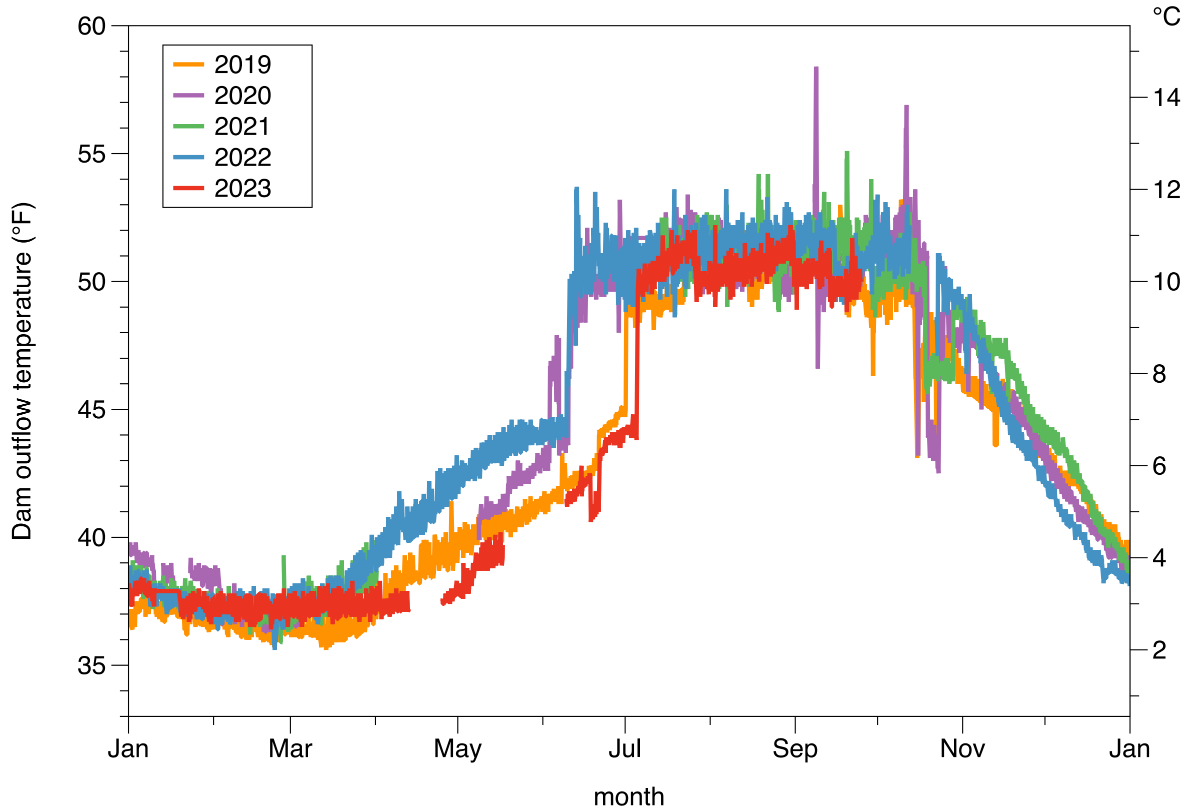

Figure 28 Jordanelle dam outflow water temperature as a function of time. Data from CUWCD.

Water temperatures downstream of the dam depend on the temperature of the water released from the dam, the outputs and inputs of water volume and temperature from irrigation diversions, runoff, tributaries and groundwater and the heat added and removed from the water volume by various physical processes as it moves downstream. Water velocity plays a role by affecting how much time these physical processes can act during the water's downstream transit. State regulations for cold water fisheries require water temperatures below 20°C or 68°F. The importance of temperature as a water quality parameter is well recognized by fishermen. The variation of temperature with distance downstream and with time of day and season affect the health of the fish and the macroinvertebrates on which they feed. Water temperature is a key factor affecting the timing of macro-invertebrate hatches or emergences. A special report on the temporal and spatial variation of water temperatures along the course of the river accompanies this report, providing detailed results from a two-year water temperature monitoring project supported by the High-Country Fly Fishers club. In this accompanying report water temperatures are shown to exceed 68°F on hot summer days in the lower Middle Provo River and in its tributaries.

The water quality analyses reported in this section have a limited scope and have focused on selected ion concentrations. Other potential pollutants of concern have not been sampled, including mercury, *E. coli*, and PFAS (Per- and Polyfluoroalkyl

Substances, also known as forever chemicals). Other state and federal agencies and organizations routinely or episodically monitor water quality in the Middle Provo River.

From these analyses, fisherman will note that pollution increases with river distance, especially below Berkenshaw Creek. This can be expected to affect the macro-invertebrate species diversity and numbers in the lower river, as different families of insect larva have different levels of pollution tolerance.

MACROINVERTEBRATES

The steady flow rates, lack of significant flooding and steady in-stream temperatures in a range suitable for trout cause good growth of the in-stream macroinvertebrates on which the trout feed. The macroinvertebrates feed on zooplankton, phytoplankton (including algae) and on leaves, twigs, and other pieces of organic matter that fall into a stream. Some phytoplankton and zooplankton enter the river through releases from the dam. The continuous flow of cold nutrient-rich water provides a constant food supply for both the macroinvertebrates and the trout. Studies have found macroinvertebrate densities as high as 13,000 to 170,000 per square meter (1,200-16,000 per square foot) at sites along the river, largely due to high numbers of midge larva (BioWest, 2006). The hatching schedules and macro-invertebrate assemblages in tailwater streams such as the Middle Provo can be quite different from natural streams. The different macro-invertebrate species have varying water quality tolerances (**Table 2**). The less tolerant species tend to inhabit the upper river, while the more tolerant species increase in number in the lower river. It should be noted that scientific studies have shown that one low-tolerance stonefly species, the Giant Salmonfly (*Pteronarcys californica*), has undergone a severe decline in numbers in the river over the years (Birrell et al., 2019). This species, which has a four-year life cycle, is a bioindicator of water pollution, suggesting that the health of the river is deteriorating.

Table 2. Estimated tolerance ratings for species from the different Orders inhabiting the Middle Provo River. These are general ratings, and there is much variation within the different Orders.

Order	**Common name**	**Tolerance rating**
Ephemeroptera	mayflies	4 (Baetis)
Plecoptera	stoneflies	1-2 (0 for Giant Stonefly)
Trichoptera	cased caddis	0-4
Trichoptera	naked caddis	0 for some free-living caddisflies
Diptera	midges, gnats and flies	6-8 (8 for blood red forms)

Coleoptera	beetles	5 (Riffle beetles)
Amphipoda	scuds and side swimmers	4-8
Isopoda	sowbugs	8
Hirudinea	leeches	10
Lumbriculida	aquatic worms	8
Stylommatophora	snails	7
Venerida	clams	7

Factors that typically decrease the production of macroinvertebrates in fisheries include channelization, deforestation, pesticides, heavy metals, siltation, thermal pollution, and low or oscillating water levels. Many of these factors are not present in the Middle Provo.

The key macroinvertebrates in the Middle Provo tailwater fishery are mayflies (ephemeropterans), stone flies (plecopterans), caddis flies (tricopterans) and true flies or midges (dipterans). There are also scuds, sowbugs, leeches, worms and other aquatic insects within the fishery. Anglers often try to imitate the major species with hand-tied imitations, but the fish in this popular fishery have become very selective. A key feature of the macro-invertebrate assemblage in the river is their generally small size, and fishermen often use flies that are too large. When hatches are present, dry flies of the right size are often productive, but there are many times when hatches are absent, or the fish are not feeding on the hatches. In these circumstances sub-surface nymph or emerger imitations work well. There are times on the river when special hatches are present. Small buffalo midges are present in mid-day in late winter giving way to blue-wing olives as spring approaches, a sparse hatch of large Skwala stoneflies progresses up the Middle Provo during a short period in the spring, and green drakes and early to late evening caddis hatches are present in summer. In the fall the blue-wing olives (of an even smaller size) hatch in the morning and evening. A rough hatch chart developed for the entire river (Upper, Middle and Lower Provo) is found on Streamline's *Provo River Fishing Map* (**Figure 29**), but there is no specific chart available just for the Middle Provo.

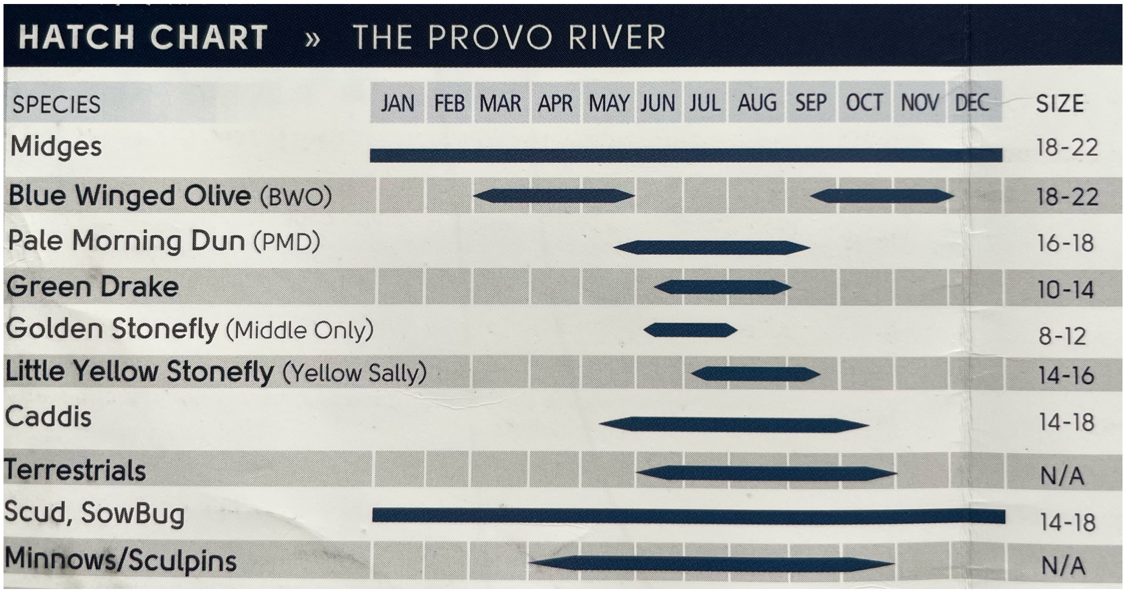

Figure 29 Provo River Hatch Chart (from Provo River Fishing Map, ©streamlinemaps.com

A BioWest report submitted to the Mitigation Commission listed the three dominant macroinvertebrate taxa sampled at four locations in the Middle Provo River in the Spring and Fall of 2004, 2005 and 2006. Professional identification of the taxa, in some cases down to the species level, may be of interest to some readers. A summary table from the report is provided in **Appendix B**.

In this section we present the results from a sampling program that was conducted in the fall of 2023 and sampled macro-invertebrate species and populations along the full length of the river. The samples, taken by Wasatch High School students under the direction of entomologist Prof. Roger Gold as part of the high school's Center for Advanced Professional Studies (CAPS) program, were not all taken on the same day, but rather on chosen dates during the fall semester. The reader should note that the fall period is not necessarily representative of other times of the year since macro-invertebrate larva emerge at different times over the year.

The counts of the key macroinvertebrates (mayflies, stoneflies, caddis and midges) at the numbered sites 1-15 along the river (locations shown back in **Figure 23**) are plotted in terms of river distance in **Figure 30**. All samples were taken using a Surber sampler, which samples a 1 square foot area of the streambed. The major species are well distributed along the streambed with substantial numbers at most sites and with higher counts in the first 6 miles of river. A midge count of 349 was found at site 7 about 5 miles down-river.

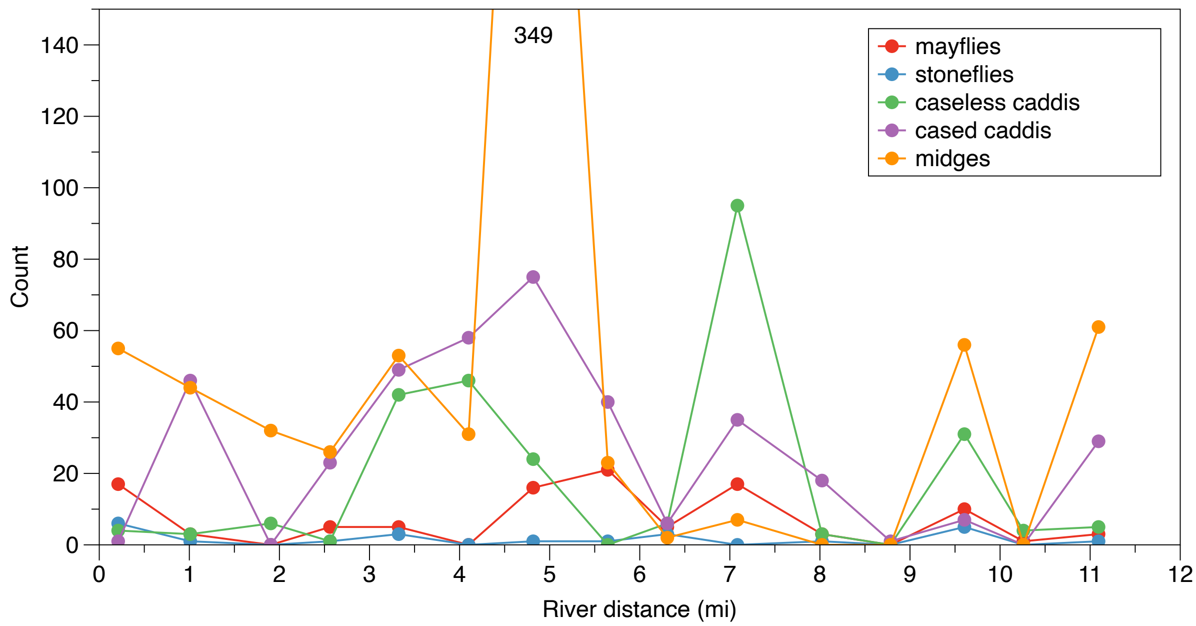

Figure 23 Counts of major macroinvertebrates as a function of river distance from the Jordanelle dam. Fall 2023. Macroinvertebrates collected by CAPS students.

Surber sampler counts of non-key species that are generally more tolerant of water pollution are shown in **Figure 31**. These species tend to be found in the lower river at and below the Legacy Bridge (mile 8.5). Other species are found occasionally in the samples including snails, clams, leeches, aquatic worms, cranefly larva, and riffle beetle larva. They occur infrequently in different locations and are not plotted in the figure.

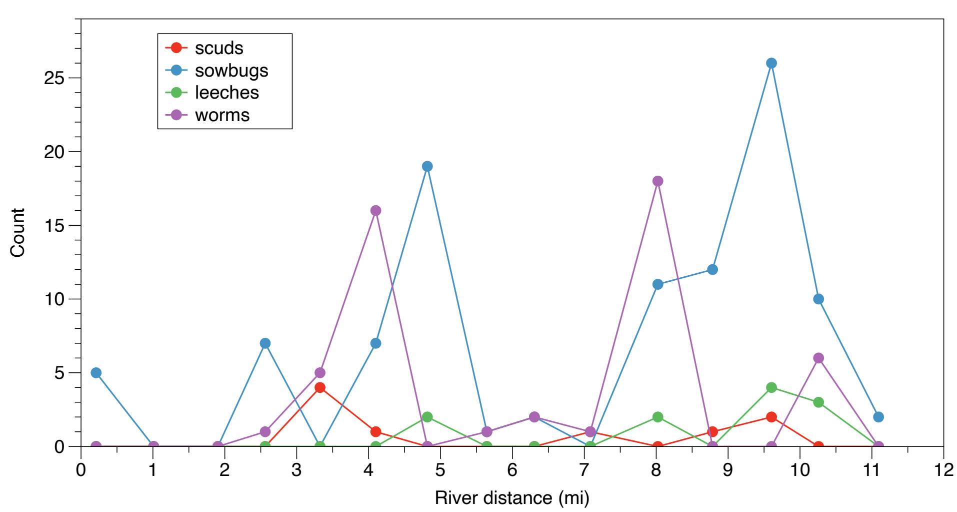

Figure 24 Counts of minor macroinvertebrates as a function of river distance from the Jordanelle dam. Fall 2023. Macroinvertebrates collected by CAPS students.

A video of live macroinvertebrates collected in the Middle Provo River, produced with the help of Wasatch High School students in the CAPS program, accompanies this report and should be of interest to fishermen who are tying or using artificial flies that mimic these river denizens.

LONG-TERM CONCERNS FOR THE FISHERY

The Middle Provo River is currently a superb fishery, and the health of the fishery is being watched carefully by different agencies and organizations.

The long-term health of the Middle Provo fishery, however, could be disturbed by several factors. Nearby Heber City and Midway are undergoing a rapid urbanization that extends into the surrounding Wasatch County. This rapid urbanization (**Figure 32**) has the potential to increase storm runoff, heavy metals, coliform bacteria, PFAS, excess nutrients and other forms of water pollution that are already being seen in the lower river. Increasing traffic (including semi-trailers carrying crude oil from the Uinta Basin to refineries along the Wasatch Front) on State Highway 40, which runs through the center of Heber, has increased demand for a needed city bypass that could move the traffic westward, closer to the river. Out of 926 metro areas in the U.S., Heber City ranked No. 5 for the biggest change in net in-migration in 2020, up by 4.7%, according to an April 19 analysis by The New York Times titled "How the Pandemic Did, and Didn't, Change Where Americans Move, using about 30 million change-of-address requests to the U.S. Postal Service in 2020. Subdivisions and houses are now encroaching on the public river corridor at several locations along and above the river. Many new sub-divisions are being platted or developed around the Jordanelle Reservoir (**Figure 32**). These may add pollutants to the reservoir.

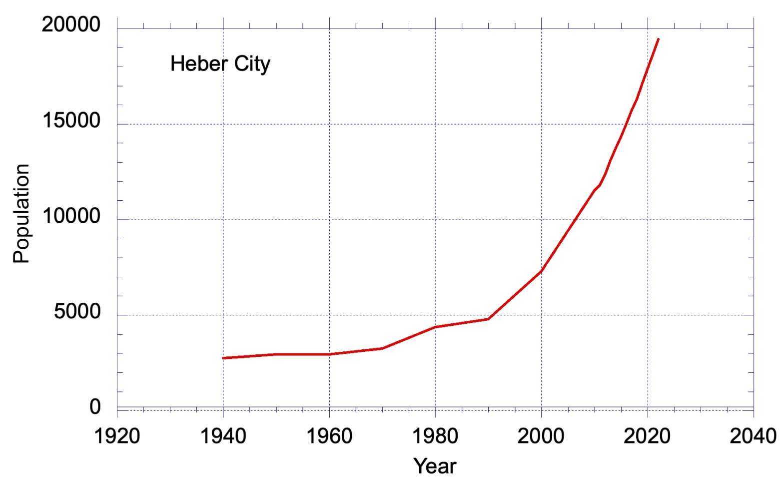

Figure 32 Macroinvertebrates collected by CAPS students.

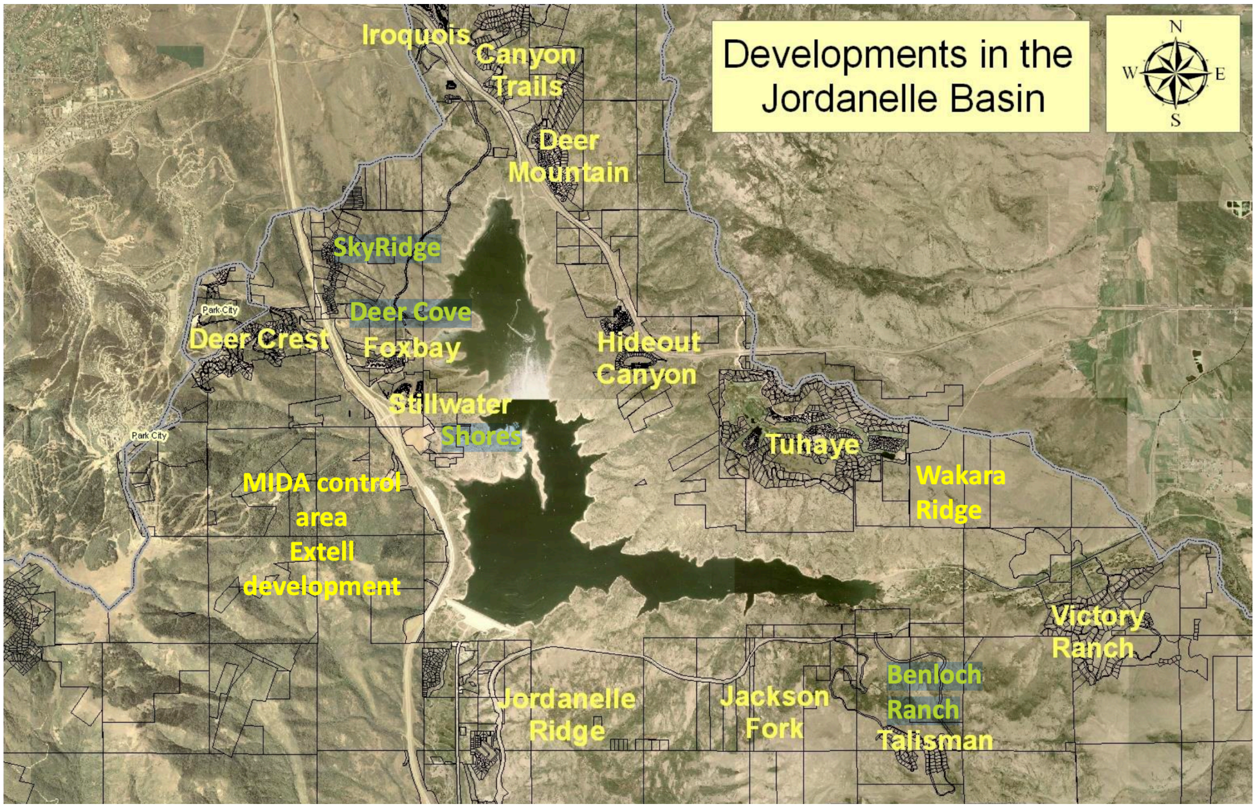

Figure 25 Residential developments underway in the Jordanelle Basin. The Mayflower ski area is presently under construction above the highway on the west side of the Jordanelle Reservoir. From Wasatch County Planning and Zoning Department.

Global and regional climate are changing as greenhouse gases are being added to the atmosphere with the burning of fossil fuels. 2023 was the world's warmest year on record, and the 10 warmest years since 1850 have all occurred in the past decade (National Oceanic and Atmospheric Administration, NOAA, 2024). The 20+ year mega-drought in the Intermountain Basin has reduced precipitation in the Provo River watershed, leading to decreased inflows to the Jordanelle Reservoir. While many have discounted the science on global climate change, it is very evident and concerning when it affects *your fishing*! It is conceivable that the reservoir may be drawn down severely under continued drought conditions. As the water is drawn down, the sediment can be disturbed and discharged into the river below bringing silt, agricultural runoff, contaminants, and higher temperatures from upstream sources (Despommier 2016). Harmful algal blooms have been reported occasionally in both the Jordanelle and Deer Creek reservoirs by the Utah Division of Water Quality, usually in the late spring or early summer. The Jordanelle algae bloom in May 2008 corresponded to elevated phosphorus levels at the surface of the reservoir. Surface water temperatures in the Jordanelle reservoir in July and

August of 2008 were above the State's Water Quality Standard for a cold-water fishery (Wasatch County Council, 2009).

Increasing numbers of fishermen may have a negative impact on the fishery, especially if a continued drought causes additional fishermen to choose the Middle Provo tailwater fishery as water levels in other nearby streams decrease and become too warm to provide healthy fisheries.

Fishermen, to keep the Middle Provo fishery healthy, must be very careful not to bring exotic or invasive species into the river on their wading boots or waders. Potential invasive species include quagga mussels, zebra mussels and Didymo algae ("rock snot"). Trout are also subject to whirling disease (caused by a parasite) and infectious bacterial agents. The High-Country Fly Fishers club has begun a conservation project to protect against the import of invasive species by providing and maintaining wader cleaning stations at each of the seven parking lots shown in **Appendix A** where fishermen access the Middle Provo River.

State, County, Federal and other agencies and organizations concerned with protection of the Middle Provo River

Local, state and federal government organizations are continuing to see that the health of the restored fishery in the Middle Provo River is maintained. Some of these organizations produce occasional reports. For example, the PRWC provides annual online water quality reports for the Middle Provo River. Occasional surveys of the macroinvertebrates in the river are conducted by the Mitigation Commission. Additionally, a Jordanelle Reservoir Resource Management Plan, last issued in 2012 and updated every 10 years, brings all the government organizations together to oversee the management plan for the reservoir.

Provo River Watershed Council (PRWC)
Bureau of Reclamation (BoR)
Trout Unlimited (TU)
Center for Advanced Professional Studies (CAPS) at Wasatch High School
Jordanelle Technical Advisory Committee (JTAC)
Central Utah Water Conservancy District (CUWCD)
Utah Division of Water Quality (DWQ)
Utah Division of Wildlife Resources (DWR)
United States Geological Survey (USGS)
Provo River Mitigation Advisory Task Force
Provo River Restoration Project (PRRP)
Wasatch County Groundwater Study
Central Utah Project (CUP)

Utah Reclamation Mitigation and Conservation Commission (Mitigation Commission)
Desert Rose Environmental
High-Country Fly Fishers (HCFF)
iUtah
Utah State University (USU)
University of Utah (UU)
Brigham Young University (BYU)

About the author:

This report was prepared by Dr. Dave Whiteman, a member of the High-Country Fly Fishers club in Park City, Utah, since 2016. He is a fly fisherman and fly tyer and often fishes the Middle Provo River. Dr. Whiteman is an Emeritus Research Professor in the Department of Atmospheric Sciences at the University of Utah in Salt Lake City.

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CAPS administration: Weston Broadbent, Matt Zierenberg, Dr. Roger Gold
CAPS students: Ian Danley, Zealand Bouwhuis, Lewis Brooks, Gray Mathewson, and Zach Yoshioka.

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SWCA Environmental Consultants, 2023: Heber Valley Watershed Plan. https://documents.deq.utah.gov/water-quality/watershed-protection/watershed-plans/DWQ-2023-007160.pdf

Streamline Maps, 2013. *The Provo River Fishing Map*. See **Appendix A.**

APPENDIX A – The Middle Provo River Map

Figure A1. Map of the upper Middle Provo River. Note that maps A1-A3 are turned relative to conventional maps where north is at the top. Figures A1-A3 ©Streamlinemaps.com. Used with permission.

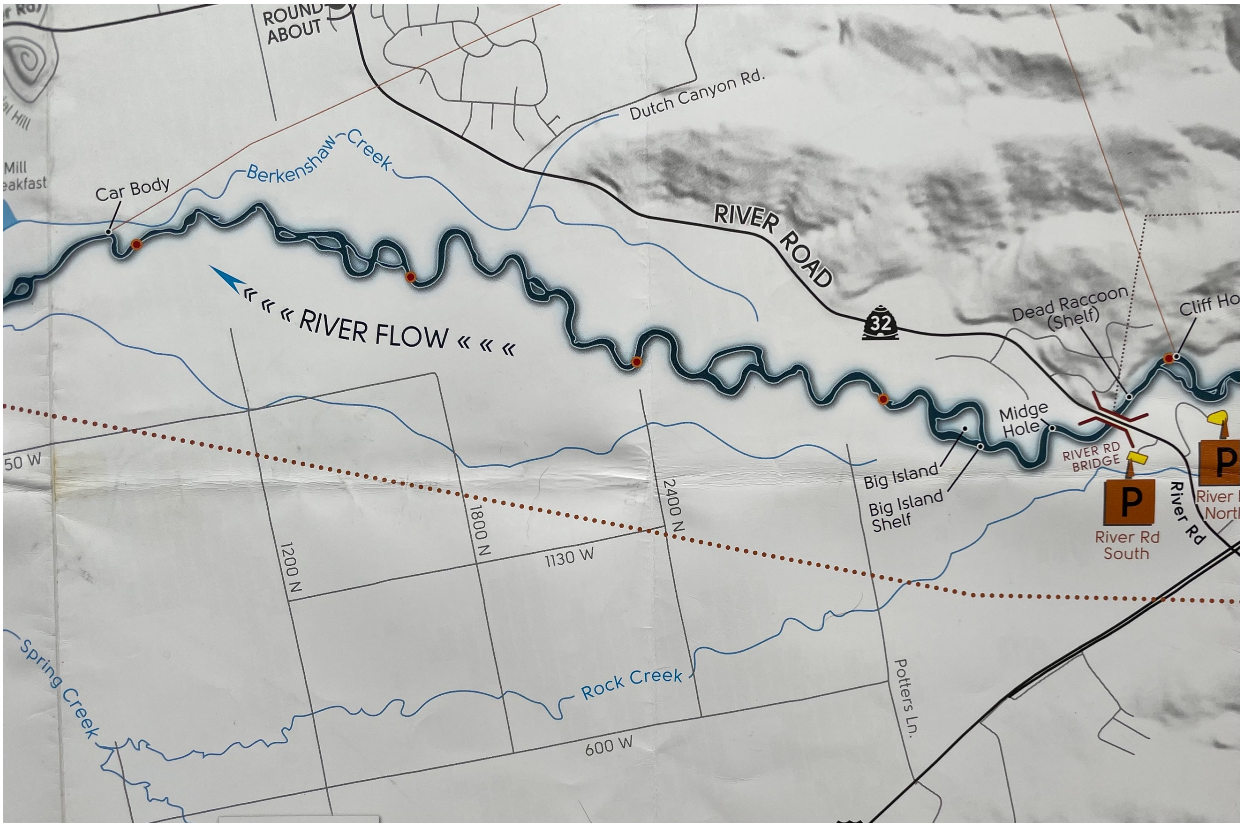

Figure A2. Map of the central section of the Middle Provo River.

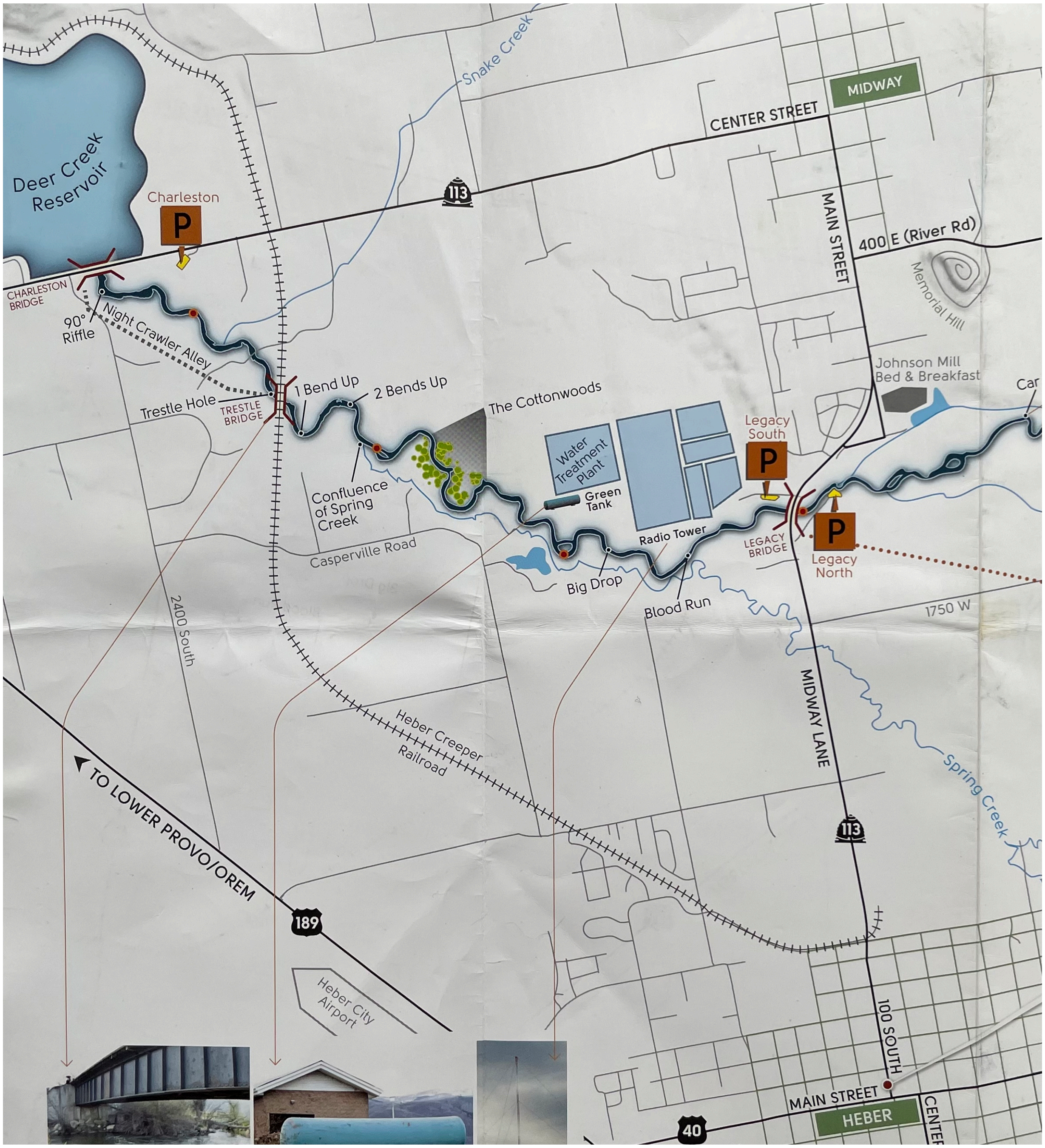

Figure A3. Map of the lower Middle Provo River.

APPENDIX B – Middle Provo River 2004-2006 macroinvertebrate taxa

The four sites where BioWest, Inc. took macroinvertebrate samples along the Middle Provo River in 2004, 2005, and 2006 are indicated in **Figure B1**. The samples, taken in both spring and fall, were reported to the Mitigation Commission.

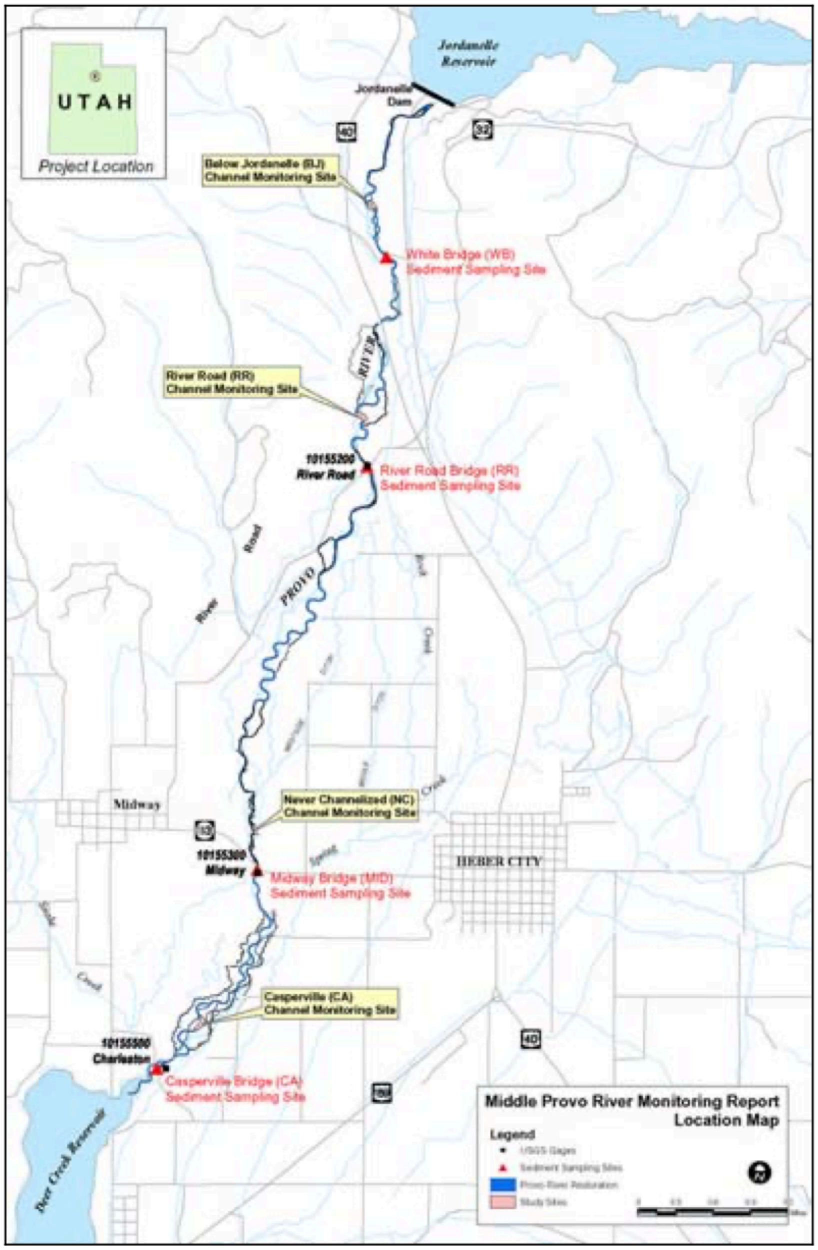

Figure B1. Yellow background text indicates the four sites where macroinvertebrate samples were taken in 2004, 2005 and 2006. From BioWest, Inc. (2019)

The three dominant taxa for Spring and Fall samples are summarized in **Tables B1 and B2**, respectively. Genus and species, where known, are italicized. The abbreviation *sp.* is used where the genus is known but the samples were not classified as to species. Oligochaeta (aquatic worms) are a sub-class and were not classified further. Chironomidae (midges) are a Family in the Order Diptera. These were not classified further into Genus or Species. *Ephemerella inermis* are also known as *Ephemerella infrequens*.

Baetis and Ephemerella are genuses of mayflies, Brachycentrus is a genus of casemaker caddisflies, Hydropsyche is a genus of net-spinning caddisflies, Optioservus is a genus of riffle beetles.

Table B1. Three most dominant taxa during spring (April or May) sampling at the four sites indicated for 2004, 2005 and 2006. From BioWest, Inc. (2019)

Yr & Order abundance	Below Jordanelle Dam	River Road	Never Channelized	Charleston
2004 #1	*Baetis tricaudatus*	Chironomidae	Oligochaeta	Oligochaeta
2005 #1	Chironomidae	Chironomidae	Chironomidae	Chironomidae
2006 #1	Chironomidae	Chironomidae	Chironomidae	Chironomidae
2004 #2	*Ephemerella inermis*	*Baetis tricaudatus*	Chironomidae	*Baetis tricaudatus*
2005 #2	*Baetis tricaudatus*	*Baetis tricaudatus*	Oligochaeta	*Hydropshyche sp.*
2006 #2	*Baetis tricaudatus*	Oligochaeta	*Hydropshyche sp.*	*Baetis tricaudatus*
2004 #3	Chironomidae	*Ephemerella inermis*	*Baetis tricaudatus*	Chironomidae
2005 #3	*Ephemerella inermis*	Oligochaeta	*Baetis tricaudatus*	*Baetis tricaudatus*
2006 #3	*Ephemerella inermis*	*Baetis tricaudatus*	Oligochaeta	*Optioservus sp.*

Table B2. Three most dominant taxa during fall (September) sampling at the four sites indicated for 2004, 2005 and 2006. From BioWest, Inc. (2019)

Yr & Order abundance	Below Jordanelle Dam	River Road	Never Channelized	Charleston
2004 #1	*Baetis tricaudatus*	Chironomidae	Chironomidae	*Baetis tricaudatus*
2005 #1	Chironomidae	Chironomidae	Chironomidae	Chironomidae
2006 #1	Chironomidae	Chironomidae	Chironomidae	Chironomidae
2004 #2	Chironomidae	*Baetis tricaudatus*	*Baetis tricaudatus*	Chironomidae
2005 #2	*Baetis tricaudatus*	*Baetis tricaudatus*	*Baetis tricaudatus*	Oligochaeta
2006 #2	*Baetis tricaudatus*	Oligochaeta	*Baetis tricaudatus*	*Hydropsyche sp.*
2004 #3	Oligochaeta	*Brachycentrus sp.*	*Optioservus sp.*	Optioservus sp.
2005 #3	*Brachycentrus americanus*	Oligochaeta	*Hydropsyche sp.*	*Hydropsyche sp.*
2006 #3	Oligochaeta	*Baetis tricaudatus*	*Hydropsyche sp.*	*Optioservus sp.*