# Upper Owyhee Watershed Assessment

## V. Hydrology



### Contents



The Oregon governor's strategic initiative for ensuring sustainable water resources for Oregon's future, Headwaters 2 Ocean, considers all water resources from the hilltops to the Pacific Ocean. The completion of the assessment of the upper Owyhee subbasin is consistent with the governor's initiative. The upper Owyhee subbasin contains the headwaters of the Owyhee River and two of its principal tributaries, the South Fork Owyhee River, and the Little Owyhee River.

## V. Hydrology

Hydrology is the study of how water moves within a system. Hydrology incorporates factors other than just precipitation, runoff into streams, and flows to the ocean. In addition to describing how water travels across the landscape, hydrology takes into account the source of the water and the fate of the water. The processes involved are described as the water cycle.

### A. The water cycle

#### 1. Description of parts of the water cycle

**Precipitation** is the water that falls out of the atmosphere and reaches the ground. The water can arrive at the earth's surface as rain, snow, hail, or a mixture of these. There are several things that can happen to precipitation.[25,45]

**Interception** occurs whenever anything interrupts the flow of precipitation into the soil or runoff to streams. This can happen when water flows into puddles or lands on vegetation or organic material. During freezing conditions, the precipitation may be "intercepted" on the surface of the ground; most of it doesn't go anywhere until it melts.[25,46]

**Infiltration** is the movement of water from the surface of the ground into the soil. The infiltration rate (how much water is absorbed into the soil) depends both on the composition, structure, and compaction of the soil and on the amount of moisture already in the soil.[25,45] Wet, frozen soil conditions greatly interfere with infiltration.

**Percolation** is the movement of water through the soil. Once underground, gravity is the primary force moving water. Impermeable layers of rock and the water table are the locations where the groundwater stops moving downward. If there are large natural underground reservoirs which can store the water, they are called aquifers.[25]

**Runoff** is the water that travels downslope on the soil surface towards streams. Runoff is made up of water that has fallen on the ground and has flowed across the surface and of water that has infiltrated or percolated into the soil and has moved horizontally to reappear on the surface. All the sources of water flowing in a stream channel form the total runoff which is called the streamflow.[25,45,50]

**Transpiration** is a plant's "sweating". Plants remove water from the soil. Water inside the plants exits the plants through pores in the leaves called "stomata". How much water is transpired depends on the species of plant, water in the soil, temperature, relative humidity, wind, and the amount of light it receives.[25,39,45]

**Evaporation** is a change in the physical state of water from a liquid to a gas. The gaseous water in the air is called water vapor. The amount of evaporation from the soil depends on soil moisture, wind, relative humidity, temperature, atmospheric pressure, and the amount of direct light (solar radiation).[25,46]

**Condensation** is the change in the physical state of water from a gaseous state to a liquid state. Condensation forms liquid water droplets on plant leaves and in the air when the air cools or the amount of vapor in the air increases to saturation point.[25,46]

Water is stored in three basic locations: in the atmosphere, on the surface of the earth, and in the ground. Storage on the surface is in lakes, reservoirs, glaciers, and the oceans. Underground storage is in the soil, in aquifers, and in small cracks in rock formations.[25,45]

## 2. Discussion

In general, the water cycle is described as evaporation off oceans, off other water bodies, and off soil and plants, adding moisture to the atmosphere. Atmospheric conditions cause the moisture to condense and fall as precipitation. Some of that precipitation is returned to the atmosphere by evaporation from water on vegetation, soil, rocks, roads, and buildings. Some of the precipitation is intercepted by plants, some is absorbed into the soil, and some of it flows into streams and rivers. The water in the soil can be returned to the atmosphere by evaporation, transpiration of plants, or it can percolate down to the groundwater. Also, some of the water in the streams and rivers can infiltrate into the soil and recharge the groundwater. In turn, the groundwater can resurface (springs) and contribute to the streamflow.[25,45]

There is no real beginning or end to the water cycle and no definite path that water follows. Water in the water cycle moves between the atmosphere, surface bodies of water, and the soil and rock underground.[25,46]

The different aspects of the water "cycle" affect the fate of water differently in different environments.

## B. The water cycle in the upper Owyhee subbasin

The upper Owyhee subbasin is part of a semiarid desert created by the rainshadow of mountain ranges. To the west, the Cascade Mountains and the Sierra Nevada both receive much more rain and snow on their western sides. The prevailing wind direction moves air from the west to the east. Air cools as it rises to cross the mountains. As air cools, the water vapor in it condenses and falls as precipitation on the western side of the mountains. The water has been "wrung out" so little rain falls to the east.[25,26,45,49] Other mountains can also capture moisture if the air flow across them still contains sufficient moisture. The Calico, the Owyhee, the Independence, and the Bull Run Mountains around the boundaries of the basin all collect precipitation as the air crosses them. Some of the water captured by these surrounding mountains supplies flow into the rivers and streams of the upper Owyhee subbasin.

The majority of the upper Owyhee subbasin to the west of the Bull Run and Independence mountains can be classified as semiarid desert, specifically cold winter desert (background section). The winter temperatures in this semiarid desert section drop significantly so that most of the winter precipitation falls as snow.

### 1. Sources of primary precipitation data.

There are two primary sources of precipitation data for the upper Owyhee subbasin: weather stations and snow surveys. Traditional meteorological stations have measured temperature and precipitation. Snow surveys have been used to forecast annual streamflow volume. Beginning in the 1930s, snow surveys were conducted manually.

In the upper Owyhee subbasin, automated SNOpack TELemetry (SNOTEL) stations which record both temperature and precipitation were installed at seven sites and have continual records since 1980: Mud Flat, Fawn Creek, Laurel Draw, Jack Creek Upper, Jacks Peak, Big Bend, and Taylor Canyon (Figure 5.1).[20,21] The SNOTEL stations measure precipitation year-round, not only during the period of winter snow. Since these records cover the same years, they are comparable. The standard measurements at the SNOTEL stations are the snow depth, the snow water equivalent, air temperature, and precipitation from rain.

There are four meteorological stations within the upper Owyhee subbasin with more than 25 years of data: Tuscarora, Tuscarora Andrae Ranch, Mountain City, and Wild Horse Reservoir (Table 2.7). ***These stations have recorded data over different years and are not directly comparable either to each other or to the SNOTEL***

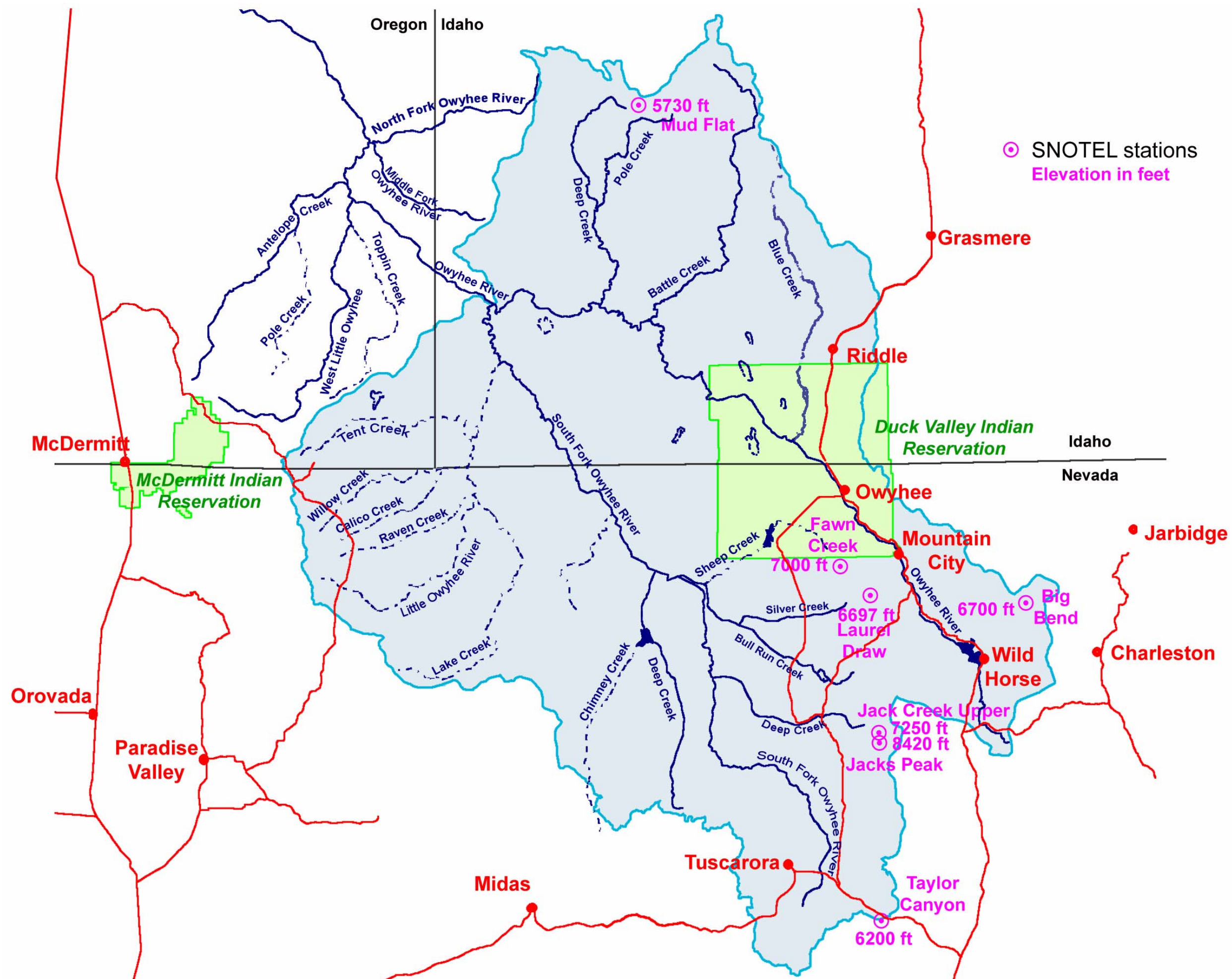


**Figure 5.1. SNOTEL stations in the upper Owyhee subbasin.**

***records***. However, the data from these stations give ideas of general conditions. In addition, the Owyhee station was included in some of the analyses of precipitation since it is within the geographical boundaries of the subbasin although it is located within the Duck Valley Indian Reservation (Figure 5.2). The temperatures recorded at these stations are discussed in the background section of this assessment.

## 2. Water cycle interactions

How does the water cycle operate within the upper Owyhee subbasin? The subbasin is at the headwaters of the Owyhee River, so the primary source of water in the subbasin is precipitation. Precipitation includes both the rainfall and the amount of water in snow.

### *a. Precipitation*

To calculate the mean monthly precipitation, the daily precipitation readings are totaled for each month. Totals for a given month of the year (e.g. March) are averaged across the multiple years of readings to obtain the mean monthly precipitation for that month. This is done for each weather station and SNOTEL station. The water year is considered to start October 1 and end September 30.

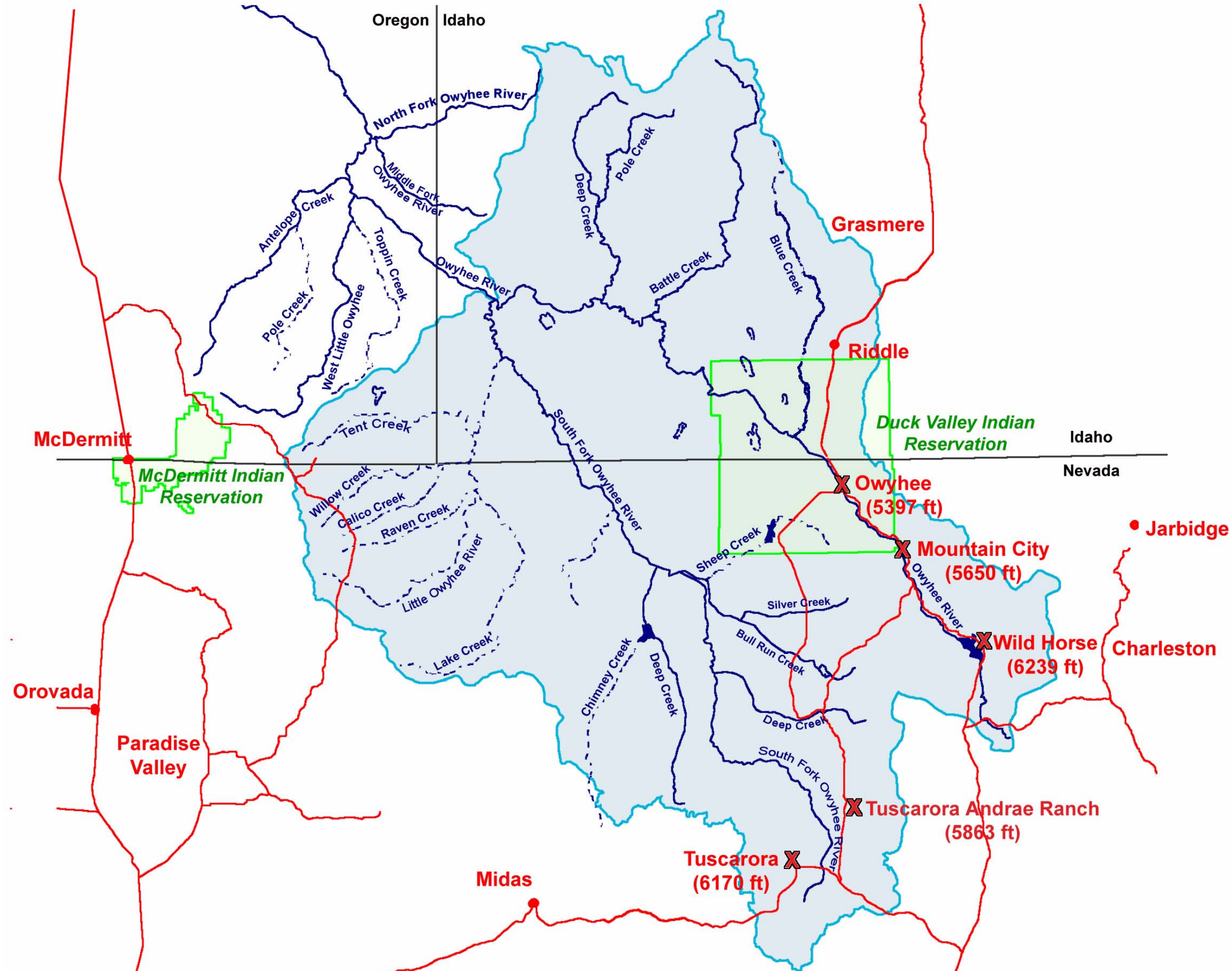


**Figure 5.2. Locations and elevations of meteorological stations within the upper Owyhee subbasin.**

The pattern of precipitation over the year has been similar between the five meteorological stations (Figure 5.3). July and August were the driest months, rainfall increased through December, dropped some in February (fewer days in the month) and peaked again in May. A similar pattern of precipitation is observed at the SNOTEL stations (Figure 5.4). However, these higher elevation stations receive greater precipitation. At the Jacks Peak station, the month with the greatest mean precipitation, January, averages close to five inches. Only the Taylor Canyon station has a mean precipitation in January less than two inches. The meteorological stations are at lower elevations. In no month did any meteorological station have a mean precipitation that reached two inches.

The total amount of precipitation which falls in a year varies significantly from year to year. These totals are based on the calendar year and span water years. On Figure 5.5, the total precipitation for a year is represented by a cross. The greatest yearly precipitation recorded and the least annual precipitation recorded are the highest and lowest marks for each station. Both the amount of precipitation and the year in which it fell are shown for the greatest and least precipitation at each station. Across all the SNOTEL stations, 1984 was the wettest year. The mean annual precipitation for each station is shown in the red box. This mean may not coincide with the amount of

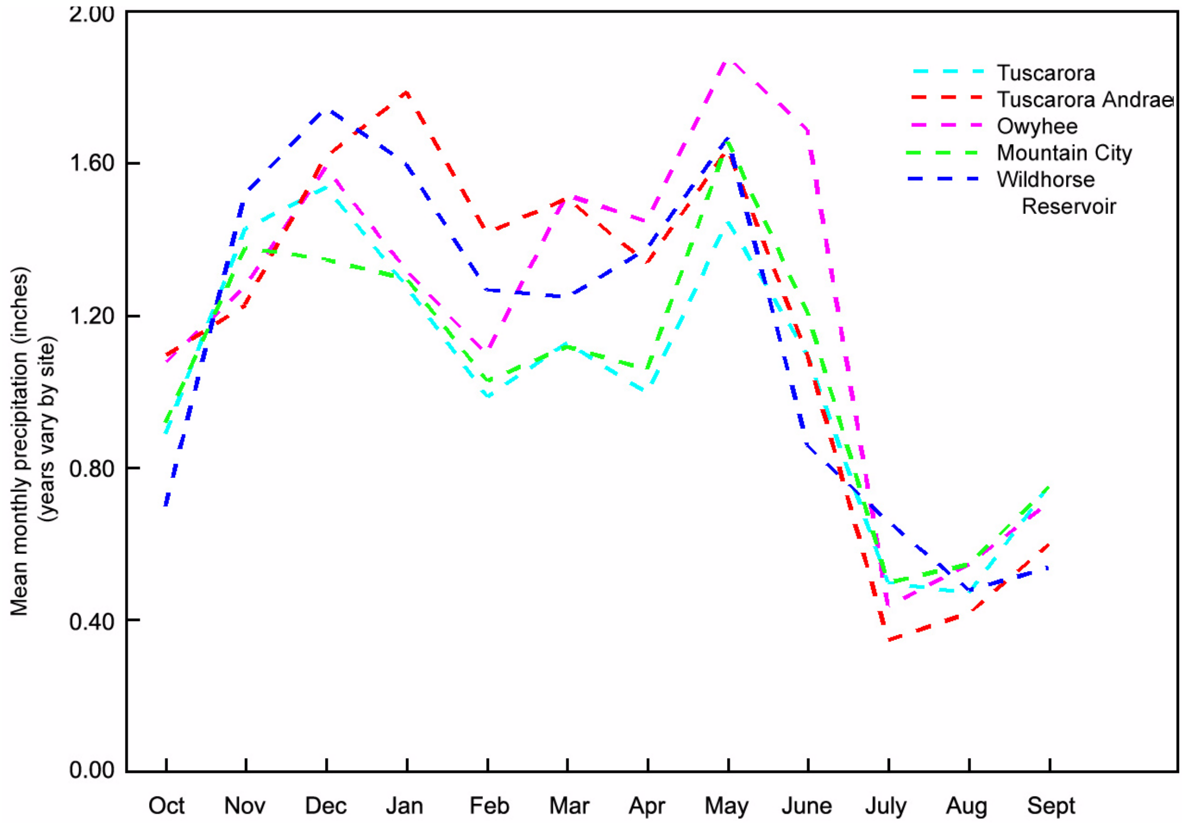


**Figure 5.3. Mean monthly precipitation at five meteorological stations in the upper Owyhee subbasin.**

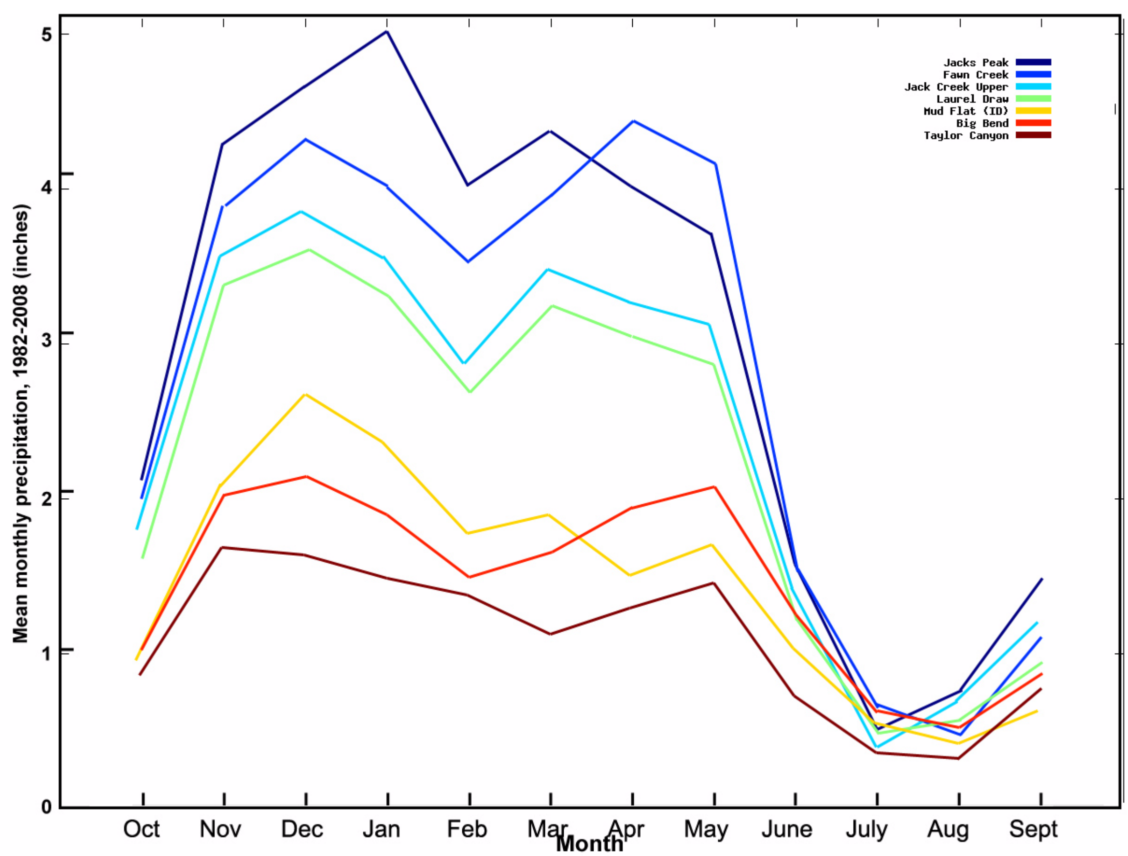


**Figure 5.4. Mean monthly precipitation at 7 SNOTEL stations in the upper Owyhee subbasin.**

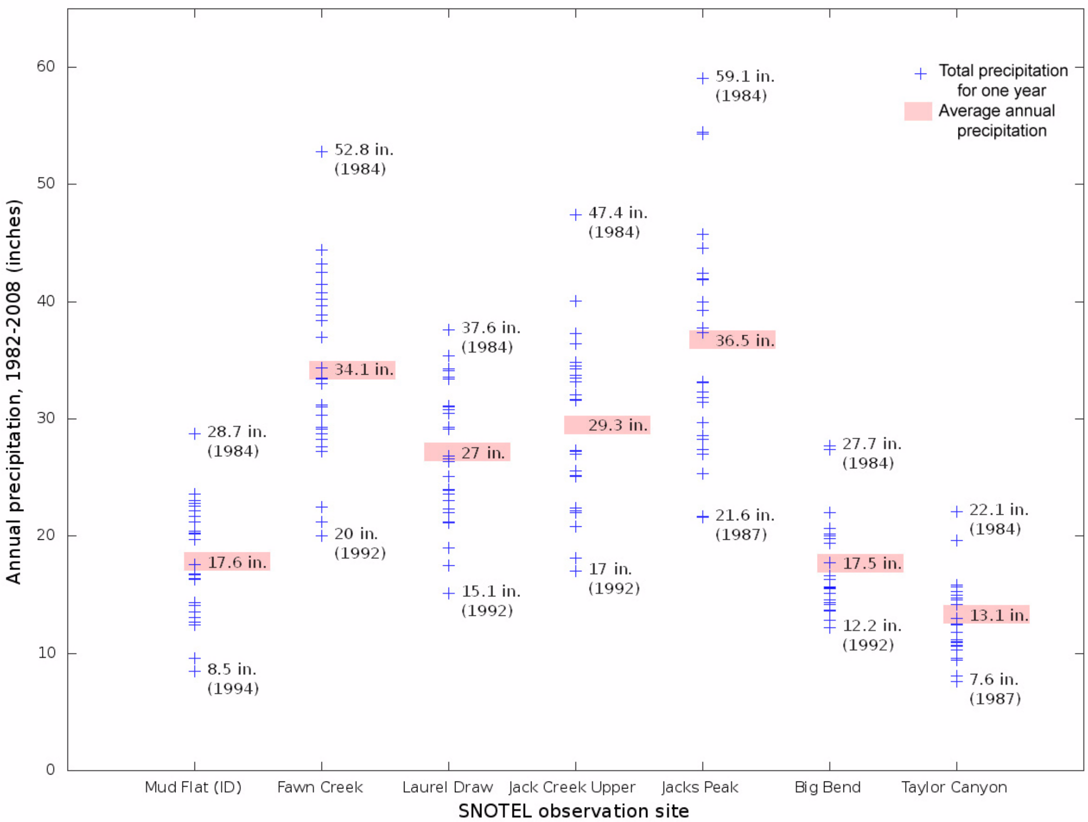


**Figure 5.5. Total annual precipitation at 7 SNOTEL sites in the upper Owyhee subbasin**

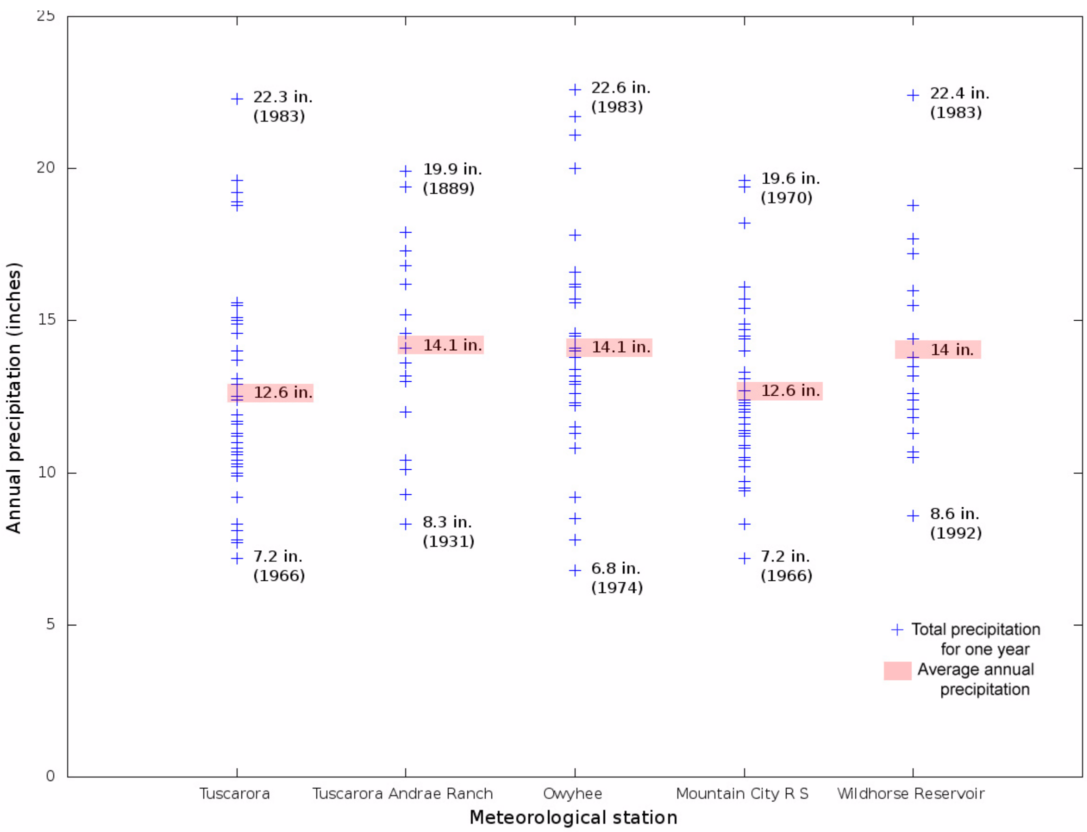


**Figure 5.6. Total annual precipitation at 5 meteorological sites in the upper Owyhee subbasin.**

precipitation in any one specific year, as is obvious for the Jack Creek Upper station. A similar graph for the five meteorological stations indicates that the mean annual precipitation was not directly related to elevation since the Owyhee station, at the lowest elevation, received the most precipitation (Figure 5.6). This information can only be taken as an indication since the five stations have data from different years.

The amount and the timing of precipitation affect what happens to the precipitation. As mentioned above, the rainfall at the stations within the upper Owyhee subbasin is not evenly distributed over the year (Figures 5.3 and 5.4). Although just two months apart, average precipitation in May is significantly more than in July, varying from 2.5 times as much at Wild Horse Reservoir to 7.7 times as much at Jack Creek Upper station (Figure 5.7).

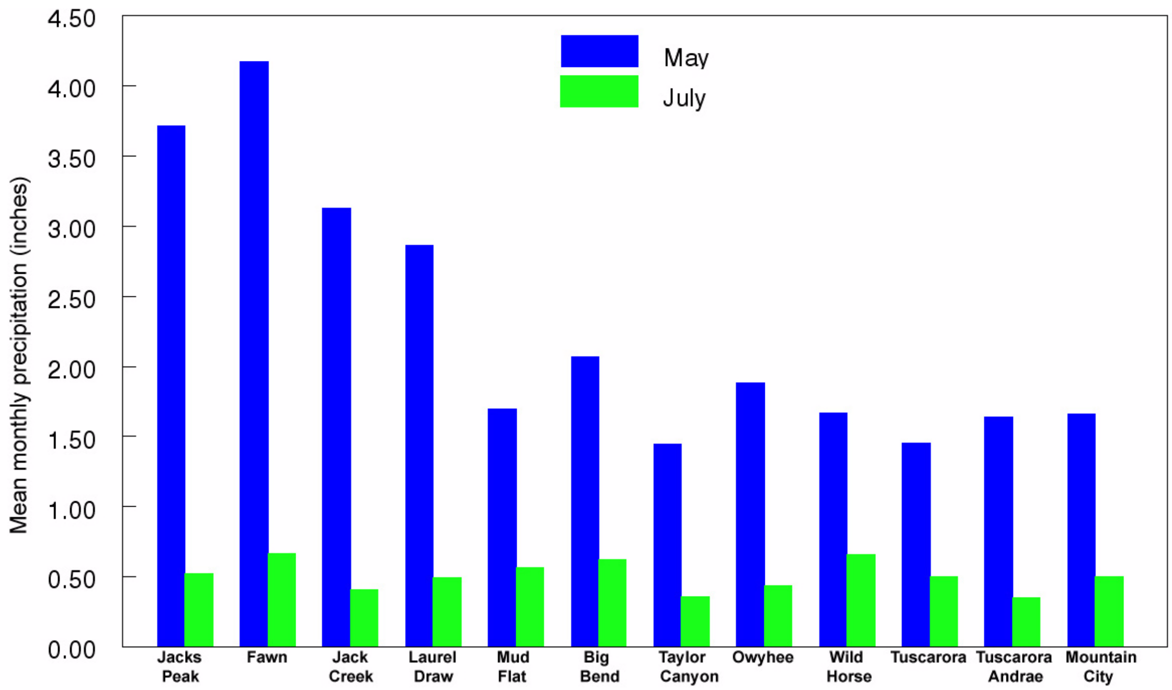

Figure 5.7. Rapid decline of precipitation from May, a wet month, to July, a dry month, at seven SNOTEL and five meteorological stations in the upper Owyhee subbasin.

### *b. Water budget*

What happens to precipitation after it arrives on the land surface? After falling, precipitation is partitioned into four principal components: evapotranspiration, runoff, groundwater recharge, and the change in soil water. This "water budget" can be expressed as an equation where P = precipitation, ET = evapotranspiration, R = runoff, G = groundwater recharge, and $\Delta S$ = change in soil water.[50] Some rainfall is directly intercepted by plants and not included in the water budget.

$$P = ET + R + G + \Delta S$$

The specific figures for the percentages that each of these components contribute to the fate of precipitation in the upper Owyhee subbasin are not available, but there are some general principles for arid rangelands which apply to the unirrigated section of the upper Owyhee subbasin.

### *c. Runoff*

Runoff is the water that flows toward stream channels. Some of the runoff may be evaporated en route or soak into the soils, but the runoff that reaches channels becomes the streamflow.[50] Although worldwide about a third of precipitation which falls on land runs off into streams and rivers,[44] runoff from rangelands is much lower. Rangeland "runoff generally accounts for less than 10%, and most often below 5%, of the annual water budget, and most of this occurs as flood flow."[50] Flood flow can result from snowmelt in the spring or large rain events at other times. Small runoff amounts are alsoimportant as they redistribute and concentrate the limited water resource.

There are a number of factors that help determine the proportion of a rainfall event that is lost to runoff. Some of the physical characteristics that affect runoff include soil permeability, soil moisture resulting from prior precipitation, soil cover, and topography. Some of the meteorological factors affecting runoff are the intensity, duration and amount of rainfall, and climatic conditions that affect evapotranspiration including temperature, wind, and relative humidity.[44] Possibly the intensity of the rainfall and the soil permeability and cover are the most important factors in determining runoff from a specific event. If soil is wet and frozen it has low permeability.

There are no data for the upper Owyhee subbasin on how much runoff will occur with rain events of different intensities on the different soil types.

In the upper Owyhee subbasin, a large percentage of the runoff that does occur comes from snowmelt. Snow fields “act as natural reservoirs for many western United States water-supply systems, storing precipitation from the cool season, when most precipitation falls and forms snowpacks, until the warm season when most or all snowpacks melt and release water into rivers. . . water supplies in the western states are [largely] derived from snowmelt.”[42]

### *d. Evapotranspiration*

Evapotranspiration is the sum of all the different processes by which water is changed from a liquid state to a gas. These include evaporation from the soil, evaporation of water that lands on plant or littered organic material surfaces (called interception loss), transpiration from plants, and sublimation.[39,50] Each of these processes is discussed separately below. Sublimation is the direct change of the state of matter from a solid to a gas (e.g. snow to water vapor) with no intermediate liquid stage.[43,46] Almost all the water from small, infrequent precipitation may be evaporated back into the atmosphere. With wind or heat, greater amounts of precipitation evaporate.[25,44]

#### *i. Evaporation*

Evaporation is a process by which liquid water is transformed back into water vapor. Evaporation can be from the soil surface or from precipitation that was intercepted. The rate of evaporation depends on a number of factors. Warmer water evaporates more quickly. Higher air temperatures increase the rate of evaporation. Drier air (lower relative humidity) above the soil surface has a greater "thirst" for water and more water evaporates into it. Wind across the soil surface increases the rate of evaporation. Sunlight directly hitting a surface increases the rate of evaporation.[5,8,11,25,48] A shaded stock trough may have 36% less evaporation than an unshaded trough.[48]

The amount of water evaporated depends on the amount of water present and on the rate of evaporation. In the upper Owyhee subbasin there are no measurements of the rate of evaporation. The closest evaporation pan is at a weather station in Elko Nevada. There is also an evaporation pan at the NOAA and AgriMet station at the Malheur Experiment station in Ontario, Oregon.[52,55] Evaporation pans measure how much evaporation occurs from a standing body of water and is indicative of the rate of evaporation. The total amount of water that can evaporate from the soil also depends on the amount of available moisture in the top layers of the soil.

Based on the climatic data from the two meteorological stations in the drier section of the upper Owyhee subbasin on the west side of the Independence Mountains, the temperatures for part of the year are relatively high. From May through September the average maximum temperatures at Tuscarora Andrae are, respectively, 63, 75, 86, 84, and 73 degrees Fahrenheit. At Tuscarora the average maximum temperatures for the same months are 63, 74, 85, 83, and 73 degrees Fahrenheit. By comparison, the maximum temperatures at the Elko airport are 70, 80, 91, 89, and 79, respectively from May through September. The five- to six-degree difference between Elko and the meteorological stations in the subbasin indicates that there would be some difference between the amount of evaporation expected due to the heat.

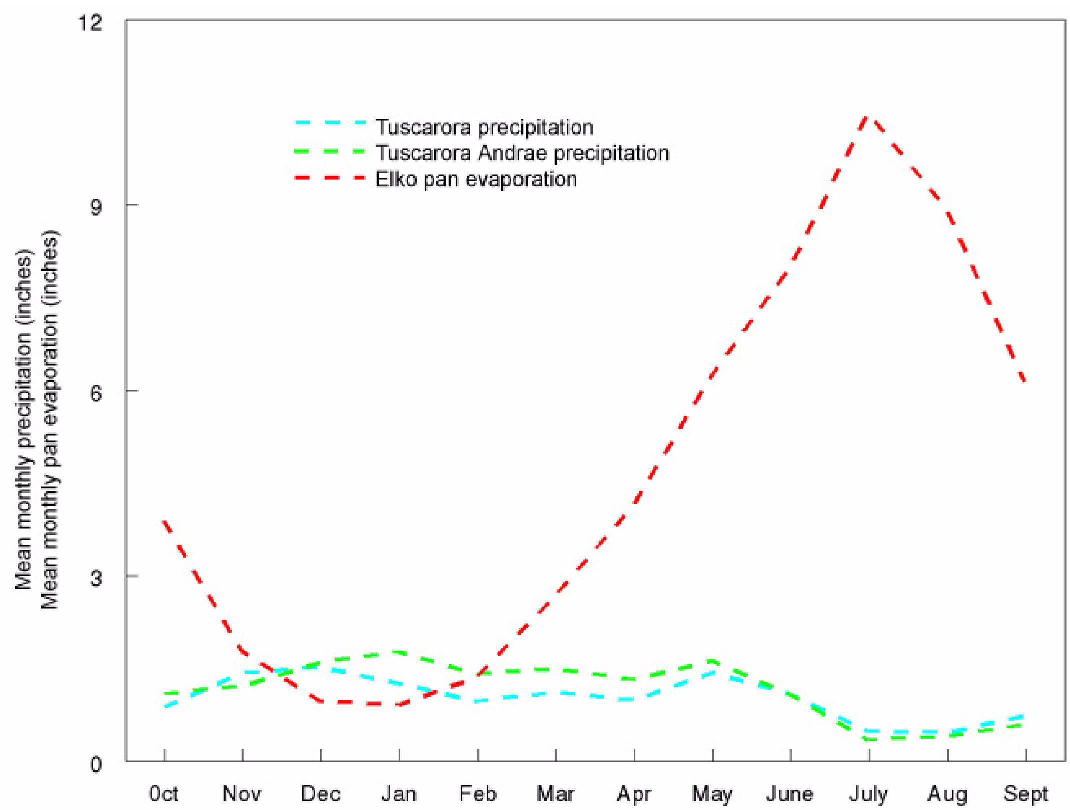


**Figure 5.8. Mean monthly precipitation at Tuscarora and Tuscarora Andrae meteorological stations in the upper Owyhee subbasin compared to pan evaporation at Elko Nevada.**

When the average monthly rainfall at Tuscarora over a 52-year period and at Tuscarora Andrae over a 68-year period are compared to the average amount of water which evaporated from a flat evaporation pan at Elko over a 108-year period, the rainfall is only a small portion of the water which could evaporate (Figure 5.8). Even assuming that the evaporation at Tuscarora and Tuscarora Andrae were less than at Elko, it would appear that the evaporative potential from April through October would be great enough to return most of the rainfall to the atmosphere. A larger rainfall event during these months might lead to some water infiltrating into the soil or running off, but a large portion of precipitation during these months could be expected to evaporate. These patterns are similar to the rainfall and evaporation patterns in the lower Owyhee subbasin.[56]

In rangelands, soil water evaporation generally accounts for 30 to 80 percent of the water budget. Soil water evaporation is often limited to the uppermost layers of the soil.[50] General estimates of soil water evaporation from mountainous areas of the western United States vary significantly. A seven year study in a semiarid region of New Mexico showed that evaporation from unvegetated ground ranged from 88 to 95%. The greater the slope of the ground, the higher the percentage of evaporation.[22]

*ii. Interception loss*

Precipitation which has been intercepted by leaves or other organic matter has a larger exposure to environmental conditions that might cause it to evaporate. Interception loss results when precipitation landing on organic matter evaporates and thus never reaches the soil surface. Drylands lose considerably more water, on a percentage basis, via interception than do more humid environments. Interception loss on rangelands may be substantial.[25,50]

The vegetative cover affects interception. In general arid shrublands have a smaller interception than a similar area with juniper cover. Juniper leaves and stems intercept a higher percentage of precipitation since they have a large leaf area all year long. They also create an organic carpet that intercepts considerable water. Measured interception, expressed as a percentage of precipitation, may be as high as 46% for juniper. For sagebrush the value ranges from 4 to 30%. The vegetative canopy in each area can only intercept so much water. For any specific storm, the percentage of precipitation intercepted varies greatly. Larger storm events have a smaller percentage of the water from that storm intercepted.[50]

Although figures for the percentage of precipitation intercepted by different types of canopy covers are available for other areas, interception data has not been collected in the upper Owyhee subbasin.

Not all precipitation that is intercepted is evaporated back into the atmosphere. Water on plants can be absorbed by plant tissues and can also drip off onto the surface beneath the plant or it can run down the leaf to the stem and from the stem to the ground.[28] The amount of precipitation that reaches the soil surface often depends on the total precipitation of a storm event as a strong rain will provide more opportunity for water to drip onto the soil surface than a light shower.

*iii. Transpiration*

In a desert environment transpiration contributes a smaller percentage to the total evapotranspiration than in less arid environments. Many arid region plants have developed adaptations that conserve water, allowing them to transpire at a slow rate when there is little available soil moisture.[25,39] Transpiration rates also vary depending on the temperature, humidity, and wind as mentioned above. The transpiration rate both goes up as the temperature increases and as the relative humidity falls. Both of these conditions are met during the upper Owyhee subbasin summer. However, as plants start to senesce (die), they transpire less.[39]

Vegetation not only transpires, it also shades the soil and reduces the wind speed. Both shade and lower wind speed slow down the evaporation from the soil surface. However, the water absorbed from the soil by the plant roots offsets any effects that the vegetation has in slowing evaporation from the soil. Transpiration not only contributes to the loss of soil moisture in the upper soil layers, but also from substantially greater depths if water is available since moisture from uptake by plant roots can reach the leaves and be transpired.[25,39,50]

*iv. Sublimation*

Since much of the precipitation in the upper Owyhee subbasin falls during the colder winter months, it may fall as snow. Even with freezing temperatures, the snow cover on the ground will gradually be reduced over time. This is sublimation. Ice (or snow) will go straight from a solid state to a vapor. Low relative humidity, dry winds, lower air pressure, and a higher sun angle increase the rate of sublimation. Sublimation is greater at higher altitudes since the air pressure is lower. The effect of the sun angle is only relevant on sunny days. At the start of winter, the sun angle is a minimum (the sun is lowest in the sky) and the angle is much higher in late winter so the rate of sublimation is apt to be much higher in late winter than in early winter.[9,43,46]

Many winter days in the upper Owyhee subbasin have low relative humidity and dry winds, favoring sublimation. The effect of sublimation may not be obvious if additional snow accumulates on the ground.

A common way for snow to disappear in the arid west is a "Chinook wind." If a warm wind (60-70$^0$F) with relative humidity less than 10% hits the snowpack, ice evaporates directly to vapor.[43] David Shirk recalls a Chinook wind in the region in about 1868. "When we retired the previous evening, there was fully twenty-four inches of snow covering the ground. At about eight o'clock, the Chinook wind began blowing, and in eight hours, not a particle of snow remained anywhere in the valley."[29]

Since the upper Owyhee subbasin snowpack supplies part of the spring runoff needed to fill Lake Owyhee, a Chinook wind could decrease the supply of water to the reservoir.

***e. Infiltration***

There are a number of factors that can affect water infiltration into the soil including precipitation, soil characteristics, soil saturation, land cover, slope of the land and evapotranspiration. The amount, intensity, duration, and form (rain, snow, etc.) of precipitation varies between precipitation events. There is variability across the landscape. More water will run off of sloped land, and more water infiltrates if the land is flat. No water infiltrates where there are impervious surfaces such as rocks or bentonite clay. Vegetation slows the movements of runoff and allows more time for water to seep into the soil.[15,28,41]

Soils with different soil textures and structures have differing infiltration rates and absorb more or less water. Some soils have greater degrees of water repellency. Fractures in the soil surface also affect the amount of water infiltrated. Infiltration slows as soil becomes wet; fully saturated soils can hold no more water.[15 ,28,41]

### *f. Groundwater recharge*

The high evaporative demand in an arid climate means that eventually most water that has infiltrated and is stored in the soil will evaporate or be transpired. If there is further precipitation, it can cause the water to percolate down. Percolation also occurs due to the pull of gravity over time if the soil moisture is not lost to evapotranspiration. Groundwater recharge in rangelands is generally only a fraction of an inch per year. Soils with high permeability because they are sandy or fractured will have higher percolation and higher groundwater recharge.[25,50]

The movement of groundwater is controlled by gravity and geologic formations below the surface soil. Not only is groundwater replenished slowly, it tends to move very slowly. The water tables are generally formed above impermeable layers of rock or salt accumulations within the soil. Like all water, if it moves, it moves downhill. Water returns to the surface at a lower elevation than where it infiltrated. Some of the infiltrated water may travel close to the surface and soon emerge as discharge into streambeds. This water tends to move over duripans, layers of soil cemented by silica, iron oxides or calcium carbonate. Most of the discharges of groundwater into a stream occur where the water table intersects the ground surface. There may be a spring or slow seepage of the water into the stream. Seepage of groundwater into a stream forms the base flow for perennial streams.[25 ,27,40,45,46]

There has been no mapping of groundwater reserves or calculation of groundwater recharge for the upper Owyhee subbasin.[37,38]

The type and stability of water flow from a spring or seep is dependent upon the size and nature of the groundwater reservoir that feeds the spring. A spring fed by a deep aquifer will be more reliable and uniform. The water being produced by the spring can be from precipitation which fell hundreds or thousands of years ago. However, a spring which is dependent upon a local shallow water

**Photo 5.1. Wilson Reservoir dam, Nevada**

table for its recharge will have a more variable flow based upon precipitation, infiltration, and water use within the last few years. The predominance of water use by deep-rooted vegetation, such as big sage or juniper, will reduce flows to riparian areas and streams from shallow aquifers.[2,13,32]

### *g. Storage in dams*

There are a number of impoundments in both Owyhee County, Idaho and Elko County, Nevada (Figure 5.9). In Idaho there are six larger reservoirs: Big Blue Reservoir on Blue Creek, Little Blue Reservoir on Little Blue Creek, Paine Creek Reservoir on Paine Creek, Juniper Basin Reservoir on Juniper Creek, Squaw Creek Reservoir on Squaw Creek, and Bybee Reservoir on Shoo-fly Creek.[24] In Nevada there are seven larger reservoirs: Wild Horse Reservoir on Owyhee River, Wilson Reservoir on Wilson Creek, Bull Run Reservoir and Rawhide Reservoir on Bull Run Creek, Desert Ranch Reservoir on Chimney Creek, Deep Creek Reservoir on Deep Creek, and Dry Creek Reservoir on Dry Creek (Appendix D).

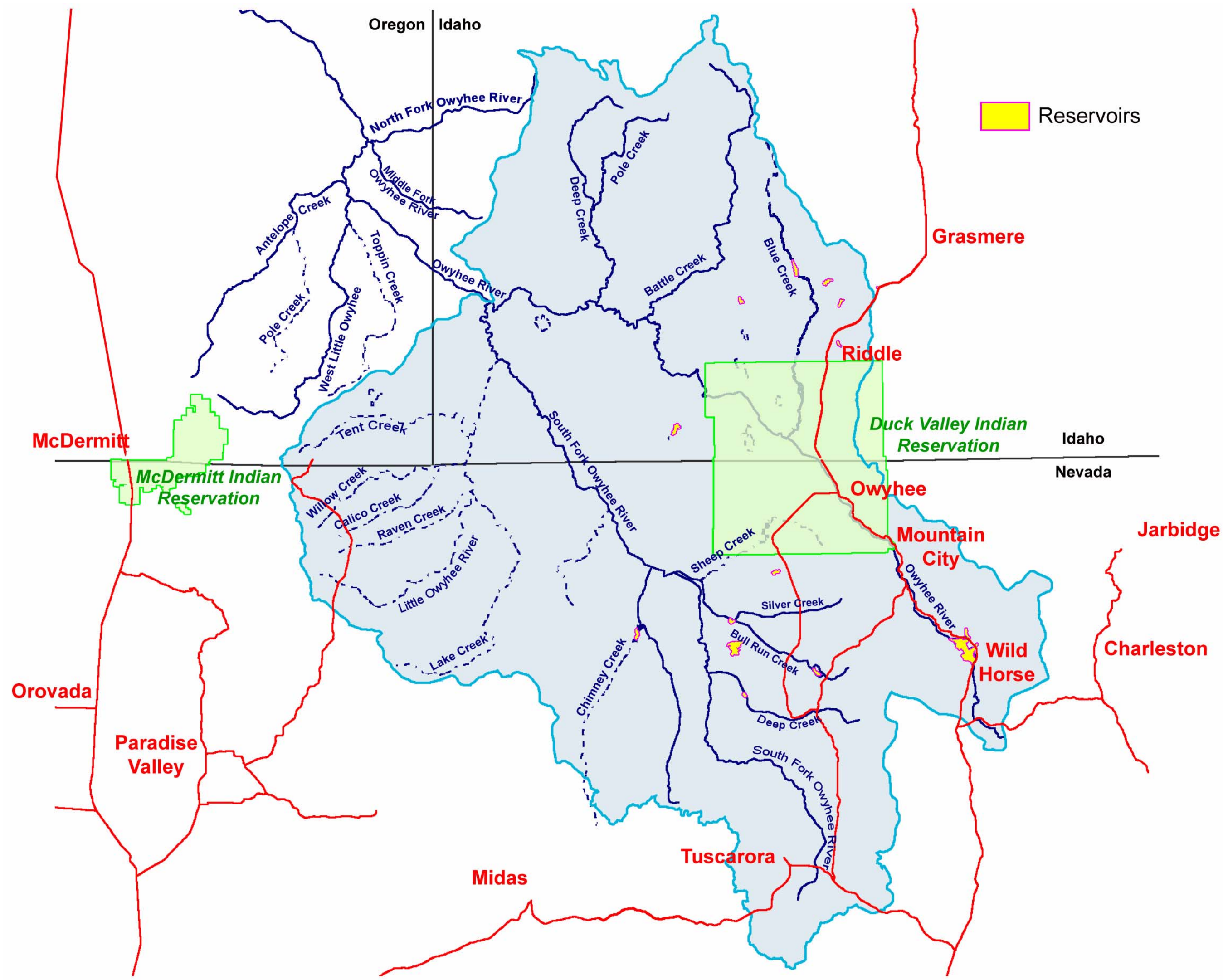


**Figure 5.9. Reservoirs in the upper Owyhee subbasin.**

**Photo 5.2. Wild Horse (above) and Wilson (left) Reservoirs are the reservoirs that cover the largest surface areas in the upper Owyhee subbasin in Nevada**.

There are several small dams as well as those mentioned above that have been built in the upper Owyhee subbasin to impound stream flows in small reservoirs or stock ponds. Dams create a different distribution of surface storage.[25] Dams on intermittent streams will increase the infiltration of water into the ground and reduce or eliminate the flow of water in the streambed. However, these ponds do not have the potential to impound much water. The guide for estimating the acres of drainage area required to average an acre-foot of pond storage shows that away from the base of the mountains, more than 80 acres are required on the plateau in the upper Owyhee subbasin.[33]

Beaver are also building dams on some of the small streams, generally streams less than 10 feet wide. Like dams created by people, beaver dams can provide a more stable water supply for wildlife. Water retention behind the dam can also increase infiltration into local water tables stabilizing the water supply for vegetation. By reducing the flow velocity following heavy rainfall, dams mitigate flow fluctuations in the stream bed below the dam. This reduces channel scouring, stream bank erosion, and

**Photo 5.3. Beaver dams on Trail Creek in the Bull Run Mountains, Nevada**.

downstream flooding. Dams also can form considerable sediment traps, reducing sediment loads in downstream water.[57,58,59]

#### *h. Subbasin water balance*

Within the relatively arid upper Owyhee subbasin, the water balance is determined by the fact that potential evapotranspiration is much greater than precipitation, creating a large soil water deficit. As a rule, evapotranspiration is the largest component of the loss side of the water balance equation, in comparison other components are generally quite small.[50]

## C. Data for flow estimates

One of the primary concerns of the assessment of the hydrology of an area is identifying potential peak flows and low flows. Using data from the past, we can try to anticipate what might happen in the future.

### 1. Precipitation

The precipitation that provides stream flow in the upper Owyhee subbasin comes from two principal sources. Snowfall, particularly in the higher elevations of the upper Owyhee subbasin, melts in the late winter and in the spring. This is supplemented by runoff from the rainfall events in winter and spring.

**Photo 5.4. Beaver dam on Current Creek along Mud Flat Road, Idaho**

There is a very great variation in both the amount of precipitation and when it occurs. In one day, more rain can fall than would be expected for total rainfall for the whole month. Figure 5.10 compares the average total monthly rainfall to the recorded maximum one day rainfall at Tuscarora. Almost every station has had at least one single event where in one day more precipitation has fallen than the average amount for the month. A single large event, if the precipitation falls as rain, will result in runoff. Smaller back-to-back significant events will also result in runoff.

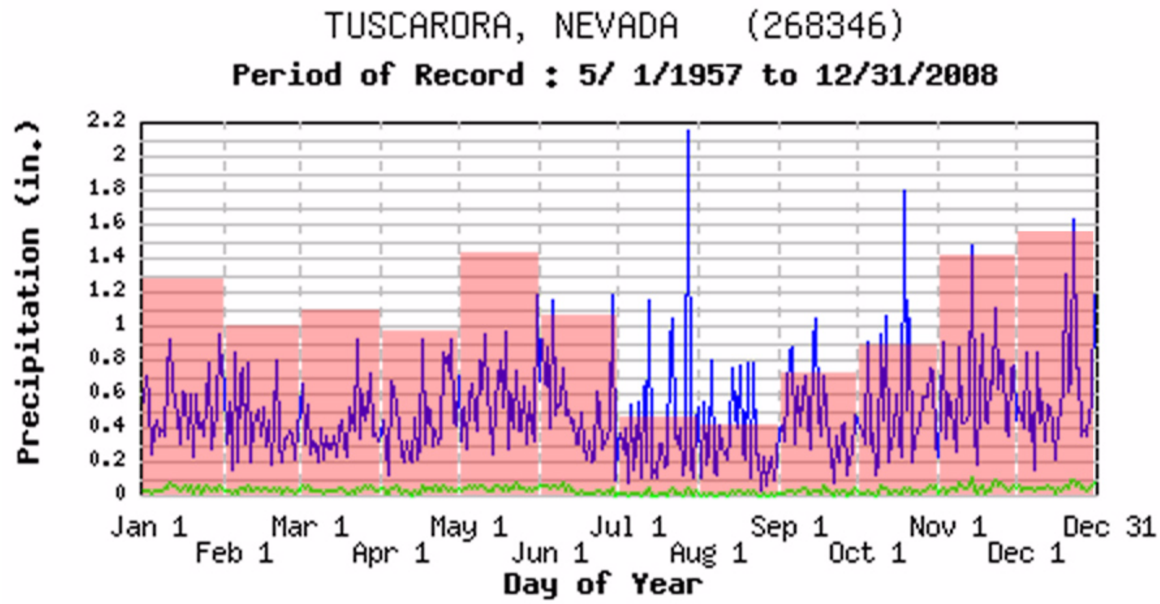


**Figure 5.10. A comparison of the extreme precipitation on one day of the year (blue line) with the average for that date (green line) with the mean monthly precipitation (background shading).**

When television weather forecasters predict rain for the following week, they give a probability of rain each day. "We can only make probabilistic statements because even if we have perfect knowledge of weather variables at some point in time, we cannot predict their values for some future time with certainty."[51] Figure 5.11 shows that there is a small probability of half an inch of rain (green line) falling at Tuscarora around

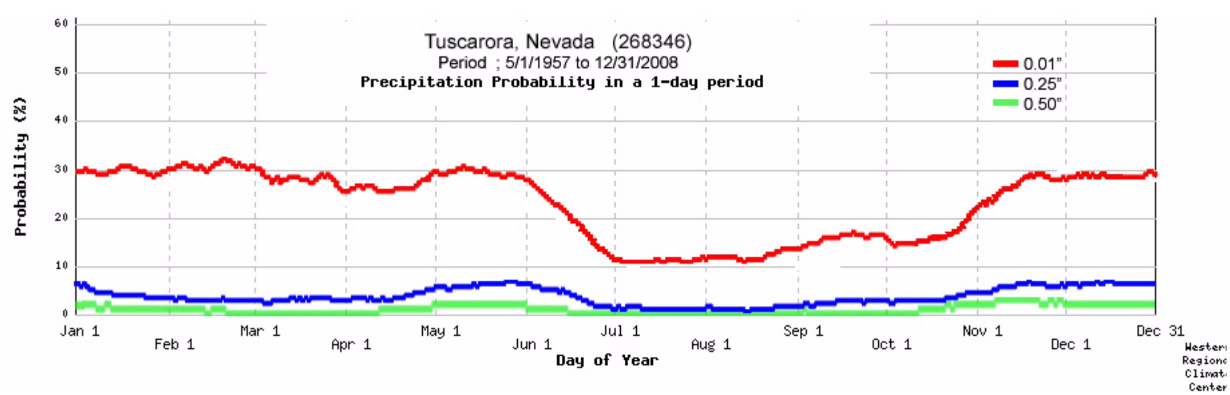


**Figure 5.11. The probability of specific amounts of precipitation on a specific day of the year.**

the first of June. However, there is the same small probability of half and inch of rain the next day and then the next day. The probability of it raining half an inch three days in a row is VERY small, but the possibility exists.

### 2. Streams with water

Although only a small percentage of the precipitation becomes runoff, the less probable large events are the ones which account for most of the runoff. During a large precipitation event or snow melt, there are many drainages in the upper Owyhee subbasin which can carry water (Figure 5.12). These drainage flow lines are ***not*** streams but the courses along which water would flow if there were water to flow in that region.

The previous condition of a stream can also affect the rate of runoff from that stream. The flatter the land, the more slowly water moves across it. Broad, flat valleys often have curving, sinuous stream channels in them. Over time the meandering

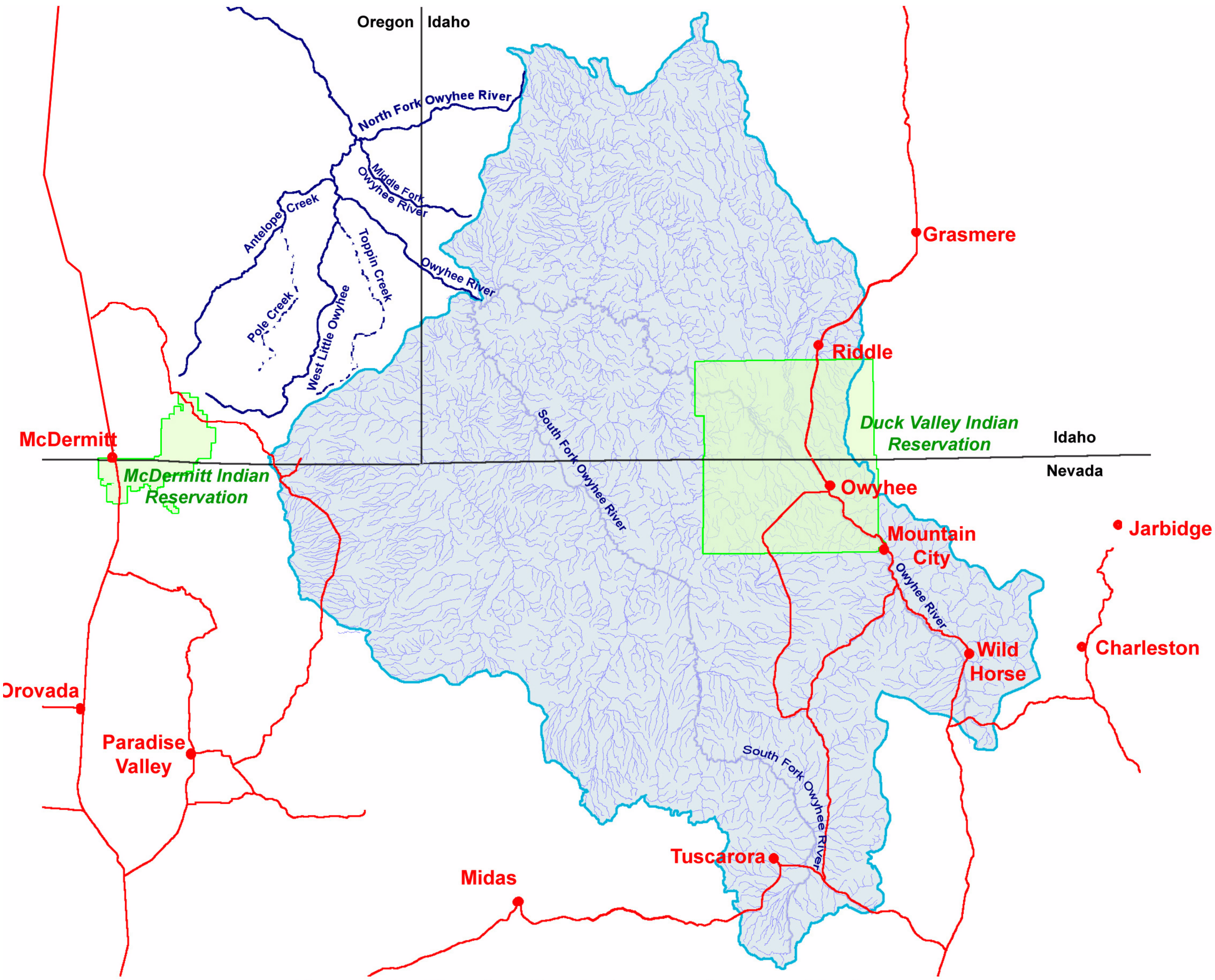


Figure 5.12. Water flow lines in the upper Owyhee subbasin.

stream reworks the entire valley floor. Sediment dropped by the stream continues to build a large flat valley. Large amounts of water entering a stretch of stream like this will spread out across the land and lose velocity. By contrast, once a stream has eroded down into the surrounding landscape, large flows will largely be contained within the stream course. Not losing velocity, they will continue to scour the channel and deliver more water downstream.[60]

**Photo 5.5. Penrod Creek, a meandering stream east of Wild Horse Reservoir, Nevada**

### *a. Perennial streams*

In an arid region, there are very few streams that carry water all year, every year. USGS topographic maps distinguish between perennial streams, those that essentially flow year-round, and intermittent or ephemeral streams which flow for only part of the year.[23] These designations are not changed in map revisions unless the information has been verified on the ground.[35]

**Photo 5.6. A stream which has started to cut down into the landscape, Nevada**

The stream reaches in the upper Owyhee subbasin identified as perennial in the National Hydrography Dataset GIS coverage of the area are not numerous (Figure 5.13). A careful comparison with a selection of the USGS topographic maps that cover the upper Owyhee subbasin indicates only minor differences between the GIS coverage and the stretches which are identified as perennial on the USGS maps.[AppendixA]

Both the South Fork Owyhee River and the Owyhee River are perennial throughout their reaches in the upper Owyhee subbasin except near their upper reaches where they become intermittent (authors' observations). A number of the creeks draining into the South Fork Owyhee River from the Independence and Bull Run Mountains, such as Bull Run Creek, Deep Creek, and Jack Creek, are also perennial throughout their reaches. Blue Creek, Deep Creek, and Battle Creek draining into the Owyhee River from the north are also perennial.

The short distances of perennial tributaries which do not continue as perennial are typical of desert landscapes where runoff decreases over distance because of transmission losses in the alluvial stream channels.[50] There are no tributaries of the Little Owyhee River that are perennial for more than a short distance. The huge expanse of the upper Owyhee subbasin south of the South Fork Owyhee River and between the Owyhee River and the South Fork contains no perennial streams.

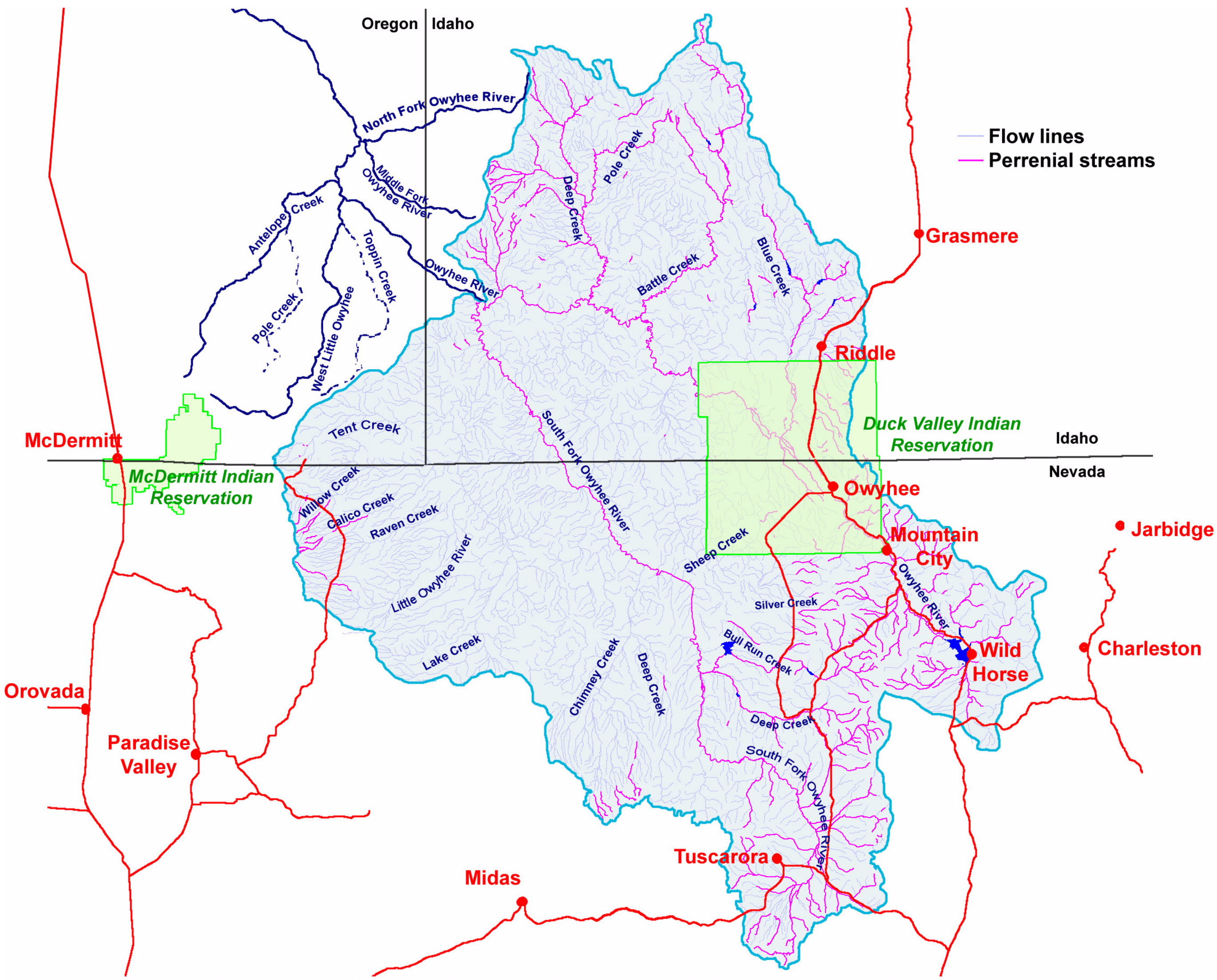

**Figure 5.13. Perrenial streams only occur along a small proportion of the water flow lines in the upper Owyhee subbasin.**

**Photo 5.7. Near the upper end of the Owyhee River, Nevada**

### *b. Intermittent and ephemeral streams*

In the USGS guidelines for creating their topographic maps, intermittent streams were not distinguished from ephemeral streams. The guidelines say "Do not distinguish between Streams that contain water for only part of the year and Streams that contain water just after rainstorms and at snowmelt in arid or semiarid regions."[36] They further define a drainage as a stream if it flows out of a lake or pond, if it is 2,500 ft in length, or if it "contains water throughout the year, except for infrequent periods of severe drought and is in an arid region."[36]

For purposes of a watershed assessment it is very important to know which streams are intermittent and which streams are ephemeral. "Intermittent streams are those which flow for only certain times of the year, when they receive water from springs or runoff. . . . During dry years they may cease to flow entirely or they may be reduced to a series of separate pools."[7] Ephemeral streams have channels which are always above the water table. They only carry water during and immediately after rain, particularly storm events.[7,31] "Most of the streams in desert regions are intermittent or ephemeral"[7] as we observe in the upper Owyhee subbasin.

### *c. Classification of streams as ephemeral*

Since the USGS maps do not distinguish between intermittent and ephemeral streams, ground survey is necessary to make a determination. This information is not available for most drainages in the upper Owyhee subbasin. How could the determination be made in the future? There are at least several lines of reasoning that could be used to classify streams as ephemeral.

Observation of streams for several years may show some streams to have water in them for many weeks each year independent of snow melt and runoff; they are probably connected to the groundwater and are intermittent. If streambeds are dry most years, they have no connection with groundwater and are ephemeral by definition. If water runs in streams only briefly in response to snow melt and very large precipitation events they are ephemeral.

Sagebrush dies when flooded. Stream channels that have sagebrush growing directly in the bottom of the wash are most likely ephemeral (Photo 5.9). Sagebrush does not tolerate saturated soil, and if the soil stays saturated for two weeks, sagebrush dies. Spreading water for two weeks on sagebrush land is a well known method of sagebrush control, since the root systems die from lack of aeration, but the method is little utilized in arid lands due to scarcity of water.[23]

Sampling of stream bed soils can show whether the soils have been subject to persistent water logging during at least part of the year. Soils subjected to water logging should develop some of the chemical and physical characteristics of hydric soils. Such a soil would indicate an intermittent stream.

**Photo 5.8. Water course of an intermittent stream draining west from the Independence Mountains, Nevada.**

### 3. Runoff

Because the other parts of the water balance equation account for the destination of much of the precipitation, it isn't possible to use the average amounts of precipitation to determine flood risk.

In streams, increased flows can be associated with winter rainstorms, winter rain-on-snow, snowmelt, spring rain-on-snow, and spring or summer cloudbursts or thunderstorms.[47] Snowmelt, the runoff produced by melting snow[14], will generally be more gradual if it isn't accompanied by rain-on-snow. When the ground is frozen, rain can cause snow to melt and run off without soaking into the ground. Rain hitting saturated ground will also flow overland.[44]

Each of the factors associated with increased flows can also increase the danger of "flash flooding" or other huge runoff events in intermittent streams. Ephemeral drainages which don't normally have flow are more apt to have runoff associated with unusual precipitation in a short amount of time. There has been no distinction made in the upper Owyhee subbasin between intermittent streams and ephemeral streams on maps or by ground truth.

During heavy rain events, water will tend to run in the established stream courses. As a liquid, water runs downhill. The path of least resistance is also the steepest gradient.[45] The steepest gradient funnels water into the established water courses of intermittent and ephemeral streams. In the beds of intermittent streams and

**Photo 5.9. Sagebrush growing in the bottom of an ephemeral stream**

in dry washes where the streambed flows only after significant rainfall, the sudden torrent of water from rains upstream may cause a flash flood.[31]

The typical condition for this ecoregion is that the maximum peak flow in each drainage is vastly greater than the average flows and average flows are much larger than the minimum flows, although data to support this fact have not been collected.

### *a. Snowmelt*

#### *i. Models*

Models that predict water runoff from snow melt on a daily time scale are important in water resource management and flood hazard assessment. Different models such as HBV and Snowmelt Runoff Model (SRM) handle meltwater modeling differently. Decisions in the modeling include problems of complexity or simplicity, the inclusion of different types of measurements, and the way spatial variability of snow cover is incorporated.[1,6,18]

Forecasting the future of any system relying on weather is difficult. The SRM model is used for areas such as the upper Owyhee subbasin where snow melt makes a significant contribution to runoff into streams. The model requires both the daily mean air temperature and the extent of the snow. The daily mean air temperature is extrapolated for each elevation zone from one or more meteorological stations so the fewer the meteorological stations the less accurate the forecast. The extent of the snow depends on the area covered, the depth of the snow, and the water content of the snow. These data for the upper Owyhee subbasin are taken from the SNOTEL stations.[18] In evaluating the SRM model in one basin, Thomas et al[101] found that the main source of error of the runoff forecasts was the limited quality of the meteorological forecasts.

#### *ii. Contribution of snowpack melt to spring runoff*

A good way to visualize the contribution of snowmelt to streamflow in rivers is to look at the hydrograph (Figure 5.14), which shows daily mean streamflow (average streamflow for each day) for nine years for the South Fork Owyhee River at Spanish Ranch near Tuscarora, Nevada (USGS real-time streamflow data). The light pink bars highlight the readings in April, May, and June of each year. The large peaks in the chart are mainly the result of melting snow, although storms can contribute runoff also.

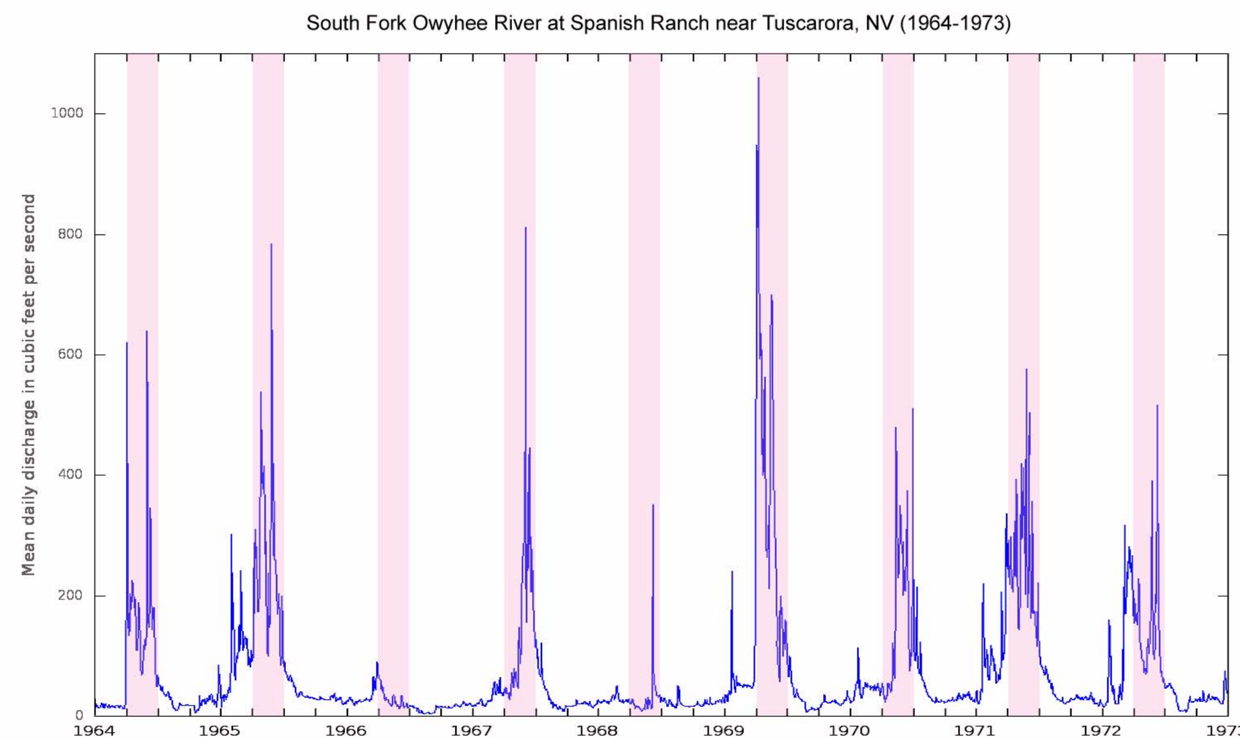


**Figure 5.14. Daily mean streamflow from 1964 to 1973 at gage 13177200 on the South Fork in the upper Owyhee subbasin. The pink blocks are the months of April, May and June each year.**

Note that runoff from snowmelt varies not only by season but also by year. Compare the high peaks of streamflows for the year 1969 with the much smaller streamflows for 1966. The lack of water stored as snowpack in the winter can affect the availability of water for the rest of the year. This can have an effect on the amount of water in reservoirs located downstream, which in turn can affect water available for irrigation or other downstream uses.[42]

Table 5.1. Sites of historic and current stream flow gages in the upper Owyhee subbasin.

| Site Number | USGS Site Name | Years of data | |
|---|---|---|---|
| South Fork Owyhee | | | |
| 13176600 | TAYLOR CYN TRIB NR TUSCARORA, NV | 1967-1979 | Peak flow only |
| 13176900 | JACK CK BLW SCHOONOVER CK NR TUSCARORA, NV | 1962 -1969 | Peak flow to 1978 |
| 13177000 | JACK CK NR TUSCARORA, NV | 1913 -1925 | |
| 13177200 | S FK OWYHEE RV AT SPANISH RANCH NR TUSCARORA, NV | 1959 -1975 | |
| 13177800 | S FK OWYHEE RV NR WHITEROCK, NV | 1955 -1981 | |
| Upper Owyhee | | | |
| 13174500 | OWYHEE RV NR GOLD CK, NV | 1916 - 2009 | |
| 13174900 | OWYHEE RV AT PATSVILLE, NV | 1971 - 1975 | |
| 13175000 | OWYHEE RV AT MOUNTAIN CITY, NV | 1913 -1948 | |

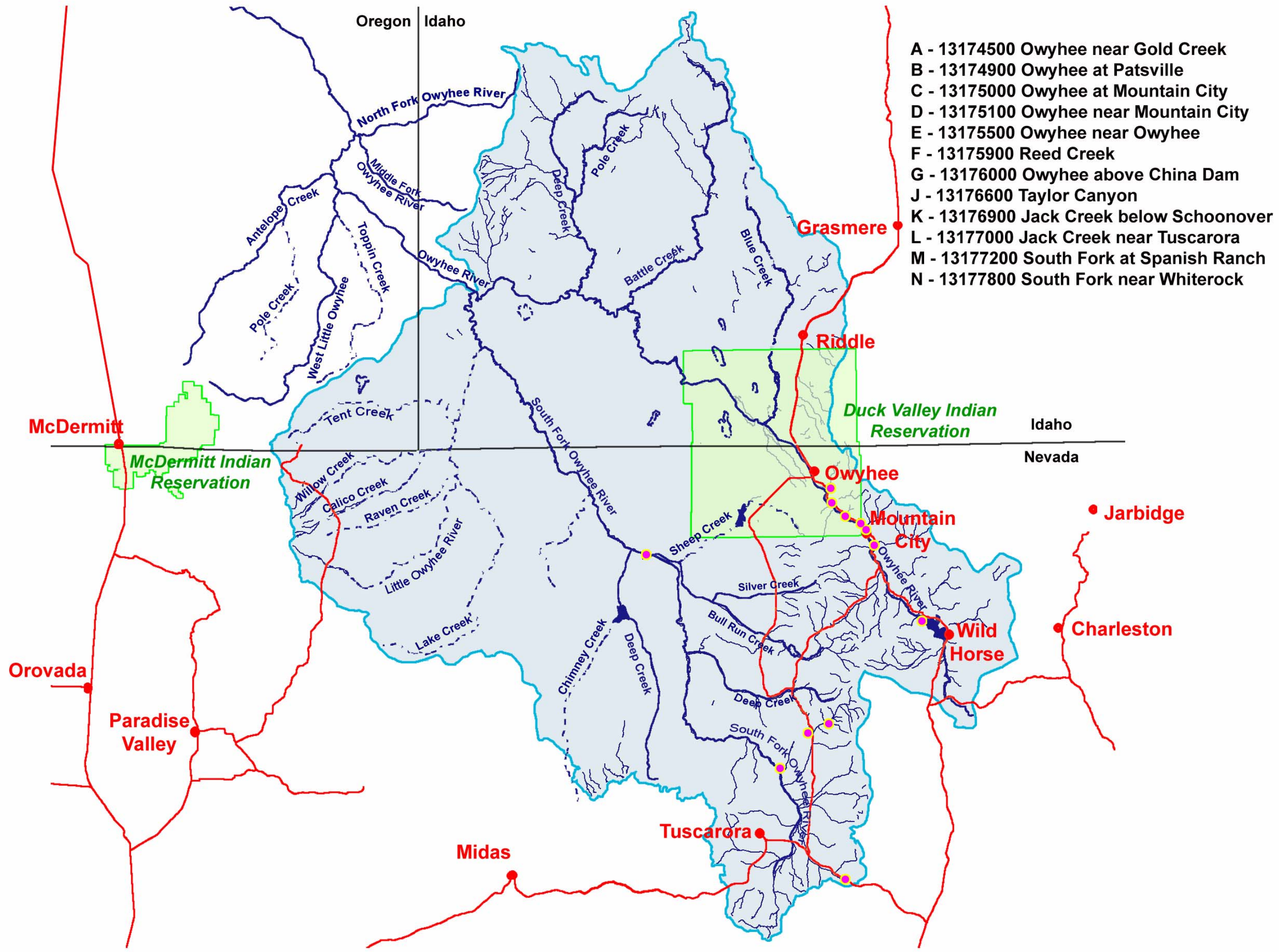

Figure 5.15. Location of historic and current stream gages in the upper Owyhee subbasin.

## 4. River flows

Due to the erratic nature of storm events, it is difficult to make any estimation of the flood danger in a particular intermittent or ephemeral stream bed. However, past records of flows in the Owyhee River can help estimate the probability of flood events along the river.

### *a. Sources of river flow data*

Within the upper Owyhee subbasin the number of locations with stream gages is extremely limited. Information from seven USGS gages in the Upper Owyhee HUC and from five gages in the South Fork Owyhee HUC is accessible. Three of the gages in the South Fork Owyhee HUC and five of the gages in the Upper Owyhee HUC have at least ten years of data (Table 5.1, Figure 5.15).

The South Fork Owyhee River and the Owyhee River remain separate rivers until close to the Idaho-Oregon border, so flow in the two systems can be considered separately. The earliest of the gages in the South Fork Owyhee drainage began recording in 1913 on Jack Creek near Tuscarora. However, after it was abandoned in

1925 no other gages were installed until 1955. Currently there is no gage on the South Fork Owyhee. On the Owyhee River, gages began recording data in 1913 near Mountain City and Owyhee. The Mountain City gage continued recording until 1948 and overlapped with gages installed later at other points along the river.

In considering stream flows, a word of caution is needed. The data for each river is very limited both in the number of years data has been collected and the number of locations. There have never been gages downstream from the one abandoned in 1981 on the South Fork Owyhee near Whiterock. There are no gages in the upper Owyhee subbasin on the Owyhee River beyond the Duck Valley Indian Reservation. The first gage on the Owyhee River after it leaves the upper Owyhee subbasin is at Rome, Oregon, after the confluences with Middle Fork Owyhee River, North Fork Owyhee River, and Jordan Creek.

An assertion made in the *Digital Atlas of Idaho* that "the Owyhee River has an annual average discharge of 661,500 acre-feet of water at the Oregon/Idaho border"[12] has no source given and can not be substantiated from any of the USGS gage data. What can be substantiated is that the mean daily flow from 1950 to 2008 at Rome, Oregon, much farther downstream, is 932 cubic feet/second or 675,000 acre-feet per year. The flow at Rome includes substantial contributions from Jordan Creek, the Middle Fork Owyhee River and the North Fork Owyhee River.

It is possible, however, to look at probable general trends in the data.

### *b. Data*

Figure 5.16 shows information from the gage at Jack Creek near Tuscarora. The central double line between the yellow and green colors shows the median daily discharge in cubic feet per second ($ft^3$/sec). Each day of the year the total flow for the day in cubic feet is averaged by the number of seconds in a day (86,400). This gives the mean daily flow (or discharge) per second. The median shows the daily discharge rate at which the mean daily discharge rate is exceeded for half of the years graphed and not exceeded for the other half. It indicates what the flow rate is on a given day in an "average" year.

The information is graphed on a logarithmic scale so that the information about the low flows is not lost due to a few extreme high flows. On a logarithmic scale the distance on the y axis from 0.1 to 1 is the same as from 1 to 10, which in turn is the same as from 10 to 100 and from 100 to 1000. Figure 5.17 shows a logarithmic scale with the multiples of 10 below. Each of these is split into the nine major intervening intervals with some of the interpretations of these intervals labeled above.

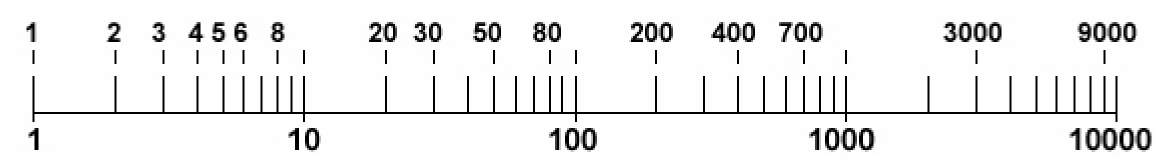


**Figure 5.17. A logarithmic scale**

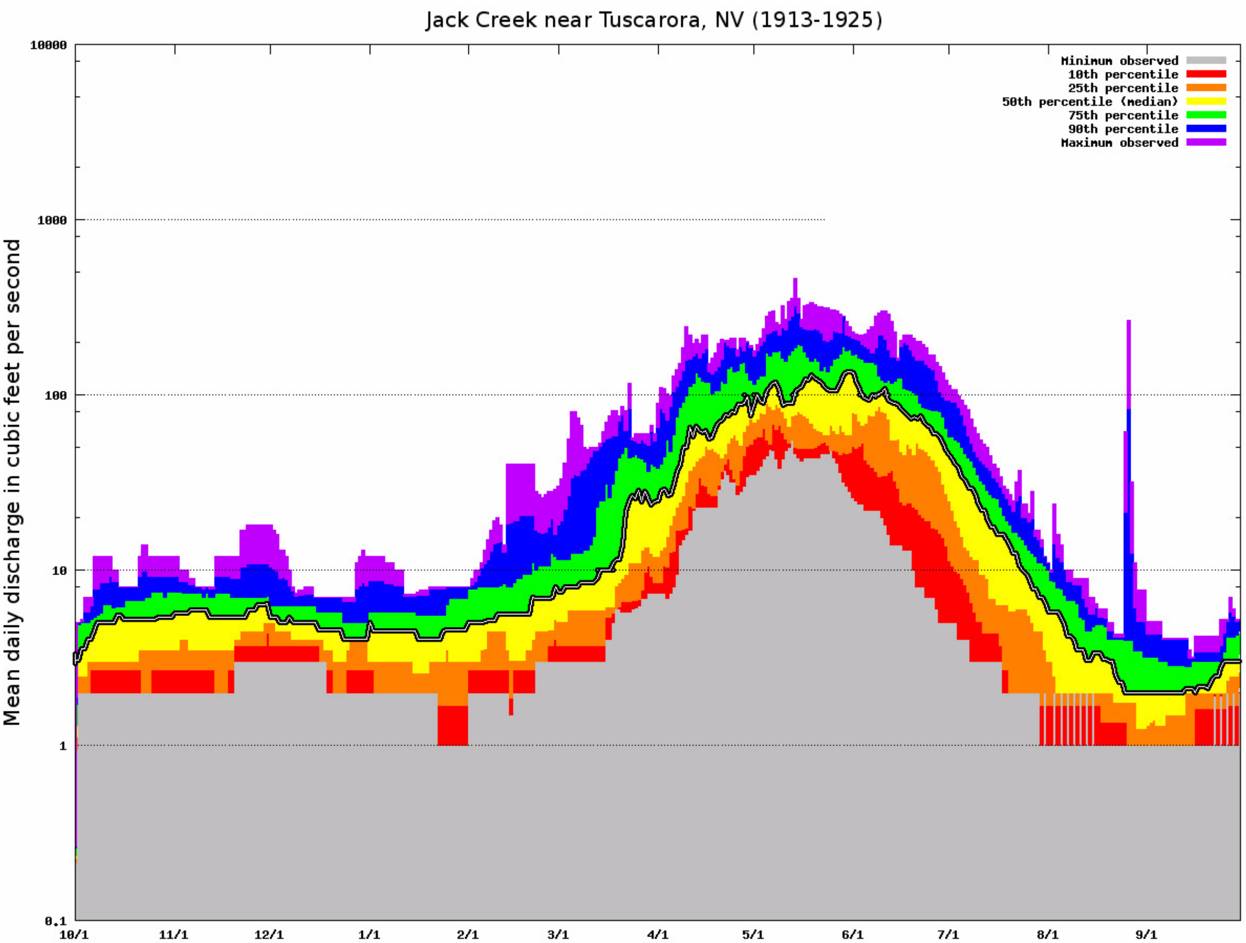


**Figure 5.16. Observed distribution of the mean daily stream flow at USGS gage 13177000 in the upper Owyhee subbasin.**

In addition to the median daily discharge shown by the border between the yellow and green sections, the distribution of daily means over the different years is shown by the differently colored sections. The top of the gray section is the minimum daily discharge on that date. At Jack Creek near Tuscarora (Figure 5.16), there were no years in which the flow was less than 1 $ft^3$/sec. The top of the purple section is the maximum daily discharge for that date. The median flows between the first of October and the first of March varied between 3 and 8 $ft^3$/sec. During March the median flows rose to 30 $ft^3$/sec. The greatest median flows, about 100 to 125 $ft^3$/sec occurred between the first of May and the middle of June. The flows dropped steadily so at the beginning of September the mean flow was close to 2 $ft^3$/sec. The unpredictability of flows is evidenced by one maximum flow near the end of August that is greater than the maximum mean flows for the year.

### *i. South Fork drainage*

Gages shown on Figure 5.15 as K, Jack Creek below Schoonover Creek; L, Jack Creek near Tuscarora; M, South Fork Owyhee River at Spanish Ranch; and N, South Fork Owyhee River near Whiterock, are downstream from each other. Although the dates of record are not comparable, the change in flows may be indicative of general trends. On Figure 5.18 the flows at the gage farthest up the mountain on Jack Creek

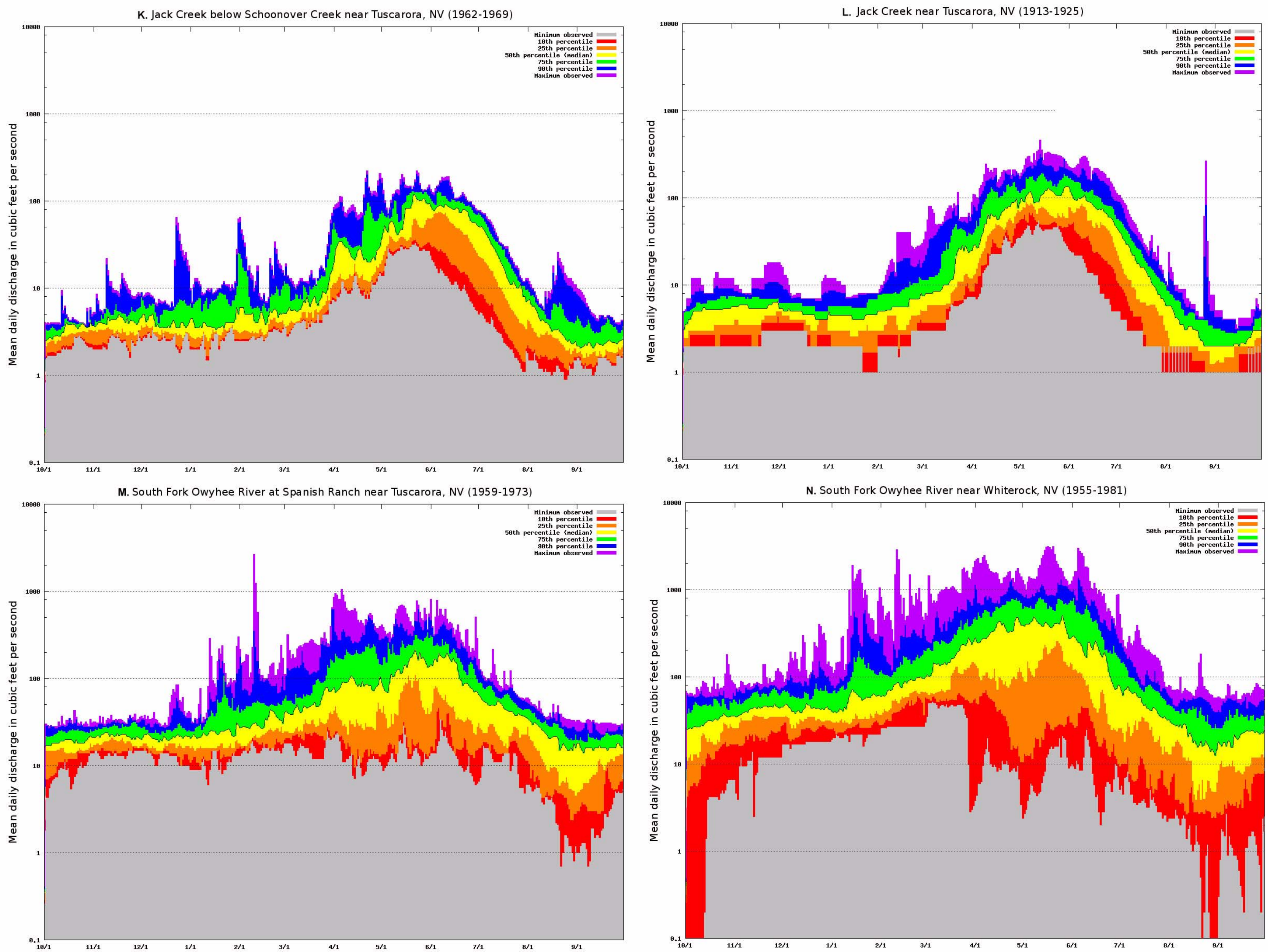


**Figure 5.18. Observed distribution of the mean daily stream flows at sequential downstream gages in the South Fork drainage in the upper Owyhee subbasin.**

tend to have the least fluctuation on any one date between the minimum flow observed and the maximum flow observed. The fluctuation between the minimum and maximum flows increases moving farther downstream. The median daily flow increases moving downstream past the gages, particularly during snowmelt during May and June from around 95 $ft^3$/sec at Jack Creek to close to 500 $ft^3$/sec near Whiterock.

The effect of the evaporative potential is shown by the gage near Whiterock. It is farther from the mountains out in the Owyhee uplands (on the Owyhee plateau). Where the bottom of the red band touches the x axis on the graph, the amount of flow in at least one year was less than 0.1 $ft^3$/sec. Since the next gage downstream is at Rome, there has been no data generated for the flows on the South Fork Owyhee River as it crosses the plateau. Between July and October, it is possible that there are years when even the South Fork Owyhee River has been at most a trickle.

*ii. Owyhee River in Nevada*

The gages on the Owyhee River in Nevada are even less comparable than those on the South Fork Owyhee River. The original Wild Horse Dam was completed in 1937[10] and changed the flows in the river. Only gage 1317550 near Owyhee recorded exclusively prior to the construction of the dam. Gages 13174500 near Gold Creek and 1317500 at Mountain City also began recording before the construction of the dam, but also continued recording after the construction. Gages 13175100 near Mountain City and 13176000 above China Diversion Dam both began recording after the construction of the dam.

**Photo 5.10. Wild Horse Reservoir is impounded behind a double-curvature arch dam completed in 1969 to replace the original dam, Nevada**

The gage on the Owyhee River near Gold Creek is currently just beyond Wild Horse Dam. The data from this gage show the radical change in the hydrology just below the dam (Figure 5.19). Before the river was impounded, the flows in late July and August were the lowest, but never fell below 1 $ft^3$/sec. As flows out of the dam were controlled following the construction of the dam, the river below the dam frequently fell below 0.1 $ft^3$/sec, including more than half the time between early February and early

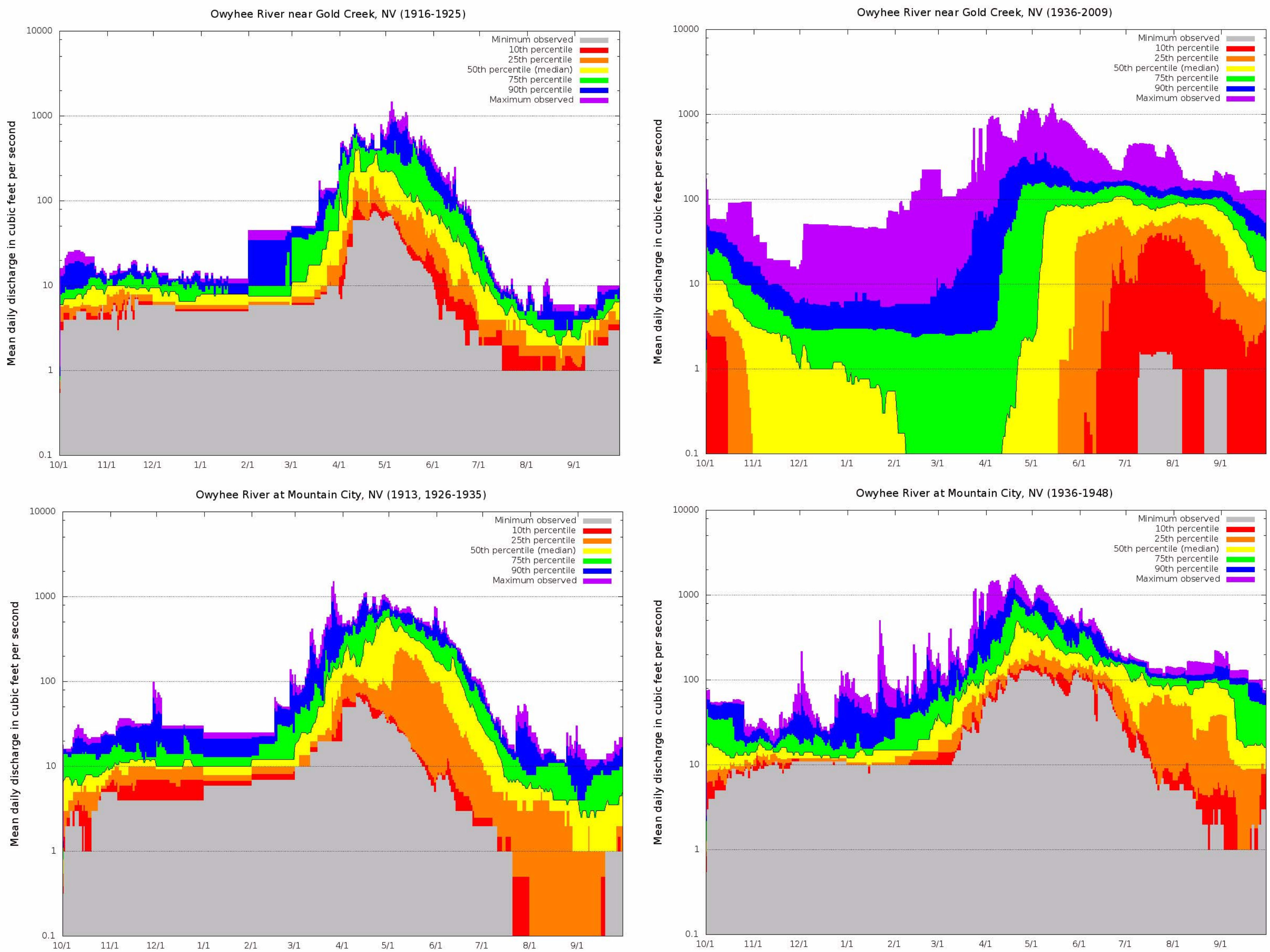


**Figure 5.19. Observed distribution of the mean daily stream flow at two stream gages on the Owyhee River before (on left) and after (on right) the construction of Wildhorse Reservoir.**

April. The fluctuations in the flow between years were also much greater than before the construction of the dam.

Farther downstream at Mountain City, the flows after the dam construction fluctuated less between years than before the construction. Following impoundment, the flows did not decrease as much between May and September as prior to impoundment. The supply of water from the dam during the growing season has been more constant, mostly in excess of 10 $ft^3$/sec.

**Photo 5.11. Water being released from Wild Horse Reservoir into the Owyhee River, Nevada**

*iii. Snowmelt*

Although the gages on the South Fork Owyhee River and Owyhee River have measured the flow generated by snowmelt in the Bull Run and Independence Mountains, Jay Chamberlin of the Owyhee Irrigation District estimates that the snow that accumulates on Mud Flat provides, on average, 35 to 40 percent of the water that eventually flows into the Owyhee Reservoir. Only one of the SNOTEL stations, Mud Flat, is in this area (Figure 5.1).

When the irrigation district flies the snow fields to look at their extent, the plane roughly circles from the Mud Flat SNOTEL station along Blue Creek to Riddle, back along the Owyhee River to the Idaho-Oregon border, and north along the western edge of the upper Owyhee subbasin.[54]

Semiarid mountain watersheds have both complex topography and vegetation that is not all of the same kind or nature. These cause the distribution and melting of seasonal snow cover to vary greatly in both space and time. The effect of topography, wind, and vegetative cover on climate conditions, snow deposition, and snow melt for these regions is not well understood.[16] Even though an estimate of the amount of snow and possible snow melt is made, the amount of water delivered to the river is also dependent on when and how quickly the snow melts. If the ground is frozen, melting snow will not soak into the ground but will flow into the Owyhee River. However, if the surface of the ground is no longer frozen when the snow melts, the soil usually absorbs a large portion of the water.

***c. Flood risk***

The information needed to accurately assess flood risk in any year in the upper Owyhee subbasin is not being collected. Flooding in the upper Owyhee subbasin on the Nevada side has not been a priority in the state's hazard mitigation plan,[30,34] possibly due to the sparse population in the subbasin. However, the National Weather Service does keep track of the gage height and flood stage at Wild Horse Reservoir and at Mountain City.[19]

On the Idaho side, the state's hazard mitigation plan identifies the Owyhee River as one of those "presenting the most significant flood risks."[14]

> "Flooding has produced the worst disasters in Idaho . . . The three types of flooding experienced in Idaho are riverine flooding, flash floods, and ice/debris jam flooding. Riverine flooding is generally associated with winter storms and spring runoff and produces the largest scale events. Flash flooding is associated with extreme precipitation and runoff events, insufficient infrastructure, and dam failures. Although typically limited in extent, flash floods are considered the most dangerous to human lives. Ice jam floods are associated with extreme winter cold events while debris jams may result from landslides or human activities."[14]

Annually the potential for flash floods exists throughout the upper Owyhee subbasin. When the ground is saturated and cannot hold much more water, the conditions are ideal for flash floods with further rain.[4] In addition, thunderstorms that are "slow-moving and strong . . . can produce heavy rain conditions and possible flooding."[17] "Predicting where the flooding might occur is difficult" so a flash flood watch is issued. If the watch turns into a flood warning, flooding has already occurred.[4]

The potential contribution of the upper Owyhee subbasin to flooding downstream can be visualized by comparing the earlier graph of snowmelt contribution to river flows (Figure 5.14) to a graph which includes a few prior years (Figure 5.20). In 1962 the mean daily streamflow on February 10 was 2,680 $ft^3$/sec followed by a streamflow of 1,250 $ft^3$/sec on February 11. This was a rain event that caused historic flooding in southeastern Idaho when earthen impoundments broke. The peak flow was over two times as great as the maximum mean daily streamflow in 1969. These flows may eventually combine with other flows to present a greater flooding danger downstream. In the lower Owyhee subbasin the Owyhee Reservoir has 100,000 acre feet of capacity assigned to flood control, however flood control is informal and advisory only. A "minimum of 70,000 acre-feet of space is maintained in Owyhee Reservoir through February and more space is maintained beginning in January if the inflow forecast is large."[3]

Real-time data to reliably forecast the contribution of the upper Owyhee subbasin to the flow into Owyhee Reservoir does not exist.

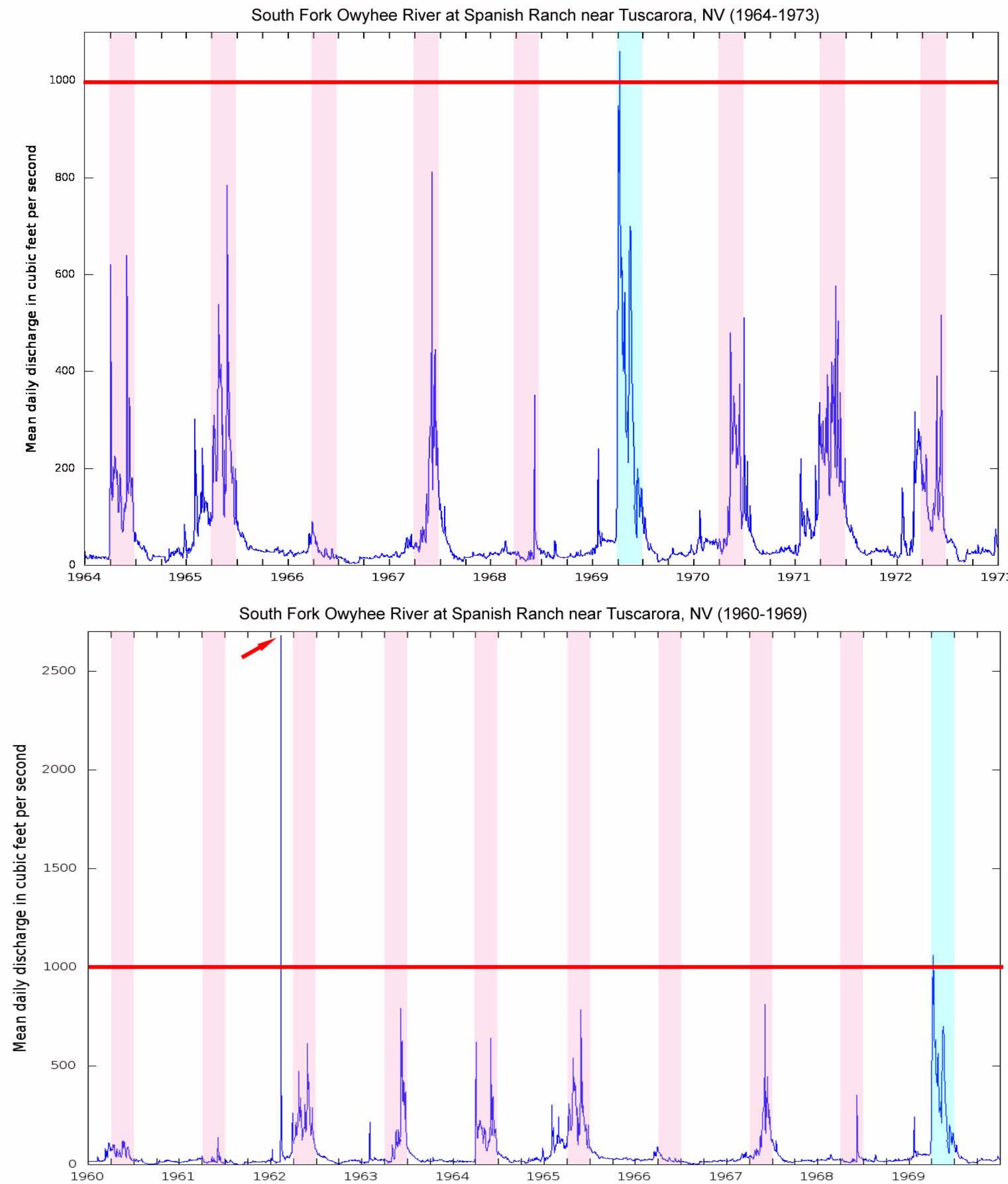


**Figure 5.20. Daily mean streamflow from 1960 to 1969 at gage 13177200 on the South Fork in the upper Owyhee subbasin compared to streamflow from 1964 to 1973. The turquoise block highlights the identical information in 1969.**

## D. Land use effect on flows

Since most of the upper Owyhee subbasin is in rangeland, the management of the rangeland could have a significant effect on the flows, particularly on the flows of intermittent and ephemeral streams. Part of the impetus behind the passage of the Taylor Grazing Act was the condition of the rangelands in the western states. Overgrazing up to 1934 had led to areas where there were few plants left to stem the flow of water across the ground surface or secure the soil; rainfall events resulted in small eroded rivulets leading to the drainage channels. The continued erosive flow in these rivulets led to deeper scars in the landscape. Controlled grazing has eliminated most of this problem, as further discussed in the rangeland section of this assessment.

Many roads across the landscape consist of only two tire tracks. These tracks tend to interrupt the normal flow of water across the landscape; water that is running across the landscape concentrates in the tracks and is delivered downstream. In general no features are planned or built to remove water at relatively short intervals from the two-track roads. Consequently these two-track roads concentrate water and provide the volume and acceleration of runoff that subjects the land to soil loss.

All terrain vehicles can denude and compact the soil, leaving many paths for accelerated water runoff.

In the upper Owyhee subbasin, human activities are not responsible for the peak flows and their potential destructive force. The construction and management of dams, stock ponds, and small reservoirs tend to mitigate peak flows.

## E. Data gaps

There are data missing for the upper Owyhee subbasin that are frequently available for other hydrologic basins. There are has been no mapping of groundwater aquifers, there are no data for water infiltration rates, and key variables for hydrology are generally unavailable. The mapping of vegetative coverage is basic.

There has been no ground verification of which streams are ephemeral, intermittent or perennial. The three types of streams can not be looked at in the same fashion when considering if any remediation is feasible. Rainfall estimates model rainfall between the sparse SNOTEL and meteorological stations in the subbasin and stations surrounding them. The sparsity of these stations means these precipitation models have limited accuracy and give little idea of any local conditions that differ. Models of snowmelt also rely on sketchy data.

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