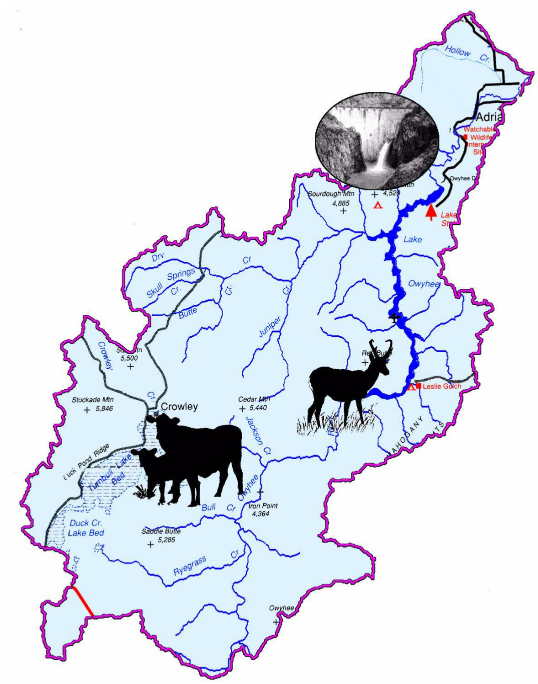



# Lower Owyhee Watershed Assessment

## V. Hydrology



### Contents



## V. Hydrology

Hydrology is the study of how water moves within a system. This is more complex than just rain falling and running down into streams and eventually to the ocean. In addition to describing how water travels across the landscape, it takes into account the source of the water and the fate of the water. The processes involved are described as the water cycle.

This discussion will demonstrate that most precipitation in the subbasin is lost to evapotranspiration and that the subbasin has very little capacity to generate water for storage or groundwater recharge.

## 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.[11,33]

**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.[11,34]

**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.[11,33] 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. The water table is the location where the groundwater stops moving downward. If there are large natural underground reservoirs which can store the water, they are called aquifers.[11]

**Runoff** is the water that travels downslope on the soil surface towards streams. Runoff is made up of water that has fallen on the surface and has flowed across the ground 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.[11,33,42]

**Transpiration** is a plant's "sweating". Plants remove the 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.[11,33,17]

**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).[11,34]

**Condensation** is the change in the physical state of water from a gaseous state to a liquid state. Condensation forms liquid water droplets in the air when the air cools or the amount of vapor in the air increases to saturation point.[11,34]

Water is stored in three basic locations: in the atmosphere, on the surface of the earth, and in the ground. Storage on the surface can be in lakes, reservoirs, glaciers, and the oceans. Underground storage is in the soil, in aquifers, and in small cracks in rock formations.[11,33]

### 2 Discussion

In general, the water cycle is described as evaporation off ocean and other water bodies 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, and buildings. Some of the precipitation 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.[11,33]

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.[11,34]

The different aspects of the water "cycle" affect the fate of water differently in different environments. Desert environments have low amounts of overall precipitation. Noam Weisbrod defines a desert as an arid region which generally receives less than 10 inches of precipitation in a year.[37] He distinguishes cold "winter deserts" from other deserts because they have a large temperature difference from season to season.[37]

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

The lower Owyhee subbasin is part of a desert created by the rainshadow of the Cascade Mountains and other mountain ranges. The area east of the Cascade Mountains receives much less rain and snow than the western side. The prevailing wind direction moves air from the west to the east. It 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 Cascades. The water has been "wrung out" so little rain falls to the east.[11,33,12,37] The Steens Mountains, the Owyhee Mountains, and the Blue Mountains can all capture moisture if the air flow across them still contains sufficient moisture. The capture of precipitation by the surrounding mountains is important to the amount of water received by the lower Owyhee subbasin.

### 1 Sources of primary precipitation data

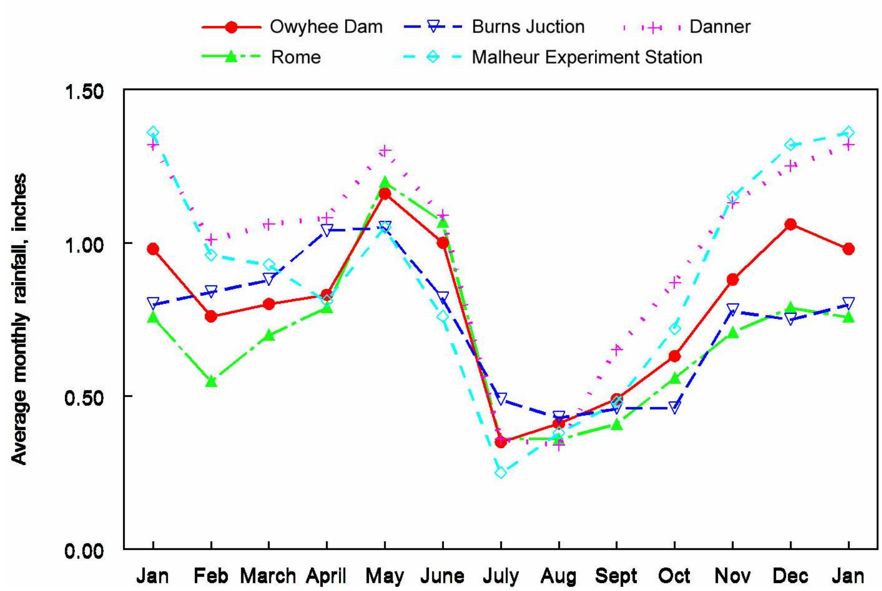
Within the subbasin, there is only one meteorological station, at Owyhee Dam, which measures and records precipitation and temperature. There are other stations around the perimeter of the subbasin. The station at Rome, Oregon is slightly south of the southern boundary of the subbasin and upstream along the Owyhee River. The station at Burns Junction is on the plateau to the west of Rome. The station at Danner is on the plateau to the east of Rome. The Malheur Experiment Station (MES) station is to the north of the lower Owyhee subbasin but still within the Owyhee Irrigation District.

The pattern of rainfall over the year is similar between these five locations although both Danner and MES receive slightly greater total amounts of precipitation

(Figure 5.1). Over the year, there is significantly less rain on average in July and August, also the hottest months of the year.

In addition to precipitation data from the Owyhee Dam, the analyses in this section will use data from the Rome station. It is essential that the reader understand that only these two points are available to extrapolate to the entire subbasin. However, the similarity of the data from these two stations to data for stations around the subbasin make it reasonable to assume that they are fairly representative of the region. The 55 years of data from the Rome station used here were recorded between December 9, 1950 and December 31, 2005. Collection of data at Owyhee Dam began on July 1, 1948. The records used here go through December 31, 2005.

**Figure 5.1. A comparison of rainfall patterns at five meterological stations in and around the lower Owyhee subbasin.**[2,38,39,40,41]

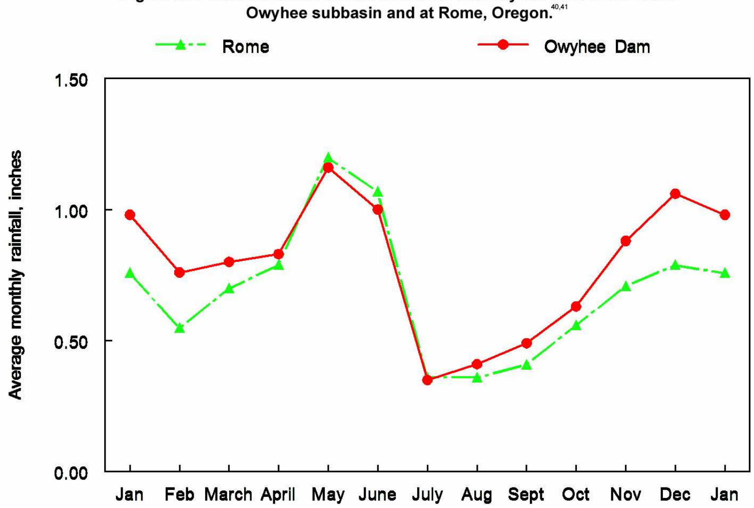



## 2 Water cycle interactions

How does the water cycle operate within the lower Owyhee subbasin? The subbasin is at the lower end of the Owyhee River and includes the mouth of the river. Much of the flow in the Owyhee River comes from upstream outside the subbasin. Meteorological events beyond the subbasin affect the functioning of the river within the subbasin. Owyhee Dam and Lake Owyhee are within the subbasin. The distribution system for the water stored in the reservoir exports water to the east and north outside of the subbasin. The Owyhee River is also the source of potential flooding downstream.

Other than the water entering the lower Owyhee subbasin in the Owyhee River, the primary source of water in the subbasin is precipitation. The amount and the timing of precipitation affects what happens to the precipitation.

**Figure 5.2. Distribution of annual rainfall at the Owyhee Dam in the lower Owyhee subbasin and at Rome, Oregon.**[40,41]



Yearly rainfall at Owyhee Dam averages 9.34 inches and at Rome averages 8.24 inches. The rainfall is not evenly distributed over the year. Rainfall in May is over two and a half times the rainfall in July . Precipitation is also higher during the cold months of November, December, and January (Figure 5.2). Year to year precipitation varies significantly from the average.

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, $\Delta S$ = change in soil water.[42] In some cases rainfall is directly intercepted by plants.

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

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

### *a. Runoff*

Runoff is the water which 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.[42] Although world wide about a third of precipitation which falls on land runs off into streams and rivers,[22] 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."[42] Although small, runoff is important as it redistributes and concentrates the limited water resource.

There are a number of factors which help determine the proportion of a rainfall event that is lost to runoff. Some of the physical characteristics which affect runoff include soil permeability, prior precipitation resulting in soil moisture, 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.[22] 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 is no data for the lower Owyhee subbasin on how much runoff will occur with rain events of different intensities and on the different soil types. Specific streamflows within the lower Owyhee subbasin will be discussed later.

### *b. 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.[17,42] 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.[21,34] Almost all the water from small, infrequent precipitation may be evaporated back into the atmosphere. With wind or heat, greater amounts of precipitation evaporate.[11,22]

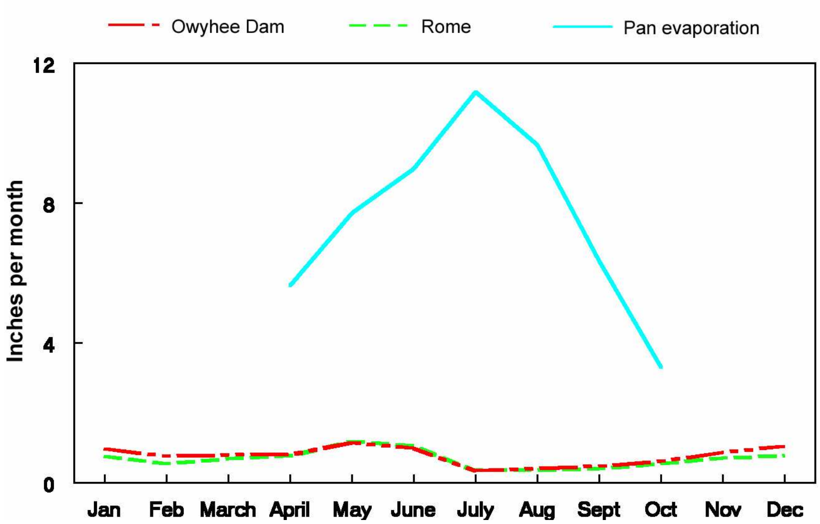
### *c. Evaporation*

Evaporation is the 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 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.[11,4,1,6,36] A shaded stock trough may have 36% less evaporation than an unshaded trough.[36]

The amount of water evaporated depends on the water still present, on how much surface area the water covers, and on the rate of evaporation.

Looking at the climatic data from the lower Owyhee subbasin, it is obvious that the temperatures for part of the year are relatively high. At Owyhee Dam, the monthly average maximum temperatures for the five months from May through September are 74, 83, 93, 92, and 81 degrees Fahrenheit average maximum and the temperatures at Rome are about one degree lower. These are comparable to the temperatures at MES. When the average rainfall at Rome for the last 55 years and at the Owyhee Dam is compared to the MES 58-year average of measurements of the amount of water which evaporates from a flat class A pan (Figure 5.3), the rainfall is only a small portion of the amount which could evaporate. Just considering evaporative potential, the rainfall from April to October could all return to the atmosphere. A larger rainfall event during these months might find some of the water infiltrating into the soil or running off, but a large portion of precipitation during these months evaporates.

**Figure 5.3. Average monthly rainfall at Rome and Owyhee Dam compared to the class A pan evaporation at the Malheur Experiment Station.**[2,40,41]




In rangelands, soil water evaporation generally accounts for 30 to 80 percent of the water budget. Soil water evaporation is limited to the very uppermost layers of the soil.[42]

### *d. 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.[11,42]

The vegetative cover affects interception. Generally 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.[42]

Although figures for the percentage of precipitation intercepted by different types of canopy covers are available for other areas, interception data has not been developed for the local region.

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.[14] 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.

### *e. Transpiration*

In a desert environment transpiration contributes a smaller percentage to the total evapotranspiration. Many arid region plants have developed adaptations that conserve water, allowing them to transpire at a very slow rate when there is less available soil moisture.[11,17] 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 lower Owyhee subbasin summer. However, as plants start to senesce (die), they transpire less.[17]

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. Plants can also draw water from substantially greater depths if water is available, so moisture from uptake by plant roots can reach the leaves and be transpired.[11,17,42]

### *f. Sublimation*

Since much of the precipitation in the lower 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 probability 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. [5,21,34]

Many winter days in the lower 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.[21] 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."[15]

Since the lower 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.

### *g. Infiltration*

There are a number of factors which 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. Vegetation slows the movements of runoff and allows more time for water to seep into the soil.[19,7,14]

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 and saturated soils can hold no more water.[19,7,14]

The soils for most of Malheur county have not been mapped. Without knowing the types of soils in the lower Owyhee subbasin, it is difficult to estimate the maximum infiltration rate and the percentage of rain that could be infiltrated.

### *h. Groundwater recharge*

The high evaporative demand in an arid climate means that eventually water that has infiltrated and is stored in the soil will mostly 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 percolation and higher groundwater recharge.[11,42]

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.[11,33,18,34,13] There has been no mapping of groundwater reserves or calculation of groundwater recharge for the lower Owyhee subbasin.

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 watertable for its recharge will have a more variable flow based upon precipitation, infiltration and use within the last few years. The predominance or water use by deep rooted vegetation, such as big sage or juniper, will reduce flows from shallow aquifers.[44,45,46]

The wells in the lower Owyhee subbasin above the dam may remove some of the groundwater which could be providing the base flow for streams.

### *i. Storages in small dams*

Throughout the lower Owyhee subbasin there are many small dams that have been built to impound intermittent stream flows. Dams create a different distribution of surface storage.[11] These dams 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 very much water. The guide for estimating the acres of drainage area required for an acre-foot of pond storage shows that more than 80 acres are required in the lower Owyhee subbasin.[23] Using this figure, all of the lower Owyhee subbasin could only supply enough water for roughly 15,000 acre-feet of storage.

### *j. Subbasin water balance*

Within the relatively arid lower Owyhee subbasin, the water balance is determined by the fact that potential evapotranspiration is much greater than precipitation, which in turn contributes to a large soil water deficit. As a rule, evapotranspiration is the largest component of the water balance equation, in comparison other components are generally quite small.[42]

### 3 Below the dam

The hydrology below the dam is affected by the storage of water in the dam and the controlled release of water below the dam. The Owyhee Irrigation District supplies full irrigation water to 105,000 acres and supplements water to 13,000 acres. About 85,000 of these acres are in Oregon, the remainder are in Idaho.[26] About 22,000 of these irrigated acres are in the lower Owyhee subbasin.[9] The water balance on the irrigated acres is very different since much more water is being applied to the soil than from precipitation alone. For each crop there are ways of measuring the crop's evapotranspiration needs and, if at all possible, at least enough water is supplied to meet the crop's needs. Some of this water percolates down to recharge the ground water, some of the water runs off the end of the field and drains to the Owyhee River and Snake River, and most of the water is utilized by the plants: some to grow plant matter and most for transpiration.

## C. Actual data

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 try to anticipate what might happen in the future.

Although the lower Owyhee subbasin only occupies 1,983 square miles[33], the Owyhee dam (Figure 5.4) and reservoir capture runoff from about 11,160 square miles.[45] Runoff from this larger area provides the greatest potential for flooding.

Much of the Owyhee River corridor above the dam is designated as wild and scenic river. There are no remaining inhabited areas on the banks of the river so flooding is not a major concern for human safety. However, along the part of the Owyhee River below the dam there are farms and houses. Here flooding is of great concern.

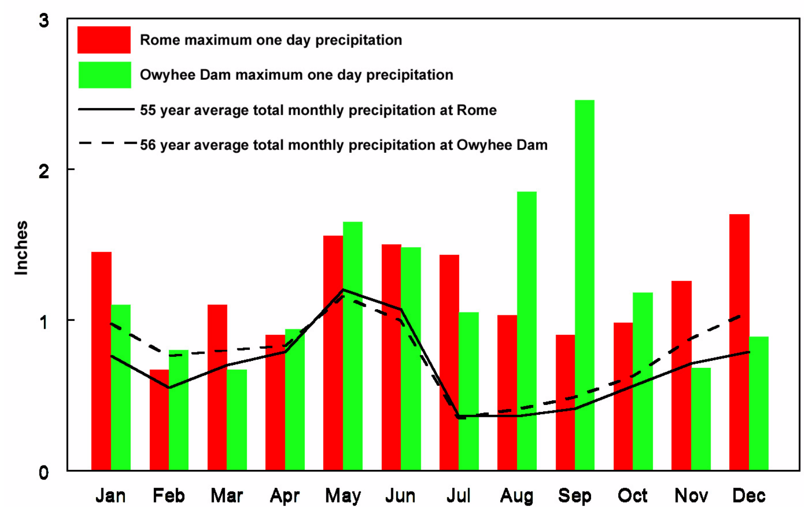
The Owyhee Dam was built for the purpose of irrigation (Figure 5.4). The storage capacity of usable water in the reservoir (Lake Owyhee) is 715,200 acre-feet. Although flood control criteria have been developed, they are advisory only. The Owyhee Irrigation District and the South Board of Control operate Owyhee Dam to store and supply irrigation water.[26]


Figure 5.4. Owyhee Dam.

### 1 Precipitation

The precipitation that fills Lake Owyhee comes from two principal sources. Snow fall in the higher elevations of the Owyhee drainage melts in the spring. This is supplemented by run off from the rainfall events in the spring. Figure 5.2 shows the average monthly rainfall at Rome and at the Owyhee Dam. As discussed earlier, between April and October, the evaporative potential of the area far exceeds the average rainfall (Figure 5.3).

**Figure 5.5. Maximum measured one day precipitation compared to average total monthly precipitation.**[40,41]



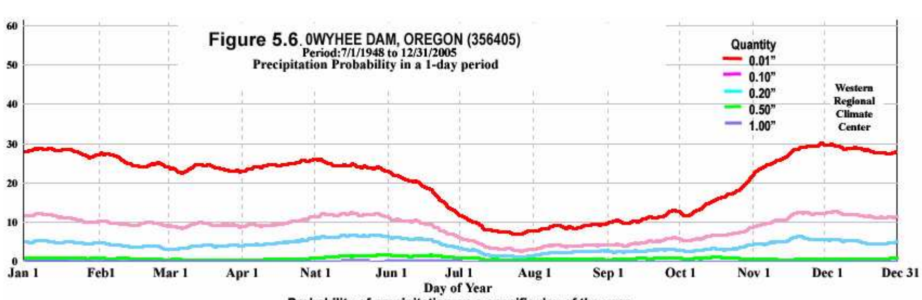

There is a very great variation in both the amount of precipitation and when it occurs. In one day more rain can fall than would be expected for total rainfall for the whole month. Figure 5.5 compares the average total monthly rainfall to the recorded maximum one day rainfall each month at Rome and the Owyhee Dam. In almost every month there has been 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.

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."[43] Figure 5.6 shows that there is a small probability of half an inch of rain falling at Owyhee Dam around 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.

There are many drainages in the lower Owyhee subbasin which can carry water. However, there are very few that carry water all year, every year. USGS topographic maps distinguish between perennial streams, those that essentially flow year-round, and intermittent streams which flow for only part of the year.[10] These



Probability of precipitation on a specific day of the year designations are not changed in map revisions unless the information has been verified on the ground.[27]

### *a. Perennial streams*

A careful examination of the USGS topographic maps that cover the region of the lower Owyhee subbasin shows that only the Owyhee River is perennial throughout all its reach. A few other streams are shown as perennial for part of their reach. Figure 5.7 shows the stretches which are identified as perennial on the USGS maps.[AppendixA] There are four streams entering the Owyhee River from the east that are shown as having water year round in their lower reaches: Spring Creek, Willow Creek, Birch Creek and Bogus Creek. The longest of these, Bogus Creek, is about nine miles long. From the west, the last one to one and a half miles of the creek down Rinehart Canyon to the Owyhee River is shown as perennial. There are two segments of upper Dry Creek, a small stretch of creek in Road Canyon, the creek from Long Spring to Crowley Creek and a small stretch of Crowley Creek, the creek past Porter Springs which disappears into Porter Field, and the Little Crowley Creek from Little Crowley Springs south for about three miles which are also indicated as having water year round.

The short distances of perennial tributaries which do not continue as perennial after joining a larger stream are typical of desert landscapes where runoff decreases over distance because of transmission losses in the alluvial stream channels.[42]

### *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."[28] 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."[28]

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."[3] Ephemeral streams have channels which are always above the water table. They only carry water during and immediately after rain, particularly storm events.[16,3] "Most of the streams in desert regions are intermittent or ephemeral."[3]

### *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 lower 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.

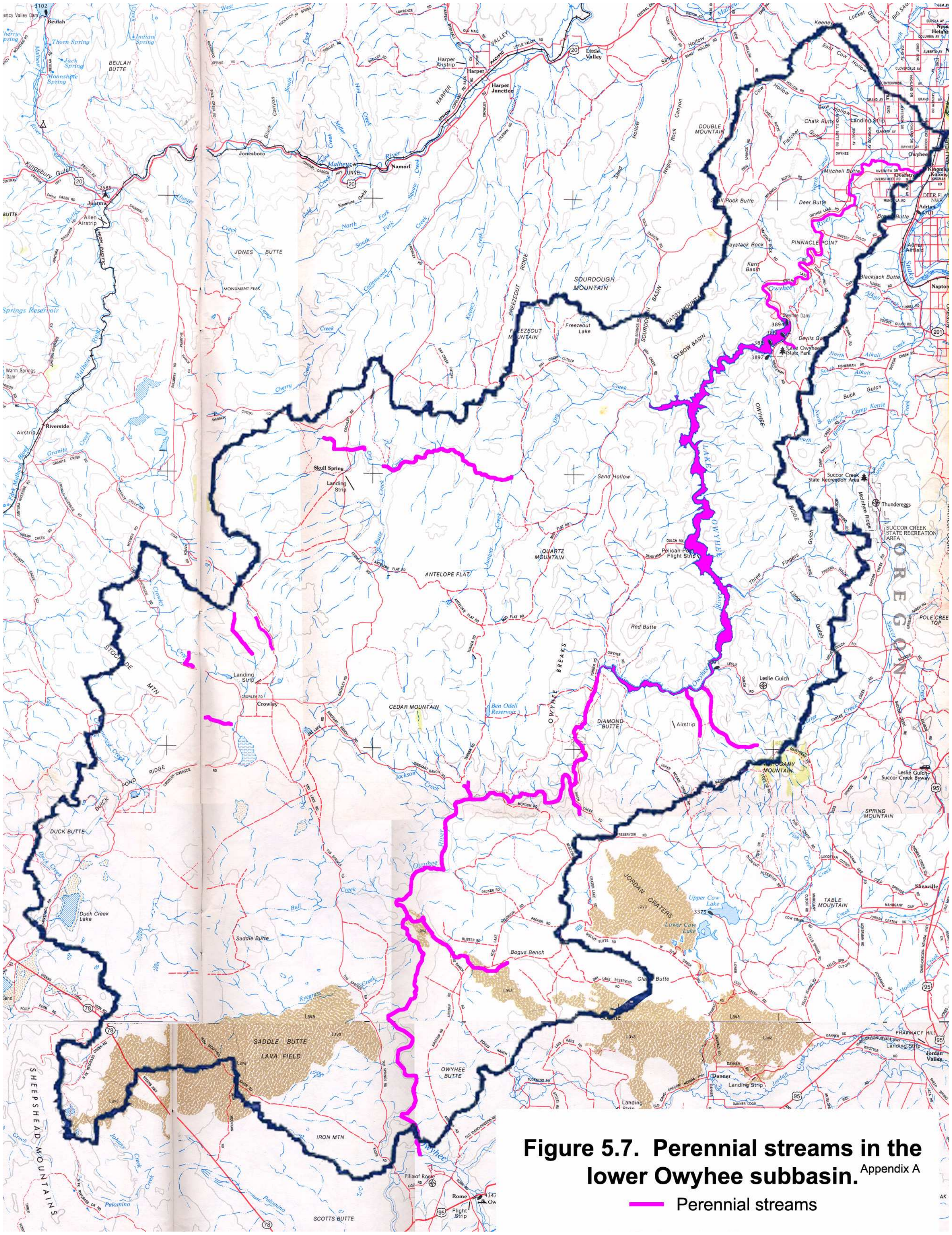



**Figure 5.7. Perennial streams in the lower Owyhee subbasin.** Appendix A

Perennial streams

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. Streams channels that have sagebrush growing directly in the bottom of the wash are most likely ephemeral (Figure 5.8). Sagebrush does not tolerate saturated soil, and if the soil stays saturated for two weeks, sagebrush dies. Water spreading 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 due to scarcity of water.[10]

Figure 5.8. An ephemeral stream in Leslie Gulch with sagebrush growing in the bottom of the wash or "streamed".

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.

## 3 Runoff

Because the other parts of the water balance equation account for the destination of most 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.[35] 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.[22]

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 lower 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.[33] The steepest gradient funnels water into the established water courses of intermittent and ephemeral streams. In the beds of intermittent streams and in dry washes where the streambed flows only after significant rainfall, the sudden torrent of water from rains upstream may cause a flash flood.[16] Entering Leslie Gulch there is a flash flood warning posted. A similar danger exists for many of the other streambeds in the lower Owyhee subbasin.

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.

## 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 and below the dam.

### *a. Sources of Owyhee River flow data*

No measurements were taken and recorded of the flow in the Owyhee River prior to the 1890s. A gauge was installed near Owyhee Corners and records of the flow in the river were kept daily from March 26, 1890 to May 15, 1897. Recording was resumed August 28, 1903 stopped September 30,1916, resumed May 17,1920 and continued until July 2, 1929.[32] On February 25, 1929 a gauge was installed at the current location below the dam and the data used in this discussion include flows through June 28, 2006.[31]

A gauge near Birch Creek Ranch above Lake Owyhee began measuring flow in 1930 at the beginning of the water year, October 1. It was in operation until the end of the water year, September 30, 1951.[30] Data from that gauge overlap data collected at a gauge on the Owyhee River at Rome. Collection there began on October 1, 1949. The analyses made here include data through June 29, 2006.[29]

### *b. Before dam construction*

Before the dam was constructed, farmers and ranchers were utilizing water from the Owyhee River, both upstream around Watson and on the land near the lower Owyhee, but irrigation water would not have been needed during winter and early spring. Therefore, the flows at the Owyhee Corners gauge can be assumed to be a fairly accurate representation of the amount of water in the Owyhee River prior to the irrigation season.

Figure 5.9. Receding floodwaters of the lower Owyhee River, April 2006

Analyzing data through July 7, 1933 from the gauge near Owyhee Corners and then the gauge below Owyhee Dam, high flows occurred in the spring months when snow was melting. Of 9,119 days with records, the average daily flow exceeded 20,000 cubic feet per second (cfs) only three times: once in February and twice in March. During this time the average flow exceeded

10,000 cfs nine times in February, 43 times in March, 46 times in April, and 37 times in May. Only 1.5% of the days had flows over 10,000 cfs.

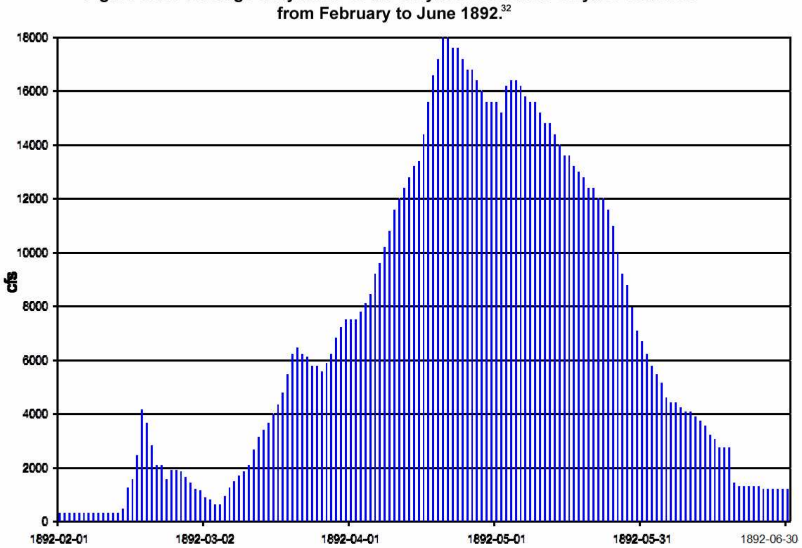
However, this does not tell the complete story of the amount of water coming down the river. Today 12,000 cfs below the dam is considered a moderate flood flow (Figure 5.9). "Flood water will approach houses near Owyhee Junction. Farm land between the dam and Owyhee Junction will be flooded. Flooding will be about 1 foot deep near the Overstreet Bridge."[8] In 1892 there were 40 days with flow over 12,000 cfs and 24 days with flow over 15,000 cfs (Figure 5.10). Today with 15,000 cfs below the dam, "flood waters will cover roads near Owyhee Junction. Some houses near Owyhee Junction will be flooded."[8]

### *c. After construction of the dam*

Today the peak flows below the Owyhee Dam are mitigated by reservoir management even though the dam is operated primarily for irrigation purposes. The "glory hole", the spillway for the dam, only operates after the reservoir is 80% full and water reaches the base of the glory hole. Before the level of the water is high enough to spill through the glory hole, the Owyhee Irrigation District can only release about 2300 cfs, mostly through the jet valves. The glory hole has a maximum spillway capacity of 41,790 cfs.[24] Most of the flow into the reservoir comes from snow melt at higher elevations in the Owyhee watershed. This flow is measured on the Owyhee River at Rome.

Although Owyhee Dam has a total storage capacity of 1,183,300 acre feet[38], over 400,000 of these are below the level of the outlets. The number of usable acre feet is considered to be 715,000 acre-feet of water and this is the base from which calculations are made. In the 69 years of records[39], the reservoir has filled to more than 700,000 acre-feet in 37 of those years. When the reservoir no longer has the capacity to capture the water which enters it from upstream, the excess must be spilled through the glory hole. This is when the danger of flooding downstream is the greatest. A rough calculation of the number of acre feet per day entering Owyhee Lake can be made by multiplying the flow in cubic feet per second by 1.98.

**Figure 5.10. Average daily flows of the Owyhee River near Owyhee Junction from February to June 1892.[32]**




The earliest in the year that the reservoir held 700,000 acre-feet was on January 20, 1971. The water in the reservoir remained above 700,000 acre-feet for 152 days. The latest date in the year when it reached 700,000 acre-feet was May 30, 1956.[25]

Although there were 152 consecutive days with the reservoir behind Owyhee

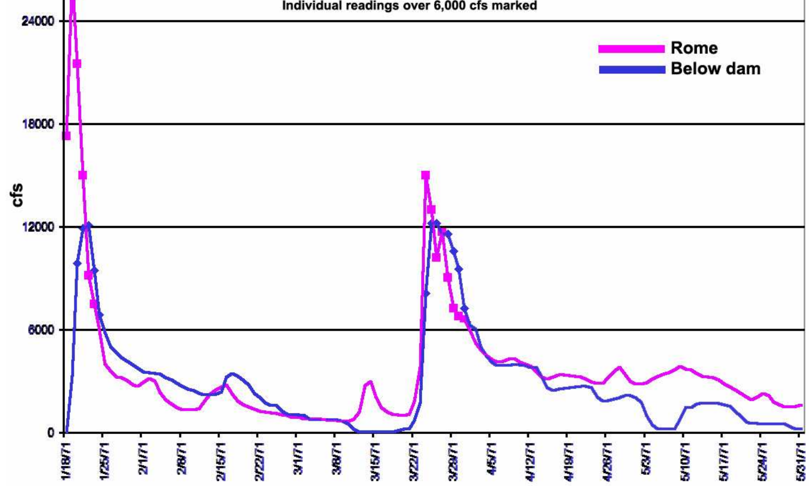


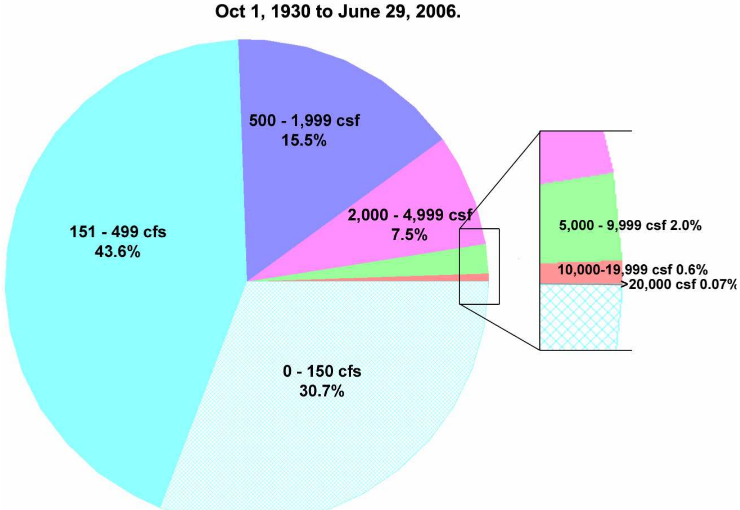
**Figure 5.11. 1971 Owyhee River average daily flow at Rome and below the Owyhee Dam.**[29,31]
Individual readings over 6,000 cfs marked

Dam filled to over 700,000 acre-feet in 1971, 1971 is not a year renowned for flooding. Water measured at Rome usually takes about two days to reach the reservoir. Figure 5.11 compares the flows of the Owyhee River at Rome with the flows below the dam for the period from January 18, 1971 to May 31, 1971. On January 18 there were 643,120 acre-feet in the dam. Despite spilling 3,300 and 9,860 cfs in the next two days, in the succeeding days the capacity of the dam was exceeded and all the excess overflowed into the Owyhee River. From the graph, it is obvious that the flow in the river below the dam mirrors the flow coming in from upstream since there was no remaining storage capacity available in the reservoir. As irrigation began, outflow fell below inflow in April 1971.

To provide capacity in the reservoir to accommodate water which is expected to come down from upstream, the Owyhee Irrigation District surveys the snow pack and watches the flow at Rome. Since the ability to release large amounts of water is only reached when the reservoir is 80% full, there isn't very much wiggle room.

The greatest chance of flooding will occur when the dam is already fairly full and there are large flows entering from upstream. Flows in excess of 20,000 cfs for one day will add 40,000 acre feet or more of water to the dam. Although this type of flow has occurred only 0.07% of the time, we can anticipate that the chance of future occurrences will continue to be about 7 out of 10,000 (Figure 5.12). In the over 37,000 readings made since 1930 there have only been three times the flow entering the reservoir as measured upstream exceeded 30,000 cfs. On March 18, 1993, 46,900 cfs were measured at Rome and there was substantial flooding above the dam. However, the reservoir only had 263,513 acre-feet in it and was able to accommodate the extra 93,000 acre-feet plus runoff from elsewhere.

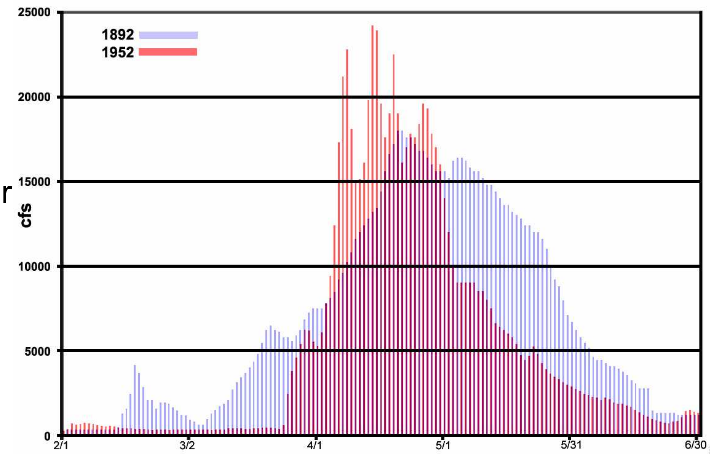
**Figure 5.12. Distribution of average daily flows in the Owyhee River from Oct 1, 1930 to June 29, 2006.**



**Data from 10/1/30 to 9/30/49 from near Birch Creek above the Owyhee Dam and data from 10/1/1949 to 6/29/06 from Rome.**[29,30]

Continued high flows for several days is reason for concern since such flows can easily fill the reservoir and necessitate dumping the excess water into the Owyhee River below the dam. In 1952 flooding below the dam washed out the old bridge. Compared to 1892 there were fewer days in 1952 with high flows, but the peaks were higher (Figure 5.13). Although statistically unlikely to occur, the chances of successive days with high flows are probably greater than the chance of winning the lottery, and large numbers of people are willing to bet on the lottery.

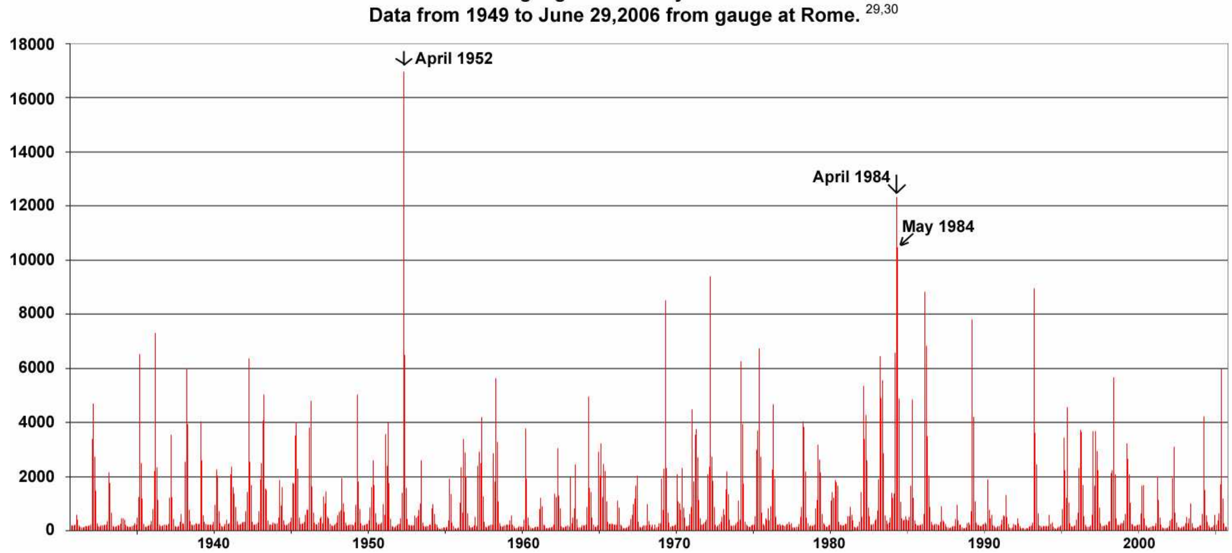
**Figure 5.13. Comparison of 1892 Owyhee River flows to those of 1952.** [29,32]




Besides day to day fluctuations in the flow of the river, the distribution of flows month to month varies from year to year. A chart of the average daily flow for a month shows these year to year variations (Figure 5.14). Since most months are of approximately the same length, the relative amounts indicate the total flow for the month. In 13 of the 76 years there was at least one month where the average daily flow exceeded 6,000 cfs (approximately 357,000 acre feet). However, by contrast, there were 21 years where the average flow per month never exceeded 2,000 cfs.

Assuming a definition of 15,000 cfs or higher as a "high inflow", historically the month with the greatest chance of high inflows into Lake Owyhee from upstream is April with 46.8% of the high flows. This is followed by March with 19.8%, February with 12.6%, January with 8.1%, and December with 1.8%. Since a large portion of the flow in the Owyhee River is from snowmelt, these are logical months to have higher flows. The potential for snowmelt to cause flooding is increased by rain-on-snow events. Besides flooding downstream, rain on snow events can trigger landslides, produce debris flow, and damage riparian areas.[20]

**Figure 5.14. Average daily flow for the month**
**Data from 1931 to 1948 from gauge above Owyhee Reservoir near Birch Creek**
**Data from 1949 to June 29,2006 from gauge at Rome.** [29,30]



The conditions to produce flooding below the dam will inevitably occur. Before the dam was constructed, the stream channel below the dam was periodically scoured by the higher flows. Fast flowing runoff also picked up more sediment and eroded the channel. If ice blocks were carried by the floodwaters they increased the amount of scouring.[22,20] Watson residents remember ice damaging their water wheels. Since the construction of the dam, the stream channel below the dam has had sediment settle in it and vegetation grow up along it and in it. These impede the amount of water which the channel can accommodate and increase the danger of flooding with lower flows. Levels of flooding which have occurred historically are extremely likely to recur.

The Bureau of Reclamation (BOR) estimates that for the Owyhee Dam the "probable maximum flood", the most severe "reasonably possible", would be 1,917,000 acre-ft over 15 days.[24] If the dam were empty when the flows started and the jet valves were releasing 2300 cfs, water could start spilling over the glory hole near the end of the 4th day. If 41,000 cfs went over the glory hole continuously, towards the end of the sixth day the dam would be full. The glory hole and jet valves could no longer get rid of the water entering, and 18,900 cfs would be going over the top of the dam while 64,500 cfs would be roaring down the Owyhee River below the dam. All this is assuming a constant inflow with no peaks above the 64,500 cfs.

This scenario seems far fetched when compared to the historical one day peak flow of 46,900 cfs entering the reservoir. However, a couple of flows like the March 18, 1993 flow of 46,900 cfs (93,000 acre-feet) could quickly cause problems with dam capacity if the reservoir were already spilling over the glory hole. Forty thousand cubic feet per second flowing in the Owyhee River below the dam would cause catastrophic flooding, especially if the Snake River were also high at the same time.

### *d. Prehistoric, precontact flooding*

Historically flows of the magnitude conceived as possible by the BOR have not occurred. However, at "Hole in the Ground" upstream (southwest) from Birch Creek Ranch there is evidence that much more catastrophic events have happened at some time in the past. Well above the presumed level of the 1993 floodwaters, there are single boulders taller than a man that were deposited there some time in the past. The event that left them high and dry may have been a combination water-ice flow to have been able to lift them that far. These boulders have been polished by water passing over them, most probably after they were deposited in their current positions. This would indicate subsequent prehistoric flood events that rose to that level. These tremendous natural flood events occurred prior to any Euro-American use of the area for grazing or other activities.

## D. Land use effect on flows

Since most of the lower 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 which is further discussed in the rangeland assessment section.

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 denude and compact the soil, leaving many paths for accelerated water runoff.

Human activities have the potential to affect the path water takes and might possibly contribute to the base flow in a stream. In the lower Owyhee subbasin, human activities are not responsible for the peak flows and their potential destructive force. The construction and management of the Owyhee Dam, stock ponds, and small reservoirs up stream tend to mitigate peak flows.

### E. Data gaps

There is data missing for the lower Owyhee subbasin which is available for most of the United States. There are no soil studies except for the irrigated lowlands, no mapping of groundwater aquifers, and no data for water infiltration rates, key variables for hydrology. The mapping of vegetative coverage is basic: it is mixed sagebrush shrubland and grass.

There has been no ground verification of which streams are ephemeral, intermittent or perennial. The three types can not be looked at in the same fashion when considering if any remediation is feasible. Rainfall estimates only model rainfall between one point in the subbasin and stations surrounding it. These models are probably only somewhat accurate and give no idea of any local conditions that differ.

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