Humboldt River Chronology

An Overview and Chronological History of the Humboldt River and Related Water Issues

The information contained in **Volume 1, Part I – Overview** of this *Humboldt River Chronology* provides a general overview and description of the Humboldt River Basin and Humboldt River and its physical, geologic, and hydrologic characteristics and attributes. **Volume 2, Part II – Pre-Twentieth Century** and **Part III – Twentieth and Twenty-First Centuries** contain a detailed listing by date of some of the more important events associated with the Humboldt River Basin, the Humboldt River, sub-basins and various tributaries, storage reservoirs, water diversions, and related water supply, water use, water rights, water resources development, fisheries and habitat, and environmental and water quality issues.

Part I – Overview

Introduction

The Humboldt River Basin is an extensive river drainage system located in north-central Nevada and extending in a generally east-to-west direction from its headwaters in the Jarbidge, Independence and Ruby Mountains in Elko County, to its terminus in the Humboldt Sink, approximately 225 miles away in the desert of northwest Churchill County. The basin encompasses an area of approximately 16,840 square miles and is the only major river system wholly contained within the State of Nevada. Connecting the Humboldt River's lofty mountain sources of water to the basin's terminus is the 310-mile long Humboldt River, which, by some claims, is actually about twice that in length accounting for its countless meanders.[1] One particularly interesting observation in a U.S. Army Corps of Engineers report's background study dealt with the meandering flow of the Humboldt River. The report noted that the river's overall length from near Wells to the Humboldt Sink was approximately 300 miles. However, "the actual length of the river was much more than this due to its extensive meandering from side to side of the valleys. At numerous points along the river the direction of flow is transverse and even opposite to the general slope of the valley, and in one valley 130 miles long it is estimated the river flows 380 miles."[2] From the river's origin near Wells, Nevada, to the Humboldt Sink, located southwest of Lovelock, the river drops in elevation by approximately 1,675 feet.

The importance of the Humboldt River and the Humboldt River Valley to early emigration is well documented in the history of the West. The river's course cutting directly through Nevada's basin and range topography became a primary route for the California Emigrant Overland Trail through Nevada beginning in the early 1840's and lasting into the early 1870's. With the completion of the transcontinental railroad in 1869, the route down the Humboldt River became a major east-west railroad passage and, through various phases of highway construction, eventually evolved into present-day U.S. Interstate 80.

The earliest use of the Humboldt River Basin by Europeans was for trapping beaver. Later the river provided water to scattered agricultural activities which served the needs of early emigrant wagon trains. Upon the discovery of silver ore in the lower Humboldt basin in 1860, the economic focus shifted to the development of the river basin's natural and mineral resources. The resultant influx of people dramatically increased the demands for agricultural produce, necessitating more intensive use of the basin's extensive rangelands for livestock grazing. By the early 1870's, extensive ranching and open-range grazing operations stretched virtually from one end of the basin to the other and reached up every major stream and tributary to the Humboldt River. By the late 1800's, most of the basin's mining activities had lapsed into near-dormancy, but the extensive rail and road transportation systems that mining had fostered now amply served the needs of an expanding farming and ranching industry.

Agriculture and transportation effectively dominated the Humboldt River Basin's economy up until the late 1980's, when gold production, primarily along the Carlin Trend in western Elko County and northern Eureka County, turned the basin into the largest producer of gold in the United States. Throughout the late 1980's and early 1990's, the mining industry came to dominate the economies of the principal counties in the Humboldt River Basin.

The Humboldt River Basin encompasses significant portions of five Nevada counties – Elko, Eureka, Lander, Humboldt and Pershing – and also includes smaller portions of three other counties – White Pine (upper Huntington Valley), Nye County (upper Reese River Valley) and Churchill County (Humboldt Sink).[3] The Humboldt River Basin, or Nevada Hydrographic Region 4, is one of 14 hydrographic regions, basins or watersheds designated within the State of Nevada.[4] The Humboldt River Basin is sub-divided into 33 hydrographic areas with one area sub-divided into a hydrographic sub-area. A hydrographic area typically represents a defined valley drainage area[5] or some other discreet drainage system within a larger hydrographic region, basin or watershed. Appendix 1 to Part I lists the hydrographic areas located within the Humboldt River Basin along with the area or valley names, surface areas, counties of coverage and whether they have been designated by the Nevada State Engineer for additional administration.[6]

For purposes of this overview of the Humboldt River Basin, the hydrographic areas have been aggregated into eleven "sub-basins", each of which consists of one or more hydrographic area. The sub-basin designation allows for more detailed analysis of the region's hydrographic and geographic characteristics than provided by the total basin or watershed concept, while at the same time providing a more comprehensive assessment than that possible using the individual hydrographic areas.

The sections which follow present detailed information and analysis of the Humboldt River Basin's physical and geographic characteristics, river reaches and stream segments, major tributaries, water-related issues, stream flows, the eleven defined sub-basins, water rights and the river's adjudication process, reservoirs and storage facilities, mining and mine dewatering, agriculture, changes in rangeland conditions, livestock grazing, erosion, flooding, cheatgrass invasion and wildfires, and snowpack water content trends and related matters. Also presented at the end of this overview is a section on climatic changes which have taken place during the Pleistocene Epoch (approximately 2 million years ago to about 11,000 years ago) and the Holocene Epoch (about 11,000 years ago to the present) and the effects on the hydrology of the Great Basin and the Humboldt River Basin.

The Great Basin and the Humboldt River Basin

The Humboldt River Basin lies wholly within a vast Intermountain region which was first recognized for its unique geophysical structure by John C. Frémont, who fittingly named it the "Great Basin".[7] The hydrographic[8] Great Basin is defined as an area of internal drainage systems bordered by the Rocky Mountains on the east, the Sierra Nevada[9] on the west, the Columbia Plateau on the north and the Colorado Plateau on the south. Surface waters within this expansive area never reach the ocean, but are confined to closed basins which ultimately drain to terminal lakes, playas, or sinks. The Great Basin covers an area of approximately 205,780 square miles (131,699,230 acres or 532,970 square kilometers) and includes nearly all of Nevada, much of eastern California, western Utah, southeastern Oregon, and portions of southern Idaho. Within Nevada, four designated hydrographic regions, basins or watersheds constitute the northern boundary of the Great Basin. These include the Northwest Region (Nevada Hydrographic Region 1),[10] the Black Rock Desert Region (Nevada Hydrographic Region 2),[11] the Humboldt River Basin (Nevada Hydrographic Region 4),[12] and the Great Salt Lake Basin (Nevada Hydrographic Region 11).[13] Of these four hydrographic regions, only the Humboldt River Basin is wholly contained within Nevada.

The Great Basin is characterized by considerable variation in its topography, with one record example for adjacent valley bottoms and mountain tops being the vertical relief of 11,331 feet between Badwater in Death Valley (282 feet below mean sea level, or MSL) and nearby Telescope Peak in the Panamint Range (11,049 feet MSL).[14] The most extreme example of this variable topography within the Great Basin is the elevation difference of 14,744 feet MSL over a distance of 84 miles which separates Death Valley's Badwater site from the summit of Mount Whitney (14,462 feet MSL).[15] More typically, the difference between the Great Basin's mountaintops and valley bottoms ranges from 3,800 feet to 7,600 feet with an average difference of 5,800 feet. The extreme topographic relief of this area greatly affects the distribution of plants and animals and provides niches for a multitude of organisms with diverse habitat requirements.[16]

The Great Basin is a land of striking contrasts containing considerable biological diversity. The Great Basin ranks as the fourth highest in terms of the number of vascular plant species among 116 ecoregions throughout North America and also ranks very high in the number of species of birds, butterflies and mammals.[17] This high biological diversity is produced by a blending of the surrounding ecoregions' flora and fauna populations with the unique species of the Great Basin and diverse habitats found within the Great Basin's "basin and range" topography. The Great Basin is home to the oldest living organisms on earth, such as the Great Basin bristlecone pines, which can live up to 4,900 years, and the creosotebush clones in the Mojave Desert, which are estimated to be 10,000-11,000 years old.[18]

The landforms of the Great Basin define the region as part of the basin and range physiographic province which, in addition to characterizing much of northern and central Nevada, also extends south to include the Sonoran Desert and Chihuahuan Desert of Arizona and Mexico. This region is characterized by hundreds of long, narrow, and roughly parallel, north-south oriented mountain ranges that are separated by deep, sediment-filled valleys. The Great Basin's mountains are geologically recent, and the landforms are a product of the formation and erosion of the Rocky Mountains and the Sierra Nevada. The structure of the more than 400 mountain ranges in the region are similar, however, their compositions are diverse and range from granite ranges in the western portion of the Great Basin, basalt ranges in the northwest, rhyolite mountains throughout the center, and limestone mountains dominating the east and southwest.[19]

The Great Basin's topographic extremes, particularly along its eastern and western mountain borders, provides for relatively abrupt ecological and biological 'transition zones', which represent areas of contact between the flora and fauna populations of two adjoining regions. These zones of habitat transition retain characteristics of both regions to varying degrees and also create their own unique habitat conditions. The Great Basin's eastern boundary is sharply defined by the Wasatch Mountains and the Colorado Plateau, while the western boundary is even more distinctly defined by the Sierra Nevada which has been referred to as one of the world's sharpest boundaries between biological regions. By contrast, the Great Basin's northern and southern boundaries are far more subtle topographically and the resultant transition zones are broader.[20]

The climate of the Great Basin is also one of the most variable and extreme in the world. The "rain-shadow" effect imposed by the Sierra Nevada in the west results in the capture of the moisture from Pacific storm systems, thereby creating semi-arid to arid continental climates in the basin's interior desert regions. Similarly, the Rocky Mountains on the basin's eastern border intercept potential storm systems coming up from the Gulf of Mexico. Even so, local weather patterns within the Great Basin are complicated by the intervening mountain ranges which tend to uplift the prevailing air flows and disperse the moisture as local storms. Therefore, depending on changes in topography, localized annual precipitation levels can vary from as little as six inches on the valley floors to over 45 inches on the upper elevations of adjacent mountain ranges.[21]

The distribution of the Great Basin's present biological communities was shaped primarily by climatic changes over the most recent glacial event. The Wisconsin Age of the Pleistocene Epoch, the last period of glaciation which lasted from about 122,000 to about 10,000 years before present, is the best known of all North American glacial advances and retreats[22] and produced extensive glaciers in the Great Basin's upper mountain regions and enormous lakes and marshes in the basin's valley lowlands. During this last ice age period the Great Basin could be geographically divided into five distinct regions: (1) Northwest Lakes of southern Oregon; (2) Lahontan System of northern and western Nevada and northeastern California and once containing the Great Basin's second largest Pleistocene lake, Lake Lahontan;[23] (3) Central Basins of central Nevada; (4) Bonneville System of eastern Nevada and western Utah and once containing the Great Basin's largest Pleistocene lake, Lake Bonneville;[24] and (5) Death Valley System of southern Nevada and southeastern California.

The higher effective moisture (a combination of cooler temperature and/or greater precipitation) characterizing the late Pleistocene Epoch greatly affected the distribution of plant and animal communities. The Holocene Epoch (approximately the last 10,000 years) has resulted in less effective moisture than during the Pleistocene and especially the Wisconsin Age. These changing climatic patterns have resulted in the northward and/or elevational migration of many plant species.[25]

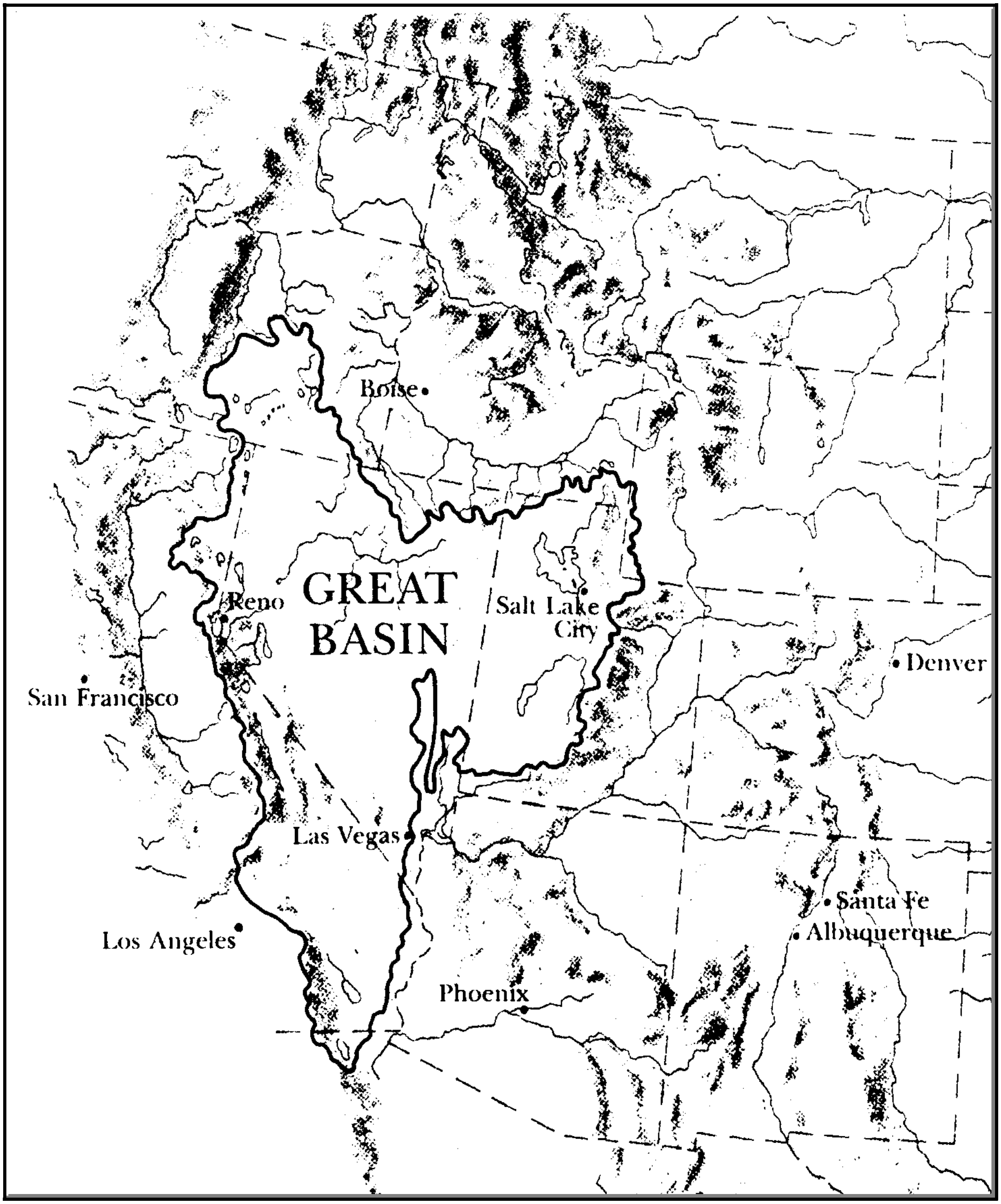


Figure 4 – The Hydrographic Great Basin

(Courtesy Stephen Trimble, *The Sagebrush Ocean – A Natural History of the Great Basin*)

The Great Basin's physical and floristic characteristics have tended to divide this region into seven vegetation zones characterized as follows:[26]

(1) Absolute Desert – includes playas, salt barrens, and sand dunes;
(2) Mojavean Zone – encompasses most of the geographic area of the Mojave Desert with the exception of the higher mountains, dominated by creosotebush scrub, saltbush scrub, shadscale scrub, blackbrush scrub, Joshua-tree woodland and annual vegetation;
(3) Shadscale Zone – named after its dominant plant species, but is also populated by many other species of widely spaced, drought-tolerant shrubs that are usually thorny with small leaves;
(4) Sagebrush-Grass Zone – the largest of all vegetative zones in the Great Basin and the most contiguous, in addition to the dominant big sagebrush, several other sagebrush species and subspecies also occur and can be locally dominant. This zone has higher precipitation than that of the shadscale zone supports greater richness of shrubs, grasses, and perennial forbs;
(5) Pinyon-Juniper and Western Juniper Zone – typically defined as the lowest elevation of the broader montane zone, this zone's plant communities are supported by higher precipitation on the mountain slopes resulting in woodlands of pinyon pine and several species of juniper with understories of grasses, perennial forbs and shrubs (principally sagebrush and bitterbrush);
(6) Montane Zone – constitutes the more restricted montane area between the montane's lower pinyon-juniper zone and the upper alpine zone, with a common feature being the widespread occurrence of quaking aspens and usually few or no conifer species in the basin's northern ranges; curl-leaf mountain-mahogany also provides important habitat in this zone;
(7) Alpine Zone – the uppermost montane zone, strictly defined as beginning at the limit of the upper treeline; relatively restricted to only a few of the highest mountain ranges and constitutes the smallest of the principal zones within the Great Basin.

Table 1 – Great Basin Geographic and Vegetation Zones

Principal Vegetation Zones by Area and Percent of Great Basin

Vegetation Zone	Area (square miles) [square kilometers]	Area (acres)	Percent of Great Basin	Rank by Area of Coverage
(1) Absolute Desert	11,390 [29,510]	7,292,060	5.54%	6
(2) Mohavean	37,860 [98,068]	24,233,030	18.40%	2
(3) Shadscale	35,260 [91,317	22,564,830	17.13%	3
(4) Sagebrush-Grass	79,560 [206,071]	50,921,050	38.66%	1
(5) Pinyon-Juniper	26,160 [67,743]	16,739,590	12.71%	4
(6) Montane	15,070 [39,037]	9,646,210	7.32%	5
(7) Alpine	473 [1,224]	302,460	0.23%	7
Total Great Basin	205,780 [532,970]	131,699,230	—	—

Source Data: Brussard, Peter F., David A. Charlet, and David S. Dobkin, "Regional Trends of Biological Resources – Great Basin", *Status and Trends of the Nation's Biological Resources*, Volume 2, U.S. Geological Survey, U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C., 1998, pages 511.

Table 1, Great Basin Geographic and Vegetation Zones, presents the approximate areas of the Great Basin's vegetation zones and their share of the basin's total area. The Humboldt River Basin occupies the north-central portion of the Great Basin. With the exception of the Mohavean Zone, all vegetation zones in Table 1 are present within the Humboldt River Basin.

A Geographic and Hydrologic Overview of the Humboldt River Basin

Overview

This overview of the Humboldt River Basin consists of two parts: (1) an overview of the upper basin, including those drainage areas located upstream of the U.S. Geological Survey (USGS) gaging station at Palisade, Nevada (USGS gaging station number 10322500),[27] and (2) a lower basin overview for those drainage areas located downstream of the Palisade gage. [Note: see USGS gage locations on Figure 3, Humboldt River Flow Schematic, located on page x.] The Palisade gage has been generally accepted as the location along the Humboldt River above which instream flows are increasing under normal flow conditions and below which the Humboldt River's flows are decreasing. Furthermore, during the Humboldt River's water rights adjudication process beginning in the 1920's and 1930's (which is discussed more fully in a later section "Humboldt River Water Rights, Adjudication and Related Court Decrees"), this location was also noted as an appropriate dividing point for climatological differences affecting the basin's growing seasons and, consequently, irrigation water requirements.

Some researchers divide the basin into three geographic areas: upper, middle and lower divisions.[28] For example, USGS studies currently underway use this type of division. By this distinction, the upper basin consists of a drainage area of about 5,000 square miles upstream from Palisade; the middle basin has a drainage areas of about 7,800 square miles and lies between Palisade and Emigrant Canyon, which is a narrow gap located just downstream from Comus; and the lower basin is an area encompassing some 4,100 square miles located downstream from Emigrant Canyon, extending to and including the Humboldt Sink. This division tends to be more geographic than hydrologic as Palisade Canyon and Emigrant Canyon represent the major constriction points along the Humboldt River Valley. For this analysis, however, we will adhere to the concepts of an upper Humboldt River Basin and a lower Humboldt River Basin, a division which is based on typical Humboldt River flow accretion above Palisade and river flow attenuation below Palisade.

The drainage area of the upper Humboldt River Basin covers approximately 5,040 square miles and accounts for nearly 30 percent of the basin's total surface area of approximately 16,840 square miles. The upper Humboldt River Basin stretches essentially from Wells, Nevada, located in Elko County, downstream to Palisade, located in Eureka County, a distance of approximately 92 miles. Over this distance, the upper Humboldt River drops approximately 740 feet in elevation, corresponding to an average river grade of just over eight feet per mile. The lower Humboldt River Basin covers approximately 11,800 square miles and accounts for the remaining 70 percent of the Humboldt River Basin's total surface area. The Humboldt River's length through the lower basin, from Palisade downstream to the Humboldt Sink, located in Churchill County, is approximately 218 miles. Over this distance, the lower portion of the Humboldt River falls nearly 940 feet, corresponding to an average grade of 4.3 feet per mile, about one-half the Humboldt River's grade through the upper basin.

While accounting for less than one-third of the Humboldt River Basin's total surface area, it is the upper Humboldt River Basin that is, in effect, the source of virtually all the Humboldt River's flows under normal (average) water years.[29] The source of Humboldt River flow is typically in the form of snowpack runoff from upper elevation watersheds, primarily those in the Ruby Mountains (Ruby Dome–11,387 feet MSL), the Jarbidge Mountains (Mary's River Peak–10,565 feet MSL), and the Independence Mountains (McAfee Peak–10,439 feet MSL). By contrast, the principal high-elevation mountain ranges located within the lower Humboldt River Basin, such as the Toiyabe Mountains (Toiyabe or Arc Dome–11,788 feet MSL) and the Shoshone Mountains (North Shoshone Peak–10,313 feet MSL), both of which are located within the Reese River drainage (sub-basin), and the Santa Rose Range (Granite Peak–9,732 feet MSL) in the Little Humboldt River drainage (sub-basin), drain to river systems that, under average or normal water year conditions, make no surface water contribution to the Humboldt River main stem.

The discussion below is divided into an overview of the upper and lower basins, with the Humboldt River beginning near Wells, which is located near the eastern border of the Humboldt River Basin. Aside from being situated very near the source of the Humboldt River, Wells also marks the starting point for many early emigrants' trips down the Humboldt River during the wagon train period of 1841 to 1870. At that time, Wells was called Humboldt Wells and was the place along the river where emigrant wagon trains arrived from the northeast using the Fort Hall route of the Overland Emigrant Trail. It was here that the early emigrants first saw the Humboldt River, no doubt unfavorably comparing it to considerably larger and far more lushly vegetated river systems that they were familiar with in the East. Nonetheless, the springs and lush meadows in the Wells area allowed these adventurous travelers to briefly refresh themselves before beginning their long and arduous journey down the Humboldt River Valley. Judging from a number of diary entries recorded during this period, the early emigrants' generally unfavorable impressions of the Humboldt River near Wells only worsened by the time they reached the river's terminus at the Humboldt Sink.

The Upper Humboldt River Basin

The Humboldt River Basin may be sub-divided into eleven distinct sub-basins, with each sub-basin consisting of one or more hydrographic areas (see Table 9, Defined Sub-Basins and Hydrographic Areas and Sub-Area, for more details on the extent of these defined sub-basins). The upper Humboldt River Basin consists of five of these sub-basins – Mary's River, Ruby Mountains (including Starr and Lamoille Valleys), North Fork, Maggie and Susie Creeks, and the Elko Segment – and also include 11 hydrographic areas. The upper basin's total surface area is approximately 5,040 square miles and includes the major mountain ranges of the Ruby Mountains to the south of the Humboldt River, and the Jarbidge and Independence Mountains to the north, which also form a northern border to the Great Basin.[30]

The generally recognized source of the Humboldt River system is located in the Mary's River sub-basin, a drainage area consisting of about 1,070 square miles. The Mary's River sub-basin qualifies as the uppermost source of the Humboldt River as it contains the tributary (Mary's River) farthermost from the river's terminus (the Humboldt Sink) and also includes the river's easternmost tributary, and the headwaters of the Humboldt River which begin at Wells, Nevada. The Mary's River is also the northernmost tributary in the Humboldt River Basin, except for some minor tributaries to the North Fork of the lower basin's Little Humboldt River (a river system which rarely, in fact, ever reaches the Humboldt River main stem). The Mary's River begins approximately 56 miles above its confluence with the Humboldt River near Deeth, Nevada. The easternmost reach of the Humboldt River lies above Deeth and up Bishop Creek, approximately 36 miles upstream from Deeth.[31] The main portion of the Humboldt River, however, originates near the town of Wells, which lies approximately 20 miles upstream from Deeth. [Note: All river distances are approximate and exclude extensive stream meanders.]

Ten miles downstream from its beginning at Wells, the Humboldt River receives the inflows of Bishop Creek flowing into the river from the northeast. On an interesting historical note, fourteen miles up Bishop Creek is the Bishop Creek Reservoir, which was the site of an ambitious colonization and reclamation project in 1910 when The Pacific Reclamation Company purchased approximately 40,000 acres of land at the mouth of Bishop Creek (Emigration) Canyon. By 1912 the company had constructed the present earth-rock fill dam on Bishop Creek with a storage capacity of 30,000 acre-feet, and a diversion canal with the intention of irrigating 30,000 acres of land. In the flats below the reservoir, a town named Metropolis was built, along with a $100,000 brick hotel, a brick school (Lincoln School), electric lights and city parks. By 1914 the population in the area had grown to almost 1,000 persons. Beginning in 1912, however, problems with water rights on Bishop, Burnt and Trout creeks had dramatically reduced available irrigable lands to only 3,000 acres. Attempts at dryland farming, the first time this had been tried on any significant scale in Nevada, proved disastrous. By 1924 the population of Metropolis had shrunk to only 200 persons and subsequent droughts and the depression era of the 1930's eventually finished off the town. Today, only scattered ruins of the town remain[32] and the Bishop Creek Reservoir (sometimes still referred to as Metropolis Reservoir) is now not even able to hold water due to cracks in the dam.[33]

Ten miles below the Humboldt River's confluence with Bishop Creek is Deeth, where the Mary's River enters the Humboldt River from the north. The Mary's River drains an area with its source waters located in the upper watersheds of the Jarbidge Mountains, approximately 56 miles upstream from Deeth. Near Deeth, a number of other tributary streams also enter the Humboldt River from Starr Valley to the southeast. These streams primarily drain the northwest slope of the East Humboldt Range, which forms the northernmost extension of the Ruby Mountains. Twelve miles downstream from Deeth is Halleck, and just below Halleck, Lamoille Creek enters the Humboldt River from the southeast, draining the northwest slopes of the Ruby Mountains. Eight miles downstream from Halleck, the North Fork of the Humboldt River enters the Humboldt River main stem. The North Fork drains an area consisting of over 1,100 square miles stretching north to the Snake River Basin. The headwaters of the North Fork are located in the Independence Mountains, approximately five miles north of McAfee Peak and nearly 70 miles upstream from the Humboldt River main stem.

Another eighteen miles down the Humboldt River from its confluence with the North Fork is the Humboldt River Basin's principal city of Elko. Elko's town site was laid out on December 29, 1868, by Central Pacific Railroad engineers, and it soon flourished as a major regional transportation hub for mines to the north and south.[34] The plentiful water supplies from the nearby Ruby Mountains served a rapidly growing local agriculture and ranching industry. Eight miles below Elko, the South Fork of the Humboldt River flows into the Humboldt River main stem. The South Fork, along with the Starr Valley and Lamoille Creek drainage areas, drains an area of nearly 1,900 square miles consisting primarily of Huntington Valley and the western slopes of the Ruby Mountains. Approximately ten miles up the South Fork from it confluence with the Humboldt River main stem is the South Fork Reservoir, which was constructed in 1987 by the State of Nevada and the Elko County Fair and Recreation Board. The South Fork Reservoir has a storage capacity of 42,000 acre-feet and is used primarily for recreation. From its confluence with the Humboldt River, the South Fork drainage extends south through Huntington Valley for approximately 68 miles to the eastern slope of the Diamond Mountains and very near Christina Peak (9,656 feet MSL). The upper, or southernmost portion of Huntington Valley actually extends approximately 15 miles into White Pine County.

Some sixteen miles below its confluence with the South Fork, the Humboldt River receives the waters of Susie Creek, and just over a mile further downstream Maggie Creek enters the Humboldt River. Maggie Creek drains an area of nearly 620 square miles above Carlin, Nevada, and encompasses a drainage area lying between the Independence Mountains on the east and the Tuscarora Mountains on the west. The Maggie Creek drainage area currently figures prominently in the Humboldt River Basin's gold mining activities and, in fact, presently receives pumped groundwater from the dewatering operations of Newmont's Gold Quarry Mine. Maggie Creek runs through the "Carlin Trend", an area containing extensive, but relatively low-grade, gold ore deposits in Western Elko County and northern Eureka County. Gold mining operations along the Carlin Trend have brought considerable fame and fortune to this portion of the Humboldt River Basin.

Just about one mile below Maggie Creek's confluence with the Humboldt River is the town of Carlin, now primarily a mining community and transportation hub servicing the needs of many of the gold-producing mines in this area. Despite its seemingly strategic location, due to Carlin's limited infrastructure and few available services, most of the region's miners and their families still reside in Elko, some 25 miles away. As a result, while Carlin showed a population of just over 3,100 persons in 1998, Elko's resident population was more than twelve times greater at nearly 38,000 persons,[35] evidencing a significantly larger and more diverse economy. Nearly five miles downstream from Carlin, the Humboldt River flows out of Elko County and into Eureka County. Another four miles downstream from the county boundary, the Humboldt River's flow is recorded at the USGS Palisade gaging station. This location marks the official end of the upper Humboldt River Basin. The total river distance along this portion of the upper Humboldt River from Wells to Palisade is approximately 92 miles.

The Lower Humboldt River Basin

Below Palisade, the lower Humboldt River Basin consists of six principal defined sub-basins – Pine Valley, Reese River Valley, Battle Mountain, Little Humboldt River, Sonoma Reach, and the Lovelock Reach – which may be further sub-divided into 22 hydrographic areas and one hydrographic sub-area. The lower basin's total surface area of approximately 11,800 square miles includes the major mountain ranges of the Toiyabe Mountains and the Shoshone Mountains south of the Humboldt River, and the Santa Rosa Range north of the river.

The lower Humboldt River is more than twice as long as the upper river's reach and typically reflects a gradual decline in the river's flow and a deterioration in water quality from Palisade downstream to the Humboldt Sink. Historically, this portion of the Humboldt River's route constituted the most arduous part of the entire river's passage by early California emigrants traveling by wagon train.

Along this stretch these early travelers were forced to bypass the narrow Palisade Canyon and travel over steep and tortuous hills to the north and south of the Humboldt River. Throughout much of the lower Humboldt River Valley, these early pioneers were confronted with a myriad of impediments, including the stifling heat of late summer, a lack of good water, scarcity of feed for livestock, swarms of mosquitos arising from stagnant pools and wetlands, a monotonous landscape, and deep and choking dust from the passage of hundreds of wagons before. During normal water years, from Palisade downstream the flow in the Humboldt River gradually declines as few of the lower basin's principal tributary streams and drainage areas (i.e., Reese River sub-basin and Little Humboldt River sub-basin, in particular) provide any surface water runoff to the river.

Less than one mile below the Palisade gage Pine Creek enters the Humboldt River from the south, draining an area of approximately 1,000 square miles. Pine Creek and its upstream tributary, Henderson Creek, extend some 64 miles up into Pine Valley and then through Garden Valley to the base of Roberts Creek Mountain (10,133 feet MSL) in the Roberts Mountains. Stretching south from the Humboldt River, the relatively narrow lower portion of Pine Valley soon opens into a broad valley containing over 3,500 acres of decreed crop and pasture lands. From its confluence with Pine Creek, the Humboldt River continues through the remainder of the relatively narrow 24-mile long Palisade Canyon. Eight miles below the outflow of Pine Creek, the Humboldt River enters into a broad, open valley basin. This typically wider and more gently-sloping river bed configuration characterizes the Humboldt River Valley for the remainder of the river's length. The relatively flat river bed also promotes the river's increased sinuosity through this lower reach. This tendency for the Humboldt River to meander excessively sometimes adds several miles to the river's twisting length for each mile the river traverses downstream.

Twenty-seven miles downstream from the river's confluence with the Pine Creek, the Humboldt River crosses out of Eureka County and into Lander County, and 19 miles below this point the river reaches the town of Battle Mountain. To the south of Battle Mountain lies the Reese River Valley, through which the Reese River extends some 150 miles to the south and encompasses a drainage area of over 3,600 square miles. The Reese River Valley is by far the largest sub-basin drainage area within the entire Humboldt River Basin. In draining this vast expanse of central Nevada, the Reese River begins on the slopes of Arc Dome in the Toiyabe Mountains in Nye County, draining some 34 miles of northern Nye County and running nearly the entire length of Lander County before it intersects with the Humboldt River . Despite the size of this drainage area, seldom can a trace of the waters of the Reese River be found near Battle Mountain. Normally stopping short of the Humboldt River by 10 to 20 miles, only the floodwaters of the Reese River ever reach the Humboldt River main stem.

Approximately nine miles below Battle Mountain, the Humboldt River exits Lander County and enters Humboldt County, and after another 21 miles the river reaches Red House. This location is of significance as it represents the highest point along the Humboldt River ever reached by Ice Age Lake Lahontan during the Wisconsin Age of late Pleistocene Epoch some 12,000 years ago. Thirty miles downstream from Red House, the Humboldt River comes to the location where the Little Humboldt River infrequently enters the Humboldt River main stem. This flood-flow tributary to the Humboldt River main stem drains Paradise Valley to the north and, above that valley, an extensive area extending north almost to the Idaho state border. Approximately 48 miles upstream from Winnemucca and 44 miles up the Little Humboldt River from the Humboldt River main stem is located Chimney Reservoir, situated at the confluence of the Little Humboldt River's North and South forks. This reservoir has a storage capacity of 35,000 acre-feet and was constructed in 1974 by the Nevada Garvey Ranches. The reservoir's water rights are owned by Garvey Ranches and the Humboldt County Fair and Recreation Board with the waters used for both irrigation and recreation.

Like the Reese River, outflows from the Little Humboldt River only reach the Humboldt River main stem during severe storm and flood events. The total drainage area of the Little Humboldt River is nearly 1,750 square miles. The Little Humboldt River drainage stretches first some 45 miles up the Little Humboldt River and then an additional 40 miles up the Little Humboldt River's North Fork into the northern portion of the Santa Rosa Range. Approximately six miles up the Little Humboldt River's generally dry streambed from the Humboldt River's main stem is located a unique landform called the Sand Dunes. This river impediment causes the Little Humboldt River's floodwaters to first form Gumboot Lake at the lower or southern end of Paradise Valley. During extreme flood events, the lake's waters eventually rise to the point where they manage to breach this sand dune formation and enter the Humboldt River with considerable force, but this occurs only rarely.

Four miles below the point where the floodwaters of the Little Humboldt River enter the river's main stem is located the City of Winnemucca, the largest city in Humboldt County and the second largest city after Elko within the Humboldt River Basin, with a population of 8,800 persons in 1998.[36] Winnemucca played an important role in the region's agricultural expansion during the 1870's and 1880's. Since then the city has become a major transportation hub and regional mining community. Seventeen miles below Winnemucca, the Humboldt River leaves Humboldt County and enters Pershing County. Pershing County contains the largest storage reservoir in the Humboldt River Basin – Rye Patch Reservoir – whose waters irrigate the fertile Lovelock Valley agricultural area. The Humboldt River's entire reach from Winnemucca to the upper portion of Rye Patch Reservoir covers a distance of 44 miles and presented an especially disagreeable stretch to early emigrants traveling by wagon train. This portion of the California Overland Emigrant Trail caused some of the greatest hardships to these early travelers due to dust, poor water quality, scant forage for livestock and miles of similar landscape.

The waters of the upper portion of Rye Patch Reservoir, which was constructed in 1936, now cover an area formerly called Lassen or Rye Patch Meadows. Here early wagon trains separated, with some early travelers taking the Applegate-Lassen cutoff towards the Black Rock Desert and thence to northern California and southern Oregon beyond. Other emigrants continued down the Humboldt River with the knowledge that the ominous Forty-Mile Desert awaited them just beyond the Humboldt Sink. To the weary emigrants, this area of Lassen Meadows represented the first reasonable grazing for livestock since Winnemucca, and the last decent forage for another 45 miles until they reached Big (or Great) Meadows located in the lower Lovelock Valley.

From Lassen Meadows, the Humboldt River's course extends some 19 miles through the bottom of Rye Patch Reservoir which, when filled to capacity, holds approximately 194,300 acre-feet of water for irrigating over 38,000 acres of water-righted crop and pasture lands in Lovelock Valley. Rye Patch Reservoir has proven to be of vital importance to lower basin Lovelock Valley farmers. Due to the highly variable flows in the Humboldt River and extensive upstream diversions, prior to the reservoir's construction dependable water supplies in the lower basin proved to be very uncertain.

Rye Patch Reservoir, along with its dedicated water rights transferred from upstream lands near Battle Mountain, has provided a crucial storage facility for downstream users. By means of an extensive conveyance and delivery system, water stored in Rye Patch Reservoir has helped to satisfy the irrigation requirements of Lovelock Valley's farmers over highly variable climatic conditions. From the Rye Patch Reservoir's dam, the Humboldt River flows another 26 miles, mostly through diversion structures, canals and irrigation and drainage ditches to the town of Lovelock and beyond.

From Lassen Meadows and the present-day location of Rye Patch Reservoir, the early emigrants faced another challenging 45 miles to the lush grasslands in Big Meadows located in the lower Lovelock Valley. But this section was not nearly as hard on the emigrants and their livestock as the Winnemucca to Lassen Meadows reach, since water and grasses were typically more plentiful and of better quality through Lovelock Valley. At Big Meadows, early emigrants rested their livestock, and themselves, in anticipation of the extreme hardships forthcoming in crossing the Humboldt Sink and the Forty-Mile Desert before reaching the waters of the lower Carson River.

In high water years, the Humboldt River flows another twelve miles from Lovelock to Toulon Lake and Humboldt Lake, which are connected to the river's main stem by the Toulon Drain and the Army Drain, respectively. Some six miles beyond these "Humboldt Lakes" lies the Humboldt Sink, where evaporation consumes virtually the entire amount of remaining river flows. The Humboldt River's terminus actually lies in Churchill County and marks the furthermost extent of the Humboldt River system. During extreme flood periods (e.g., most recently, 1983, 1984 and 1997), the Humboldt River may even extend beyond the Humboldt Sink, following the course of the Humboldt Drain and Humboldt Slough to the Carson Sink, located some eights miles further to the south and lying approximately 20 feet lower than the Humboldt Sink.[37] During these relatively infrequent flood periods, a hydrologic link is formed between the Humboldt River and Carson River watersheds.

In all, the river's course through the lower Humboldt River Basin from Palisade to the Humboldt Sink covers approximately 218 miles. When combined with the river's length through the upper Humboldt River Basin from Wells to Palisade, a distance of 92 miles, the Humboldt River flows a total distance of about 310 miles from beginning to end. Although the reader has now covered the Humboldt River's entire length in just a matter of minutes, during the wagon train era of the early 1840s's to the late 1860s's, those who traversed the Humboldt River Basin typically took as much as a month to complete the entire trip. For those of us today who attempt to document and come to better understand the Humboldt River Basin's important natural and man-made features, and reconstruct the basin's historical conditions and the impressions of its earliest travelers, we owe a debt of gratitude to the many records left behind by these determined and pioneering people.

Humboldt River Basin Principal Water-Related Issues

Overview

A number of water-related issues presently affect the Humboldt River Basin. This section provides a brief summary of major water-related issues and explores some of the relevant aspects of each. Arguably, the most important of these issues include:

(1) variable climate and uncertain stream flows and the relatively small amount of overall water storage capacity within the basin for irrigation, recreation, fisheries, instream flows, etc.;

(2) out-of-basin and interbasin, water transfers due to more rapid growth and greater water needs in other parts of the state;

(3) open-range grazing and its effects on the basin's native vegetation, ecological balance, invasive grass species like cheatgrass, erosion, flooding and wildfires;

(4) mine dewatering and mine pit lake formation, and their potential near-term and long-term effects on groundwater levels and surface-water flows;

(5) habitat restoration of the native Lahontan cutthroat trout which, at one time, thrived throughout much of the northern and western portions of the Great Basin and the entire Humboldt River Basin; and

(6) the restoration of the Argenta Marsh in part of the area known as the "Community Pasture" located between Argenta and Battle Mountain.

Some of the Humboldt River's water-related issues are more or less common to other waterbasins in northern Nevada, for example, variable precipitation, limited water storage capacity, the growing controversy over interbasin or intercounty water transfers and the habitat conditions of the threatened Lahontan cutthroat trout. Other issues are more specific to conditions existing within the Humboldt River Basin, for example, rangeland grazing, cheatgrass invasion, rangeland wildfires and mine dewatering. Most of these issues are covered, to varying degrees, in other sections of Part I of this chronology and therefore will be presented only briefly here.

Variable Climate and Stream Flows, and Limited Water Storage Facilities

The Humboldt River Basin is subject to highly variable climatic conditions. Trends in annual snowpack water content measures are more extensively analyzed in a following section ("Humboldt River Basin Snowpack Water Content Analysis"). Here the focus is on the resultant hydrologic conditions caused by the region's highly variable climate and runoff conditions. Like other major waterbasins and river systems of northern Nevada, the majority of the precipitation within the Humboldt River Basin occurs during the winter months, typically from November through March or April. Typically, precipitation comes in the form of rain at the lower elevations and snow in the upper elevations. As a consequence, the most significant water storage 'facility' within these basins consists of the water content within the snowpack that is accumulated in the upper elevation watersheds. It is the release of the snowpack's water over time which provides the surface water runoff to recharge groundwater aquifers and contribute to stream flows.

In terms of variability of Humboldt River flows, Table 2, Northern Nevada Principal River Flow Variation Analysis, presents one, albeit a relatively superficial, measure of stream flow variability among the major water basins of northern Nevada. In this analysis, the "High-Low Difference (Ratio)" measure for each river system shows the difference between the record high (flood) year flow and the record low (drought) year flow. [Note: all stream flow measures presented in this table are taken at USGS gaging station locations representing the maximum point of flow during average water years; flows accrete above these locations and attenuate below them.]

Table 2 – Northern Nevada Principal River Flow Variation Analysis†

Average Annual, Low and High Water Year Runoff Volumes in Acre-Feet per Year
[High Flow/Low Flow Ratio – Times]‡ (Percent Change from Average Water Year)*

By Basin and USGS Gaging Station Location – (Listed by Gaging Station Number – See notes)	Average† Water Year (see notes)	Low† Water Year (see notes)	High† Water Year (see notes)	High-Low Difference (Ratio)‡
Humboldt River (at Palisade) (Gaging Station 10322500)[1]	**291,040**	**25,190** (-91.3%)*	**1,336,450** (359.2%)*	**[53.0]‡**
Truckee River (at Vista below Steamboat) (Gaging Station 10350000)[2]	**600,170**	**114,390** (-80.9%)	**2,016,980** (236.1%)	**[17.6]**
Carson River (near Carson City) (Gaging Station 10311000)[3]	**301,170**	**42,350** (-85.9%)	**826,770** (174.5%)	**[19.5]**
East Walker River (near Bridgeport, CA) (Gaging Station 10293000)[4]	**107,150**	**27,150** (-74.7%)	**320,720** (199.3%)	**[11.8]**
West Walker River (near Coleville, CA) (Gaging Station 10296500)[5]	**203,440**	**53,940** (-73.5%)	**484,340** (138.1%)	**[9.0]**

† Average water year, low water year and high water year flows are measured at the U.S. Geological Survey (USGS) gaging station where each respective river flow is at a maximum under average water year flows, i.e., river flows accrete (increase) up to this point and attenuate (decrease) after this point.

‡ Bracketed bold figures represent the ratio (in times) of the high water year flow to the low water year flow as an indication of river flow variability from record year high flow to record year low flow.

* Figures in parentheses represent the low and high water year percent differences from the flow volume of the average water year, showing the range of variability of flows for these respective river systems.

Gaging Station Period of Record Notes:
[1] For years of record 1903–1998; High water year: 1984; Low water year: 1934.
[2] For years of record 1900–1998; High water year: 1983; Low water year: 1992.
[3] For years of record 1940–1998; High water year: 1983; Low water year: 1977.
[4] For years of record 1922-1998; High water year: 1983; Low water year: 1931.
[5] For years of record 1903-1998; High water year: 1907; Low water year: 1977.

Source Data: *Water Resources Data, Nevada, Water Year 1998,* U.S. Geological Survey Water-Data Report NV–98–1, Nevada District Office, Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1999.

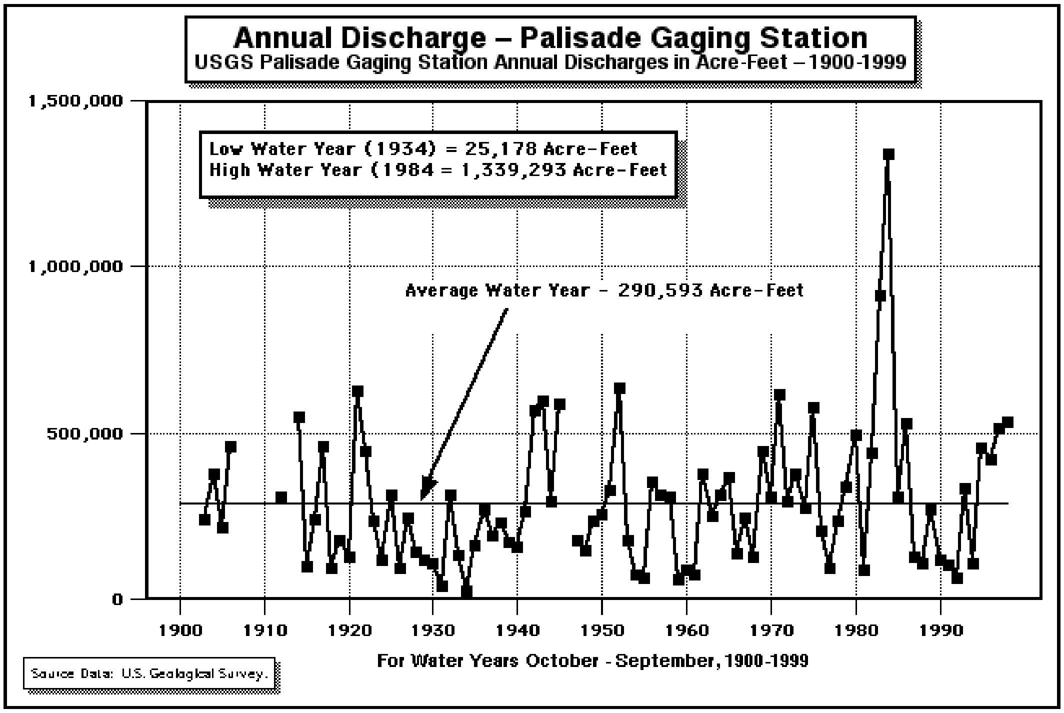
In addition to the climatologic differences between the watersheds of northern Nevada, some portion of the higher variability of the Humboldt River's flows using this simple ratio method may be explained by the relative differences in these water basins' agricultural conditions and practices. One principal factor affecting the low-flow figures in these northern Nevada river systems may well be the relatively greater degree of irrigation water diversions and withdrawals based on differences in irrigated acreage above Palisade on the Humboldt River as compared to the principal river systems of western Nevada.[38] During low water years, the relatively more intensive upstream irrigation diversions tend to result in lower river flows downstream (at Palisade) as more water is used consumptively (i.e., without appreciable return flows) on upper basin irrigated lands.

Without question, compared to other watersheds in northern Nevada, there exists a relative scarcity of significant water storage facilities within the Humboldt River system, especially given the basin's overall surface area and intensive uses, primarily agriculture. This means that water users, particularly irrigators, are dependent to a large extent on natural surface water flows. They depend on weather and snowpack conditions favorable to creating sufficient snowpack storage and conducive to extending the release and runoff from these mountain "reservoirs" for as long as possible. However, most of the smaller stream systems within the Humboldt River Basin experience relatively rapid runoff, a condition referred to as "flash flows", in the spring and early summer, with surface water flows essentially exhausted by May or June. Without the ability to effectively store and better regulate this runoff, the irrigation season along these "flash" stream systems is more limited, reducing agricultural activities and production.

A number of water storage facilities exist within the Humboldt River Basin and a number of other reservoir sites have been proposed. Even so, there are no storage facilities located above Rye Patch Reservoir in the lower basin. Those reservoirs currently existing are presented in a later section ("Principal Storage Facilities of the Humboldt River Basin"). Table 3, Humboldt River Basin Proposed Dam and Reservoir Sites, lists those proposed reservoir sites which were either listed for further study by the U.S. Army Corps of Engineers or Bureau of Reclamation, or which were, at some point in time, recommended for construction within the designated sub-basins and on the specified stream systems.

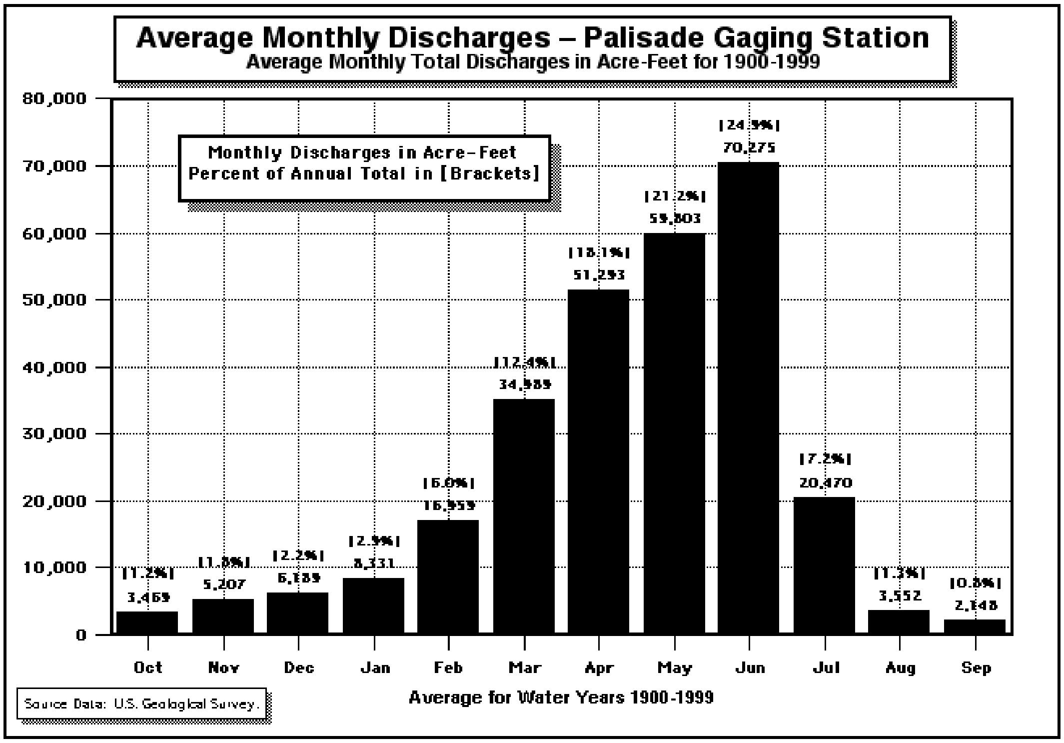
Most of the proposed reservoir sites in Table 3 have proven to be uneconomical, meaning that the cost of construction is generally not sufficiently covered by potential economic benefits either in terms of project economic returns or by the anticipated avoided costs due to potential flood damage mitigation savings. Some reservoir sites listed in Table 3 have been developed at or near their recommended locations. For example, the South Fork Reservoir is located at the old proposed Hylton dam site on the South Fork Humboldt River, and the Chimney Reservoir is located near the merger of the North and South forks of the Little Humboldt River. In addition, the intermittent nature of some of these stream systems may not provide sufficient water to maintain a reservoir at some of these sites.

Figures 5 and 6 on the facing page show the Humboldt River's flow variations on both an annual basis over the years 1900 through 1998 and on a monthly basis for a "normal" water year (October 1 through September 20). Specifically, Figure 5, Humboldt River Annual Flows at Palisade, shows the variations in river flows for the entire period of record for the USGS Palisade gage. Due to limited upstream storage above this location, these flows are essentially unregulated. Figure 6, Humboldt River Monthly Average Flows at Palisade shows similar variation of flows at the Palisade gage for each month based on an average or normal water year. Also noted on this graph are the percent of average annual flows which occur during each month. From this information, we can see that nearly 77 percent of an average year's discharge occurs during the four months of March, April, May and June.



Source Data: U.S. Geological Survey.

Figure 5 – Humboldt River Annual Flows at Palisade – 1900-1998



Source Data: U.S. Geological Survey.

Figure 6 – Humboldt River Average Monthly Flows at Palisade

Table 3 – Humboldt River Basin Proposed Dam and Reservoir Sites

Principal Dam and Reservoir Sites Surveyed for the Humboldt River Basin

Dam/Reservoir	Estimated Size (Acre-Feet)	Humboldt River Sub-Basin†	Reservoir Approximate Location
Mary's River Dam Site	7,000-10,000	Mary's River	Mary's River just below the confluence with Meadow Creek, approximately 36 miles from Humboldt River.
Vista Dam Site	50,000	Mary's River	Mary's River nearly 24 miles upstream from Humboldt River and just above Hot Springs Creek
Hylton Dam Site	120,000	Ruby Mountains	South Fork below the mouth of Tenmile Creek (near present site of South Fork Reservoir)
Devil's Gate Dam Site	80,000	North Fork Humboldt River	North Fork, just over 26 miles upstream from Humboldt River main stem
Pie Creek Dam Site	4,000	North Fork Humboldt River	North Fork, just over three miles below confluence with Pie Creek
Maggie Creek Upper Dam Site	4,000	Maggie Creek	Maggie Creek at upper narrows, 26 miles above Humboldt River and one mile below confluence with Beaver Creek
Maggie Creek Lower Dam Site	5,000	Maggie Creek	Maggie Creek at lower narrows, 10 miles above Humboldt River and two miles below confluence with Simon Creek
Susie Creek Dam Site	6,500	Maggie Creek	Susie Creek just over six miles above Humboldt River main stem
Rock Creek Dam Site	80,000	Rock Creek	Rock Creek at its exit from the Sheep Creek Range and just up from the USGS gaging station
Greeley Flat Dam Site	12,500	Little Humboldt River	North Fork, approximately 24 miles upstream from confluence with South Fork
Latons Spring Dam Site	10,800	Little Humboldt River	South Fork, nine miles above confluence of South and North Forks
Hot Spring Dam Site	20,000‡	Little Humboldt River	Little Humboldt River at USGS Little Humboldt River gage five miles upstream from Paradise Valley
Hardscrabble Dam Site	12,500‡	Little Humboldt River	Martin Creek approximately eight miles upstream from northern Paradise Valley
Sugarloaf Dam Site	20,000	Little Humboldt River	Martin Creek at USGS Martin Creek gaging site approximately two miles up from northern end of Paradise Valley

† For a detailed explanation and listing of the Humboldt River Basin's defined sub-basins, see the section "Humboldt River Sub-Basin Analysis." ‡ Estimated storage capacity.

Source Data: *Humboldt River Basin, Nevada, Water and Related Land Resources,* Nevada Department of Conservation and Natural Resources and the U.S. Department of Agriculture, 1962-1966, and "Rock Creek Reservoir – Preliminary Proposal," Prepared by Chilton Engineering for the Rock Creek Recreational Use and Management Board (A Bi-County Agency of Eureka and Lander Counties), Elko, Nevada, February 1979.

Out-of-Basin or Interbasin Water Transfers

[Note: The concept of interbasin or intercounty water transfers is covered more extensively in the *Nevada State Water Plan, 1999,* Part 3 – Water Planning and Management Issues, Section 1 – Water Supply and Allocation, Interbasin and Intercounty Transfers. The following information summarizes some of the material presented in that issue paper.][39]

In addition to being the driest state in the Union based on average annual precipitation, Nevada is also one of the fastest growing states and one of the most urbanized states. Unfortunately, most of the state's available water resources are not located near its rapidly expanding population areas. Because of the limited options available in moving businesses, industries, jobs and people to water, interbasin and intercounty transfers of both surface and ground waters are likely to become more important in meeting future water needs than in the past. Growing urban areas are continually looking to appropriate new water rights or purchase existing water rights and transfer them to new places of use, frequently in a different basin or county. As Nevada's most rapid economic growth and development has occurred in its principal population centers of Las Vegas (Clark County) and Reno (Washoe County), some have considered that the water resources of the Humboldt River Basin, especially water used for irrigation, might satisfy out-of-basin urban growth. However, any analysis of the potential for future water transfers out of the basin must take into account the use of those waters by the basin's critical agricultural industry and the concerns that interbasin transfers could severely restrict future economic growth and development in the basin-of-origin.

Nevada Revised Statutes (NRS) 533 and 534 provide basic criteria for evaluating all water appropriations or changes of water rights, including interbasin and intercounty transfers. Over the last several legislative sessions, Nevada has considered a number of ways to ensure that interbasin transfers do not cause undue economic or environmental harm, especially to its rural counties where considerable water resources exist relative to these counties' populations. Senate Bill 108, passed by the 1999 Nevada Legislature, now requires the State Engineer to evaluate whether an interbasin transfer is truly needed, whether an applicant for such a transfer needs a water conservation plan and such a plan is being implemented, whether the transfer is environmentally sound, and whether the proposed transfer will unduly limit future growth and development in the area of origin, among other factors.[40]

Focus groups conducted in the early 1990's[41] found Nevadans' views on interbasin water transfers ranged from allowing them under the efficiency of free-market conditions to a more "Antediluvian Policy" which promotes development policies based primarily on an area's natural ability to support population and economic growth only through existing, readily available natural resources, particularly water. Due to the inherent importance of water to the very survival of a region, its people, ecology and environment, the mere proposal of an interbasin or intercounty water transfer is controversial and understandably draws strong public reactions. Realistically, such transfers in Nevada have been taking place since the early 1860's and the Comstock mining era. Based on a continued geographic imbalance between water demands and water supplies in Nevada, this issue is likely to continue to rank high in a listing of importance and sensitivity. Any resolution to this issue must attempt to judiciously balance the rights of current water-right owners with the alternative beneficial uses to which that water can be applied.

Rangeland Grazing

The rangeland grazing issues are more extensively covered in two other sections in Part I, one section dealing with the importance of agriculture to the Humboldt River Basin ("Agriculture and Its Importance to the Humboldt River Basin") and another section dealing more specifically with the effects of open-range grazing ("Livestock Grazing, Cheatgrass, Rangeland Wildfires, and Flooding"). Together, these sections review the growth of the agricultural industry within the Humboldt River Basin and the conditions which led to impacts on the basin's fragile native grasses and contributed to the dominance in many areas of less-desirable invasive plant species.

During agriculture's rapid development in the Humboldt River Basin during the 1870's and 1880's, open-range livestock grazing reached virtually every lowland meadow and upland watershed. By the early 1900's, a recognition of the grazing effects on vegetation depletion and subsequent enhanced erosion within the upper watersheds led to the inclusion of a number of these mountainous headwater areas into the national forest system. For example, during this period the Forest Service incorporated portions of the Ruby Mountains, Jarbidge Mountains, Independence Mountains and the Santa Rosa Range into the Humboldt National Forest, while the upper watershed area of the Reese River Valley was included in the Toiyabe National Forest. While livestock grazing in the basin has continued to the present day, improved rangeland conditions have generally resulted from less intensive grazing operations as the result of better management programs.

Cheatgrass

The issue of the effects of cheatgrass on the Humboldt River Basin is covered far more extensively in two subsequent sub-sections in Part I, "Livestock Grazing, Cheatgrass, Rangeland Wildfires, and Flooding". These sub-sections include "The Cheatgrass 'Invasion' " and "Rangeland Grazing, Cheatgrass, Fires and Flooding".

It has been primarily the lowland areas of the Humboldt River Basin which have experienced the greatest invasion of the annual exotic species of cheatgrass. As a forage plant, cheatgrass has only limited grazing use by livestock and tends to quickly crowd out other, more desirable forage grasses which do not demonstrate the flammability, fire recovery, early germination and rapid growth of cheatgrass. The "choking" effect of cheatgrass effectively turns diverse grassland landscapes into cheatgrass monocultures making these areas highly susceptible to the repetition of wildfires. Studies on the effects of fire on native and invasive grasses have shown that repeated burning will tend to deplete perennial native grasses and allow annual grasses, primarily cheatgrass, to increase its coverage dramatically.

Once portions of the basin's sagebrush-grassland plant community are depleted of its perennial grass cover, as in a wildfire, a secondary succession begins which eventually results in the dominance of cheatgrass within only a few years. The effects of open-range livestock grazing on increasing the severity of flooding and wildfires arguably constitute the most substantive changes to the Humboldt River Basin's ecological balance. In this regard, the basin has proven to be a relatively fragile ecosystem subject to pressures that human activities have placed upon it.

Hydrologic Effects of Mine Dewatering

The topic of mine dewatering is presented in more detail in its own section of this overview ("Mining and Mine Dewatering in the Humboldt River Basin"). The mine dewatering section also includes various information on the mining industry's effects on early settlement patterns, the boom-bust nature of early Nevada mining activities, the era of modern gold mining in Nevada, and the concept of mine dewatering and its effects on local groundwater conditions and on surface water bodies, including the Humboldt River. Within the Humboldt River Basin, a number of surface mining operations have resulted in large, open pits. Many of these mine pits have extended below local groundwater levels and therefore require dewatering or the pumping out of groundwater to access the ore. After removal, the groundwater must be disposed of through reuse (for example to grow alfalfa), surface water discharge, re-injection, or infiltration.

Open pit mine dewatering operations typically consist of perimeter wells to intercept groundwater flows into the pit and thereby allow for access to and extraction of the ore bodies. Mine dewatering effectively creates a "cone of depression" near the groundwater extraction points, drawing down the groundwater table. This cone of depression may have incidental effects on the surface water flows of nearby springs, streams or other surface water bodies which are dependent on groundwater flows or recharge. Mine dewatering applies to both surface mining as well as underground mining.

The State of Nevada has recognized the potential effects that these open-pit mining operations may have on the region's hydrologic conditions. As a result, the State Engineer has established a mitigation process of preferred uses for the pumped groundwater from these surface mining operations. To every extent possible, this process attempts to either minimize or localize the effects of dewatering, or allow the water to substitute for other existing groundwater withdrawals. The effects and concerns over mine dewatering fall into two distinct time periods: (1) the short-term effects which are expected to occur during active mine dewatering operations; and (2) the long-term effects anticipated when dewatering operations have ceased, the mine pits begin to fill, and the resultant pit lakes reestablish equilibrium with the local groundwater table. The short-term effects deal primarily with issues related to the disposal of the pumped groundwater, including quantity, quality and water temperature.

The long-term effects of mine dewatering operations are less well known, and thus have resulted in extensive study, research, analysis and, certainly, controversy. The major long-term issues deal primarily with:

(1) effects on local groundwater conditions during and after filling;
(2) effects of evaporation on both pit lake levels and the surrounding groundwater conditions;
(3) quality of water flowing into the pits as well as the overall quality of the water within the pit lakes based on interaction with ore bodies;
(4) effects on local springs and creeks and other surface waters during and after filling; and
(5) long-term effects on the flows in the Humboldt River main stem from changes in groundwater conditions and possible changes in tributary flows.

Habit Restoration for the Native Lahontan Cutthroat Trout

The Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) is an inland subspecies of cutthroat trout endemic to the physiographic Lahontan Basin[42] of northern Nevada, eastern California, and southern Oregon. In 1970 the U.S. Fish and Wildlife Service (USFWS) listed the Lahontan cutthroat trout (LCT) as "endangered". In 1975 it reclassified it as "threatened" to facilitate management and allow regulated angling. There is no designated critical habitat for LCT and the species has been introduced into habitats outside its native range. Based on geographical, ecological, behavioral, and genetic factors, the USFWS has determined that three vertebrate population segments of LCT exist: (1) Western Lahontan Basin comprised of the Truckee, Carson, and Walker River basins; (2) Northwestern Lahontan Basin comprised of Quinn River, Black Rock Desert and Coyote Lake Basins; and (3) Humboldt River Basin. The evolution of these cutthroat trout subspecies has taken place since the last highstand of Lake Lahontan some 12,000 years ago when all the seven sub-basins comprising that Ice Age lake were connected for the last time. Genetic and morphometric differentiation of LCT has suggested that cutthroat trout native to the Humboldt River Basin warrant formal recognition and classification as a unique subspecies of cutthroat trout.[43]

At one time, due to the interconnection of the rivers and major lakes within the Lahontan Basin, LCT ranged throughout much of the Great Basin, particularly throughout the Humboldt River Basin of north-central Nevada, the Truckee, Carson, Walker and Susan River basins of western Nevada and eastern California, and the Black Rock/Quinn, Alvord and Coyote Lake basins of northern Nevada and southern Oregon. At present, however, LCT exist in only about ten percent of its historic stream habitat and in less than one percent of its historic lake habitat. Within the Humboldt River Basin, cutthroat trout populations are restricted to the uppermost reaches of a number of principal tributary streams to the Humboldt River including the upper Humboldt River (East Fork) above Lamoille Creek, Mary's River, South Fork Humboldt River, North Fork Humboldt River, Maggie Creek and Rock Creek. In addition, cutthroat trout populations also exist in the upper reaches of the Reese River and portions of the Little Humboldt River, both of which do not normally connect to the Humboldt River main stem.[44]

For thousands of years before the arrival of European explorers and settlers LCT served as an important and plentiful food source throughout Nevada's waters for Northern Paiute, Shoshone and Washoe native American Indian tribes. On January 10, 1844, John C. Frémont's first expedition into the Great Basin arrived at Pyramid Lake in the Truckee River Basin and enjoyed the hospitality of the local Paiute Indians and the munificence of the local waters which teemed with an "incredibly large" Pyramid Lake sub-species of LCT. Some of these fish reportedly weighed well over 40 pounds and attained a length of up to four feet.[45] In his diary and record of his travels, Frémont commented that "Their flavor was excellent – superior, in fact, to that of any fish I have ever known. They were of extraordinary size – about as large as the Columbia River salmon – generally from two to four feet in length."[46] Within one hundred years, due to a combination of over-fishing, pollution, river impediments preventing upstream spawning, river diversions and the introduction of exotic, more aggressive and even predatory fish species, this once-plentiful sub-species of LCT became extinct, and other populations of cutthroat trout in other river systems were either extirpated[47] or severely restricted in their habitat.

Throughout the LCT's rapidly dwindling habitat, and particularly within the Humboldt River Basin, the pressures on the species were only slightly less intense than those experienced in Pyramid Lake and the Truckee River Basin. Even as early as 1870, it was evident that the native trout species were experiencing severe threats to its survival. Reporting on the rapid demise of fish stocks due to over-fishing, on October 19, 1870, the *Elko Independent* called for greater restraint: "Last season the abundance of fine trout in this portion of the Humboldt [River] furnished the followers of Isaac [Izaak] Walton[48] with rare sport, as well as the private table with many a savory meal. Now, there are scarcely any fish to be found. During the summer, Indians, Chinamen with queues, and Chinamen without queues, have slaughtered them with nets, traps, seines, poison, by draining portions of the river,[49] and by the murderous use of giant powder [explosives]. The result has been the destroying of small trout and spawn and driving the larger fish to more peaceable waters…"[50] Elsewhere in the Humboldt River Basin the situation was similar and typified human activities prevalent throughout the cutthroat trout's habitat. Leaving little wonder why fish stocks began disappearing from the Reese River and its tributaries, the *Reese River Reveille* (Austin) reported on July 16, 1870 that "A party of the disciples of Izaak Walton returned to town at an early hour this morning bringing a large catch – upwards of five hundred – of the speckled beauties with them, which were disposed of among their friends…The fishing grounds were near the head waters of the Reese River, in the vicinity of Mount O'Leary[51] – a high mountain peak in the Toiyabe Range, christened by the party in honor of one of their number…"[52]

While too late to save the Pyramid Lake sub-species of LCT from extinction, cooperative efforts to improve the status of the cutthroat species in Nevada were begun in the 1940's with the salvage of a few large spawning fish from Walker Lake during their last runs up the Walker River. Since 1963, LCT have been transplanted into more than 50 streams throughout the region. Surveys have been undertaken to identify pure populations of the species and evaluate habitat conditions throughout their former range. As early as 1969, habitat improvement projects and livestock grazing exclosures were initiated and land use practices identified specifically to help in recovering the trout and their former habitat.

One of the first and most dramatic projects to restore LCT habitat took place in the Lahontan Cutthroat Trout Natural Area located in the Black Rock Range in northwest Nevada. Portions of Mahogany Creek were fenced to exclude grazing livestock. The results were nothing less than remarkable. By the 1970's, after many years of open-range grazing, Mahogany Creek had degraded into a wide and shallow spillway and virtually all adjacent vegetation had been removed by grazing livestock. In just three years after the removal of the livestock, however, the riparian conditions showed significant recovery with the streambanks lush and stabilized with native grasses and shrubs and the creek narrowing and deepening its channel, thereby creating far more promising conditions for the LCT.[53] Today, a number of such restoration projects are being undertaken within the Lahontan cutthroat trout's native habitat to significantly improve these area's riparian and aquatic habitats. A key factor in these efforts lies in the modification of past management practices and working in close cooperation and harmony with a number of diverse stakeholders. In addition to the evident benefits to the surviving populations of native LCT, these partnerships are also improving water quality and water quantity, providing better flood protection, and increasing the opportunities for recreation.[54]

The Argenta Marsh

The Argenta Marsh, formerly referred to as the Tule Swamps, the Lakes, Big Slough and the Argenta Swamp, was an extensive riparian and wetland area totaling an estimated 12,000 to 15,000 acres located throughout a considerable portion of the Humboldt River's floodplain between Argenta and Battle Mountain.[55] Until it was drained and the Humboldt River channelized through the area in 1950's by the U.S. Army Corps of Engineers, acting in cooperation with the U.S. Bureau of Reclamation (BOR), this area represented one of the most productive and naturally-protected wildlife habitats along the entire Humboldt River system. Its open waters, direct connections to the Humboldt River's main and south channels, the region's labyrinth of sloughs, swamps and braided and abandoned river channels, thick expanses of tules and dense stands of tall willows formed an invaluable and virtually inaccessible wetland refuge for a wide variety of wildlife.

The area's proliferation of wildlife, particularly water fowl, was only surpassed by the nearly impenetrable nature of its vegetation. Reportedly, Peter Skene Ogden and his Hudson's Bay Company fur trappers took some 1,500 beavers from the area in two trapping seasons. Early emigrants through the region were forced to detour around this area due to the saturated ground and dense vegetation. Later, local hunters were frequently stymied in their efforts to reap some rewards from the abundant wildlife present due to the virtual inaccessibility of the willow stands. Despite these difficulties, the productivity of the region was legendary. Historical accounts of the Argenta Marsh from old journals and newspapers of the late 1800's speak of "wagon loads of fish" and "hundreds of ducks" being taken by local sportsmen.[56]

One early reference broadly located the former Argenta Marsh area by "What is known as the big slough, extending from the lakes, near Argenta, a distance of fourteen miles down the river…"[57] In another reference alluding to the productivity of the area, it was noted, probably with some exaggeration, that "Beaver and otter are in larger numbers on the Humboldt River than those unacquainted with the stream and its animal inhabitants are aware. An experienced trapper informs the editor that in his opinion there are ten thousand beaver in the sloughs and main channel…At Robert Henderson's ranch, near Stone House, the beaver are thick and several dams are to be seen…Traps were placed and thirty-four beaver caught, the fur of which brought $200 in the Chicago market…Several beaver lodges can be seen in the big slough [i.e., the Argenta Marsh], a mile north of Battle Mountain."[58]

In 1934, the BOR and the Pershing County Water Conservation District (PCWCD) signed a repayment agreement for a reclamation project (the "Humboldt Project") to effect delivery of water to Rye Patch Reservoir, located in the lower Humboldt River Basin.[59] Near Battle Mountain the BOR began buying water rights for transfer to Rye Patch Reservoir.[60] Then in the 1950's the U.S. Army Corps of Engineers channelized a section of the river between Argenta and Battle Mountain for the expressed purpose of draining the floodplain,[61] then commonly known as the Argenta Marsh or Swamp, and move the river's waters more efficiently to the lower basin for storage and use in Lovelock Valley. The wetland area below Argenta, as surveyed and mapped out under contract for the Surveyor General of Nevada in May 1869, originally included two distinct open water areas totaling some 2,740 acres, which were then known as the Tule Swamps (or the Lakes).

One mapped open water area, located immediately below Argenta, was approximately one mile wide and nearly four miles long and contained some 2,060 acres through which the South Channel of the

Humboldt River ran. It was generally referred to as the "Argenta Marsh".[62] The main channel of the Humboldt River was located approximately one mile to the north of this upper marsh open water swamp area. The second swamp or lake area, consisting of some 680 acres, was about one-half to one mile wide and one and one-half miles long and was also bisected by the Humboldt River's South Channel. It was located about one mile northeast of the site of Battle Mountain and just above the confluence of the South Channel and the Humboldt River main stem, hence the name given to it was generally the "Confluence Marsh".[63] The Humboldt River's main channel formed the northern boundary of this lower marsh swamp and open water area.[64]

These two primary open water swamp areas were separated by approximately three miles of sloughs, oxbows and braided and abandoned river channels which afforded extensive and invaluable riparian habitat for a wide variety of animal species. However, as a consequence of the efforts of the BOR and U.S. Army Corps of Engineers, which performed the actual channelization of the Humboldt River through the area, this entire wetland area was effectively drained and the riparian habitat and the wildlife that depended upon it lost. Presently, these lands, totaling nearly 30,000 acres, are arranged in 42 separate fields and administered as common pasture (the "Community Pasture") by the PCWCD, which has been the primary beneficiary of the BOR's water reclamation projects within the Humboldt River Basin.[65]

By the late 1960's, as the PCWCD approached its final payment for the construction costs of the Humboldt Project, questions arose as to who actually held title to the project and how could title be transferred to the PCWCD.[66] Irrespective of the complete repayment by the PCWCD, the BOR's contract specifically stated that title to the project lands and facilities "…shall be and remain in the name of the United States until otherwise provided by Congress…"[67] Subsequently, at least two attempts in the late 1980's and early 1990's to transfer title to the PCWCD failed due to widespread public opposition. One of the main points of debate was the enabling legislation's failure to address the issue of restoring, to some degree, the Argenta Marsh.

In 1997 the issue of transferring title to the Humboldt Project to PCWCD regained interest and the water district hired a consulting firm[68] to outline the costs and obstacles in gaining title to approximately 30,000 acres of federally-managed lands. It was suggested that the PCWCD was making a preemptive move to secure ownership before other interests – i.e., Elko County Conservation Association, Sierra Club, Ducks Unlimited, Lahontan Valley Wetlands, and even the BOR – could place a different priority on this land's use, possibly attempting to convert some portion of it back into wetlands.[69]

In 1997 the Nevada Division of Wildlife (NDOW) became actively involved in the discussions to resolve the PCWCD's opposition to the restoration of the Argenta Marsh. In the spring of 1998, in order to initiate marsh restoration efforts, NDOW assembled a task force to assess the feasibility of utilizing mine dewatering water from the Barrick and Newmont mining operations in Boulder Flat. It was believed that this water could be delivered to the proposed marsh area via the existing White House and Blue House ditch systems and contained in a series of diked cells and open areas.

Notwithstanding certain engineering and water rights issues, the mining companies agreed with the concept and in the summer of 1998 NDOW sought the assistance of Ducks Unlimited (DU) and their engineering staff to analyze the possibility of restoring the Argenta Marsh. In the fall of 1998, NDOW broadened the participation of interest groups to approximately 20 agencies and entities.[70] The resultant proposal encompassed a number of objectives:[71]

(1) Restore to the maximum extent practicable, the Argenta Marsh at or near its former location and under NDOW management;

(2) Title to the balance of the pasture not converted to wetlands (i.e., the remaining "Community Pasture" lands) would pass to another entity (PCWCD, BLM, Lander County, other);

(3) Rye Patch Dam and all project lands, not designated under the 6F Land and Water Conservation Funds (which would go to the Nevada Division of State Parks), would pass to the PCWCD;[72]

(4) As part of the transfer legislation, a water-righted minimum pool of 3,000-5,000 acre-feet would be established in Rye Patch Reservoir to support the economically important fishery located there;

(5) NDOW also proposed making a mutual commitment with the PCWCD for greater cooperation on downstream water delivery to the Humboldt Sink and Wildlife Management Area.

Unfortunately, on the key issue of restoring the Argenta Marsh, the principal participants – the Pershing County Water Conservation District and the Nevada Division of Wildlife – still remain apart, particularly with respect to the ultimate size of the restored wetland. While NDOW and Ducks Unlimited had initially contemplated a restored wetland area of up to 10,000-12,000 acres, nearly equaling the size of the area estimated to have been lost in the 1930's, the PCWCD was considering a far more modest effort of only 600 acres of restored wetlands. The PCWCD is especially concerned that while the Argenta Marsh may effectively be restored by mine dewatering operations, when mining operations cease marsh proponents and environmentalists will be forced to find water elsewhere, and irrigation water supplies will represent one obvious source.

Presently, NDOW's plans call for the construction of approximately 5,000 acres of new wetland areas carved out of the existing 30,000 acres of the Community Pasture. It is anticipated that to maintain this wetland area approximately 15,000 to 20,000 acre-feet of water rights (at a 3:1 to 4:1 ratio of water to acres) will have to be purchased.[73]

Humboldt River Basin Selected Gaging Station River and Stream Flows

[*Note: See Figure 3, Humboldt River Flow Schematic on page x in the front of this publication for a flow chart indicating the general locations of the U.S. Geological Survey's streamflow gaging stations which are referred to in this section. Also see Appendix 3 for a presentation of gaging station periods of record.*]

This section provides information on stream flows within the Humboldt River Basin. Table 4, Upper Humboldt River Principal Stream Flows, and Table 6, Lower Humboldt River Principal Stream Flows, together present stream flows for USGS gaging stations located along the Humboldt River system's main stem and for a number of principal tributaries. These tables are divided by geographic and hydrologic convention into an upper Humboldt River Basin (Table 4), including stream flows for drainage areas located upstream from the USGS gage at Palisade, Nevada, and a lower Humboldt River Basin (Table 6) encompassing stream flows for all drainage areas located below Palisade. The information in these two tables shows the average water year flow volumes (in acre-feet per year) and the corresponding average annual rates of flow (cubic feet per second) for specific periods of record for each selected gaging station location. In addition to the average water year flows,[74] these tables also present a record low (drought) water year flow[75] and record high (flood) water year flow[76] for each gaging station. The tables' footnotes detail the period of record for these three different measures of stream flows.[77]

An intervening table, Table 5, Northern Nevada River System "Productivity" Comparisons, presents an analysis and comparisons of water "productivity", or surface water runoff, for the Humboldt River system as compared to the Truckee, Carson and Walker River systems of western Nevada. River productivity measures a river's maximum discharge during an average water year relative to the drainage area contributing to that discharge. By such admittedly simplified measures, river systems can be compared to one another in terms of acre-feet of water produced in terms of runoff to stream systems (versus groundwater infiltration) in an "average" water year per square mile of drainage surface area.

A gaging station's period of record over which continuous (contiguous) flows are taken is important in comparing the flows between two points on a stream system. Longer periods of record provide more inclusive and statistically significant information on a region's extreme hydrologic events (i.e., floods and droughts) and thereby enhance the comparability of flow information among various gaging stations located along different reaches of a river. While data presented in the following tables is for "years of record," this reflects the overall period of record which may include a number of discontinuous time periods. For example, the annual overall record of the USGS Battle Mountain gaging station is listed as 1897 through 1998. However, the contiguous record is May 1896 through December 1897; March 1921 through April 1924; October 1945 through September 1981; and February 1991 through the current water year (1998). Similarly, the contiguous period of record for the Comus gaging station is October 1894 through December 1909; September 1910 through September 1926; and October 1945 through September 1998. Another important gaging station location is Palisade which has contiguous periods of record from October 1902 through October 1906 and July 1911 through September 1998. It is interesting to note that none of these important gaging station locations were in operation during the Humboldt River Basin's record estimated flood which severely affected various portions of the basin between February and April 1910.

Table 4 – Upper Humboldt River Principal Stream Flows[†]

Average Annual Runoff Volumes in Acre-Feet [Flow Rates in Cubic Feet per Second][‡]

By USGS Gaging Station Location (Listed by Gaging Station Number—See notes on respective average, low, and high water years)	Average Water Year (see notes)	Low Water Year (see notes)	High Water Year (see notes)
Mary's River (near Deeth, Nevada) (Gaging Station 10315600)[1]	**42,210** [58.3 cfs]	**8,760** [12.1 cfs]	**62,190** [85.9 cfs]
Lamoille Creek (near Lamoille, Nevada) (Gaging Station 10316500)[2]	**32,580** [45.0 cfs]	**14,840** [20.5 cfs]	**56,250** [77.7 cfs]
Humboldt River (near Elko, Nevada) (Gaging Station 10318500)[3]	**185,340** [256 cfs]	**25,770** [35.6 cfs]	**797,090** [1,101 cfs]
South Fork Humboldt River (above Dixie Cr.) (Gaging Station 10320000)[4]	**86,880** [120 cfs]	**26,140** [36.1 cfs]	**170,130** [235 cfs]
Humboldt River (near Carlin, Nevada) (Gaging Station 10321000)[5]	**278,730** [385 cfs]	**46,040** [63.6 cfs]	**1,252,470** [1,730 cfs]
Susie Creek (at Carlin, Nevada) (Gaging Station 10321590)[6]	**7,960** [11.0 cfs]	**16,000** [22.1 cfs]	**1,300** [1.80 cfs]
Maggie Creek (at Carlin, Nevada) (Gaging Station 10322000)[7]	**23,090** [31.9 cfs]	**2,940** [4.06 cfs]	**55,310** [76.4 cfs]
Marys Creek (at Carlin, Nevada) (Gaging Station 10322150)[8]	**4,190** [5.79 cfs]	**1,990** [2.75 cfs]	**6,910** [9.54 cfs]
Humboldt River (at Palisade, Nevada) (Gaging Station 10322500)[9]	**291,040** [402 cfs]	**25,190** [34.8 cfs]	**1,336,450** [1,846 cfs]

[†] Streams have been listed sequentially by their U.S. Geological Survey (USGS) gaging station numbers. Upper Humboldt River gaging sites include those from Palisade upstream.

[‡] Gaging station runoff volumes are based on average annual rates of flow in [bracketed] cubic feet per second (cfs). Bolded figures above these rates of flow measures show the average annual corresponding runoff volumes in acre-feet. One acre-foot equals 325,851 gallons. As a conversion measure between the rate of flow and the total runoff, a continuous rate of flow of one cubic foot per second is equivalent to a total runoff of approximately 723.97 acre-feet per year.

Gaging Station Notes:

[1] For years of record 1992–1998; High water year: 1997; Low water year: 1992;

[2] For years of record 1915–1998; High water year: 1997; Low water year: 1959;

[3] For years of record 1895–1998; High water year: 1984; Low water year: 1961;

[4] For years of record 1988–1998; High water year: 1998; Low water year: 1992;

[5] For years of record 1944–1998; High water year: 1984; Low water year: 1959;

[6] For years of record 1992–1998; High water year: 1997; Low water year: 1994;

[7] For years of record 1913–1998; High water year: 1997; Low water year: 1924;

[8] For years of record 1990–1998; High water year: 1998; Low water year: 1992;

[9] For years of record 1903–1998; High water year: 1984; Low water year: 1934.

Years of record indicated above are inclusive full years and are not necessarily reflective of continuous gaging periods. See Appendix 3, Humboldt River Basin Gaging Station Records.

Source Data: *Water Resources Data, Nevada, Water Year 1998*, U.S. Geological Survey Water-Data Report NV–98–1, Nevada District Office, Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1999.

One interesting hydrologic-related observation we may make about the Humboldt River system is that for the basin's total area of approximately 16,840 square miles, the Humboldt River does not appear to be a particularly "productive" river. In comparison to the rivers of other major watersheds of northern Nevada – Truckee, Carson and Walker Rivers – the Humboldt River is not nearly as productive in terms of the relationship between its average year maximum discharge or highest rate of flow (taken at a specific gaged location where the average water year flow is the greatest, or the "maximum flow") and the basin's total drainage area or, alternatively, only for the drainage area above this location, thereby including only that portion of the total watershed actually contributing to the river's maximum or peak flow. Table 5, Northern Nevada River System 'Productivity' Comparisons, presents the complete analysis of this assessment of river productivity and comparisons between and among river systems of northern Nevada.

For example, with an average annual maximum or peak flow[78] of 291,040 acre-feet (period of record: 1903-1998) recorded at Palisade, Nevada, the Humboldt River shows a slightly lower maximum flow than the Carson River measured at the Carson City gaging location of 301,170 acre-feet per year (1940-1998).[79] But the Carson River's drainage basin has a total area of only about 3,520 square miles, or just over 20 percent of the area of the entire Humboldt River Basin. By this measure, all other things being equal, the Carson River appears to be nearly five times as water productive as the Humboldt River.

Table 5 – Northern Nevada River System "Productivity" Comparisons†

Relative Measures of "Maximum Flow" to Total Watershed and Effective Drainage Areas‡
(Ratios Measured in Acre-Feet per Year per Square Mile – af/yr/mi^2)

Basin/River System and Gaged Location	Maximum or Peak Flow‡ (acre-fee per year)	Total Basin (Watershed) Surface Area (square miles)	Effective Drainage Area (1) (square miles)	Ratio – Peak Flow to Total Basin Area (af/yr/mi^2)	Ratio – Peak Flow to Effective Drainage Area (af/yr/mi^2)
Humboldt River at Palisade, NV	291,040	16,840	5,010	17.3	58.1
Carson River at Carson City, NV	301,170	3,520	886	85.6	339.9
Truckee River at Vista (Reno, NV)	600,170	2,300	1,430	260.9	419.7
Walker River – Total (combined both forks)	310,590	3,046	609	102.0	510.0
East Fork Walker below Bridgeport, CA	107,150	—	359	—	298.5
West Fork Walker near Coleville, CA	203,440	—	250	—	813.8
Western Nevada River Systems Combined (2)	1,211,930	8,866	2,925	136.7	414.3
Times More "Productive" Relative to the Humboldt River (3)				**7.9X**	**7.1X**

† River system "productivity" measures the volume of surface water runoff in a river system at a particular (gaged) location relative to the river system's or watershed's total drainage area or its drainage area above the point of maximum flow measurement.

‡ The "maximum flow" measures the greatest annual volume of discharge (or the maximum annual average rate of flow) for an "average" water year at a particular (gaged) location along a river system or along a specific defined river reach. Above this point river flows accrete (increase) and below this point river flows attenuate (decrease) for an average water year. This measure is not to be confused with "peak year" or flood flows, which refer to a year in which the annual total river's discharge was the greatest.

(1) The effective drainage area measures the drainage area above the point on the river system at which the maximum flow is recorded. In effect, this is the surface area contributing to that maximum flow.

(2) Includes combined Carson, Truckee and total Walker River system measures.

(3) Measures the relative water productivity figures of the combined three western Nevada river systems as compared to the Humboldt River system above Palisade.

Source Data: *Water Resources Data, Nevada, Water Year 1998,* U.S. Geological Survey Water-Data Report NV–98–1, Nevada District Office, Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1999.

In comparisons to other rivers' productivity shown in Table 5, the combined maximum flows of the East Walker River measured below Bridgeport Reservoir (1922-1998) and the West Walker River recorded near Coleville (1903-1998) of approximately 310,590 acre-feet per year,[80] are produced from a drainage basin totaling 3,046 square miles, or just over 18 percent of the total area of the Humboldt River Basin. And finally, within the smallest of all the major river basins of western Nevada, the Truckee River measured at Vista below Reno shows an average peak flow of 600,170 acre-feet per year (1899-1998)[81] within a drainage basin totaling only 2,300 square miles in area, or less than 14 percent of the size of the Humboldt River Basin. Therefore, over admittedly somewhat different, but nonetheless extensive periods of record, the western Nevada waterbasins' rivers have shown a combined average annual maximum flow of 1,211,930 acre-feet within a total drainage (basin) area of 8,866 square miles. Consequently, with maximum annual river flows nearly 4.2 times greater than the Humboldt River at Palisade, and a combined drainage area equal to only 52.6 percent of that of the entire Humboldt River Basin, these western Nevada river systems appear to be 7.9 times more water productive as the Humboldt River.[82]

Another, and more realistic way to assess these rivers' differences in water productivity is to use only the drainage areas above the location where these respective maximum river flows occur, thereby including only the surface areas actually contributing to the maximum flow. In this manner, the western Nevada watershed rivers' combined maximum flow actually comes from an effective drainage area of 2,925 square miles (versus 8,865 square miles for these basins' combined total area), while the effective drainage area above the Palisade gage on the Humboldt River totals 5,010 square miles (versus a total basin area of 16,843 square miles). Even by this measure, however, the water productivity of these western Nevada rivers is still 7.1 times greater than that of the Humboldt River above Palisade.[83]

Several explanations exist for the apparent differences in water productivity, whether on a total watershed basis or a drainage area-only basis, between the Humboldt River and those river systems of western Nevada. One possible explanation is the differences in the geography and topography of these northern Nevada watersheds, and that the Humboldt River Basin lies, at least partially, in the rain shadow of the Sierra Nevada. The western Nevada river systems tend to have a far greater proportion of their areas in high-elevation, mountainous drainages which provide considerably greater snowpack accumulation and potential runoff relative to the basins' total surface areas. This is particularly true for the drainage areas above these rivers' maximum flow locations. For example, the 506-square mile Lake Tahoe Basin comprises nearly 17 percent of the total Truckee River Basin or over 35 percent of the basin's drainage area above the Truckee River's point of maximum flow, which is measured at the Vista gage located just below Reno, Nevada.

Within the Humboldt River Basin, by contrast, the basin and range nature of much of this watershed results in far less area found in high-elevation mountainous watersheds and a far greater proportion of the basin lying in lowland valleys. These lowland valley areas make virtually no contribution to surface water flows (except during flood periods) in the Humboldt River system (but do contribute, to some degree, to groundwater recharge). This is especially true when considering that many of these lowland areas, while receiving annual average precipitation of only 6-8 inches also experience evaporation rates of over 40 inches per year.

Table 6 – Lower Humboldt River Principal Stream Flows†

Average Annual Runoff Volumes in Acre-Feet [Flow Rates in Cubic Feet per Second]‡

By USGS Gaging Station Location (Listed by Gaging Station Number—See notes on respective average, low, and high water years)	Average Water Year (see notes)	Low Water Year (see notes)	High Water Year (see notes)
Humboldt River (at Dunphy, Nevada) (Gaging Station 10323425)[1]	**328,680** [454 cfs]	**57,770** [79.8 cfs]	**527,050** [728 cfs]
Rock Creek (near Battle Mountain, Nevada) (Gaging Station 10324500)[2]	**29,900** [41.3 cfs]	**1,640** [2.27 cfs]	**170,130** [235 cfs]
Humboldt River (at Battle Mountain, Nevada) (Gaging Station 10325000)[3]	**270,040** [373 cfs]	**39,460** [54.5 cfs]	**643,610** [889 cfs]
Humboldt River (at Comus, Nevada) (Gaging Station 10327500)[4]	**246,150** [340 cfs]	**26,640** [36.8 cfs]	**1,463,870** [2,022 cfs]
Little Humboldt River (near Paradise Valley) (Gaging Station 10329000)[5]	**16,650** [23.0 cfs]	**5,620** [7.76 cfs]	**58,060** [80.2 cfs]
Martin Creek (near Paradise Valley) (Gaging Station 10329500)[6]	**25,340** [35.0 cfs]	**5,920** [8.18 cfs]	**78,190** [108 cfs]
Humboldt River (near Imlay, Nevada) (Gaging Station 10333000)[7]	**206,330** [285 cfs]	**18,820** [26.0 cfs]	**1,460,250** [2,017 cfs]
Humboldt River (below Rye Patch Reservoir) (Gaging Station 10335000)[8]	**184,610** [255 cfs]	**21,140** [29.2 cfs]	**1,450,840** [2,004 cfs]

† Streams have been listed sequentially by their U.S. Geological Survey (USGS) gaging station numbers. Lower Humboldt River gaging sites include those downstream from the Palisade gage.

‡ Gaging station runoff volumes are based on average annual rates of flow in [bracketed] cubic feet per second (cfs). Bolded figures above these rates of flow measures show the average annual corresponding runoff volumes in acre-feet. One acre-foot equals 325,851 gallons. As a conversion measure between the rate of flow and the total runoff, a continuous rate of flow of one cubic foot per second is equivalent to a total runoff of approximately 723.97 acre-feet per year.

Gaging Station Notes:

[1] For years of record 1991–1998; High water year: 1997; Low water year: 1992;

[2] For years of record 1918–1998; High water year: 1984; Low water year: 1994;

[3] For years of record 1897–1998; High water year: 1971; Low water year: 1955;

[4] For years of record 1895–1998; High water year: 1984; Low water year: 1920;

[5] For years of record 1975–1998; High water year: 1984; Low water year: 1992;

[6] For years of record 1922–1998; High water year: 1984; Low water year: 1931;

[7] For years of record 1935–1998; High water year: 1984; Low water year: 1955;

[8] For years of record 1936–1998; High water year: 1984; Low water year: 1955.

Years of record indicated above are inclusive full years and are not necessarily reflective of continuous gaging periods. See Appendix 3, Humboldt River Basin Gaging Station Records.

Source Data: *Water Resources Data, Nevada, Water Year 1998,* U.S. Geological Survey Water-Data Report NV–98–1, Nevada District Office, Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1999.

Another possible explanation for these differences in runoff and surface areas lies in differences between these watersheds in terms of the water-holding and infiltration capacity of the soils. In one particular analysis using solely data provided by the U.S. Geological Survey, two somewhat similar drainage areas were examined for hydrologic differences. One drainage area included the region above the Norther Fork Humboldt River gage (which is no longer in operation) in the Humboldt River Basin and the other area was the lands in the Carson River Basin above the Carson River gage at Carson City. The North Fork drainage surface area totaled approximately 830 square miles, had a mean basin elevation of 7,000 feet MSL, and averaged 14 inches of precipitation per year.[84] The Carson River drainage above the USGS Carson City gaging station had a total area (above the gage) of 886 square miles, a mean basin elevation of 7,100 feet MSL and an average of 12 inches of precipitation per year.[85] Total precipitation was estimated at nearly 620,000 acre-feet per year in the North Fork watershed and about 567,000 acre-feet in the Carson River watershed.[86]

Using 47 years of systematic record, the mean discharge of the North Fork watershed measured at Devil's Gate near Halleck was about 54,190 acre-feet. This equated to only 8.7 percent of total precipitation appearing as surface runoff. For the Carson River watershed, using 59 years of record, the mean discharge was about 301,400 acre-feet, producing a significantly larger 53.2 percent of total precipitation appearing as surface water runoff at the Carson City gage. From this analysis, it would appear reasonable to conclude that the water-holding capacity and infiltration rates of the upland and floodplain soils in the Humboldt River's North Fork sub-basin, at least, are considerably greater, overall, than those of the Carson River Basin above Carson City.

Aside from hydrologic, geographic, topographic and climatologic considerations, another important reason for this significant difference in water productivity measures between these rivers of northern Nevada has to do with the varied irrigation requirements along these basins' river systems. For the most part, the drainage areas above the rivers' maximum flow points within the western Nevada watersheds are not as extensively irrigated as within the Humboldt River system. The combined total irrigated acreage located above the maximum flow locations on the Truckee, Carson and Walker River systems is estimated at less than 100,000 acres.[87] For the Humboldt River above Palisade, estimates of decreed water-righted irrigated acreage total over 150,000 acres and decreed water rights total almost 400,000 acre-feet.[88] Allowing for differences in consumptive use[89] and leaching requirements,[90] actual water use and re-use in the upper Humboldt River Basin may be greater than this amount. Other sources for these estimates put the total irrigated acreage for all of Elko County, most of which lies above the Palisade gage, at nearly 200,000 acres and total water withdrawals[91] at over 900,000 acre-feet in 1997, to include overland flooding and water re-use.[92]

Beginning with some perceptive observations made by early emigrants about the geography of the Humboldt River Valley,[93] the Humboldt River Basin has been either geographically, climatologically or hydrologically divided into an upper basin and a lower basin at Palisade Canyon. The water rights adjudication process of the 1930's more precisely marked this division hydrologically at the USGS gaging station at Palisade. Early court decisions adjudicating the river's water rights (see "Humboldt River Water Rights, Adjudication, and Related Court Decrees" later in Part I) used this location in recognizing the climatological differences in crop irrigation requirements and watering periods between irrigated lands in the upper and lower basins, noting the earlier start and later finish for the growing season in the lower basin (i.e., March 15 through September 15) than in the upper basin (i.e., April 15 through August 15) by decree.

Analysis of the stream flows in Tables 4 and 6, point out one particular problem created by using river flow readings between gaging stations with significantly different inclusive periods of record and especially different contiguous periods of record. In viewing Table 4 for average water year Humboldt River flows at Palisade (291,040 acre-feet per year) and then Table 6 at the first gage located downstream from Palisade at Dunphy (328,680 acre-feet per year), it appears that Humboldt River flows continue increase below Palisade. The reason for this apparent discrepancy lies in the different periods of record for these specific gages. Specifically, the Palisade gage's record extends back to 1903 and the period of record for the Dunphy gage (located below Palisade) extends back only to 1991 (although some earlier records do exist). Consequently, the Dunphy gage will tend to overstate long-term average river flows at this location by omitting all or some of the most severe drought periods on record for this river system, i.e., the early 1930's and the late 1980's and early 1990's, readings which are included in the Palisade gage's period of record.

One question that frequently arises with respect to Humboldt River system flows is the estimated flood-flow contribution to Humboldt River flows of the Reese River and the Little Humboldt River. Despite the rather extensive system of gaging stations that exist on the Humboldt River system, a number of which are presented in Tables 4 and 6, outflows of these two sub-basins are not monitored by the U.S. Geological Survey or the Nevada Division of Water Resources due to their infrequent (i.e., flood-only) discharges. Furthermore, differences in the periods of record for gages above and below these rivers' respective inflows effectively preclude the use of analyzing flow differences during flood years to estimate these streams' contribution to Humboldt River flows. However, one particular study for the Reese River did make estimates of these high-water year outflows into the Humboldt River. The authors of that report estimated that the average outflow of the Reese River was 5,000 acre-feet per year, but the occurrence of outflow was only about once every 15 years on the average.[94] Consequently, this implied an average flood year contribution to the Humboldt River from the Reese River of about 75,000 acre-feet.[95]

Another report noted that during the water years of 1953 and 1958, a total of about 58,000 acre-feet was artificially drained from Gumboot Lake and the lower Little Humboldt River by dredging through the Sand Dunes formation at the lower end of Paradise Valley.[96] It is also perhaps noteworthy that the total discharge recorded during the 1952 water year at the Little Humboldt River gage above Paradise Valley[97] was about 64,330 acre-feet and the total discharge recorded at the Martin Creek gage where it enters Paradise Valley[98] was 63,940 acre-feet. The sum of these two discharges is 128,270 acre-feet, only slightly less than the sum of the corresponding discharge of the Little Humboldt River of 136,500 acre-feet recorded during the high water year of 1984.[99]

Table 7, Humboldt River Main Stem Flows, provides a summary of selected gaging station average water year stream flow information extracted from Tables 4 and 6 for only Humboldt River main stem gages over more consistent (and relatively extended) periods of record. Gaging stations in this table are listed in upstream to downstream order and more clearly show the Humboldt River's flow accretion (increase) above the Palisade gaging station site and the river's attenuation (decrease) below this point under normal, or average water year flow conditions. Table 7 shows that between the Humboldt River's Elko gage and its Palisade gage, average annual flows increase by 105,700 acre-feet, or 57 percent. Between Palisade and Imlay, which is located just above Rye Patch Reservoir, Humboldt River average flows decline by 106,710 acre-feet, or nearly 37 percent.

Analysis of the gaged river flow information in Table 7 tends to support the concept of a hydrologic "division" of the Humboldt River Basin at Palisade based on the increase (accretion) in Humboldt River flows above the USGS Palisade gage and the decrease (attenuation) in river flows below Palisade. Disregarding different periods of record, Table 7 also shows that the cumulative change in the Humboldt River's flow between Elko and Imlay is practically zero, meaning that the accretion in river flows between Elko and Palisade is virtually eliminated by the affects of attenuation in flows between Palisade and Imlay.[100] This may be seen in the "Cumulative Change" column in Table 7.

Table 7 – Humboldt River Main Stem Flows†

Average Annual Runoff Volumes (Acre-Feet) for Main Stem Gaging Stations Only

USGS Humboldt River Gage	Average Year Flow (Acre-Feet)	Increase or (Decrease) (AF)*	Cumulative Change (AF)*	Period of Record (Total)
Humboldt River – Elko	185,340	—	—	1895-1998
Humboldt River – Carlin‡	278,730	93,390	93,390	1944-1998
Humboldt River – Palisade	291,040	12,310	105,700	1903-1998
Humboldt River – Battle Mountain	270,040	(21,000)	84,700	1897-1998
Humboldt River – Comus	246,150	(23,890)	60,810	1895-1998
Humboldt River – Imlay‡	206,330	(39,820)	20,990	1935-1998
Humboldt River – Lovelock Valley‡+	184,610	(22,000)	(1,010)	1936-1998

† Includes only those U.S. Geological Survey (USGS) gaging stations on the Humboldt River main stem.

‡ Average year flows tend to be overstated (too high) due to the shorter period of records not including the extreme drought period of the early 1930's.

* Measured from immediate upstream gage.

\+ Measures outflows immediately downstream from Rye Patch Reservoir

Source Data: *Water Resources Data, Nevada, Water Year 1998*, U.S. Geological Survey Water-Data Report NV–98–1, Nevada District Office, Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1999.

Hydrologic Delineation of the Humboldt River Basin: USGS's "Hydrologic Units" versus Nevada's "Hydrographic Areas"

The Nevada Division of Water Resources, Department of Conservation and Natural Resources, in cooperation with the U.S. Geological Survey (USGS), Water Resources Division (WRD), have divided the State of Nevada into discrete hydrologic units called hydrographic areas (and sub-areas) for water planning and management purposes. A hydrographic area is defined as a discrete surface drainage area, normally consisting of a defined valley or a portion of a valley possessing distinctive hydrologic and geographic properties. Using this drainage system classification concept within Nevada, there have been identified 232 hydrographic areas with some areas sub-divided into hydrographic sub-areas (resulting in 256 hydrographic areas and sub-areas, combined). These hydrographic areas and sub-areas comprise the 14 major hydrographic regions or water basins which cover Nevada.

On the other hand, the USGS Hydrologic Unit Classification Code system provides a means by which the entire United States has been divided and subdivided into successively smaller hydrologic units for analysis purposes.[101] By this classification system, the continental U.S. and its territories and possessions have been classified into four levels consisting of 21 major water resources "regions" (i.e., Region 16, Great Basin), which are sub-divided into 222 "subregions" (i.e., Sub-Region 1604, Black Rock Desert - Humboldt), which are further sub-divided into 352 "accounting units" (Accounting Unit 160401, Humboldt River Basin), which are ultimately sub-divided into 2,149 "cataloging units". Within the Humboldt River Basin the USGS has identified nine cataloging units. These cataloging units are presented in Table 8, USGS Humboldt River Basin Hydrologic Cataloging Units, which also shows the cataloging units' surface areas and the corresponding Nevada hydrographic areas and sub-area contained within each defined USGS cataloging unit.

Table 8 – USGS Humboldt River Basin Hydrologic Cataloging Units

USGS Hydrologic Cataloging Units Conversion to Nevada Hydrographic Areas/Sub-Area

Region 16–Great Basin; Sub-Region 1604–Black Rock Desert-Humboldt; Accounting Unit 160401–The Humboldt River Basin, Nevada; Cataloging Units 16040101 through 16040109 (Listed Below)

USGS Cataloging Units	Area (sq. miles)	Area (acres)	Nevada Hydrographic Area Number and Name
01 – Upper Humboldt River	2,720	1,740,790	**42**–Mary's River; **43**–Starr Valley; **45**–Lamoille Valley; **49**–Elko Segment; **50**–Susie Creek; **51**–Maggie Creek; **52**-Marys Creek
02 – North Fork Humboldt	988	632,320	**44**–North Fork Humboldt River
03 – South Fork Humboldt	1,270	812,800	**46**–South Fork; **47**–Huntington Valley; **48**–Dixie Creek-Tenmile Creek
04 – Pine Valley	985	630,400	**53**–Pine Valley
05 – Middle Humboldt River	3,180	2,035,190	**54**–Crescent Valley; **55**–Carico Lake Valley; **60**–Whirlwind Valley; **61**–Boulder Flat; **64**-Clovers; **65**–Pumpernickel Valley; **66**–Kelly Creek Valley
06 – Rock Creek	888	568,320	**62**–Rock Creek Valley; **63**–Willow Creek
07 – Reese River	2,310	1,478,390	**56**–Upper Reese River Valley; **57**–Antelope Valley; **58**–Middle Reese River Valley; **59**–Lower Reese River Valley
08 – Lower Humboldt River	2,590	1,657,590	**70**–Winnemucca Segment; **71**–Grass Valley; **72**–Imlay; **73**–Lovelock Valley; **73A**–Lovelock Valley/Oreana; **74**–White Plains
09 – Little Humboldt River	1,740	1,113,600	**67**–Little Humboldt Valley; **68**–Hardscrabble; **69**–Paradise Valley

Source Data: State Engineer's Office, Nevada Division of Water Resources, Department of Conservation and Natural Resources; U.S. Geological Survey (USGS), Water Resources Division (WRD).

Irrespective of the delineation by which a region's hydrology is analyzed, the basic (i.e., lowest level) hydrologic classification unit of study within Nevada remains the hydrographic area (or sub-area). In the following section, the 33 hydrographic areas and one hydrographic sub-area contained within the Humboldt River Basin will be combined in a slightly different manner to form eleven sub-basins. These designated sub-basins will then be used to assess various regional characteristics with respect to geography and topography, history and development, hydrology, climate and vegetation patterns. Figure 7, Humboldt River Basin Hydrographic Areas, found in the next section, presents a map of the Humboldt River basin with each of the 33 hydrographic areas and one sub-area delineated. Appendix 1 at the end of this Part I provides more detailed information on these hydrographic areas and sub-area.

Humboldt River Sub-Basin Analysis

Overview

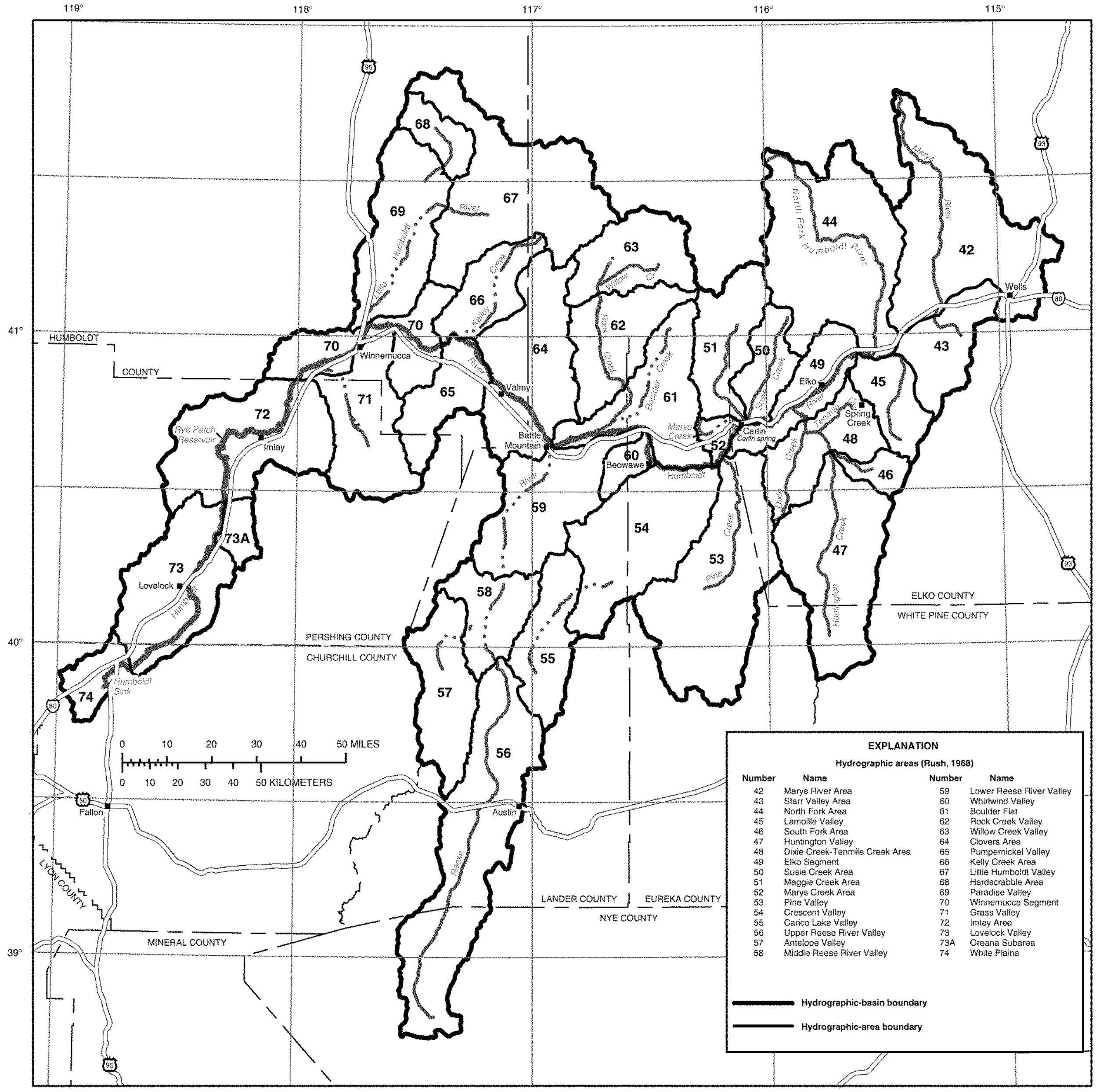
Due to the vast extent of the Humboldt River Basin and the unique geographic, hydrologic and floristic characteristics of its various principal drainage areas, the more expansive hydrographic basin has been dis-aggregated and will be analyzed from a sub-basin perspective. In this regard, the Humboldt River Basin can be divided into eleven sub-basins, each possessing relatively unique geography, topography, geology, climatology and hydrology. The Humboldt River Basin's sub-basins, listed in a general ordering from upper basin to lower basin, consist of the following:[102]

(1) Mary's River
(2) Ruby Mountains
(3) North Fork
(4) Maggie Creek
(5) Elko Reach
(6) Pine Valley
(7) Reese River
(8) Battle Mountain
(9) Little Humboldt River
(10) Sonoma Reach
(11) Lovelock Reach

Table 9, Defined Humboldt River Basin Sub-Basins, lists the principal sub-basins of the Humboldt River Basin and, for purposes of this analysis, their relationship to the basin's 33 hydrographic areas and one sub-area, along with each sub-basin's counties of coverage, surface areas and the hydrographic numbered areas and sub-area contained within each respective sub-basin. Also, Appendix 1 to this part lists all the Humboldt River's Hydrographic Areas and Sub-Area and certain information for each.

In terms of our convention of defining an upper and lower Humboldt River Basin, the upper Humboldt River Basin includes the Mary's River, Ruby Mountains, North Fork, Maggie Creek and Elko Reach sub-basins. The lower Humboldt River Basin includes the Pine Valley, Reese River, Battle Mountain, Little Humboldt River, Sonoma reach and Lovelock Reach sub-basins. This dividing point is determined at the USGS Palisade gaging station, which lies just upstream from the inflow of Pine Creek (discharging from Pine Valley).

Figure 7, Humboldt River Basin Hydrographic Areas, presents a map of the Humboldt River Basin and the location of the 33 hydrographic areas and one sub-area (73A, Orena). More detailed information on these hydrographic areas may be found in Appendix 1 at the end of Part I. [Note: For information on the relative location of Nevada's fourteen hydrographic regions and basins that are referred to in this section and their relationship to the Humboldt River Basin, see Figure 2, Nevada Hydrographic Regions and Basins, on page ix in the front portion of this volume.]



Hydrographic areas (Rush, 1968)

Number	Name	Number	Name
42	Marys River Area	59	Lower Reese River Valley
43	Starr Valley Area	60	Whirlwind Valley
44	North Fork Area	61	Boulder Flat
45	Lamoille Valley	62	Rock Creek Valley
46	South Fork Area	63	Willow Creek Valley
47	Huntington Valley	64	Clovers Area
48	Dixie Creek-Tenmile Creek Area	65	Pumpernickel Valley
49	Elko Segment	66	Kelly Creek Area
50	Susie Creek Area	67	Little Humboldt Valley
51	Maggie Creek Area	68	Hardscrabble Area
52	Marys Creek Area	69	Paradise Valley
53	Pine Valley	70	Winnemucca Segment
54	Crescent Valley	71	Grass Valley
55	Carico Lake Valley	72	Imlay Area
56	Upper Reese River Valley	73	Lovelock Valley
57	Antelope Valley	73A	Oreana Subarea
58	Middle Reese River Valley	74	White Plains

Base from U.S. Geological Survey digital data, 1:100,000, 1977-88;
Universal Transverse Mercator projection, Zone 11

Figure 7 – Humboldt River Basin Hydrographic Areas
(Courtesy of U.S. Geological Survey (USGS), Water Resources Division, Carson City, Nevada)

Table 9 – Defined Sub-Basins and Hydrographic Areas and Sub-Area
(Humboldt River Sub-Basins Listed in General Upstream to Downstream Order)

HUMBOLDT RIVER SUB-BASINS†	County(ies)‡	Surface Area (acres)	Surface Area (sq. mi.)	Percent of Total Basin	Nevada Area* Numbers
Mary's River Sub-Basin	Elko	686,720	1,073	6.4%	42
Ruby Mountains Sub-Basin	Elko, White Pine	1,194,880	1,867	11.1%	43, 45 46, 47, 48
North Fork Sub-Basin	Elko	710,400	1,110	6.6%	44
Maggie Creek Sub-Basin	Elko, Eureka	396,160	619	3.7%	50, 51
Elko Reach Sub-Basin	Elko, Eureka, Lander	240,000	375	2.2%	49, 52
Pine Valley Sub-Basin	Eureka, Elko	641,280	1,002	6.0%	53
Reese River Sub-Basin	Lander, Eureka, Nye	2,320,000	3,625	21.5%	54, 55, 56 57, 58, 59
Battle Mountain Sub-Basin	Elko, Lander, Eureka, Humboldt	1,605,120	2,508	14.9%	60, 61, 62 63, 64, 66
Little Humboldt River Sub-Basin	Humboldt, Elko	1,114,880	1,742	10.3%	67, 68, 69
Sonoma Reach Sub-Basin	Humboldt, Pershing	802,560	1,254	7.4%	65, 70, 71
Lovelock Reach Sub-Basin	Pershing, Churchill	1,067,520	1,668	9.9%	72, 73 73A, 74
Total Humboldt River Basin		**10,779,520**	**16,843**		

† Upper Humboldt River basin sub-basins consist of Mary's River, Ruby Mountains, North Fork, Maggie Creek and Elko Reach; Lower Humboldt River basin sub-basins include Pine Valley, Reese River, Battle Mountain, Little Humboldt River, Sonoma Reach and Lovelock Reach.

‡ Counties listed in order of area of coverage. All Humboldt River sub-basins lie wholly within Nevada.

* See Appendix 1 for description of these Hydrographic Areas and Sub-Area.

Source Data: *Humboldt River Basin, Nevada, Water and Related Land Resources* and *Nevada Hydrographic Basin Statistical Summary*.

Mary's River Sub-Basin

The Mary's River[103] sub-basin is a southward-draining tributary to the Humboldt River located in the north-central portion of Elko County, Nevada. By means of primarily the Mary's River, this sub-basin drains the farthermost extent of the Humboldt River system. The sub-basin is identified hydrographically as Nevada Hydrographic Area 42, Mary's River Area, and encompasses a surface area of 1,073 square miles. Among the eleven sub-basins within the Humboldt River Basin, the Mary's River sub-basin ranks as the eighth largest with 6.4 percent of the basin's total surface area. The Mary's River sub-basin encompasses the northeastern drainages of the Humboldt River system to include the upper reach of the Humboldt River lying above the town of Deeth, Nevada, including the upper Humboldt River's principal tributary streams of Tabor Creek, Burnt Creek, Bishop Creek and Town Creek. Also included are the smaller drainage areas to the east of Wells and, most importantly, the drainage area of Mary's River and its various tributaries.

Principal tributaries of Mary's River include "T" (Anderson) Creek, Hanks Creek, Currant Creek, Storm (Tom Cain) Creek, Hot Creek, Wildcat Creek and Meadow Creek. It has been estimated that approximately 96 percent of the surface water emanating from this sub-basin comes from the Mary's River alone.[104] The Mary's River extends northward up into the southern portion of the Jarbidge Mountains, just below Mary's River Peak (10,565 feet MSL) and Fox Creek Peak (9,551 feet MSL), some 50 miles above its confluence with the Humboldt River main stem at Deeth.

The lower portion of the Mary's River sub-basin between Wells and Deeth have figured prominently in Nevada's early history as a gateway for emigrant wagon trains heading for California. Basically, two routes were open to early travelers using the Overland Emigrant Trail route through north-central Nevada. The northern, or Fort Hall route came down from the northeast (Thousand Springs Valley) and joined the Humboldt River at Wells (then referred to as Humboldt Wells), while the more southern route used the longer Hastings Cutoff route. This route led the early emigrant wagon trains across the southern portion of the Great Salt Lake Desert, entered Nevada at Pilot Peak (10,704 feet MSL), then led early travelers south along the eastern side of the Ruby Mountains, across Overland Pass (then called Hastings Pass), and then north through Huntington Valley and along Huntington Creek to its confluence with the South Fork of the Humboldt. From there, the route followed the South Fork to the Humboldt River main stem through the narrow South Fork canyon, coming out about eight miles downstream from present-day Elko, Nevada.

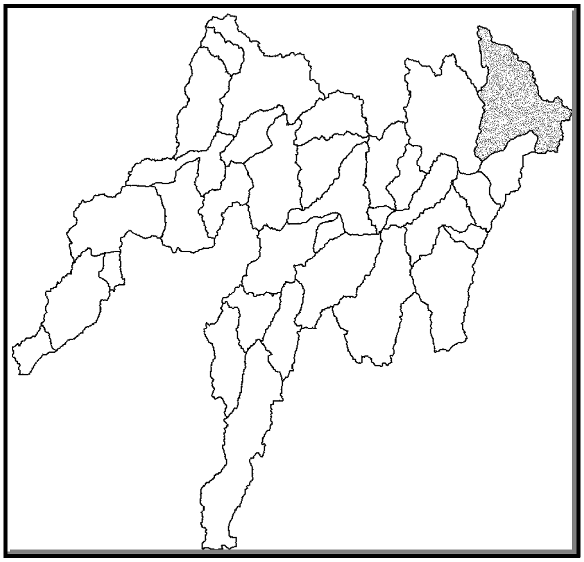


Figure 8 – Mary's River Sub-Basin

The longer and considerably more difficult Hastings Cutoff route added about 10 days to the emigrants' travel time compared to the more direct northern route. Once this route's many drawbacks were more fully publicized, it was virtually abandoned by the early 1850's. The shorter Fort Hall route separated from the Oregon Trail in southern Idaho, entered Nevada in the extreme northeastern corner of Elko County, headed up Goose Creek and then over to Rock Spring Creek and down to the junction with Thousand Springs Creek. From here the trail led up through Thousand Springs Valley and across Summer Camp Ridge and into the Humboldt River Basin near the headwaters of Bishop Creek. From there the route led down Town Creek to Humboldt Wells, later becoming present-day Wells. From this resting area, with its plentiful water and abundant forage, the wagon trains then proceeded down virtually the entire length of the Humboldt River, a distance of some 300 arduous miles.

The extreme conditions of the "White Winter" of 1889-90 were especially devastating on large cattle ranching operations in the upper Humboldt River Basin as ranchers recognized the need to restrict open-range grazing operations and raise more forage for winter feed. This winter event, with its enormous livestock losses, effectively brought to an end the practice of open-range grazing operations during the winter months without the use of supplemental feed stocks. By one account, it was noted that after this extremely hard winter, one supposedly could walk from Wells, Nevada for 100 miles to the Mary's River fork of the Humboldt River and never step off the carcasses of cows that died during this period.[105] From this time forward, the cultivation of irrigated native grasses and alfalfa hay for winter livestock feeding became a major agricultural pursuit throughout the entire Humboldt River Basin.[106] These activities intensified the concerns over Humboldt River water rights issues as now the basin's ranchers were forced to increase their forage stocks through even greater irrigation diversions and multiple hay croppings throughout the growing season.

In the early twentieth century, the Mary's River sub-basin experienced an aborted attempt at colonization. In May 1910, the Pacific Reclamation Company, a corporation composed of eastern capitalists, embarked upon an ambitious settlement, land development, and reclamation project in the lower portion of the Mary's River sub-basin. Approximately 40,000 acres of land at the mouth of Bishop Creek (Emigration) Canyon were purchased and by 1912 the company had constructed an earth-rock fill dam on Bishop Creek and a diversion canal to irrigate 30,000 acres of land in the valley below. A town named Metropolis was created, along with a $100,000 brick hotel, a brick school (Lincoln School), city streets, electric lights and parks. In December 1911, the Southern Pacific Railroad opened a branch office and by 1914 the area's population had grown to almost 1,000 persons. By 1912, problems with water rights on Bishop, Burnt and Trout Creeks had dramatically reduced the project's irrigable acreage from 30,000 acres to only 3,000 acres. Attempts at dryland farming, the first time this had ever been tried on any measurable scale in Nevada, proved disastrous after the wet year of 1914. By 1924 the population had shrunk to only 200 persons, the railroad was dismantled in 1925, and droughts and the depression era of the 1930's eventually finished off the town. Today, only scattered ruins of the town remain; however, the Bishop Creek Reservoir (sometimes still referred to as Metropolis Reservoir) and the diversion canal still exist, but the reservoir cannot be used due to extensive leaks.[107]

Topographically, the Mary's River sub-basin may be divided into three distinct parts to include the mountain highlands, the valley uplands, and the valley lowlands. The lowest part of the sub-basin is located at Deeth at an elevation of 6,000 feet MSL. The sub-basin is bound to the east by the Snake Mountains, to the north and northwest by the Jarbidge Mountains, to the southeast by the Windemere Hills and to the south by the northern portion of the East Humboldt Range. In the western portion of the sub-basin, the north-south Mary's River drainage area is separated from the drainage area of the North Fork Humboldt River to the west by a relatively low range of hills. The Humboldt River runs through the southernmost portion of the Mary's River sub-basin and exits the sub-basin to the southwest. Other Humboldt River sub-basins bordering the Mary's River sub-basin include the Ruby Mountains sub-basin to the south and the North Fork sub-basin to the west. To the north and northwest, the Mary's River sub-basin borders the Snake River Basin (Nevada Hydrographic Region 3); to the east it borders the Great Salt Lake Basin (Nevada Hydrographic Region 11); and to the southeast it borders the Central Region (Nevada Hydrographic Region 10).

Due to its relatively wide variation in altitude, from mountain peaks well over 10,000 feet MSL in the Jarbidge Mountains in the north to 6,000 feet at the confluence with the Humboldt River in the south, this sub-basin also shows considerable variation in both its climate and precipitation and, consequently, in its land uses and vegetation. Climatological data show an average annual precipitation in the south end of the Jarbidge Mountains (upper Mary's River watershed) to be approximately 35 inches at elevations above 9,000 feet MSL and about 30 inches for elevations between 8,000 and 9,000 feet MSL. Beyond the influences of the lofty Jarbidge Mountains, sub-basin elevations at between 8,000 and 9,000 feet MSL show about 20 inches of annual precipitation and in the lower valleys where most of the irrigation is conducted, the sub-basin's precipitation averages only about nine inches per year. Virtually all precipitation received by the Humboldt River's sub-basins occurs during the winter months and is typically in the form of snow at the higher elevations and rain-snow at the lower elevations.

Sagebrush-grass constitutes the predominant plant cover over much of the Mary's River sub-basin. In addition, along the Mary's River from Deeth, located on the Humboldt River main stem, to the lower narrows above the Mary's River Ranch (located approximately 20 miles upstream from Deeth), irrigated hay meadows are found interlaced with willows (*Salix spp.*) and rabbitbrush (*Chrysothamnus nauseosus*). Extensive rabbitbrush areas are also found along the bottoms of the drainages above Deeth. Between the lower narrows on the Mary's River and the Humboldt Forest boundary there exist thin stringers of willow interspersed with scattered cottonwood trees (*Populus fremontii*). In the Jarbidge Mountains throughout the Mary's River headwaters the willow and cottonwood stands give way to Great Basin wildrye (*Elymus cinereus*) meadows and at the upper elevations the meadow grasses yield to stands of aspen trees (*Populus tremuloides*) along the stream bottoms and in the small basins which, in turn, give way to clumps of subalpine fir (*Abies lasiocarpa*) on the more favorable north and west exposures. Also along the upper elevation slopes throughout the basin are found extensive areas of curl-leaf mountain mahogany (*Cercocarpus ledifolius*) and small amounts of limber pine (*Pinus flexilis*).

Throughout this sub-basin, much of the native Great Basin wildrye, Indian ricegrass (*Oryzopsis hymenoides*), and Nevada bluegrass (*Poa nevadensis*) has disappeared entirely due to many years of extensive grazing operations by domestic livestock, both cattle and sheep. Significant expanses of these native species of ryegrass-bluegrass-wheatgrass understory can now only be found on protected national forest lands or in remote or inaccessible areas of the sub-basin. In other well-grazed areas, most of the perennial grass understory has been replaced with the invasive, exotic annual cheatgrass (*Bromus tectorum*) and other less desirable browsing and forage plants such as big sagebrush (*Artemisia tridentata*), Sandberg bluegrass (*Poa secunda*), bottlebrush squirreltail (*Sitanion hystrix*) and small amounts of needlegrass (*Stipa spp.*).

The more saline or alkali-laden sites within the Mary's River sub-basin have seen increased growth of greasewood (*Sarcobatus vermiculatus*) and saltgrass (*Distichlis stricta*).[108] In many areas of the sub-basin, as generally found throughout the entire Humboldt River Basin, the decline in these soil and moisture-holding perennial native grass species has had a telling effect on the land's water-holding capacity and severely accelerated the effects of erosion. As one indication of the deteriorated and weakened condition of the native grasses on the open ranges in the Humboldt River Basin, this sub-basin holds the distinction for being the site of the discovery of the invasive toxic plant halogeton (*Halogeton glomeratus*), which was found south of Wells in 1934.

Ruby Mountains Sub-Basin

The Ruby Mountains[109] sub-basin is a northward-draining tributary to the Humboldt River located in the southwestern portion of Elko County and extending south from the Humboldt River main stem into the northwest portion of White Pine County, which includes the upper reach and tributaries of Huntington Creek and the extreme southern portion of the Ruby Mountains. The Ruby Mountains sub-basin is bordered by the Mary's River sub-basin to the north, the North Fork Humboldt River and Elko Reach sub-basins to the northwest, and the Pine Valley sub-basin to the west. To the southwest, south and east, the Ruby Mountains sub-basin is bordered by the Central Region (Nevada Hydrographic Region 10).

The Ruby Mountains sub-basin includes five of Nevada's hydrographic areas lying within the Humboldt River Basin and covers a total surface area of 1,867 square miles. In terms of the other sub-basins within the Humboldt River Basin, the Ruby Mountains sub-basin ranks as the third largest with 11.1 percent of the basin's total surface area. The five hydrographic areas contained within the Ruby Mountains sub-basin include: (1) Starr Valley, hydrographic area 43, covering 332 square miles; (2) Lamoille Valley, hydrographic area 45, covering 257 square miles; (3) South Fork Area, hydrographic area 46, covering 99 square miles; (4) Huntington Valley, hydrographic area 47, covering 787 square miles; and (5) the Dixie Creek and Tenmile Creek Area, hydrographic area 48, covering 392 square miles.

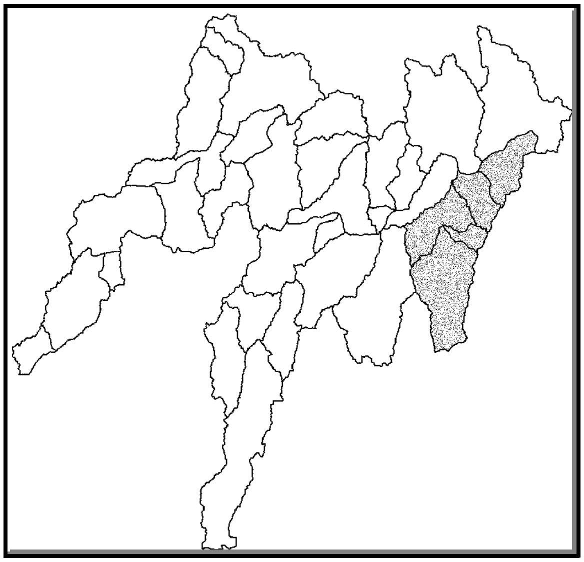


Figure 9 – Ruby Mountains Sub-Basin

The Ruby Mountains sub-basin drains the extreme upper southeast portion of the Humboldt River system covering the drainages of the western slopes of the Ruby Mountains and East Humboldt Range in the eastern portion of the sub-basin and the Sulphur Spring and Pinon Mountain ranges in the western portion of the sub-basin. Major drainage areas within the sub-basin include Huntington Valley, Dixie Valley and the Lamoille-Starr Valley area. The South Fork of the Humboldt River constitutes the principal stream within the sub-basin, receiving the waters of both Huntington Creek and Dixie Creek before its confluence with the Humboldt River main stem some eight miles below Elko, Nevada. Lamoille Creek, the other principal source of outflow from this sub-basin, drains part of the northern and central Ruby Mountain range and meets the Humboldt River main stem approximately three miles below Halleck, Nevada. Starr Valley, located in the northeastern portion of the Ruby Mountains sub-basin, and the western slopes of the East Humboldt Range, are drained by a number of smaller creeks to include Greys Creek, Ackler Creek, Deering Creek, Boulder Creek, Stephens Creek and Reed Creek.

Historically, the Ruby Mountains sub-basin played only a secondary role in early westward migration to California. The Ruby Mountains and East Humboldt Range to the north, which extend down the entire eastern side of the sub-basin, afforded a serious impediment to early explorers and particularly emigrant wagon trains. The first emigrant party to use the Overland Trail down the Humboldt River Valley, the Bartleson-Bidwell Party, came through the Ruby Mountain sub-basin in 1841. Recognizing the difficulties that lay ahead, they decided to abandon their wagons to the east of the Ruby Mountains sub-basin at the base of the Pequop Mountains. From there they proceeded south along the western side of Ruby Valley to near Franklin Lake, and then traversed the Ruby Mountains more easily as a pack train, using the Harrison Pass route,[110] which leads directly into the middle portion of Huntington Valley on the western side of the Ruby Mountains. From there they traveled north and down Huntington Creek and then the South Fork of the Humboldt River to the river's main stem. As Harrison Pass was too step and rugged for wagons, subsequent emigrant wagon trains using the Hastings Cutoff route were forced to go some 25 miles further south until they could cross the Ruby Mountains at Overland Pass (then called Hastings Pass), bringing them into the Ruby Mountains sub-basin near the extreme southern end of Huntington Valley. This added up to ten days to their travel time versus the northern Fort Hall Overland Emigrant Trail route, which came down to the Humboldt River main stem from the northeast using the Thousand Springs Valley route in the Mary's River sub-basin. As a result of the disadvantages of this route, the southern Hastings Cutoff route was virtually abandoned by the early 1850's.

In other matters of historical significance, in December 1845, John C. Frémont undertook his third expedition into the west and his second into the Great Basin region.[111] The Third Frémont (Great Basin) Expedition entered the Great Basin from the east, separating at Whitton Spring (now known as Chase Spring) in Independence Valley to the east of the Ruby Mountains in eastern Nevada. The main group, under Theodore Talbot and guided by Joseph Walker, crossed the Ruby Mountains at Secret Pass and proceeded down Secret Creek and then Soldier Creek to the Humboldt River, intercepting the main stem near present-day Halleck, Nevada. A smaller party under the command of Frémont and guided by Kit Carson headed off to the south down Ruby Valley and crossed the Ruby Mountains at Harrison Pass, eventually arriving at Walker Lake nineteen days later. Three days later the Talbot–Walker group, which had used the Humboldt River Valley route, joined Frémont at Walker Lake.

It was during this expedition that Frémont assigned the name Humboldt Mountains to the imposing Ruby Mountain Range.[112] Then in September 1854, a member of Colonel E.J. Steptoe's detachment searching for a feasible military route across central Nevada found "rubies" (actually garnets) in his gold pan while prospecting one of the streams above Ruby Valley (east side of the Ruby Mountain range) near Hastings Pass (later renamed Overland Pass). Based on this chance discovery, the range was then named the Ruby Mountains by Colonel Steptoe, replacing the name Humboldt Mountains assigned by Frémont in 1845 during his Great Basin Expedition.[113]

In terms of topographic characteristics, the Ruby Mountains sub-basin shows even greater variation in its topography than the Mary's River sub-basin to the north. After the Toiyabe Range in the Reese River sub-basin, the Ruby Mountains are the second highest mountain range in the Humboldt River Basin. Crest elevations of the Ruby Mountains extend up to 11,387 feet MSL (Ruby Dome) with the lower portions of the basin at approximately 5,000 feet MSL. These differences in elevation from valley floor to mountain uplands have resulted in significant climatological differences and especially variations in precipitation throughout the sub-basin, greatly affecting vegetation types over relatively short distances. Along the crest of the Ruby Mountains around Ruby Dome, annual precipitation ranges from 40-45 inches above 10,000 feet MSL, whereas at the lower elevations annual precipitation measures only around seven inches.[114]

In terms of plant coverage, sagebrush-grass constitutes the predominant plant cover over much of the Ruby Mountains sub-basin. In the Ruby Mountains area of the sub-basin, the sagebrush overstory on the lower southern and western exposures yields to chokecherry (*Prunus virginiana*), snowberry (*Symphoricarpos spp.*), serviceberry (*Amelanchier alnifolia*), bitterbrush (*Purshia tridentata*) and small rabbitbrush (*Chrysothamnus viscidiflorus*) as the elevation increases. Between 7,500 and 9,000 feet MSL, mountain mahogany is found on many of the southern and western exposures. Rockspirea (*Holodiscus discolor*) is also found in this same exposure and elevation zone on drier and rockier slopes. On the northern exposures and extended valleys of the Ruby Mountains, dense groves of aspen may be found, giving way to scattered stands of limber pine and some white bark pine (*Pinus albicaulis*) above 8,500 feet MSL. Small stands of subalpine fir and, rarely, white fir (*Abies concolor*), may also be found at these upper mountain elevations; however, none of these conifer stands presently offer any commercial logging value. It has been estimated that high-altitude conifers constitute less than one percent of the Ruby Mountain's total vegetation.[115]

In the Sulphur Spring and Pinon (Pinyon) Mountain ranges running along the western portion of the Ruby Mountains sub-basin, the sagebrush-grass vegetation types on the lower slopes give way to stands of mountain mahogany and pinyon-juniper, primarily juniper (*Juniperus utahensis*) in this area. Greater concentrations of pinyon (*Pinus monophylla*) may be found on the slopes of the Ruby Mountains north of Harrison Pass. Extensive stands of juniper also occur on the broken hills south of White Flats, between Dixie Creek and lower Huntington Creek, and on the southern and eastern exposures of Grindstone Mountain (7,377 feet MSL), located north of Dixie Flat. Very few stands of aspen are found in the relatively short canyons emanating from the mountain ranges along the sub-basin's western border. Somewhat extensive stands of cottonwood may be found in the semi-wet meadows along the South Fork of the Humboldt River from above Lee to the South Fork's junction with Huntington Creek at Twin Bridges. In the irrigated areas of the Ruby Mountains sub-basin, cottonwoods have generally been replaced by narrow strings of willows along the stream margins and the irrigation ditches.[116]

North Fork Humboldt River Sub-Basin

The North Fork Humboldt River sub-basin is a southward-draining tributary to the Humboldt River located in central Elko County and consists of one hydrographic area: Nevada hydrographic area 44, North Fork Area. The North Fork sub-basin has a surface area of approximately 1,110 square miles. Among the eleven sub-basins within the Humboldt River Basin, the North Fork sub-basin ranks as the seventh largest with 6.6 percent of the basin's total surface area. The North Fork sub-basin encompasses the northern and eastern drainage of the Humboldt River system lying between the Mary's River sub-basin to the east and the Maggie (and Susie) Creek sub-basin to the west. To the south of this sub-basin lies the Humboldt River and the Elko Reach sub-basin and the northern border of the Ruby Mountains sub-basin. To the northeast, north and northwest, the North Fork sub-basin is bordered by the Snake River Basin (Nevada Hydrographic Region 3).

The North Fork sub-basin is drained virtually entirely by the North Fork of the Humboldt River along with its principal tributaries of Pie Creek and Beaver Creek. The headwaters of the North Fork lie approximately 65 miles upriver to the north from the Humboldt River main stem at the foot of the Independence Mountains and some five miles north of McAfee Peak (10,439 feet MSL). The sub-basin is confined by a ridge of low hills separating it from the Mary's River sub-basin to the east, broken hills and mountains to the north separating it from the Snake River Basin, and the Independence Mountains to the west separating it from the Maggie Creek sub-basin. To the south, the lower portion of the Adobe Range separates the North Fork sub-basin from the Elko Reach sub-basin within the Humboldt River system.

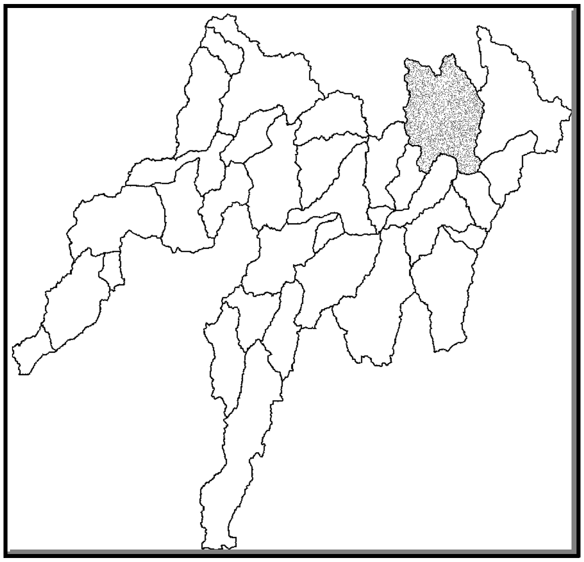


Figure 10 – North Fork Sub-Basin

Due to its remoteness and ruggedness, much of the North Fork sub-basin saw little early exploration and settlement until May 1869. At that time, silver chloride deposits were discovered by the James (Jesse) Cope party of prospectors on the upper East Fork of the Owyhee River, located just beyond the northern border of the North Fork sub-basin drainage. The Cope Mining District was established with Mountain City as its center of operations. Also in this year, Columbia, Cornucopia and Tuscarora began extensive production of silver in areas adjacent to the upper reaches of the North Fork of the Humboldt River. The increased economic activity of these mining endeavors had a profound influence on the agricultural and transportation development within the North Fork sub-basin.[117] The importance of mining to the development of the upper Humboldt River's sub-basins can be appreciated from a June 1869 article in the *Elko Independent*. The article stated that 30 to 40 Central Pacific Railroad freight cars unloaded daily at Elko with machinery and supplies for the mining camps to the north and south of Elko. The railroad's records showed that receipts in this month alone for both passengers and freight exceeded $5,000 per day. Within two months (August 1869), when the freight wagon traffic to the Cope, Cornucopia and Columbia mines to the north of Elko had taken off, these receipts had grown to $5,000 per day for freight alone.[118]

Even by July 1869, the North Fork sub-basin's isolation remained largely well preserved. In this month, the *Elko Independent* commented on this fact, describing the North Fork of the Humboldt River as a beautiful, fertile, but nameless valley, "the paradise of Nevada", on the proposed road to the Cope Mining District, in which no settler had yet pitched his tent. But that was soon to change with the completion of the Elko and Idaho Toll Road in October 1869. This freight and passenger road ran north from Elko along the North Fork Humboldt River drainage and through Mountain City and the Cope Mining District to the Idaho state line. At that point it connected with the Idaho Central Toll Road to Silver City and Boise City.[119] But these early mining influences would not last for long, and even to this day the valley of the North Fork of the Humboldt River remains, in effect, nameless, remote and relatively isolated, except for Nevada State Highway 225 which runs through its uppermost portion.

Shortly after the initial surge in nearby mining activity, around 1870, the range potential of the North Fork sub-basin was recognized when Dan Murphy acquired and stocked with Texas longhorn cattle the area comprising the present Devil's Gate, Haystack and Rancho Grande ranches. Daniel Murphy was one of the sons of Martin Murphy, of the famous Stevens-Murphy-Townsend wagon train which had traversed the Humboldt River Basin in 1844 en route to California. This wagon train was singular as it was the first emigrant train to use the Truckee River and Donner Pass route over the Sierra Nevada. Mr. Murphy's ranch headquarters was established at Halleck, which up until the early 1900's was the railroad shipping point for the Murphy-Morgan Hill Ranches and was well known throughout the state as a bustling, boisterous and roistering cow town.[120]

After the disastrous cattle losses of the "White Winter" of 1889-90, sheep began to move into the North Fork sub-basin. By early 1906, several large sheep outfits had bought, leased or homesteaded enough key acreage to effectively control the summer range not only in the Independence Mountain watersheds but also in the high country formerly used as Daniel Murphey's summer range around Gold Creek and the headwaters of the Bruneau River (Snake River Basin), which lies adjacent to the northern boundary of the North Fork sub-basin. In an effort to protect the valuable watershed source areas of the North Fork sub-basin from growing threats from extensive grazing operations, in May 1906 the federal government established the Independence Forest Reserve. This action made possible the initiation of a grazing management program aimed at preventing further deterioration of the high water-yielding lands in the Independence Mountain Range. On July 1, 1908, the Independence Forest Reserve and the Ruby Mountains Forest Reserve (located in the Ruby Mountains sub-basin) were consolidated into a new unit called the Humboldt National Forest. Forest headquarters were established at Elko, Nevada.[121]

Heavy grazing by sheep ranchers continued to supplant cattle ranching in the upper reaches of the North Fork sub-basin and dramatically changed the vegetation patterns and promoted extensive gully erosion throughout the sub-basin's upper and middle drainage areas. By 1911, sheep ranchers began to homestead the lower Beaver Creek area in the sub-basin, thereby controlling virtually all of the former cattle range within this lower drainage area. In just a few years, the extensive flocks and "huge" numbers of sheep of both resident ranchers and transient sheep outfits had virtually devastated the natural vegetation throughout an extensive area and reduced much of the soil-holding grasslands across significant portions of the sub-basin. These activities effectively changed the landscape from a well-vegetated state of desirable perennial grasses and forbs and fostered extensive sheet and gully erosion.[122]

Topographically, the North Fork sub-basin consists of three distinct land forms: the mountain highlands, the valley uplands and the valley lowlands. Elevations with the sub-basin extend from above 10,000 feet MSL in the Independence Mountains to just over 5,000 feet MSL at the North Fork's confluence with the Humboldt River main stem.. Based on this relatively extreme range in elevations, precipitation measures also show wide variations, ranging from approximately 35 inches around Jacks Peak (10,198 feet MSL), which is located some three miles south-southwest of McAfee Peak, to 8-9 inches in the sub-basin's lower bottom and bench lands.[123] The predominant plant cover over much of the sub-basin is the big sagebrush-grass varieties. Low sagebrush (*Artemisis arbuscula*) and grasses are found on large claypan bench lands on the northern and western slopes of the Adobe Range in the southern portion of the sub-basin, extending along the middle and upper reaches of the

North Fork drainage. Expanses of phreatophytes, principally rubber rabbitbrush and some greasewood exist along the lower North Fork bottom lands between Devil's Gate (located some 18 miles upstream from the Humboldt River) and along the Humboldt River main stem. Willows also line much of the North Fork's channels from south of the Devil's Gate Ranch all the way to the headwaters of the North Fork and its tributaries.

On the national forest lands in the Independence Mountains, aspen is prevalent and interspersed with small mixed grass-forb meadows which occupy the bottoms and small basins of the North Fork's tributaries. Covering much of the drier slopes in the Independence Mountains is a combination of sagebrush-browse-grass vegetation, giving way to mixed stands of subalpine fir and limber pine in the high basins and on the north and easterly exposures. The perennial native grasses – bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*) and Nevada bluegrass – which once constituted the predominant understory of the sagebrush-grass and mixed browse-aspen-grass cover types, have largely disappeared over much of the North Fork sub-basin. These more desirable forage varieties are now found in significant quantities only on the national forest lands or on protected, remote or inaccessible relict areas and privately owned range lands. Through extensive grazing operations, these preferred perennial grass and forage varieties have been largely replaced by cheatgrass and other less desirable forage types such as big sagebrush, Sandberg bluegrass, bottlebrush squirreltail and lesser amounts of needlegrass.[124]

The vegetation of the North Fork sub-basin has also been adversely impacted by periodic over-populations of beaver on the headwaters of many of the streams emanating from the Independence Mountains. In the past, extensive destruction to aspen groves by the numerous beaver have been experienced on Winters Creek, upper Ganz Creek, Pratt Creek and the upper North Fork itself. The destruction of these aspen groves has severely affected the soil-binding capabilities of these upper watersheds as well as harmed the aesthetic and recreational value of these areas.[125]

Maggie Creek Sub-Basin

The Maggie Creek sub-basin is a southward draining tributary to the Humboldt River lying in the southwest portion of Elko County and the extreme northeast corner of Eureka County. This sub-basin has a total surface area of approximately 619 square miles. Among the eleven sub-basins within the Humboldt River Basin, the Maggie Creek sub-basin ranks as the second smallest sub-basin with only 3.7 percent of the basin's total surface area. The Maggie Creek sub-basin consists of two defined Nevada hydrographic areas: Nevada hydrographic area 50, the Susie Creek Area which covers 223 square miles, and Nevada hydrographic area 51, the Maggie Creek Area covering 396 square miles. This maple-leaf shaped sub-basin extends north from the Humboldt River's main stem at Carlin with most of it lying within Elko County and a smaller portion in Eureka County.[126]

The Maggie Creek sub-basin drains a relatively small area consisting of two sub-drainage areas to include the Maggie Creek drainage occupying the western and northern portions of the sub-basin and about 64 percent of the sub-basin's total area, and the smaller Susie Creek drainage covering some 36 percent of the eastern portion of the sub-basin. The Maggie Creek sub-basin is wedged between the North Fork sub-basin to the east, the Battle Mountain sub-basin to the west, the Elko Reach sub-basin to the south and southeast, and the Snake River Hydrographic Region to the north. The basin is bound by the Adobe Range to the southeast, the Tuscarora Mountains to the west, the Humboldt River to the south and is divided essentially down its center by the southern extension of the Independence Mountain Range.

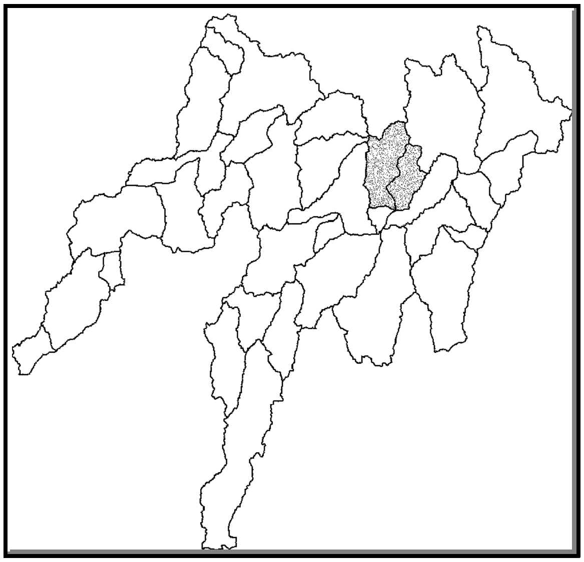


Figure 11 – Maggie Creek Sub-Basin

The headwaters of Susie Creek originate on the eastern slopes of the Independence Mountains with the highest elevation being Lone Mountain (8,657 feet MSL). Other Susie Creek tributaries have their headwaters located in the Adobe Range. The headwaters of Maggie Creek originate between the eastern slopes of the Tuscarora Mountains and the western slopes of the Independence Mountains with the highest elevation being Beaver Peak in the Tuscarora Mountains at 8,786 feet MSL. The lowest part of the sub-basin is located around Carlin on the Humboldt River main stem at just over approximately 4,900 feet MSL.

Due to its relatively isolated and inaccessible nature, except for the portion of the sub-basin in the Carlin area, the Maggie Creek sub-basin did not figure prominently in any early exploration, emigrant transportation or settlement patterns. The first recorded development of agriculture within the sub-basin occurred in July 1868 when J.A. Palmer took up lands for farming along the Humboldt River and a portion of lower Maggie Creek.[127] Carlin, the oldest town in Elko County, was established in December 1868 as a railroad division point by the Central Pacific Railroad. When the railroad construction crews reached the Carlin Meadows, always a favorite stopping place for early wagon trains along the California Emigrant Trail, a town site was laid out and a large roundhouse and shops were erected.

The town of Carlin grew rapidly, vying over time with Elko and Palisade for the stage and freighting business to Bullion, Mineral Hill, Eureka and other booming mining communities to the south. In 1872, Carlin became a rival of not only Elko, but also Winnemucca and Battle Mountain as a shipping point for the silver, lead and gold ores from the Cornucopia, Tuscarora and Bull Run Mining Districts to the north in the Snake River drainage.[128] In September 1872, in order to facilitate the direct access to the northern mining districts, Woodruff & Ennor, a well-known staging and freighting firm of this period, built a toll road north from Carlin up Maggie Creek, traversing Taylor Canyon and exiting from the sub-basin into Jack's Valley, Tuscarora and Cornucopia.[129]

The growing of small grains along the lower Maggie and Susie Creeks began in 1869 and met with some success. On July 14, 1969, the *Elko Independent* newspaper commented on the luxuriant barley crops being raised along Maggie Creek. Around 1870 the sub-basin's agriculture industry began its transformation from grains to livestock and animal feed. At this time, Dr. G.W. Grayson, a San Francisco physician, began the Horseshoe Ranch at Beowawe which, until more recent times, was among the oldest and one of the largest cattle ranches in eastern Nevada. Under the Horseshoe-Bar brand, the ranch owned or controlled over 200,000 acres in Elko, Eureka and Lander counties, including the Horseshoe Ranch on Maggie Creek. Around 1875, the agricultural pursuits in many sub-basins within the upper Humboldt River Basin underwent a more substantive change from the production of small grains and agricultural produce to the raising of livestock, particularly cattle raising.[130] By 1875, carloads of cattle were being shipped from Carlin and Beowawe from ranches which included extensive acreage in the Maggie Creek sub-basin.[131]

Around 1875, Tom and William Hunter began grazing cattle in the Susie Creek drainage. Around 1910, George Hunter, Tom's son, formed a partnership with George Banks and the resultant firm, Hunter and Banks, became one of the largest cattle operations in eastern Nevada. At its peak, this partnership boasted a herd of at least 5,000 head of cattle along Susie Creek, extending from its lower reaches upstream to Lone Mountain (8,657 feet MSL). A combination of drought and hard times eventually forced the dissolution of the company in 1925. In 1877 the W.T. Jenkins Company was established at Battle Mountain and began grazing cattle and sheep on 278,000 acres of deeded lands in Lander, Pershing and Elko counties, including the Stampede Ranch on the upper portions of Maggie Creek.[132] In addition to extensive cattle and sheep herds being sustained on the bench lands and open grassy ridges in the Maggie and Susie Creek watersheds, the sub-basin also sustained extensive herds of horses in this period of open range use. On June 18, 1890, the Winnemucca *Silver State* newspaper reported that approximately 650 head of horses had perished in the snows of upper Maggie and Susie Creeks as a result of the "White Winter" of 1889-90.[133]

Topographically, surface elevations within the Maggie Creek sub-basin vary from between 8,000 feet to nearly 9,000 feet in both the Independence and Tuscarora Mountains to under 5,000 feet at Carlin along the Humboldt River main stem. Climatologically, this variation in topography has resulted in wide variations in localized precipitation as well. The average annual precipitation typically varies from seven inches in the vicinity of Carlin to approximately 12 inches per year in the Adobe Range (6,000 to 7,000 feet MSL), 20 inches in the Independence Mountains (8,000 to 9,000 feet MSL), to 25 inches along the crest of the Tuscarora Mountains at elevations of 8,000 to 9,000 feet MSL. It has been estimated that nearly 70 percent of the Maggie Creek sub-basin's gross water yield originates on the U.S. Bureau of Land Management (BLM) managed public lands located in the Tuscarora Mountains.[134]

Based on the sub-basin's variations in topography and climate, the Maggie Creek sub-basin also shows wide differences in vegetation types and coverage. The predominant vegetative cover over much of the sub-basin is big sagebrush-grass. Low sagebrush is found on large claypan bench sites on the south extremity of the Independence Mountains lying between Maggie and Susie Creeks. Similar coverage and claypan benchlands are found west of Maggie Creek in the northwest portion of the sub-basin on the eastern slopes of the Tuscarora Mountains. Extensive areas of black sagebrush (*Artemisia nova*) and grass coverage are found on the shallow-soiled steep mountain slopes and mountain tops from 6,500 feet to over 8,000 feet MSL along the Tuscarora Range west of

Maggie Creek.[135]

At one time, more extensive meadows of ryegrass existed along both Susie and Maggie Creeks; however, these areas have been greatly desiccated and reduced by the deep gullying (i.e., erosion) along both of these stream systems. This has allowed the spread of rabbitbrush into much of these former grassland areas. Small amounts of willow occur in areas lining the upper portions of Susie and Maggie Creeks and their tributaries, such as Coon Creek, Lone Mountain Creek, Cold Creek, Blue Basin Creek and others. Stands of aspen grow in scattered areas along the water courses in the high drainages at the headwaters of Beaver, Coyote and other streams draining the Tuscarora Mountains. Similar aspen stands may be found on the west side of Lone Mountain in the Independence Mountains at the head waters of Coon and Lone Mountain Creeks, among others. There are no extensive stands of conifers within the sub-basin, except for scattered clumps of limber pine along the Lone Mountain crest (Independence Mountains), and scattered stands of juniper in the Adobe Range just north of the Humboldt River.[136]

Elko Reach Sub-Basin

The Elko Reach sub-basin of the Humboldt River system includes the river's bottomlands and small tributaries to the Humboldt River main stem between Rydon and Palisade, Nevada, a distance of approximately 45 miles. Through this reach, the Humboldt River runs in a generally southwesterly direction. The Elko Reach sub-basin has a total surface area of approximately 375 square miles and is the smallest of the eleven Humboldt River sub-basins, comprising only 2.2 percent of the basin's total surface area. The Elko Reach sub-basin includes two of Nevada's hydrographic areas, Nevada hydrographic area 49, Elko Segment, and Nevada hydrographic area 52, Mary's Creek Area. The Elko Segment contains 314 square miles and comprises nearly 84 percent of the sub-basin's total area, while the Marys Creek Area contains 61 square miles and 16 comprising percent of the sub-basin's total surface area.

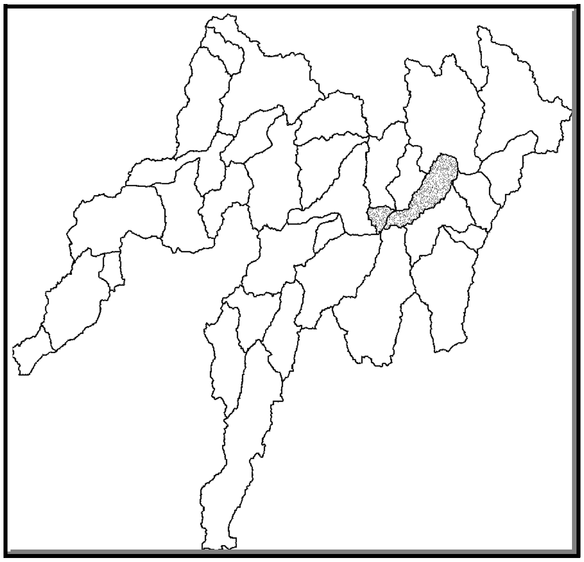


Figure 12 – Elko Reach Sub-Basin

Humboldt River flows through the Elko Reach sub-basin are affected by major tributaries entering from other sub-basins either upstream of the Elko Reach sub-basin – Mary's River and upper Humboldt River (Mary's River sub-basin), North Fork Humboldt River (North Fork sub-basin), Lamoille Creek (Ruby Mountains sub-basin) – or entering directly within the sub-basin – South Fork Humboldt River (Ruby Mountains sub-basin) and Maggie and Susie Creeks (Maggie Creek sub-basin). Other small tributaries also empty directly into the Humboldt River main stem through this reach. Due to the limited drainage areas contained within this sub-basin, most of these smaller direct tributaries are seasonal or ephemeral streams and include (in upstream to downstream order) Jackstone Creek, Sherman Creek, Kittridge Creek, East Adobe Creek, Tonka Creek, Marys

Creek and Woodruff Creek.

Geographically, most of the Elko Reach sub-basin is located in southwestern Elko County with the extreme downstream portion of the sub-basin, to include most of the Marys Creek drainage, located in northeastern Eureka County. The sub-basin is totally enclosed by other Humboldt River sub-basins, to include the North Fork sub-basin on the north, the Ruby Mountains sub-basin to the east and southeast, the Pine Valley sub-basin to the south, and the Maggie Creek sub-basin to the northwest and west. Downstream, the Elko Reach sub-basin connects directly to the Battle Mountain sub-basin. Due to the restricted nature of this sub-basin to small drainage areas contiguous to the Humboldt River main stem, the sub-basin's topography does not reflect the extremes in elevations which characterizes surrounding, more expansive sub-basins, which tend to include both lowland valley basins and lofty mountain ranges. To the east, the Elko Reach sub-basin is bordered by the Elko Hills with Elko Mountain (7,505 feet MSL) and Grindstone Mountain (7,377 feet MSL) and to the west the sub-basin is enclosed by the Adobe Range and Mouse Mountain (7,475 feet MSL). Downstream, the Marys Creek drainage includes Marys Mountain at 6,704 feet MSL. The lowest elevation within the sub-basin is located at Palisade, which is at an elevation of just over 4,800 feet MSL.

Due to its strategic location along the Humboldt River main stem, the Elko Reach sub-basin has figured prominently in virtually all events pertaining to early exploration, emigration, transportation and commerce. On November 9, 1828, Peter Skene Ogden, a fur trapper for the Hudson Bay Company, led a party of trappers comprising the Fifth Snake County Expedition south from the Columbia River Basin and was the first visit by Europeans to the Humboldt River Basin.[137] Coming down the Little Humboldt River through Paradise Valley, Ogden found the Humboldt River lined with willows and well-stocked with beaver. At first, he explored the river to the west and downstream for several days, but was then forced upriver by bad weather.[138] On December 12, 1828, Ogden and his party passed the location of present-day Elko.[139] It was during this expedition that one of Ogden's trappers, Joseph Paul, died and was the first European to be buried along the Humboldt River.

Known by many names – Ogden's River, Mary's River, Paul's River, Barren River, Swampy River and Unknown River – the Humboldt River was later (1848) and finally named by John C. Frémont after Baron Alexander von Humboldt, a German scientist whom Frémont admired, but who had never even seen the river.[140] This river valley, first explored in its entirety by Peter Ogden during 1828 and 1829, would soon become the most important transportation corridor for early emigrants traversing the Great Basin on their way to California by means of the Overland Emigrant Trail. Basically, there were two early routes into the Humboldt River Basin as part of the Emigrant Trail which brought early wagon trains into the Elko Reach sub-basin. The Fort Hall route came down from northeastern Nevada using the route through Thousand Springs Valley to Humboldt Wells, while the Hastings Cutoff route brought emigrants through the Ruby Mountains and down Huntington Creek and the South Fork of the Humboldt River to the Humboldt River main stem just below the present-day site of Elko, Nevada.

The period of emigration and the development of early transportation routes through this region began in 1841 with the Bartleson–Bidwell emigrant party, which made the first successful crossing of the Great Basin, passing directly through most of the Elko Reach sub-basin using the Hastings Cutoff route.[141] Between this time and the completion of the Central Pacific Railroad in 1868, the Elko Reach sub-basin served as a portion of the primary western route to California for thousands of wagons and countless emigrants. The route was not an easy one, however. The entire passage down the Humboldt River Valley's over 300 miles generally took as much as three weeks under the most favorable circumstances, and the weary emigrants and their oxen, mules and horses all suffered greatly in the process. By late summer, the lack of precipitation and the heavy traffic made animal forage extremely scarce along the route and available springs could not always be relied upon late in the season. And then there was the river itself. As noted somewhat derisively in 1849 in the diary of Elisha D. Perkins: "The stream itself does not deserve the name of river being only a good sized creek…For the first days travel in its valley the grass is splendid, then the valley begins to narrow and feed to get poorer and less of it all the rest of its course, till for the last 80 miles, except in special spots we could hardly get enough for our mules to eat and water barely drinkable from saline and sulphurous impregnation and having a milky color. I think Baron Humboldt would feel but little honored by his name being affixed to a stream of so little pretension."[142]

The Elko Reach sub-basin's agricultural industry began its rapid expansion around 1868 with the raising of hay and grains for the draft animals used to pull the huge "sagebrush clipper" freight wagons and the Concord coach stagecoaches on the north-south toll roads serving the various mining districts. Construction of the Central Pacific Railroad through the sub-basin from November 1868 through January 1969 heralded the demise of the era of the covered wagon. By the 1870's, extensive herds of Texas longhorn cattle were brought into the sub-basin to feed on the lush ryegrass in the lower meadowlands and the native bunch grasses on the upper slopes and hillsides. With the demise of the mining industry in the late 1870's, the towns of Elko, Carlin and Palisade, which began their existence as freight and shipping points for the bustling mining communities to the north and south, now became important embarkation points for the region's cattle ranching industry.[143]

Variations in elevation within the Elko Reach sub-basin are not as great as other sub-basins within the upper Humboldt River Basin. Mountain peaks are below 8,000 feet MSL (Elko Mountain, 7,505 feet MSL; Grindstone Mountain, 7,377 feet; and Mouse Mountain, 7,475 feet) and the lowest point in the basin, Palisade, lies slightly above 4,800 feet in elevation. Precipitation measures across the Elko Reach sub-basin range from about 7 inches at Carlin on the Humboldt River to between nine and 15 inches in the mountain highlands above 6,000 feet. Big sagebrush and invasive cheatgrass make up the predominant plant cover over most of the upland bench lands and intermediate mountain slopes within the sub-basin. Juniper may be found on the low rolling hills south of the Humboldt River from Elko Mountain, nine miles northeast of Elko, Nevada, to the rolling uplands west of Grindstone Mountain, located nearly 12 miles southwest of Elko. A small amount of single-leaf pinyon pine may be found with the juniper on Grindstone Mountain as well. North of the Humboldt River, small expanses of juniper are present near the ridge tops from Carlin Canyon to Sherman Creek. A few small groves of aspen are also located on the north side of the river in the upper reaches of Sherman and Jackstone Creeks. Willows may be found in the Elko Reach sub-basin along the natural water courses and the irrigation ditches.[144]

Pine Valley Sub-Basin

The Pine Valley sub-basin is a northward-draining tributary to the Humboldt River lying south of Palisade, Nevada, situated mostly in north-central Eureka County and extending into a relatively small portion of southwestern Elko County. The sub-basin has a total surface area of approximately 1,002 square miles and is the ninth largest of the eleven sub-basins within the Humboldt River Basin, comprising nearly 6.0 percent of the basin's total surface area. The Pine Valley sub-basin consists of one hydrographic area, Nevada hydrographic area 53, Pine Valley. Within the sub-basin there also exist several distinct watersheds to include Henderson Creek in the extreme southern portion of the sub-basin, Denay Creek in the southwestern portion of the sub-basin, the Upper Pine Creek watershed in the central portion of the sub-basin, and the Lower Pine Creek watershed in the northern portion of the sub-basin and joining the Humboldt River main stem just below the U.S. Geological Survey's Palisade gaging station location.

Geographically, the Pine Valley sub-basin drains a relatively narrow, north-south running valley within the south-central part of the Humboldt River Basin and is wedged between the Ruby Mountains sub-basin to the east and the Reese River sub-basin to the west. To the north lies the Humboldt River and to the southeast, south and southwest lies the Central Region (Nevada Hydrographic Region 10). The Pine Valley sub-basin is bounded by the Pinyon Range in the northeast (Ravens Nest, 8,710 feet MSL and Pine Mountain, 8,285 feet MSL), the Sulphur Springs Range extending down the eastern side of the sub-basin (Coffin Mountain, 8,168 feet MSL, Bald Mountain, 7,686 feet MSL, and Mineral Hill, 7,439 feet MSL), the Roberts Range in the south (Roberts Creek Mountain, 10,133 feet MSL), the Simpson Park Mountains in the west and southwest (Twin Peaks, 7,625 feet MSL), and the Cortez Mountains (Mount Tenabo, 9,162 feet MSL) extending along the western and northwestern portion of the sub-basin. The Humboldt River and the Elko Reach sub-basin constitute the northern boundary of the Pine Valley sub-basin.

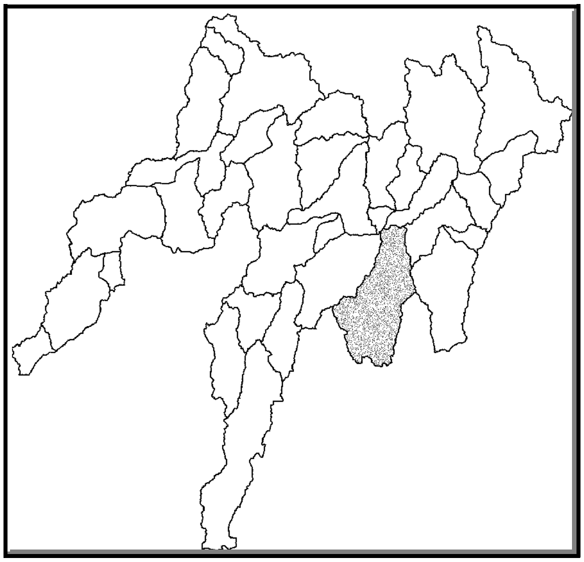


Figure 13 – Pine Valley Sub-Basin

The Pine Valley sub-basin remained relatively isolated and unchartered through the Humbodlt River Basin's early exploration and emigration period of the first half of the 1800's. During this period, the sub-basin was only infrequently visited by early fur trappers, remaining largely a haunt of Western Shoshone Indians. During the 1841-1868 emigration period, the lower portion of Pine Valley was occasionally crossed by emigrant parties using the Woodruff Canyon-Crescent Valley bypass of the narrow Palisade Canyon. More extensive penetration and exploitation of the Pine Valley sub-basin and its grass and timber resources began with the arrival in late 1868 of the Central Pacific Railroad at Palisade (first named Palisades). Due to the naturally constricted nature of any townsite in Palisade Canyon, at first the Central Pacific Railroad refused to establish a townsite and division point at that location. However, the subsequent emergence of the Eureka and Mineral Hill mining districts to the south showed the distinct benefits of this location as well as establishing a freight transportation route directly through Pine Valley.

The "sagebrush clipper" freight wagons and the stagecoach reigned supreme along the Palisade-Pine Valley-Eureka route from June 1870 until the construction of the Eureka & Palisade Railroad .[145] The ninety-mile narrow gauge (3-foot) Eureka & Palisade Railroad was completed through Pine Valley in late 1875 to accommodate the growing freight traffic to and from the lead and silver mines at Eureka and the mines at Mineral Hill in Pine Valley and Cortez in Crescent Valley to the west of the Cortez Mountains. The Eureka & Palisade Railroad provided the primary economic stimulus and access to the Pine Valley sub-basin and served the sub-basin's development until its forced abandonment in 1938 due to increased highway truck traffic. Its only extended break in service came in 1910 when a disastrous winter flood, very possibly the worst flood event to visit the Humboldt River Basin in recorded history, washed out nearly one-third of the railway's track.[146]

The Pine Valley sub-basin's agricultural industry began to develop in the early 1870's when hay was grown to serve the needs of the large numbers of draft animals used on the stage and freight roads connecting Palisade with the Mineral Hill, Eureka and the White Pine mines to the south. With the completion of the Eureka & Palisade Railroad in 1875 and the curtailment in freight and stage traffic through the valley, much of the area's hay production was then shipped out of the sub-basin. The agriculture industry shifted to dairy ranching during the late 1870's and 1880's, primarily in the lower portion of the Pine Valley sub-basin. The open-range livestock industry also took off at about this time and continued to expand throughout the sub-basin until the disastrous "White Winter" of 1889-1890. Numerous livestock of all kinds starved and froze to death during this severe winter event, proving the impracticality of wintering large herds of livestock on the open range without adequate supplemental feed. After 1890 the sub-basin's ranching industry began a slow and gradual recovery characterized by fewer farms and ranches, but of typically larger size.[147]

In terms of topography and its effects on precipitation within the Pine Valley sub-basin, elevations within the sub-basin range from a maximum of just over 10,000 feet MSL in the southern part of the sub-basin (Roberts Mountains) to just over 4,800 feet MSL at Palisade along the Humboldt River. While high peaks and mountain ranges virtually surround Pine Valley – Roberts Creek Mountain (10,133 feet MSL) in the Roberts Mountains, Mount Tenabo (9,162 feet MSL) in the Cortez Mountains, and Ravens Nest (8,710 feet MSL) in the Pinyon Range – precipitation at these elevations is generally significantly less than in other sub-basins within the upper reaches of the Humboldt River Basin. The higher elevations in the Roberts Mountains, located in the southern portion of Pine Valley, receive about 16 to 18 inches of precipitation each year while the annual average precipitation in the lower portions of the sub-basin is about 8-9 inches.[148]

Based on these variations in altitude and climate, the Pine Valley sub-basin also shows wide variations in its vegetative cover. The predominant plant cover over much of the sub-basin is sagebrush-grass. Before the arrival of European settlers and ranchers, the pristine grass understory within the Pine Valley sub-basin consisted of desirable perennial bunchgrasses such as Idaho fescue and bluebunch wheatgrass, with small amounts of Sandberg bluegrass and the needlegrasses. Extensive grazing throughout the late 1800's and early 1900's decimated much of these native perennial grasses and exposed these areas to the effects of erosion. Since 1910, major flooding and subsequent extensive gully erosion have greatly reduced the extent and condition of the sub-basin's natural meadowlands, effectively draining these productive grassland areas. As a result, the desiccated meadows, which consisted primarily of Great Basin wildrye and some creeping wildrye (*Elymus triticoides*), have been replaced by sagebrush, or non-beneficial phreatophytes such as rubber rabbitbrush and greasewood.

The higher elevations of the Pine Valley sub-basin, located in the Pinyon, Sulphur Springs, Simpson Park and Roberts mountains, have some extensive growth of pinyon pine and juniper, as well as curl-leaf mountain mahogany, most of which is second growth. However, there still exists little or no grass or herbaceous understory in these areas. Most of the original stands of pinyon pine were clear cut during the 1870's for the production of charcoal, and pinyon pine is now scarcely found on many of its former sites in the Pinyon and Sulphur Springs ranges. In these areas, pinyon pine has been largely replaced by sagebrush or by juniper, which was not used for early charcoal production.

Small stands of aspen may also be found within the sub-basin in the upper stream bottoms in the Cortez Mountains on the west side of Pine Valley, for example, Big and Little Pole Creeks, Sheep Creek and other streams. On the east side of Pine Valley, however, aspen stands are more scarce, being principally found at the head waters of Trout Creek and Smith Creek in the Pinyon Range. Limited stands of aspen may also be found along some of the perennial streams flowing north out of the Roberts Mountains, which border the southern part of the sub-basin.[149]

Due to early heavy use of forage and timber resources within the sub-basin, there has resulted a considerable change in Pine Valley's vegetation quantity and quality from early descriptions. From 1869-1870 files of the *Elko Independent* newspaper, one writer described Pine Valley as being a "long, grassy valley, with a clear, silvery stream of water running through the center." Another writer described the section of Pine Valley running from Palisade to Mineral Hill, located in the Sulphur Spring Range, as "one of the most beautiful and fertile in the state, containing a vast amount of fine meadow land." From other descriptions, the higher mountain slopes were reported as being thickly covered with bunchgrass, while winterfat, also referred to as white sage (*Krascheninnikovia lanata*), which has largely disappeared from these areas, clothed the lower slopes and the terraces above the valley floor.

According to these early reports, the mountain ranges on both sides of Pine Valley were spread "with a thick and tangled growth of mountain mahogany, nut-pine (pinyon pine) and cedar wood." The mountains (the Sulphur Spring Range) immediately to the east of the now deserted mining camp of Mineral Hill were described in 1870 as "dark round hills, covered with timber." Today, by contrast, these same hills are virtually devoid of either pinyon pine or juniper cover. In addition, primarily due to extensive grazing operations, most of the desirable perennial grasses that once covered the slopes and drainages above the stream bottoms have been virtually eliminated and replaced by cheatgrass. Overall, very little of the pristine ground cover that existed before the arrival of European settlers now remains in Pine Valley.[150]

Reese River Sub-Basin

The Reese River sub-basin is a north-draining tributary of the Humboldt River extending southward from Battle Mountain and the central portion of the Humboldt River Basin in the north through Lander County into central Nevada and Nye County in the south. From the Humboldt River main stem, the Reese River drainage extends southward some 150 miles to its headwaters in the southern portion of the Toiyabe Range below the mountain peaks of Toiyabe Dome (11,788 feet MSL), Toiyabe Dome Southeast Summit (11,353 feet MSL) and Mahogany Mountain (11,165 feet MSL). The Reese River sub-basin is the largest of the eleven sub-basins within the Humboldt River Basin, covering 3,625 square miles and making up 21.5 percent of the Humboldt River Basin's entire surface area.

The Reese River Valley's southernmost extent thrusts the sub-basin well into central Nevada and the Central Region (Nevada Hydrographic Region 10). Most of the sub-basin lies within Lander County; however, the eastern portion of Crescent Valley, which is a "closed" (or non-tributary) hydrographic area within the Reese River sub-basin, extends eastward into Eureka County. The far western portion of the Reese River sub-basin also just touches the eastern boundary of Pershing County. The sub-basin is bound by the Central Hydrographic Region to the west, south and southeast, by the Pine Valley sub-basin to the east, and by the Humboldt River and Battle Mountain sub-basin to the north.

The Reese River sub-basin incorporates six Nevada hydrographic areas that lie within the Humboldt River Basin. However, two of these hydrographic areas are essentially "closed" basins (hydrographic areas) that neither contribute to the flows of the Reese River nor to the flows of the Humboldt River. These include Nevada hydrographic area 54, Crescent Valley, covering 752 square miles, and Nevada hydrographic area 55, Carico Lake Valley, covering 376 square miles. Any flows out of Carico Lake Valley would enter into Crescent Valley and thence spread out across extensive desert playas located there.

The remaining four hydrographic areas of this sub-basin consist of the Reese River drainage proper and include: (1) hydrographic area 56, Upper Reese River Valley, covering 1,138 square miles; (2) hydrographic area 57, Antelope Valley, covering 452 square miles; (3) hydrographic area 58, Middle Reese River Valley, covering 319 square miles; and (4) hydrographic area 59, Lower Reese River Valley, covering 588 square miles.

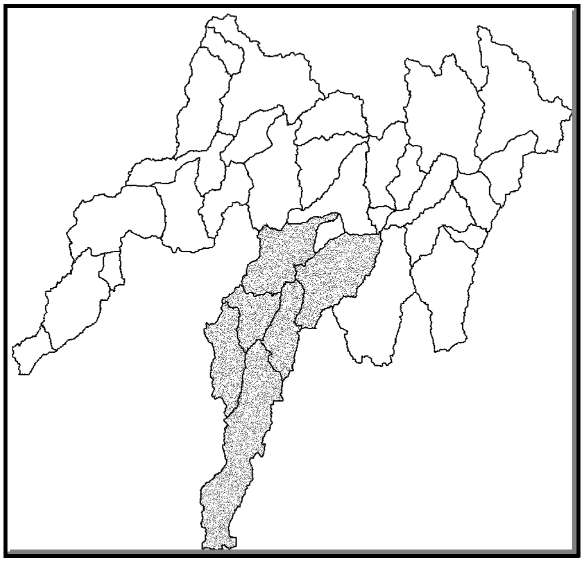


Figure 14 – Reese River Sub-Basin

The Upper Reese River Valley hydrographic area extends from the river's headwaters in the Toiyabe Range, located in Nye County, northward through the Shoshone Mountain Range in central Lander County. The Middle Reese River Valley hydrographic area extends from this point to below the Fish Creek drainage, also picking up outflow from Antelope Valley. The Lower Reese River hydrographic area extends from this point to the Humboldt River main stem, running northward between the Shoshone Range to the east (Mount Lewis, 9,680 feet MSL; Goat Peak, 9,060 feet; and Horse Mountain, 8,210 feet) and the northern portion of the Fish Creek Mountains and the Battle Mountain Range (Galena Range) to the west and just south of the Humboldt River (North Peak, 8,550 feet MSL and Antler Peak, 8,236 feet).

While generally considered as a "tributary" of the Humboldt River, the Reese River, in fact, only contributes to the surface water flows of the Humboldt River main stem during high water years, i.e., flood events, typically from severe wet-mantle storm events[151] or the rapid spring meltdown of heavy mountain snowpack. In more normal climatological periods, i.e., normal or average water years, the Reese River's surface water flows cease some 10-20 miles short of the Humboldt River south of Battle Mountain. This can best be seen from Table 6, Lower Humboldt River Principal Gaged Stream Flows. Based on average water years, the flows at the USGS Battle Mountain gage, located above the Reese River confluence, have averaged 270,040 acre-feet per year, whereas some 35 miles downstream at the USGS Humboldt River gage at Comus, average year flows have averaged 246,150 acre-feet per year. This pattern of diminishing average Humboldt River flows is typical of the river's hydrology below Palisade.[152]

Early discovery and exploration of the Reese River sub-basin began in November 1854, when John Reese, the first European known to have explored the Reese River "wilds" to any great extent and for whom the river was named, left Colonel E.J. Steptoe's detachment near the present-day site of Battle Mountain and proceeded up the Reese River Valley.[153] In 1859, as a result of his previous solitary exploration of the Reese River Valley, John Reese was appointed as a guide for Captain J.H. Simpson of the U.S. Topographic Engineers and his party. Captain Simpson had been instructed to find a route for a good military road to Genoa, located in Carson Valley in western Nevada, and the route fixed upon became known as the Central Route. This route roughly approximated the cattle and emigrant trail established in 1855 between Salt Lake City and Genoa by Major Howard Egan, Mormon guide, mountaineer, and cattle drover.

The Central Route across Nevada crossed through the Toiyabe Range in the eastern portion of the Reese River sub-basin, about three miles north of Austin, then down to Jacobs Springs, located near the east bank of the Reese River. From the river, the route finished crossing the Reese River Valley by cutting through the Shoshone Range to the west about 10 miles west of Jacobs Springs and three miles north of the present Railroad Pass on U.S. Highway 50. In its early history, this Central Route also accommodated the Pony Express riders during their 1860-61 brief but highly publicized reign. The route also accommodated the stagecoach, mail, express and freight service from eastern to western Nevada from 1861 to 1869, as well as the Overland Telegraph Company line, all of which provided the earliest access to the central and upper portions of the Reese River sub-basin.[154]

Battle Mountain, located along the Humboldt River, and Austin, located about 85 miles up the Reese River Valley, represent the only two communities of any significant size within the Reese River sub-basin, and both have interesting early histories. Battle Mountain's name was derived from the mountain range to the southwest of that location where, in 1850, a group of angry California emigrants ambushed a band of Shoshones after the Indians had attacked their wagons. In October 1868, the Central Pacific Railroad established the Reese River Siding at the present-day site of Battle Mountain, located near the outflow of the Reese River (when it does outflow) and made Argenta (Siding), located five miles eastward (up river), its principal station and point of departure for the busy mining camps to the south. In January 1870, the Argenta operations were moved in its entirety to the present-day site of Battle Mountain, and the Reese River Siding was renamed Battle Mountain Switch, creating the town as well.[155]

Austin, referred to as the mother town of mining camps, essentially began its existence on May 2, 1862 when William Talcott, Overland Stage employee and former Pony Express rider, discovered silver ore in Pony Canyon near the town's site. Talcott came from Jacobsville (formerly Jacobs Springs), a stage stop six miles to the west on the Reese River, which also served as the first Lander County seat. His discovery set off the famous "Rush to Reese" or the "Reese River Excitement" as it came to be known. With this discovery, the Reese River sub-basin's largely pastoral existence was dramatically altered and a period of intense exploitation of the area's timber, mineral, range and water resources began. A nearby town called Clifton flourished briefly in Pony Canyon, but fast-growing Austin soon took over and became the county seat in 1863, with a population of about 1,200 persons. Early in 1864, Clifton, Austin and Upper Austin were all combined and incorporated as the City of Austin. Before the mines began to fail in the 1880's, Austin was a substantial community boasting as many as 10,000 people.[156] From Austin, prospectors fanned out to explore Nevada's vast expanse and establish many other important mining camps throughout central and northern Nevada.[157]

Livestock raising and ranching operations in the Reese River sub-basin became established in 1862 shortly after the start of the Austin mining boom. It was in that year that Lewis R. Bradley, who became Nevada's second Governor (1870-1878), moved to the upper Reese River Valley from California with 500 head of Texas longhorn cattle. Along with his son and two other partners, Bradley began the first large-scale ranching operation in Nevada, eventually stocking the lush meadows of the upper Reese River Valley and the Toiyabe Canyons north and south of Austin with thousands of longhorn cattle. In the 1880's, 1890's and early 1900's, thousands of nomadic and unregulated bands of sheep grazed the upland areas of the Toiyabe and Shoshone Mountain ranges in the middle and upper Reese River sub-basin. Some of the destructive overuse of these upland watershed areas was eventually curbed with the establishment in March 1907 of the 600,000-acre Toiyabe Forest Reserve, which later became part of the Toiyable National Forest.[158]

In terms of topography, the Reese River sub-basin shows significant changes in elevation from a low point in the drainage system of just over 4,500 feet MSL at Battle Mountain along the Humboldt River to well over 11,000 feet in the Toiyable Range (Toiyabe Dome, 11,788 feet MSL) and over 10,000 feet in the southern Shoshone Range (North Shoshone Peak, 10,313 feet MSL). Due to the nature of predominant storm patterns, however, these elevations do not produce nearly the abundance of precipitation (i.e., snowpack) as do, for example, the Ruby Mountains, which tend to receive additional precipitation from more northward-tracking storm systems moving southeasterly from the Pacific Northwest.

Average annual precipitation on the irrigated lands in the sub-basin is estimated to vary from six inches around Battle Mountain and Beowawe to 10 inches in the southern portion of the Reese River Valley. Precipitation in the mountain regions of the sub-basin varies by elevation and the location of the mountain range. In the Toiyabe Range, precipitation typically varies from 12-20 inches per year in the southern portion at elevations from 7,000 to over 11,000 feet and from 10-25 inches in the northern part of the range at elevations of 6,000 to over 11,000 feet. In the Shoshone Range to the west, annual precipitation levels range from 12-15 inches in the southern end at elevations of 7,000 to over 10,000 feet and from 8-15 inches in the north at elevations of 6,000 to 8,500 feet.[159]

The Reese River sub-basin may be characterized as a "transition zone" among sub-basins within the Humboldt River Basin where the predominance of the big sagebrush-grass vegetation type of the river's upper sub-basins begins to give way to the desert species of shadscale (*Atriplex confertifolia*) and greasewood plant communities which largely characterize the lower Humboldt River's sub-basins. These desert plant communities, particularly greasewood intermixed with scattered rubber rabbitbrush, become more prominent in the lower reaches of the Reese River sub-basin, particularly north of the Reese River-Fish Creek confluence. Cheatgrass also appears in the less saline sites and wildfire burn sites throughout the sub-basin. South of U.S. Highway 50 in the upper Reese River drainage, big sagebrush occupies the upland benches and terraces along with an understory of cheatgrass or, less frequently, perennial grasses such as Sandberg bluegrass, Nevada bluegrass, or bottlebrush squirreltail.

On the sub-basin's upper slopes, big sagebrush eventually gives way to low sagebrush as elevation increases, usually with a bluegrass understory, along with scattered expanses of bitterbrush. The mountain slopes above the sagebrush areas are generally covered with stands of pinyon pine and Utah juniper. In the Shoshone Range, juniper predominates, whereas in the Toiyabe Range the pinyon pine are most prevalent. Cheatgrass is also widely distributed in these upper areas as well. On the steep slopes and along the ridge tops, thick stands of mountain mahogany are found on the southern and western exposures, and limber pine grow on the northern exposures. These pine stands, particularly around Arc Dome, were extensively logged in the mining boom period of the 1860's and 1870's. The upper Reese River area, as well as the upper canyon bottoms of the Shoshone and Toiyabe Mountain ranges, are characterized by willow and cottonwood stands giving way to thin stands of aspen at the higher elevations.[160]

Battle Mountain Sub-Basin

The Battle Mountain sub-basin is a south and southwesterly-draining area to the Humboldt River system located in the north-central portion of the Humboldt River Basin. The sub-basin's drainage is essentially divided into eastern and western parts by the southern extent of the Sheep Creek Range and other isolated hills and low mountains stretching northward from the Humboldt River at Battle Mountain, Nevada. The eastern half of the sub-basin is drained primarily by Rock and Boulder Creeks, with Rock Creek typically being the only perennial (year round) stream flowing along most of its reach.[161] The western half of the sub-basin is drained principally by Kelly and Evans Creeks, both of which produce only seasonal surface water flows. The sub-basin's most pronounced physical borders include the Tuscarora Mountains on the east side and the Osgood Range on the west. To the north, the Battle Mountain sub-basin is separated from the Little Humboldt River sub-basin by a ridge of relatively low peaks called the Snowstorm Mountains. The sub-basin's southern extent encompasses the Humboldt River Valley.

The Battle Mountain sub-basin is the second largest of eleven sub-basins within the Humboldt River Basin, covering 2,508 square miles and comprising 14.9 percent of the Humboldt River Basin's total surface area. The sub-basin stretches across four Nevada counties to include Elko County in the north and northeastern portion of the sub-basin, Eureka County in the southeastern part, Lander County in the south-central part of the sub-basin, and Humboldt County in the western portion of the sub-basin. Interestingly, the sub-basin is nearly equally divided among these four Nevada counties. The sub-basin is bordered by the Maggie Creek and Elko Reach sub-basins to the east, the Reese River sub-basin to the south, the Central Region (Nevada Hydrographic Region 10), to the southwest, the Sonoma Reach sub-basin to the west, the Little Humboldt River sub-basin to the northwest and north, and the Snake River Basin (Nevada Hydrographic Region 3) to the north and northeast.

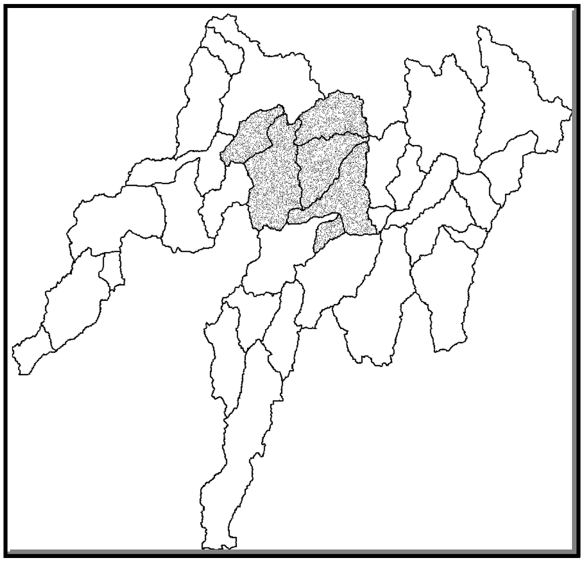


Figure 15 – Battle Mountain Sub-Basin

The Battle Mountain sub-basin includes six Nevada hydrographic areas: (1) hydrographic area 60, Whirlwind Valley, covering 94 square miles; (2) hydrographic area 61, Boulder Flat, covering 544 square miles; (3) hydrographic area 62, Rock Creek Valley, covering 444 square miles; (4) hydrographic area 63, Willow Creek, covering 405 square miles; (5) hydrographic area 64, Clovers Area, covering 720 square miles; and (6) hydrographic area 66, Kelly Creek Valley, covering 301 square miles.

One particularly interesting characteristic of the Battle Mountain sub-basin is that while being the Humboldt River Basin's second largest sub-basin in terms of surface area, it is also one of the driest in terms of contributing surface water flows into the Humboldt River, being largely drained by seasonal or ephemeral streams.[162] From average annual Humboldt River flows of 270,040 acre-feet

(1897-1998) at Battle Mountain to average annual flows of 246,150 acre-feet (1895-1998) at Comus, this sub-basin more typically acts as a net sink (averaging -23,890 acre-feet per year) for the Humboldt River's surface waters between these two locations. Rock Creek is the largest and most consistently flowing (perennial) tributary within the sub-basin, recording average annual flows of 29,900 acre-feet at its USGS gage. However, this gage is located some 22 miles northeast of Battle Mountain and the Humboldt River at the creek's emergence from the Sheep Creek Range, making its actual contribution to the Humboldt River main stem difficult to determine.

In terms of Rock Creek's flows actually reaching the Humboldt River, this stream is also seasonal in nature. Rock Creek is also the longest tributary stream within the Battle Mountain sub-basin, originating in the Tuscarora Mountains just below Dry Creek Mountain (8,391 feet MSL). Rock Creek extends over 60 miles from its headwaters to where it enters the Humboldt River Valley, then exhibits seasonal flows as it runs another ten miles parallel to the Humboldt River main stem until its confluence. A principal tributary of Rock Creek is Willow Creek (and the Willow Creek Reservoir), which drains the western slopes of the Tuscarora Mountains below Toe Jam Mountain (7,123 feet MSL). The remaining tributaries and stream systems of the Battle Mountain sub-basin which drain towards (but do not necessarily reach) the Humboldt River are considerably smaller in volume and typically do not sustain year-round surface water flows.

Most of the historical aspects of the Battle Mountain sub-basin were concentrated in the lower portion of the sub-basin located within the Humboldt River Valley. The sub-basin's history and early European's use and development of its water, range and croplands, and the extraction of mineral and other natural resources, can be roughly divided into three periods. The first period encompassed the years of 1828-1841 which marked the era of early exploration and fur-trapping. The second period lasted from 1841 to essentially 1869 and included the period from the passage of the first emigrants through the Humboldt River Valley portion of the sub-basin (the Bartleson–Bidwell emigrant party) to the joining of the Central Pacific rails (from the west) and Union Pacific rails (from the east) at Promontory Summit (Point), Utah on May 10, 1869.[163] The third period spans from 1869 to the present and marks the development of the Battle Mountain sub-basin's ranching, farming and mining industries.

Peter Skene Ogden was reportedly the first European to explore this portion of the Humboldt River Basin. On November 16, 1828, during his fifth Snake Country Expedition for the Hudson's Bay Fur Company, Ogden passed Iron Point, located in the Battle Mountain sub-basin some eight miles due east of the southernmost extent of the Osgood Mountains, on his way upstream while trapping beaver and other fur-bearers as he went. In June 1831, John Work, Ogden's successor, traversed the Humboldt River main stem from present-day Dunphy, located in the eastern portion of the Battle Mountain sub-basin and at the southern end of Boulder Valley, westward as far as Winnemucca, Nevada.[164]

The emigration era through the Battle Mountain sub-basin was inaugurated in 1841 by the Bartleson–Bidwell emigrant party, which made the first successful crossing of the Great Basin without major event or loss of life. Their passage was made somewhat easier than those wagon trains which followed. Before entering the Humboldt River Basin, the Bartleson–Bidwell party abandoned their wagons on the eastern slopes of the Pequop Mountains in eastern Nevada, proceeding the rest of the way as a pack train. Following in their path down the Humboldt River Valley and through the Battle Mountain sub-basin were countless other emigrant wagon trains, continuing through the year 1869 when the transcontinental railroad was eventually completed. These early passages were filled with extreme hardships. The Humboldt River Valley did not always offer the most hospitable conditions to early travelers, particularly late in the season and after the passage of numerous emigrants, wagons and hungry livestock cut down the trees for firewood, pulverized the roads into fine, blowing dust, and denuded accessible pastures of forage for livestock.

Many of the early emigrants using this portion of the Emigrant Trail felt bitterly mislead by the guidebooks and early favorable testimonies of this region. On July 20, 1849, Bennett C. Clark noted in his diary: "…came to the river and nooned – grass only tolerable. We begin to be greatly disappointed in our calculations of finding good grass on this measly Humboldt [River] as Mr. Ware [author of a guidebook] had prepared us to expect. Let no traveler hereafter be governed by Wares Guide as it is perfectly worthless." The bitterness was not limited to the guidebook writers, however, and even John C. Frémont, who had come through the area in December 1845, took a drubbing: "I would ask the learned and descriptive Mr. Frémont and the elegant and imaginative Mr. Bryant, where was the beautiful valley, the surpassing lovely valley of Humboldt? Where was the country presenting the most splendid 'agriculture features?' Where were the splendid grazing, the cottonwoods lining the banks of their beautiful meandering stream, and every thing presenting the most interesting and picturesque appearance of any place they ever saw?" (Vincent Geiger, 1849)[165]

The construction of the Central Pacific Railroad up the Humboldt Valley in 1868 and the completion of the transcontinental railway in 1869 effectively brought to a close the era of westward emigration down the Humboldt River Valley by wagon train. In November 1868 Argenta Station was set up as a terminus for the freight and stage roads serving the bustling mining communities up the Reese River. Early in 1870, this station was moved five miles west to the junction of the Reese River and the Humboldt River and a new town, Battle Mountain emerged. The arrival of the railroad had a profound effect on the land and natural resource use of the Battle Mountain sub-basin. The once-lush meadowlands along the Humboldt River from Beowawe in the east to Iron Point in the west, which had previously fed and watered westward-bound emigrant wagon trains, now began serving the needs of some of Nevada's largest and best-known cattle operations.[166]

The Horseshoe Ranch at Beowawe was established by Dr. George W. Grayson of San Francisco and Aaron Benson of Beowawe under the famous Horseshoe (branding) iron. This represented the first brand to be registered in Lander County and the first major ranching operation established in the Battle Mountain sub-basin. Ultimately, Dr. Grayson and his various partners would come to own or control over 200,000 acres of grazing lands in Elko, Eureka and Lander counties.[167] Another major operator, the W.T. Jenkins Company, was established with headquarters at Battle Mountain and began grazing cattle and sheep on 278,000 acres of deeded lands in Lander, Pershing and Elko counties.[168] By 1891, W.T. Jenkins was known as one of the largest sheep and wool growers in Nevada, with flocks numbering some 25,000 head.[169]

Early mining activities in the Battle Mountain sub-basin were never very extensive, except for the Midas District in the central portion of the sub-basin in the Snowstorm Mountains, and the tungsten and gold mines in the Potosi Mining District in the Osgood Mountains in the western portion of the sub-basin. Gold was discovered in the Midas (Gold Circle) District in 1907, during the general surge in prospecting throughout the state following the rich strikes at Tonopah and Goldfield. The peak of this early boom period lasted from 1916 to 1921, with Midas boasting a population of some 2,000 persons, 21 saloons, a town water system, a newspaper, four general stores and several hotels and rooming houses. Today this once-booming mining community is virtually deserted. The Potosi Mining District, on the other hand, has faired considerably better. In fact, the Getchell Mine, while closing its tungsten operations in 1957, has since evolved into a relatively productive gold mining operation along the Getchell Gold Trend, thanks mainly to new gold-extraction techniques.[170] More recently, the Battle Mountain sub-basin has become the center of the state's gold mining industry which is centered primarily in the upper reaches of Boulder Valley along the Carlin Trend.

Topographically, the Battle Mountain sub-basin does not show the extremes in elevations of the other sub-basins within the Humboldt River system. Peak elevations vary from just over 8,000 feet MSL in the Tuscarora Mountains to the sub-basin's low point of 4,360 feet MSL at the USGS Comus gaging station located on the Humboldt River main stem. It might be interesting to note that during the last peaking highstand of Ice Age Lake Lahonton which occurred some 12,000 years ago at a surface elevation of about 4,380 feet MSL, its farthermost extent up the Humboldt River Valley was to a point about five miles above Comus to the present-day location of Red House. At this location it formed a small lake (by late Pleistocene standards) of approximately 30 square miles.

Climatologically, the Battle Mountain sub-basin benefits from its enclosure to the east, north and west by mountains producing surface water runoff from snowpack accumulation. In the east, along the Tuscarora Mountains, elevations above 8,000 feet are estimated to experience up to 25 inches of precipitation per year. In the north along the Snowstorm Mountains and in the west along the Osgood Mountains, elevations over 8,000 feet generally experience up to 20 inches of precipitation per year, mostly in the form of snowfall. Along the lower reaches of the sub-basin, located within the Humboldt River Valley, annual precipitation averages from only six to seven inches between Beowawe in the east to Comus in the west.[171]

Vegetation coverage within the Battle Mountain sub-basin is as varied as within any sub-basin in the entire Humboldt River system and ranges from virtually nothing on the low semi-playa bottomlands to expanses of trees, shrubs and grasses in the higher elevations. Generally, however, the predominant plant cover includes either big sagebrush-grass or black greasewood, which together cover approximately 70 percent of the entire Battle Mountain sub-basin. Other common plant species within the sub-basin includes shadscale, black sagebrush, Utah juniper and aspen. Dense stands of quaking aspen are found at the drainage headwaters in the higher mountains of the Tuscarora Mountains, primarily along the northern slopes. While the upper elevations have a variety of grasses, much of the lower elevations have little desirable grass understory, with invasive cheatgrass having taken over much of these areas, particularly as the result of numerous and repetitive open range wildfires. Willows extend along natural water courses and irrigation ditches throughout the sub-basin's river bottoms.[172]

Little Humboldt River Sub-Basin

Situated in the extreme north-central portion of the Humboldt River Basin, the Little Humboldt River sub-basin is a south-draining, essentially "closed" drainage area comprised of a number of north-south trending valleys. Most of the sub-basin is located in east-central Humboldt County; however, the easternmost portion of the sub-basin, consisting of most of the Little Humboldt River's South Fork watershed, extends into western Elko County. The sub-basin's "normal" drainage area extends from the south at a formation called the "Sand Dunes", lying six miles north of the Humboldt River, northward over fifty miles to the vicinity of Capitol Peak (8,255 feet MSL) in the northern portion of the Santa Rosa Mountain Range. The east-west extent of the sub-basin carries it from the Santa Rosa Range in the west to a high plateau area in the east, the 6,000-foot Owyhee Plateau, which extends some twenty miles inside the western border of Elko County.

Principal streams and drainage areas within the Little Humboldt River sub-basin include the Little Humboldt River's North Fork watershed, the South Fork watershed, and the Martin Creek watershed. In addition, the lower portion of the sub-basin encompasses the confluence of the North and South forks of the Little Humboldt River, the agricultural area of Paradise Valley, and extends to the Sand Dunes formation at the sub-basin's lower end. After the confluence of the river's North and South Forks, the Little Humboldt River picks up Eden Creek and then Martin and Indian Creeks. Under normal hydrologic conditions (i.e., average water years), the surface waters of the Little Humboldt River do not exit the sub-basin and therefore do not contribute to the flows of the Humboldt River main stem, being blocked by the Sand Dunes formation. Under heavy flow conditions (i.e., severe flooding), however, a lake, called Gumboot Lake, forms on the upstream side of the Sand Dunes. And during especially severe flood conditions this lake back ups sufficiently to breach the Sand Dunes and empty into the Humboldt River at a point just over three miles above Winnemucca.

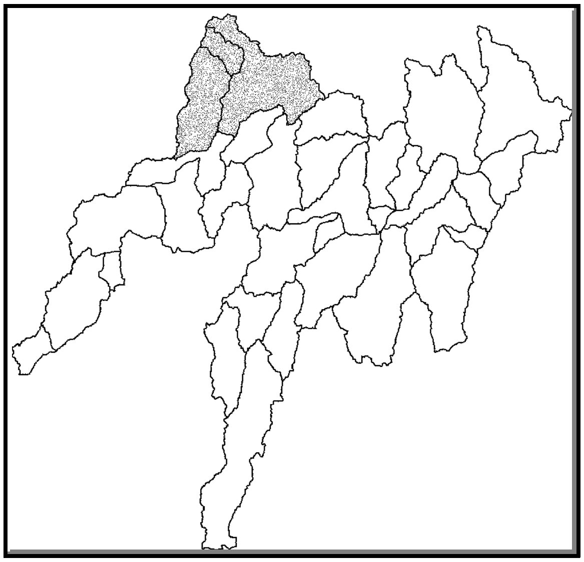


Figure 16 – Little Humboldt River Sub-Basin

The Little Humboldt River sub-basin is the fourth largest of eleven sub-basins within the Humboldt River Basin. The sub-basin covers 1,742 square miles, accounting for 10.3 percent of the Humboldt River Basin's total surface area. The sub-basin appears triangular in shape, with one corner pointing to the east and into Elko County, another pointing southwest towards the Humboldt River, and the third corner marking the northern extent of the Santa Rosa Mountains. The sub-basin is bound by the Sonoma Reach and Battle Mountain sub-basins to the south, the Snake River Basin (Nevada Hydrographic Basin 3) to the north, and the Black Rock Desert Region (Nevada Hydrographic Region 2) to the west. In addition to stretching across two Nevada counties (Humboldt and Elko), the Battle Mountain sub-basin also includes three Nevada hydrographic areas within the Humboldt River Basin: (1) hydrographic area 67, Little Humboldt Valley, covering 975 square miles; (2) hydrographic area 68, Hardscrabble Area, covering 167 square miles; and (3) hydrographic area 69, Paradise Valley, covering 600 square miles.

Principal geographic features of the Little Humboldt River sub-basin include the Osgood and

Snowstorm Mountains separating this sub-basin from the Battle Mountain sub-basin to the south, and the Santa Rosa Mountain Range stretching along the entire western border of the sub-basin. The northern half of the Santa Rosa Range lies within a portion of the Humboldt National Forest. To the north and northeast, the Little Humboldt River sub-basin is bordered by the rolling 6,000-foot Owyhee Plateau area of the Snake River Basin.

Historically, the Little Humboldt River basin is particularly noteworthy as it represented the gateway by which the first European explorers and trappers entered the Humboldt River Basin from the north. In November 1828, Peter Skene Ogden, a trapper for the Hudson's Bay Company, led a party of trappers comprising the Fifth Snake County Expedition south from the Columbia River Basin.[173] Entering Nevada near present-day Denio, Nevada, the trappers traveled southward along the Quinn River and then entered the Little Humboldt River sub-basin on November 9 via Paradise Hill Pass. This represented the first known visit by Europeans to the Humboldt River Basin. Proceeding down the Little Humboldt River, Ogden reached the Humboldt River main stem, arriving near the vicinity of present-day Winnemucca, Nevada. Knowing neither its origin nor its destination, Ogden initially named the Humboldt simply "Unknown River".[174] Subsequently, Ogden was to conduct two additional expeditions into the Humboldt River Basin in 1829, both times using the northern entry route through the Little Humboldt River sub-basin. Ogden's Humboldt River Basin explorations of 1828-1829 were especially important as they traced the Humboldt River virtually from its source to its sink and produced the first maps and written descriptions of northern and central Nevada.[175]

Paradise Valley was first occupied by settlers in 1863. Indian trouble started in 1864 and worsened in 1865, leading to the establishment of Camp Winfield Scott (1866-1870), located about four miles from the present-day community of Paradise Valley. The valley soon became the granary and fruit-raising center for the mining camps of central and eastern Nevada and those of southwest Idaho Territory as well. Scottsdale, named for the nearby Army Post, was established in 1866. It was renamed Paradise City in 1869 and eventually was called simply Paradise Valley. During Paradise Valley's period of mining activity, which extended from 1878 to 1920, the community served as a supply center for the small mining camps of Queen City, Spring City and Gouge-Eye. With the decline of mining activity in the area beginning about 1918, the Little Humboldt River sub-basin's diverse agricultural industry shifted primarily to ranching and the raising of cattle and sheep. By the 1950's, cattle raising had entirely replaced the sheep herds and remains the area's main economic activity today.[176]

The breakthrough of the Little Humboldt River through the sand dune formation to the Humboldt River main stem has occurred only infrequently. The "White Winter" of 1889-90 and subsequent heavy snowpack spring meltdown caused extensive flooding in virtually all of the Humboldt River's sub-basins. This was also the first recorded event in which the Little Humboldt River became a surface water tributary to the Humboldt River's main stem. Within the sub-basin the flooding from this winter's heavy snowpack meltdown extended from March to June of 1890 and caused considerable loss of livestock as Paradise Valley became virtually one large lake. Gumboot Lake formed on the upstream side of the Sand Dunes and the Little Humboldt River eventually broke through to the Humboldt River above Winnemucca. During this time, it was reported that deep snows packed the canyons at the head of the Little Humboldt River nearly as solidly as ice and were measured up to 100 feet deep in places.[177]

The next recorded breakthrough of the Sand Dunes by the Little Humboldt River occurred in the twentieth century during the flood event of March-April 1907.[178] Similar floods, the formation of Gumboot Lake and the breaching of the Sand Dunes by the Little Humboldt River took place in February-April 1910, probably representing the worst flooding in the entire Humboldt River Basin, and again in January-April, 1914. During the 1914 event the Little Humboldt River's depth at its confluence with the Humboldt River main stem was reported at 10.5 feet.[179] After a lengthy hiatus, in late January 1943, the Little Humboldt River sub-basin flooded again and Gumboot Lake again breached the Sand Dunes. Martin Creek discharged into Paradise Valley at a peak rate of 9,000 cfs (typical annual flows average about 34 cfs at this location) and the Little Humboldt River discharged into the Humboldt River at a peak rate of 4,000 cfs.[180] Gumboot Lake formed again in 1952 and broke through the Sand Dunes, with the Little Humboldt River showing a peak rate of flow of 5,371 cfs into the Humboldt River's main stem.[181]

Topographically, elevations within the Little Humboldt River Basin range from a low of 4,300 feet MSL at the Sand Dunes to over 9,000 feet MSL in the Santa Rosa Range (Paradise Peak, 9,443 feet MSL; Santa Rosa Peak, 9,701 feet; Granite Peak, 9,732 feet). Precipitation within the sub-basin ranges from 8-9 inches in Paradise Valley to about 25 inches in the upper elevations of the Santa Rosa Range, with virtually all precipitation coming during the winter months.[182] Plant cover generally follows the extremes shown in surface elevations and ranges from nothing on the shifting sand dunes in the lower sub-basin to groves of aspen and scattered conifers in the higher elevations of the Santa Rosa Mountains. The predominant ground cover in the high county above 6,000 feet is sagebrush-bunchgrass, while the lower areas throughout the sub-basin are dominated with sagebrush and greasewood with little perennial grass types present.[183]

Sonoma Reach Sub-Basin

The Sonoma Reach sub-basin lies along the Humboldt River Valley in the west-central portion of the Humboldt River Basin. Most of the sub-basin lies south of the Humboldt River in the vicinity of Winnemucca, Nevada; however it also includes short drainages north of the river and the bottomlands along the Humboldt River main stem between Comus and a point downstream and just north of the Pershing County northern boundary. South of the Humboldt River, the major portions of the sub-basin draining into the Humboldt River include Pumpernickel Valley to the east, which is drained primarily by Ragan Creek towards Comus, and Grass Valley to the west, which is drained primarily by Clear Creek draining towards the Humboldt River some ten miles below Winnemucca. Both of these creeks, as well as virtually all other tributary streams within this sub-basin, are typically seasonal or ephemeral in nature. The Sonoma Reach sub-basin's prominent geographic characteristics include the Tobin Mountain Range on the sub-basin's southeast boundary, Buffalo Mountain and the Osgood Mountains on the east, the East Range on the west, Hot Springs Range to the north and the Krum Hills to the north and west of Winnemucca. Pumpernickel Valley and Grass Valley, located to the south of the Humboldt River, are separated by the Sonoma Range, containing the highest peaks in the sub-basin and from which the sub-basin derives its name.

The northern portion of the Sonoma Reach sub-basin lies within Humboldt County and the southern portion is located in Pershing County. The sub-basin has a surface area of 1,254 square miles and is the sixth largest of the eleven sub-basins within the Humboldt River Basin, comprising 7.4 percent of the basin's total surface area. The sub-basin is bordered by the Battle Mountain sub-basin to the east, the Central Region (Nevada Hydrographic Region 10) to the southeast and south, the Lovelock sub-basin to the west, the Little Humboldt River sub-basin to the north, and the Black Rock Region (Nevada Hydrographic Region 2) to the northwest. The Sonoma Reach sub-basin includes three hydrographic areas within the Humboldt River Basin: (1) hydrographic area 65, Pumpernickel Valley, covering 299 square miles; (2) hydrographic area 70, Winnemucca Segment, covering 435 square miles; and (3) hydrographic area 71, Grass Valley, covering 520 square miles.

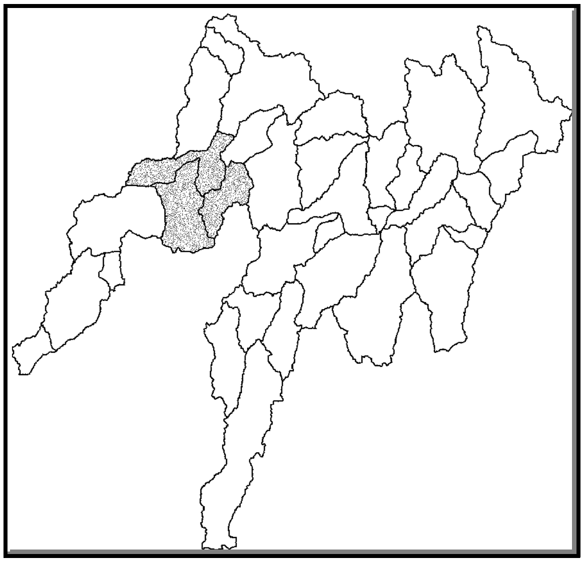


Figure 17 – Sonoma Reach Sub-Basin

Due to the "gateway" role of the Little Humboldt River to the north, the Sonoma Reach sub-basin figured prominently in early exploration of the Humboldt River Basin by European explorers and fur trappers. In November 1828 Peter Skene Ogden, a trapper for the Hudson's Bay Company, came down the Little Humboldt River from the Columbia River Basin (Snake River) in the north and discovered the Humboldt River main stem, arriving near the vicinity of present-day Winnemucca, Nevada, on November 9, 1828. Here he found the Humboldt River lined with willows and well-stocked with beaver. From here, he explored downstream for several days until reaching a point near the present-day site of Mill City, located some 30 miles downstream from Winnemucca. Bad weather interrupted further exploration and forced Ogden's party to retreat up the Humboldt River towards Salt Lake Valley in Utah. Ogden returned to the Humboldt River the following year and arrived at the present-day site of Winnemucca on May 10, 1829. This time he was able to press on and reach the terminus of the Humboldt River, the Humboldt Sink on May 29, 1829. Combined with his travels along the river the previous year, this completed Ogden's exploration of the Humboldt River's entire length.[184]

During the early emigrant wagon train period, which lasted essentially from the Barttleson-Bidwell emigrant party in 1841 to just after the completion of the transcontinental railroad in 1869, the stretch of the Humboldt River Valley from present-day Winnemucca downstream to Lassen Meadows, a distance of approximately 35 miles, was a particularly torturous part of the journey for early California emigrants. Along this stretch the early emigrants probably suffered more than anywhere else along the river's entire length. By this time they had been on the Humboldt for over 200 miles. Their supplies were low, feed for the stock animals was very scarce, they encountered deep sand, water quality became worse where it was available, and the powdery blowing dust was nearly unbearable. Depressing spirits even more was the knowledge that the Forty-Mile Desert awaited them at the river's end, just beyond the Humboldt Sink.[185]

The site of Winnemucca was first settled in 1861. In 1863, Frank Baud, a Frenchman, was generally credited with founding the town of Winnemucca. Baud, along with two other Frenchmen, Louis and Theophile Lay, and an Italian, Joseph Ginaca, built a toll bridge across the Humboldt River and a store. The town came to be known by a number of names, including French Fort, Frenchman's Ford, French Bridge, and Ginaca Bridge. In 1866 it was finally named after the famous Paiute chieftain when a post office was established in the town. During the latter part of the wagon train emigration period, Winnemucca was one of the principal rest stops and supply centers along the Humboldt River.[186] Baud originally came to the location with Louis Lay from California to work on the Humboldt Canal, a project headed by Dr. A. Gintz and Joseph Ginaca who devised the plan to link Golconda and Mill City by means of a 66-mile long canal and provide water for the mills in the area. The project was never completed, however.[187] After considerable investment and several years of labor, the canal reached from Golconda to Winnemucca, a distance of 28 miles and went no further. Because of poor engineering there was insufficient drop to develop a head of water adequate for the projected needs. The canal continued to be used for irrigation purposes until about 1870, however, when it was finally abandoned. While the canal itself was a failure, its development brought to the Winnemucca area a number of young, ambitious and enterprising individuals who were to figure prominently in the future economic and water resources development of this area.[188]

Golconda, located nearly 20 miles upstream from Winnemucca, was first settled in 1863 and was a by-product of the ill-fated Ginaca-Gintz Humboldt Canal. The town later became the headquarters for the Golconda & Western Exploration Company, Ltd., and boasted some 500 inhabitants, six hotels, a newspaper, several stores, many bars, a racetrack and a flourishing tenderloin district at the height of the region's mining boom in 1899. The Golconda mining boom, however, was relatively short-lived. By 1900, because of difficulties in treating the Adelaide and Copper Canyon ores, upon which the town had flourished, the mine, mill and narrow-gauge railroad to the mine site were abandoned and shut down.[189]

On September 16, 1868, the Central Pacific Railroad reached Winnemucca. A stage and freight toll road was opened from Winnemucca northward to the new silver strikes in Idaho Territory, at Silver City and Boise City. In 1873 the Humboldt County seat was moved from Unionville, which was founded in 1861, to Winnemucca. By 1875 Winnemucca was the hub of stage and freight roads radiating not only to Idaho points, but also to Unionville, Humboldt City, Star City, and Dun Glen, to the south and west, and Paradise City, Spring City, and Queen City in Paradise Valley to the north. Through the years, because of its strategic location, Winnemucca has continued to be an important staging point and transportation hub.[190]

Cattle ranching began in earnest in Humboldt County in 1873 when Frank Button and his uncle I.V. Button drove cattle into the Winnemucca area to begin ranching operations in the rich, fertile valleys of northern and eastern Humboldt County. At that time, the town of Winnemucca consisted of a few houses, a ferry across the Humboldt River and Bridge Street paved with sagebrush stubs. Using their famous Double Square brand, the Buttons raised thousands of fine horses on their 4,000 square miles of ranch land.[191] During the period from the late 1870's to the 1890's, Winnemucca was the shipping point to California for enormous herds of cattle from the huge northern Nevada and southern Oregon cattle baronies of Miller & Lux, Peter French, and Stauffer & Sweetser. During this period, Winnemucca's role as a cattle shipping point transcended its other activities.[192]

Beginning around 1890, and continuing essentially until the passage of the Taylor Grazing Act in 1934, the Sonoma Reach sub-basin was visited by "countless thousands" of migrant sheep which passed through Grass Valley (south of Winnemucca) en route to and from their summer ranges in the Sonoma, Santa Rosa, East Range, Humboldt Range, and other higher elevation pastures. According to newspaper articles at the time, this continual procession led to the trampling out or extensive grazing of the once verdant ryegrass meadows in Grass Valley, to the point where only a few scattered native grassland meadows remained. The high summer ranges in the nearby mountains, particularly the Sonoma and Santa Rosa Ranges, were also subjected to heavy use by transient sheep operators. Much of the resultant watershed erosion damage evident in these upper watersheds can be attributed to this past range and upper watershed grazing use.[193]

The topography of the Sonoma Reach sub-basin is fairly characteristic of other sub-basins in the Humboldt River system: relatively high mountain ridges, mountain highlands, valley lowlands and, in this case, river bottomlands along the Humboldt River main stem. The highest elevations within the sub-basin are located in the Sonoma Range (Sonoma Peak, 9,395 feet MSL) located in the central portion of the sub-basin. Other mountain ranges are typically less imposing, for example, the East Range (Dun Glen Peak, 7,441 feet and Auld Lang Syne Peak, 7,233 feet), Buffalo Mountain (7,997 feet) and the Krum Hills and Blue Mountain (7,342 feet). The lowest point in the sub-basin is along the Humboldt River at the Pershing County boundary, which is approximately 4,000 feet MSL. Based on these elevation differences, annual precipitation varies from 6-8 inches in the sub-basin's lowlands to up to 25 inches in the upper reaches of the Sonoma Range. Annual precipitation in the sub-basin's various mountain ranges, which typically is experienced during the winter months as snow or rain, varies by location and elevation as follows: (1) East Range – 8 to 15 inches (5,000 to over 7,000 feet); (2) Sonoma Range – 8 to 25 inches (5,000 to over 9,000 feet); (3) Tobin Range – 8 to 20 inches (5,000 to over 8,000 feet); (4) Osgood Mountains – 8 to 15 inches (5,000 to 8,000 feet); (5) Hot Springs Range – 8 to 10 inches (5,000 to over 6,000 feet); and (6) Winnemucca Mountain – 8 to 10 inches (5,000 to 6,000 feet).[194]

The predominant vegetation cover over most of the Sonoma Reach sub-basin is either big sagebrush-grass, which is more prevalent, or shadscale-grass. Generally, big-sagebrush occupies the steep mountain slopes and basins and the upland bench lands and terraces, but it can also be found fringing the Humboldt River bottomlands wherever light-textured, well-drained, dune-type soils are found. Shadscale occupies the flat uplands and alluvial fans between the valley bottomlands and the rolling foothills in both Grass Valley and Pumpernickel Valley. Black greasewood is generally the dominant plant cover throughout the bottomlands of Grass Valley and the northern half of Pumpernickel Valley. Sometimes greasewood may be found intermixed with expanses of rubber rabbitbrush. Cheatgrass is by far the most common grass found throughout the sub-basin, particularly on burn sites such as Winnemucca Mountain, located just north of Winnemucca. Utah juniper is found thinly scattered across the western face of the Sonoma Mountain Range and on the ridgetops and fans of the East Range, but most of these trees are stunted and poorly formed and have little commercial value. Other trees found within the sub-basin include cottonwood and chokecherry, which are found along most of the creek bottoms. A few small stands of quaking aspen also occur on the north slopes of the Sonoma Mountains near the ridge lines and within the upper watersheds.

Lovelock Reach Sub-Basin

The Lovelock Reach sub-basin includes the western-most portion of the Humboldt River Basin and river system to include the Humboldt and Toulon lakes and the Humboldt Sink. The sub-basin extends in a generally northeast to southwest direction and includes a relatively narrow strip some 15-20 miles wide and 80 miles long of all of the lands draining directly into the lower Humboldt River from just north of the Humboldt County-Pershing County border in the north to the Humboldt River's terminus just inside the Churchill County boundary in the south.[195] Most of the Lovelock Reach sub-basin lies within Pershing County, and the central area includes Rye Patch Reservoir and the agricultural areas around Lovelock, Nevada.

Principal geographic features of the Lovelock Reach sub-basin include an extensive expanse of Humboldt River bottomlands and meadows surrounded by a series of mountain ranges. Bordering the eastern portion of the sub-basin from south to north are the West Humboldt Range, the Humboldt Range, and the East Range. To the north, the sub-basin is bordered by the Eugene Mountains, and to the west by the Trinity Range in the south and the Antelope Range in the north-central part of the sub-basin. Much of the lower portion of the sub-basin around Lovelock is used extensively for agricultural purposes and receives its irrigation waters from the 194,300 acre-foot capacity (effective) Rye Patch Reservoir, which was completed by the U.S. Bureau of Reclamation in 1936.

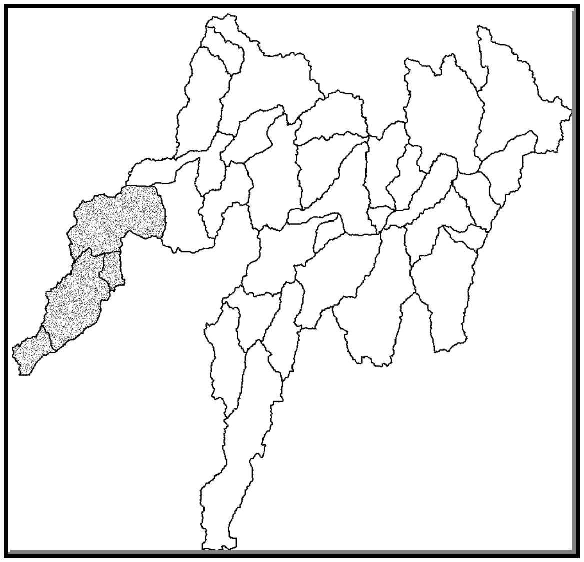


Figure 18 – Lovelock Reach Sub-Basin

The Lovelock Reach sub-basin is the sixth largest of eleven sub-basins within the Humboldt River Basin, comprising 1,668 square miles and accounting for 9.9 present of the basin's total surface area. The sub-basin stretches across three Nevada counties (Humboldt, Pershing and Churchill) and includes three Nevada hydrographic areas and one sub-area. These are: (1) hydrographic area 72, Imlay Area, covering 771 square miles; (2) hydrographic area 73, Lovelock Valley, covering 635 square miles; (3) hydrographic sub-area 73A, Lovelock Valley/Oreana Sub-Area, covering 98 square miles; and (4) hydrographic area 74, White Plains, covering 164 square miles. The Lovelock Reach sub-basin is bordered by the Sonoma Reach sub-basin to the east and northeast, the Black Rock Desert Region (Nevada Hydrographic Region 2) to the north and northwest, the West Central Region (Nevada Hydrographic Region 5) to the west, the Carson River Basin (Nevada Hydrographic Basin 8) to the south, and the Central Region (Nevada Hydrographic Region 10) to the southeast. The lower extent of the Lovelock sub-basin, comprising the Humboldt Sink and the terminus of the Humboldt River Basin, forms a hydrologic link with the Carson Sink in the Carson River Basin during particularly high-water years. The last time these two watersheds were joined was after the 1997 flood, when waters left the Humboldt Sink via the Humboldt Slough and Drain and entered the Carson Sink to the south. This portion of the lower Lovelock sub-basin, along with the Carson Sink and Lahontan Valley, once formed the largest of seven sub-basins making up Ice Age Lake Lahontan during its several highstands, the latest of which existed some 12,000 years ago.

Due to the Lovelock Reach sub-basin's "gateway" status along the Humboldt River main stem, it has figured prominently in the region's earliest exploration, use of its natural meadow lands, and development of early transportation routes. Peter Skene Ogden was the first recorded European to come into the sub-basin when he arrived near the location of present-day Mill City on November 11, 1828, on a fur-trapping expedition. The following year, in May and June 1829, Ogden and his Hudson's Bay Fur Company brigade returned to the Lovelock Reach sub-basin and trapped beaver and other fur-bearing animals around Lovelock and in the sloughs and lakes down to the Humboldt River's terminus. It was at this time that Ogden contemplated changing his earlier names for the Humboldt River – Unknown River and Paul's River – to Swampy River for the extensive wetlands and generally saturated conditions prevalent in the lower portion of the sub-basin. American fur trappers, principally the Bonneville-Walker group of 1833-1834, also trapped this reach of the Humboldt River through 1846, but met with little success.[196] Even so, later explorations, particularly those by Joseph Walker, recognized the natural gateway to the west afforded by the Humboldt River Valley, eventually establishing this route as the California Emigrant (Overland) Trail.

Portions of the Lovelock Reach sub-basin contained abundant natural meadows and were important resting stops on the California Emigrant Trail. In the north-central portion of the Lovelock sub-basin, now partly submerged by the waters of the northern portion of Rye Patch Reservoir, was Lassen Meadows (also referred to as Rye Patch Meadows), located near present-day Imlay, Nevada. This area represented the first major resting place for early emigrants after nearly 200 miles of weary, monotonous travel down the Humboldt River Valley. It also represented the turn-off for the Applegate-Lassen (Cutoff) Trail, which was used between 1846 and 1848 and took some early emigrant wagon trains over to the Black Rock Desert and into northern California and southern Oregon. From Lassen Meadows the California emigrants who decided to continue on the regular route down the Humboldt River headed toward the site of present-day Lovelock, some forty miles distant. This section of the trail was one of the most arduous of the whole Humboldt River route, and abundant grass and good water were almost nonexistent. As Harriet S. Ward wrote in her diary in 1853 while traveling this section of the trail: "Today we have been toiling through the deep dust, as uncomfortable for us all as a person who has never traveled this route can ever imagine, with not a green thing to rest our weary eyes upon. It is a perfectly barren land for forty long miles, and it is distressing to hear the complaints of the poor cattle, which are suffering for want of food.[197]

Having reached the lower portion of Lovelock Valley, referred to as the Big (or Great) Meadows and lying below present-day Lovelock, the early emigrants had effectively reached the end of the Humboldt River and a place where they could feed and rest their weary livestock. The Big Meadows was a place of great rejoicing as the survivors at this point had traveled the nearly 300 miles of the Humboldt River Valley and conquered all the adversities and hardships it had to offer. As noted in an 1850 journal entry of one of those early travelers, Lorenzo Sawyer, about the Big Meadows: "It would almost seem that these extensive meadows were placed here expressly to supply the means of traversing this desert country. At any rate they are precisely at the point where they are most needed." This opinion was supported by Eleazer Stillman Ingalls in this same year: "There is an abundance of grass at this point for all the stock that can ever reach here. We have to wade to get it, then cart it to the channel, and boat it across that in a wagon box…Two miles below our camp there are some falls in the river, at which point the meadows terminate." And a year earlier, Vincent Geiger would write of this place: "This marsh for three miles is certainly the liveliest place that one could witness in a lifetime. There is some two hundred and fifty wagons here at all time. Trains going out and others coming in and taking their places, it's the constant order of the day."[198]

After leaving Lovelock (Big) Meadows, the early emigrants came to Humboldt and Toulon Lakes and the Humboldt Sink, an area which was a haven for the ducks, geese, and other waterfowl, but with mud so thick and extensive that it largely precluded the emigrants from using the waterfowl to replenish their dwindling food supplies. As noted by Elisha D. Perkins in 1849: "The ponds of the sink were covered with all kinds of wild fowl, geese, ducks, curlews, snipes, cranes, etc. Perfectly secure from man or beast, as the ground is a perfect mire in every direction. Continuing around the sink or marsh, in a South East course you come to the 'last wells' at the foot of the marsh and ponds, being the last place where water can be obtained before crossing the desert to Salmon Trout [Truckee River]…"[199]

In 1860 silver ore was first discovered in the northern areas of the Humboldt and East Mountain ranges near present-day Lovelock. These silver ore discoveries began the ensuing "Rush to Humboldt" resulting in a steady influx of miners to the Humboldt River Basin. This in-migration would eventually taper off in the 1880's and then virtually come to a halt by 1893 following the repeal of the Sherman Silver Purchase Act and the demonetization of silver. Shortly after silver ore was discovered in 1860, Humboldt City and Dun Glen in the Humboldt River Basin and Unionville and Star City, just south of the sub-basin's boundaries, became the first white settlements to emerge in Nevada north and east of the Comstock-influenced cities of western Nevada.[200] Today, portions of the Lovelock Reach sub-basin are literally studded and pock-marked with weathered mine dumps, decaying headframes, abandoned shafts, caved-in tunnels, and ghost mining camps as bygone reminders of this intensive, but short-lived mining period which represented the earliest mining to take place in the Humboldt River Basin.[201]

Agricultural development in the Lovelock Reach sub-basin began immediately after the birth of the mining camps. It is generally recognized that in 1861 J.A. Callahan, of the old Callahan Ranch in the Lassen Meadows west of Imlay, established the first irrigation system in the Humboldt River Basin and, thereby, lays claim to the basin's earliest priority ("first in time, first in right") water right. These water rights were later transferred to the Southwest Ditch and the Irish-American Canal in Lovelock Valley.[202] Alfalfa seed, also known as "Chile clover," reached the Lovelock Valley area in 1877 when it was introduced by Colonel Joseph Marzen.[203]

In July 1868, the Central Pacific Railroad entered the Lovelock Reach sub-basin (and, for that matter, the Humboldt River Basin) by laying its rails across the White Plains Summit and down into the Humboldt-Carson Sink area. The present-day site of Lovelock (then referred to as Lovelock's Station, or simply Lovelock's) was reached by the railroad in August 1868. In exchange for George Lovelock's donation of approximately 80 acres of land for a railway station and trackside facilities, the Central Pacific named the new station Lovelock's. The site quickly became the point of departure for the booming mining camps of Arabia and Trinity in the Trinity Range to the north.[204]

Beginning with the sub-basin's first water right in 1861, proceeding through an era of dam building, canal construction and the development of early irrigation systems, by 1890 agriculture had become entrenched as the Lovelock Reach sub-basin's economic mainstay. The industry received a further boost to its fortunes in the 1930's. Based on the drought years of the early 1920's, the Lovelock Irrigation District was formed for the purpose of constructing a dam at Oreana, located almost 15 miles up the Humboldt River from Lovelock. After spending some $100,000 for engineering and legal services, the proposed structure was canceled due to insufficient storage capacity. In 1929, the Lovelock Irrigation District changed its name to the Pershing County Water Conservation District and it was this organization that promoted the construction of the Rye Patch Dam and Reservoir by the U.S. Bureau of Reclamation beginning in 1935 and completed in 1936.[205]

In terms of general topography, the Lovelock Reach sub-basin is surrounded by a number of mountain ranges – West Humboldt, Humboldt, East Range, Trinity Range, Antelope Range, Eugene Mountains – which provide little effective runoff to the sub-basin's lowlands. Virtually all usable water coming into the sub-basin comes from the Humboldt River itself. The sub-basin's climate is characterized as arid with little precipitation, high summer temperatures and high rates of evaporation. Annual rates of precipitation in the Lovelock Valley area average only about four inches per year and six inches at Imlay in the northern portion of the sub-basin. The surrounding mountain ranges have peaks and ridges of typically 5,000 to 7,000 feet high, with the sub-basin's highest peak (Star Peak, 9,834 feet MSL) located in the Humboldt Range. At these elevations, annual precipitation generally averages about 8-15 inches.[206]

The predominant vegetation cover in the Lovelock sub-basin is a mixture of shadscale, which is more common, and bud sagebrush (*Artemisia spinescens*). This vegetative cover occupies most of the valley bottoms and alluvial fans, extending into the upland terraces. Black greasewood may be found along the Humboldt River's floodplain as well as scattered areas of saltgrass and other phreatophytes. The upland benches and terraces typically find a mixing of principally shadscale, bud sagebrush, big sagebrush, littleleaf horsebrush (*Tetradymia glabrata*), black sagebrush, Bailey greasewood (*Sarcobatus baileyi*) and rabbitbrush. Higher elevations have extensive growth of big sagebrush along with stands of Utah juniper. A number of phreatophye species are present on the Humboldt River's bottomlands, the most prominent being rubber rabbitbrush, black greasewood, willows, cottonwood, and smallflower tamarisk (salt cedar) (*Tamarix parviflora*).[207]

Humboldt River Water Rights, Adjudication, and Related Court Decrees

Overview

Unlike the settlement of water rights issues on the river systems in western Nevada – i.e., Truckee, Carson, and Walker – which involved the interstate transfer of water between California and Nevada and therefore required federal court decrees and federal water masters, all the waters of the Humboldt River system lie wholly within Nevada. Consequently, the adjudication process[208] within the Humboldt River Basin has been effected solely through state decrees. With two exceptions, the diversion and use of the waters of the Humboldt River and its (normal) tributary streams are presently regulated by two water rights decrees: the October 1931 Bartlett Decree and the October 1935 Edwards Decree. The exceptions to the coverage of these decrees are the Reese River and the Little Humboldt River systems. These sub-basins are, in effect, "closed" hydrographic sub-basins[209] with respect to their "normal" (i.e., average water year) surface flows. Consequently, their normal discharges do not contribute to Humboldt River flows and are subject to different decree and water rights enforcement mechanisms for the allocation of their surface waters. Specifically, the January 1935 E.P. Carville Decree applies to water rights in the Little Humboldt River sub-basin,[210] while virtually all water rights in the Reese River sub-basin are vested rights.[211] Vested water rights are claims to surface waters initiated prior to 1905 which have been used continuously ever since and are subject to final determination through judicial proceedings (i.e., adjudication).[212]

The Bartlett Decree applies to and is used in the distribution of the Humboldt River and its tributaries below Palisade, Nevada[213] (except, as noted for the Reese River and Little Humboldt River sub-basins), while the Edwards Decree applies to and is used in the distribution of water above Palisade.[214] The 1931 Bartlett Decree initially applied to the entire Humboldt River system (except for the two noted closed sub-basins); however, the initial judicial determination of water rights within the Humboldt River Basin was subsequently modified by the 1935 Edwards Decree.[215] The fact that the majority of the changes and corrections to the Bartlett Decree were applicable to water rights in the upper Humboldt River Basin (i.e., above Palisade) resulted in the establishment of a dividing line for the application of these two decrees at Palisade.

Two primary differences between the Humboldt River system's two principal decrees are that the lengths of the irrigation season (number of days and specific dates) and rates of flow vary between the two decrees, and that the Bartlett Decree incorporates the "doctrine of relation" while the Edwards Decree does not. This concept of relation means that a water priority is claimed as of the date of appropriation for the amount appropriated, even though a part of it may not have been put to beneficial use until a later date.[216] Also, in most cases under the Bartlett Decree the water rights are appurtenant[217] to the land and irrigation is confined to the land specifically described in the decree. Under the Edwards Decree, by contrast, the water-righted lands are not specifically described, but the water rights are appurtenant to the lands included in groups of legal subdivisions. These lands are shown in the decree as enclosed by brackets and are commonly referred to as "bracketed" land. The water rights are then limited to the aggregate acreage of land and quantity of water indicated in the decree for each bracket. Some lands in the Bartlett Decree are similarly bracketed and are handled in the same manner as in the Edwards Decree.[218]

Both the Bartlett and Edwards decrees stipulate that the maximum length of the irrigation season below Palisade shall be from March 15 to September 15, and the maximum length of the irrigation above Palisade shall be from April 15 to August 15, a difference in the irrigation season of sixty days. The decrees also provide for a continuous rate of flow of 0.81 cubic feet per second (cfs) for each 100 acres, or proportional amounts thereto, for water-righted lands below Palisade, and a rate of flow of 1.23 cfs for water-righted lands above Palisade. Irrigated lands are divided into three classes in both decrees (A, B and C), with different water duties (acre-feet per acre per irrigation season) and irrigation seasons (number of days and specific dates of allowable irrigation) as shown in Table 10, General Humboldt River Water Rights.[219]

Table 10 – General Humboldt River Water Rights†

Land Classes and Type, Water Rights, Number of Days and Dates of Irrigation

Class and Type of Land	Water Right (acre-foot/acre)	Irrigation Days	Dates of Irrigation
Below Palisade [Bartlett Decree]‡ (flow rate–0.81 cfs)			
Class A – Harvest Crop	3.0	180	March 15 – September 15
Class B – Meadow Pasture	1.5	90	March 15 – June 13
Class C – Diversified Pasture	0.75	45	March 15 – April 28
Above Palisade [Edwards Decree] (flow rate–1.23 cfs)			
Class A – Harvest Crop	3.0	120	April 15 – August 15
Class B – Meadow Pasture	1.5	60	April 15 – June 15
Class C – Diversified Pasture	0.75	30	April 15 – May 15
Little Humboldt River [Carville Decree] (flow rate–1.0 cfs)			
Class A – Harvest Crop	3.6	180	March 15 – September 15
Class B – Meadow Pasture	1.8	90	March 15 – June 13
Class C – Diversified Pasture	0.9	45	March 15 – April 28

† Based on water rights adjudicated by the October 1931 Bartlett Decree, the January 1935 Carville Decree, and the October 1935 Edwards Decree. Excludes Reese River sub-basin water rights which are vested and have not been adjudicated.
‡ The Pine Valley sub-basin, which discharges through Pine Creek into the Humboldt River just below Palisade, is an exception to this and generally takes on characteristics of an upper Humboldt River sub-basin.
Source Data: *Humboldt River Basin, Nevada, Water and Related Land Resources*, various reports, based on a cooperative survey by the Nevada Department of Conservation and Natural Resources and the United State Department of Agriculture and prepared by the USDA's Economic Research Service, Forest Service and Soil Conservation Service, 1962-1966.

Table 11, Upper Humboldt River Water Rights, and Table 12, Lower Humboldt River Water Rights, which follow later in this section, provide a more detailed breakout of growing seasons, acreage and water right allowances by specific Humboldt River sub-basin based on their location in either the upper Humboldt River Basin or the lower Humboldt River Basin.

Water Rights Background

A number of important historical events figure prominently in the evolution of Nevada's water law, its water allocation system and the water rights adjudication process. First, in 1885 the Nevada Supreme Court formally approved the doctrine of prior appropriation for all the state's water supplies, although an earlier (1875) lower court decision had given recognition to the doctrine of riparian ownership.[220] Even so, the implementation of the concept of prior appropriation for water rights required some form of statewide centralized record keeping as to when individual water rights were initiated (vested) and the water put to beneficial use. However, the requirement for any such systematic recording and judicial determination of water rights (the adjudication process) and related priority dates was still lacking in Nevada.

By the late 1880's, the increase in competing water uses along virtually the entire Humboldt River system dramatically intensified the conflicts and controversy over water rights issues, particularly between upstream users in Elko County and those in the lower basin in Lovelock Valley. The 1888-1889 period represented extreme drought years in the Humboldt River Basin and, in fact, throughout much of the entire Great Basin. Despite having generally known and substantiated earlier dates of water withdrawal (i.e., a proven prior appropriation date[221]), many lower Humboldt River basin water appropriators were still unable to receive sufficient water due to existing drought conditions and extensive upstream diversions. Unfortunately, the controversy over the conflicting concepts of "prior appropriation"[222] and "riparian water rights"[223], while already settled by the Nevada Supreme Court, could not be effectively implemented until all water rights were formally recorded and judicially verified according to their earliest date of use. This situation was not unique to the Humboldt River system and only further emphasized the need for a more equitable and fully codified allocation of water rights along all of Nevada's major water courses.

As a result of this and similar conflicts within the Truckee, Carson and Walker River basins, on March 9, 1889, the Nevada Legislature passed a water law which provided the state's first means for determining or adjudicating individual water rights. The 1889 Water Act was designed to regulate the use of water for irrigation and other purposes. It was modeled after Colorado water law and imposed a self-regulating system by dividing the state into seven irrigation districts by major drainage basins. Each basin had a water commissioner who had the authority to decide individual water entitlements within their respective districts. The act decreed that all water rights were to be filed with each county recorder by September 1, 1889. It also reserved unappropriated water to the State of Nevada for future appropriation and prevented new construction or enlargement of any irrigation works without the expressed permission of the respective water commissioner. No doubt fearing potential water restrictions associated with the new law, individual water user's initial claims to stream flows were typically wildly exaggerated and in combination far exceeded the capacity of most stream systems for which they were filed.[224]

The drought years of 1888-1889 forced downstream Humboldt River water users to file a suit over water rights and thereby test the recently passed (1889) Nevada water law. P.N. Marker, et al., filed suit in Humboldt County on behalf of Lovelock Valley farmers (Pershing County was still part of Humboldt County at that time) against some 540 Humboldt River Valley water appropriators specifically asking that all Humboldt River water rights be determined, i.e., adjudicated. The basic issue involved with that suit was a ruling in favor of the concept of the prior appropriation of water rights along the Humboldt River. Such a ruling would necessarily have favored the lower basin's water users over riparian water rights, which were being claimed by upstream ranchers, particularly those in Elko County whose lands bordered the river. The ranchers in Elko County argued against such a settlement (i.e., the adjudication of water rights based on the date of appropriation) claiming that the 1889 water regulation statute was, in fact, unconstitutional.

The presiding judge, A.F. Fitzgerald of the District Court in Humboldt County (Winnemucca), agreed with the upstream ranchers' position and in June 1890 declared Nevada's 1889 water law to be unconstitutional. In a petition of constitutionality filed before the Nevada Supreme Court on behalf of water users on the Humboldt, Truckee, and Carson rivers, the law's validity was questioned on several grounds, the primary one being that it was a special law in a case where a general law can be made applicable.[225] Therefore, the basic issue over riparian water rights versus prior appropriation water rights was never even considered by the court. The state's initial attempt at a statewide water law was subsequently repealed by the Nevada Legislature in 1893 and no further effort was made to systematically record water rights and allocate the state's surface waters until 1905.[226]

In addition to the drought in 1888 and 1889, the extremely severe winter of 1889-90 also contributed to the eventual adjudication of water rights in the Humboldt River system. The "White Winter" of 1889-90 had especially disastrous effects on large cattle ranching operations throughout the

Humboldt River Basin with countless thousands of cattle and other livestock being lost in the incredibly deep snows during this period. The Humboldt River's middle and upper basin ranchers, in particular, who used public lands extensively for open-range cattle grazing, were especially hard hit during this period. Their inability to adequately feed their wide-ranging herds during this severe winter period forced the ranchers to recognize the need to restrict open-range grazing operations and grow more feed for their herds' winter needs. The need for more irrigation waters on upstream lands in order to cultivate sufficient hay for supplemental winter forage only intensified the conflicts with lower basin water users over Humboldt River water rights issues.

Efforts to more definitively determine water rights in Nevada's river systems began to intensify in the early 1900's. On February 16, 1903, the Nevada Legislature passed the Irrigation Law of 1903 which, among other things, created the Office of the State Engineer to solve water problems, to protect existing water rights, and to bring about a better method to utilize the state's water resources. This was, in effect, the first step made by the state in providing a speedy and relatively inexpensive (to the water appropriator) method of adjudicating existing (vested) water rights.[227] On March 1, 1905, this process of better allocating the state's water resources continued when the Nevada Legislature amended the Irrigation Act of 1903 to require that any person desiring to appropriate water must file an application with the State Engineer for a permit. If the State Engineer found that there existed unappropriated water, he could grant a permit. Within six months following the granting of a permit, the applicant was required to file a map in support of such application. Upon satisfactory proof that the application had been "perfected," the State Engineer could issue a certificate of appropriation. The act also provided a method to adjudicate existing water rights.[228]

On February 26, 1907, the Nevada Legislature repealed the Irrigation Law of 1903 and provided a statutory method to determine existing water rights. The 1907 act, creating a new water law, did not differ materially from the act of 1903, as amended in 1905.[229] And finally, on March 22, 1913, the Nevada Legislature repealed the water law of 1907, along with its amendments, and approved the so-called "1913 General Water Law," which became the foundation of Nevada's present water law. In addition to affecting all the state's surface waters, for the first time underground water (i.e., groundwater) was also included under provisions of the state's "doctrine of prior appropriation" for water rights.[230]

The Adjudication Process

In order to help resolve continuing water rights issues on the Humboldt River, on January 17, 1923, the Nevada State Engineer compiled a listing of existing Humboldt River Basin water rights then on file and submitted this compilation to the Sixth Judicial District Court of the State of Nevada, in and for the County of Humboldt, as a "Final Order of Determination of the Relative Rights of Claimants and Appropriators to the Use of the Water of the Humboldt River Stream System and its Tributaries." According to Nevada State Law, water appropriators were then allowed to file exceptions to the State Engineer's findings of fact with respect to diversion rights (amounts) and dates of appropriation (the priority date).[231] Further, the court allowed for an extension of these exception filings.[232] On January 5, 1925, a hearing was held before the Judge George A. Bartlett on the State Engineer's "Final Order of Determination" to hear and rule on all exceptions to the order by appropriators of the waters of the Humboldt River system.[233]

On January 2, 1931, after nearly six years of taking evidence and testimony, the Bartlett Decree was issued adjudicating water rights along the Humboldt River and its tributaries.[234] In addition to adjudicating the river system's water rights, this decree also recognized that the surface waters within the Humboldt River system were already fully appropriated, leaving no surplus water for irrigation during an average, or normal water year. Another important finding of the Bartlett Decree recognized the differences in growing seasons between the Humboldt River's upper basin and its lower basin[235] and therefore divided the river system into two districts, District No. 1 below Palisade (USGS gaging station) and District No. 2 above Palisade.[236]

The Bartlett Decree also recognized the seasonal and ephemeral nature of many streams within the Humboldt River Basin through the concept of "flash streams" and the special need to accommodate water appropriators along such stream systems. These water courses were defined as streams "that have a sudden or flash flow or flush flow for a comparatively brief period of time, while such stream is draining the particular basin or source of supply fed by melting snows…These flash streams in varying degrees are typical of the necessity of cumulating the flow during the flush for the particular rights to be served. Where lands are entitled to irrigation from such flash streams, they must be served at the times when the water is available."[237]

The Bartlett Decree established three classes of lands with different irrigation requirements (water duties) and irrigation periods (both with respect to the number of days of allowable irrigation and the specific periods of irrigation). These irrigable land classes included: (1) Harvest crop lands (Class A) – all lands devoted to cultivated crops, including irrigated native or other grass lands which normally receive sufficient water to produce a crop which will justify cutting for hay, although it may sometimes be pastured and not cut; (2) Meadow pasture lands (Class B) – all grass lands free from brush which receive sufficient water to produce what may be classed as good pasture, but not sufficient to warrant cutting for hay; and (3) Diversified pasture lands (Class C) – all lands from which the brush has not been cleared but which are artificially irrigated to some extent for the production of grasses for pasturage. Further, the irrigation periods within the Humboldt River system varied by both the class of the land and whether it was in District No. 1 (below Palisade) or District No. 2 (above Palisade). Due to extensive review and corrections of the written findings by Judge Bartlett, the final Bartlett Decree would not be entered until October 20, 1931.[238]

Based on subsequent protests, on December 16, 1931, the first of a number of rulings for the modification, correction and amendment of the October 1931 Bartlett Decree was made by District Judge H.W. Edwards, in the Sixth Judicial District Court.[239] This was followed by additional changes and amendments entered on April 27, 1933,[240] February 8, 1934,[241] June 8, 1934,[242] October 1, 1934,[243] November 19, 1934,[244] February 11, 1935,[245] and finally on March 11, 1935.[246] Collectively, this compilation of modifications and changes to the 1931 Bartlett Decree became known as the Edwards Decree. One particular change of some importance to the Bartlett Decree was the one entered on February 8, 1934 by Judge Edwards which removed language pertaining to the formal division of the Humboldt River system into a District No. 1 below Palisade and a District No. 2 above Palisade. In its place, the Edwards Decree merely established specific irrigation seasons and reaffirmed the three classes of land for specific water rights, the water duty for each land class, and the period over which water was to be received by these lands.[247]

In a related matter pertaining to Humboldt River Basin water rights, on October 1, 1929, in preparation of the adjudication process for the Little Humboldt River, the Nevada State Engineer filed an "Abstract of Claims in and to the Waters of the Little Humboldt River and its Tributaries in Humboldt and Elko Counties, State of Nevada."[248] Based on hearings begun in November 1931, the E.P. Carville Decree (Case No. 3157) was subsequently issued on January 24, 1935 adjudicating water rights for the Little Humboldt River. As with the Bartlett Decree (and the later Edwards Decree), the Carville Decree determined water rights for three classes of lands: (1) Class A – harvest crops; (2) Class B – meadow pasture; and (3) Class C – diversified pasture.[249] In general, the decree provided for a flow of 1.0 cfs per 100 acres of decreed land, or at rates proportional to this. When water was available, Class A water rights are for the delivery of water at this rate of flow for a period of 180 days from March 15 to September 15, or a total water diversion during the season of 3.6 acre-feet per acre. Class B rights are for 90 days from March 15 to June 13, for a total of 1.8 acre-feet per acre. Class C rights are for 45 days from March 15 to April 28, for a total of 0.9 acre-feet per acre.[250]

On October 8, 1935, based upon a sequence of changes to the October 20, 1931, Bartlett Decree, the Edwards Decree was issued correcting a number of earlier adjudicated water rights for the Humboldt River Basin.[251] As most of the corrected water-rights contained within the Edwards Decree applied to lands above Palisade (i.e., the upper Humboldt River Basin), the Edwards Decree was applied to and used for distribution of the Humboldt River system's waters above Palisade, while the Bartlett Decree continued to apply to and be used in the distribution of water below Palisade.[252] In general, the Edwards Decree provided for a flow of 1.23 cfs per 100 acres of decreed land or at proportional rates. Three land classes were established (the same as for the Bartlett Decree) with different dates of use and number of days of allowed irrigation. Each sub-basin within the overall Humboldt River Basin had its unique amount of decreed land and decreed water within the three land classes (A, B and C). Diverted water for irrigation purposes was to be measured where the main ditch enters or becomes adjacent to the land to be irrigated.[253]

In resolving the final appeals to the Humboldt River adjudication process, on December 3, 1936, Judge J.M. Lockhart of the Sixth Judicial District Court denied a final October 28, 1935 motion filed by John M. Marble and Robert E. Marble and others to declare null and void a document entitled "Amended, Changed and Corrected Findings of Fact, Conclusions of Law and Decree" signed by H.W. Edwards (i.e., the Edwards Decree). One of the motion's crucial points was that Judge Edwards was not the *presiding* judge when he signed the decree. In denying the motion, Judge Lockhart noted that "ever since February 19, 1867, the power has been given to district judges to perform certain acts after they have retired from office."[254] Finally, on November 26, 1938, the Nevada Supreme Court refused to allow any further protests to the Edwards Decree and the case was declared closed, officially completing the adjudication of the Humboldt River's water rights through the 1931 Bartlett Decree and the 1935 Edwards Decree.[255] While this may have completed the adjudication process for the Humboldt River, it by no means resolved all water-related issues within the basin.

Upper Humboldt River Basin Water Rights

The upper Humboldt River Basin's water rights (above Palisade) were established by the 1935

Edwards Decree. In general, this decree provides for a flow of 1.23 cfs per 100 acres of decreed land, or at proportional rates. Water diverted for irrigation purposes is measured where the main ditch enters or becomes adjacent to the land to be irrigated. According to Nevada Water Law:

> "The State Engineer shall consider the duty of water as therefore established by court decree or by experimental work in such area or as near thereto as possible. He shall also consider the growing season, type of culture, and reasonable transportation losses of water up to where the main ditch or channel enters or becomes adjacent to the land to be irrigated, and may consider any other pertinent data deemed necessary to arrive at the reasonable duty of water."[256]

Table 11, Upper Humboldt River Water Rights, presents information for those sub-basins located in the upper Humboldt River Basin by classes and types of decreed lands, irrigation days allowed by land class, dates of irrigation, decreed land and water and the specific water duty by land class in acre-feet per acre per season (year).

Table 11 – Upper Humboldt River Water Rights†

Land Classes, Number of Days, Dates of Irrigation, Decreed Land and Water Rights

Class and Type of Land	Irrigation Days	Dates of Irrigation	Decreed Land (acres)	Decreed Water (acre-feet)	Water Duty (af per acre)
Mary's River Sub-Basin (flow rate–1.23 cfs)					
A – Harvest Crop	120	4/15 – 8/15	9,260	27,770	3.00
B – Meadow Pasture	60	4/15 – 6/15	1,240	1,860	1.50
C – Diversified Pasture	30	4/15 – 5/15	7,700	5,770	0.75
Sub-Basin Totals			18,200	35,400	1.95
Ruby Mountains Sub-Basin (flow rate–1.23 cfs)					
A – Harvest Crop	120	4/15 – 8/15	78,575	235,260	3.00
B – Meadow Pasture	60	4/15 – 6/15	3,020	4,565	1.50
C – Diversified Pasture	30	4/15 – 5/15	9,060	6,925	0.75
Sub-Basin Totals			90,655	246,750	2.72
North Fork Humboldt River Sub-Basin (flow rate–1.23 cfs)					
A – Harvest Crop	120	4/15 – 8/15	17,525	52,238	3.00
B – Meadow Pasture	60	4/15 – 6/15	238	357	1.50
C – Diversified Pasture	30	4/15 – 5/15	512	378	0.75
To Sub-Basin Totals			18,275	52,973	2.90
Maggie Creek Sub-Basin (flow rate–1.23 cfs)					
A – Harvest Crop	120	4/15 – 8/15	1,962	5,855	3.00
B – Meadow Pasture	60	4/15 – 6/15	540	811	1.50
C – Diversified Pasture	30	4/15 – 5/15	1,335	985	0.75
Tot Sub-Basin Totals			3,837	7,651	1.99
Elko Reach Sub-Basin‡ (flow rate–1.23 cfs)					
A – Harvest Crop	120	4/15 – 8/15	15,000	45,000	3.00
B – Meadow Pasture	60	4/15 – 6/15	800	1,200	1.50
C – Diversified Pasture	30	4/15 – 5/15	6,000	4,500	0.75
Sub-Basin Totals			21,800	50,700	2.33
Upper Humboldt River Basin Totals			**152,767**	**393,474**	**2.58**

† Based on water rights enforced by 1935 Edwards Decree.
‡ Because of the intermingled use of water between the Humboldt River and side streams, there is some duplication of water rights in this sub-basin with those adjoining sub-basins, i.e., Ruby Mountains, North Fork, Maggie Creek and Pine Valley.
Source Data: *Humboldt River Basin, Nevada, Water and Related Land Resources*, Nevada Department of Conservation and Natural Resources and the United State Department of Agriculture.

Lower Humboldt River Basin Water Rights

Water rights for the lower Humboldt River Basin (below Palisade and excepting the Little Humboldt River and Reese River systems) were established by the 1931 Bartlett Decree. In general, this decree provides for a flow of 0.81 cfs per 100 acres of decreed land, or at proportional rates. Water diverted for irrigation purposes is measured where the main ditch enters or becomes adjacent to the land to be irrigated. Water rights for the Little Humboldt River, which is a closed sub-basin of the Humboldt River Basin except during particularly severe flood events, were established by the 1935 Carville Decree.[257] Reese River water rights are not included as they are vested water rights and have not, as yet, been fully adjudicated for all this sub-basin's streams. Also, Pine Valley water rights, while established by the Bartlett Decree, have flow and duration characteristics of upper Humboldt River sub-basins. Table 12, Lower Humboldt River Water Rights, presents information for those sub-basins located in the lower Humboldt River Basin by classes and types of decreed lands, irrigation days allowed by class, dates of irrigation, decreed land and water and the specific water duty by land class in acre-feet per acre per season (year).

Table 12 – Lower Humboldt River Water Rights[1]

Land Classes, Number of Days, Dates of Irrigation, Decreed Land and Water Rights

Class and Type of Land	Irrigation Days	Dates of Irrigation	Decreed Land (acres)	Decreed Water (acre-feet)	Water Duty (af per acre)
Pine Valley Sub-Basin (flow rate–1.23 cfs)					
A – Harvest Crop	120	4/15 – 8/15	3,431	10,293	3.00
B – Meadow Pasture	60	4/15 – 6/15	182	273	1.50
C – Diversified Pasture	30	4/15 – 5/15	304	228	0.75
Sub-Basin Totals			3,917	10,794	2.76
Battle Mountain Sub-Basin[2] (flow rate–0.81 cfs)					
A – Harvest Crop	180	3/15 – 9/15	14,790	46,730	3.00
B – Meadow Pasture	90	3/15 – 6/13	16,260	24,390	1.50
C – Diversified Pasture	45	3/15 – 4/28	25,500	19,120	0.75
Sub-Basin Totals			56,550	90,240	1.60
Sonoma Reach Sub-Basin (flow rate–0.81 cfs)					
A – Harvest Crop	180	3/15 – 9/15	8,940	26,810	3.00
B – Meadow Pasture	90	3/15 – 6/13	2,000	2,990	1.50
C – Diversified Pasture	45	3/15 – 4/28	5,920	4,440	0.75
Sub-Basin Totals			16,860	34,240	2.00
Lovelock Reach Sub-Basin (flow rate–0.81 cfs)					
Pershing County Water Conservation District[3]	180	3/15 – 9/15	37,086	137,536	3.70
Other Irrigated Land in Pershing County[4]	—	—	3,798	7,297	1.90
Sub-Basin Totals			40,884	144,833	3.50
Little Humboldt River Sub-Basin[5] (flow rate–1.00 cfs)					
A – Harvest Crop	180	3/15 – 9/15	30,361	109,300	3.60
B – Meadow Pasture	90	3/15 – 6/13	1,539	2,770	1.80
C – Diversified Pasture	45	3/15 – 4/28	10,087	9,078	0.90
Sub-Basin Totals			41,987	121,148	2.90
Lower Humboldt River Basin Totals			**160,198**	**401,255**	**2.50**

[1] Generally based on water rights enforced by 1931 Bartlett Decree with the exception of the Little Humboldt River sub-basin in which water rights are enforced by the 1935 Carville Decree (and Bonnifield Decree).

[2] Most of the water rights were established by the Bartlett Decree. There are some rights, however, that were established by the Edwards Decree, and others by permits from the State Engineer's office. In general, the decreed rights provide for a rate of flow of 0.81 cfs per 100 acres of decreed land, or at proportional rates, for the periods indicated.

[3] After the completion of Rye Patch Dam and Reservoir and the transfer of the purchased water rights (to include those water rights from the Battle Mountain sub-basin) to the Humboldt Project, the water rights assigned as meadow pasture (Class B) and diversified pasture (Class C) within the project area were converted, by proportion, to harvest crop (Class A) water rights.

[4] Includes about 2,500 acres in the Imlay-Mill City area, which receive water from the Humboldt River, 200 acres near Oreana which are irrigated from underground water, and 1,100 acres of non-project land in Lovelock Valley which receive water from the river through the Rye Patch Reservoir.

[5] Based on water rights enforced by the 1935 Carville Decree (and Bonnifield Decree).

Source Data: *Humboldt River Basin, Nevada, Water and Related Land Resources*, Nevada Department of Conservation and Natural Resources and the United State Department of Agriculture.

Principal Storage Facilities of the Humboldt River Basin

The following provides information on water storage facilities located within the Humboldt River Basin. The "NV" numbers refer to the National Inventory of Dams (NID) numbering system while the "J" numbers (in parentheses after the NID) refer to the Nevada Safety of Dams Permit Number (per Nevada Revised Statutes 535.010). The sub-basins refer to the eleven defined principal drainage regions of the Humboldt River Basin presented in an earlier section ("Humboldt River Sub-Basin Analysis") while the hydrographic area (and hydrographic area number) refer to one of the 33 hydrographic areas and one sub-area contained within the Humboldt River Basin as defined by the Nevada Division of Water Resources, Department of Conservation and Natural Resources. The source for this material was the Office of the State Engineer, Division of Water Resources, Department of Conservation and Natural Resources (September 1999).

(1) Bishop Creek Reservoir (Metropolis Reservoir)

NID: NV00050
Location: Bishop Creek, 20 miles upstream from Deeth, Nevada
Sub-Basin/Hydrographic Area: Mary's River/Mary's River Area (42)
Construction Date: 1912
Dam/Reservoir Built By: Pacific Reclamation Company
Dam/Reservoir Owned By: Pacific Reclamation Company
Dam Type: Earthfill with concrete facing
Reservoir Specifics: Depth–70 feet; length–5 miles; surface area–11,500 acres
Storage Capacity: 30,000 acre-feet (has storage restriction imposed by the State Engineer of zero acre-feet due to leaks)
Water Rights Owned By: Pacific Reclamation Company
Water Used For: Irrigation
Where Used: Lands of Pacific Reclamation Company
Other Information: Dam leaks badly; no storage currently allowed until fully repaired; water rights are junior in priority to U.S. Bureau of Reclamation water rights.

(2) South Fork Reservoir

NID: NV00226 (J-237)
Location: South Fork Humboldt River, 23 miles upstream from Carlin, Nevada, and ten miles up the South Fork from its confluence with the Humboldt River main stem
Sub-Basin/Hydrographic Area: Ruby Mountains/Huntington Valley Area (47)
Construction Date: 1987
Dam/Reservoir Built By: State of Nevada and Elko County Fair and Recreation Board
Dam/Reservoir Owned By: State of Nevada
Dam Type: Zoned earthfill
Reservoir Specifics: Depth–73 feet; length–4 miles; surface area–1,600 acres
Storage Capacity: 42,000 acre-feet
Water Rights Owned By: State of Nevada
Water Used For: Recreation/fisheries
Where Used: In situ (locally)
Other Information: Minimum required flow downstream of dam is 5 cubic feet per second.

(3) Maggie Creek Dam/Reservoir

NID: NV10195 (J-410)
Location: Off-stream, Maggie Creek, 6 miles upstream from Carlin, Nevada
Sub-Basin/Hydrographic Area: Maggie Creek/Maggie Creek Area (51)
Construction Date: 1994 (last modified)
Dam/Reservoir Built By: Newmont Gold Corporation
Dam/Reservoir Owned By: Newmont Gold Corporation
Dam Type: Zoned earthfill
Reservoir Specifics: Depth–90 feet; length–one-half mile; surface area–160 acres
Storage Capacity: 6,500 acre-feet
Water Rights Owned By: Newmont Gold Corporation
Water Used For: Excess mine water (dewatering); also minor irrigation
Where Used: Lower Maggie Creek area and discharged to the Humboldt River
Other Information: Only allowed to discharge during certain times of the year. Water source is groundwater and leakage into pit of Maggie Creek.

(4) T-S Ranch Dam and Reservoir

NID: NV10258 (J-320)
Location: Off-stream from Boulder Creek
Sub-Basin/Hydrographic Area: Battle Mountain/Boulder Flat Area (61)
Construction Date: Last modified in 1996
Dam/Reservoir Built By: Barrick Goldstrike
Dam/Reservoir Owned By: Barrick Goldstrike
Dam Type: Zoned earthfill
Reservoir Specifics: Depth–68 feet; length–one-half mile; surface area–260 acres
Storage Capacity: 1,900 acre-feet
Water Rights Owned By: Barrick Goldstrike
Water Used For: Excess mine water (dewatering) and used for irrigation
Where Used: Boulder Flat on T-S Ranch
Other Information: Actual storage approximately 40 acre-feet due to a crack in the reservoir.

(5) Willow Creek Reservoir

NID: NV00054 (J-506)
Location: Rock Creek, 66 miles above Battle Mountain, Nevada
Sub-Basin/Hydrographic Area: Battle Mountain/Willow Creek Valley Area (63)
Construction Date: 1910-1925 (original); 1999 (last repaired)
Dam/Reservoir Built By: Golconda Cattle Company, Ellison Ranching Company, Barrick Goldstrike
Dam/Reservoir Owned By: Barrick Goldstrike
Dam Type: Rockfill, concrete face
Reservoir Specifics: Depth–56 feet; length–3 miles; surface area–600 acres
Storage Capacity: 18,000 acre-feet
Water Rights Owned By: Barrick Goldstrike
Water Used For: Irrigation
Where Used: Squaw Valley Ranch
Other Information: Barrick Goldstrike recently (1999) repaired outlet works, spillway and

parapet wall.

(6) Chimney Reservoir

NID: NV01151 (J-134)
Location: Little Humboldt River, 48 miles upstream from Winnemucca, Nevada, and 44 miles up from the Humboldt River main stem near the merger of the Little Humboldt River's North and South Forks
Sub-Basin/Hydrographic Area: Little Humboldt River/Little Humboldt Valley Area (67)
Construction Date: 1974
Dam/Reservoir Built By: Nevada Garvey Ranches
Dam/Reservoir Owned By: Nevada Garvey Ranches
Dam Type: Zoned earthfill
Reservoir Specifics: Depth–59.7 feet; length–6 miles; surface area–2,080 acres
Storage Capacity: 35,000 acre-feet
Water Rights Owned By: Nevada Garvey Ranches and Humboldt County Fair and Recreation Board
Water Used For: Irrigation and recreation
Where Used: Little Humboldt Valley
Other Information: Joint usage reservoir.

(7) Lone Tree (Mine) Cooling Ponds

NID: NV10464 (J-436)
Location: North of the Lone Tree Mine site near Valmy Power Plant, off-stream, approximately eighteen miles upstream from Golconda
Sub-Basin/Hydrographic Area: Battle Mountain/Pumpernickel Valley Area (65)
Construction Date: 1997 (one cell)
Dam/Reservoir Built By: Santa Fe Pacific Gold
Dam/Reservoir Owned By: Newmont Gold Corporation
Dam Type: Zoned earthfill
Reservoir Specifics: Depth–8 feet; length–one-half mile; surface area–35 acres
Storage Capacity: 105 acre-feet
Water Rights Owned By: Newmont Gold Corporation
Water Used For: Excess pit water
Where Used: Once cooled, water is discharged to the Humboldt River
Other Information: Source is groundwater. Water is continuously discharged (recycled) through the ponds (cells). While 105 acre-feet is the resident capacity, actual water being discharged is considerably greater.

(8) Upper and Lower Pitt-Taylor Reservoirs

NIDs: NV00062 and NV00063
Location: Pitt-Taylor Canal (from Humboldt River), 32 miles upstream from Lovelock, Nevada
Sub-Basin/Hydrographic Area: Lovelock Reach/Imlay Area (72)
Construction Date: 1907-1911
Dam/Reservoir Built By: Humboldt-Lovelock Irrigation, Power & Light Company
Dam/Reservoir Owned By: Pershing County Water Conservation District
Dam Type: Homogeneous earthfill
Reservoir Specifics (Upper Reservoir/Lower Reservoir): Depths–16 feet/24 feet; lengths–3

miles/5 miles; surface areas–2,000 acres/2,200 acres
Storage Capacity (Combined/Upper Reservoir/Lower Reservoir): 36,600 acre-feet/20,800 acre-feet/15,800 acre-feet
Water Rights Owned By: Pershing County Water Conservation District
Water Used For: Irrigation
Where Used: Lovelock Valley
Other Information: Storage restrictions imposed by the State Engineer; last amended in 1971 increasing total (combined) storage capacity from 35,000 acre-feet to present 36,600 acre-feet.

(9) Rye Patch Reservoir
NID: NV10124
Location: Humboldt River and outflow from Upper and Lower Pitt-Taylor Reservoirs, 9 miles upstream from Lovelock, Nevada
Sub-Basin/Hydrographic Area: Lovelock Reach/Lovelock Valley Area (dam) (73) and Lovelock Valley and Imlay Areas (reservoir) (73 and 72)
Construction Date: 1935 (begun)/1936 (completed)
Dam/Reservoir Built By: U.S. Bureau of Reclamation
Dam/Reservoir Owned By: U.S. Bureau of Reclamation
Dam Type: Zoned earthfill
Reservoir Specifics: Depth–60.5 feet; length–19 miles; surface area–11,970 acres
Storage Capacity: 194,300 acre-feet
Water Rights Owned By: U.S. Bureau of Reclamation
Water Used For: Irrigation
Where Used: Lovelock Valley
Other Information: A 1976 rehabilitation and betterment project raised the height of the dam by 3 feet and the normal surface elevation by 2 feet, adding an additional 23,000 acre-feet to storage capacity.[258] U.S. Bureau of Reclamation recently (1995-1996) upgraded seismic resistance of dam with downstream buttress.

Mining and Mine Dewatering in the Humboldt River Basin

Mining and Early Settlement of the Humboldt River Basin

Mining has played an integral role in Nevada’s earliest settlement patterns. Even today, many of Nevada’s more rural counties, particularly those counties within the Humboldt River Basin, continue to be strongly impacted by regional and local mining activities. Before the discovery of the fabulous wealth of the Comstock Lode in the late 1850’s, the vast expanse that was the Nevada portion of the Great Basin was considered primarily as an inhospitable and tortuous impediment to westward migration. What little commerce existed within the region at that time consisted mostly of fledgling agricultural outposts selling produce and other supplies to early emigrants hastily traversing this western portion of the Utah Territory to reach California and Oregon beyond.

However, Nevada’s vast mineral wealth soon brought the region to national prominence in the early 1860’s, making Nevada a territory separate from Utah in 1861, and the 36th State of the Union in

1864.[259] Mining within the Humboldt River Basin first got its start when silver ore was discovered in 1860 at Humboldt City, located in present-day Pershing County, and in 1862 at Dun Glen, located ten miles northeast of Mill City and four miles south of Dun Glen Peak.[260] Just outside the basin, in 1861 silver ore was found on the eastern slopes of the Humboldt Range up Buena Vista Canyon. The town of Unionville (initially called Dixie by local Southern sympathizers), located approximately 15 miles due south of present-day Imlay and just outside the basin's borders, quickly grew up to become the Humboldt County seat. By the late 1870's, however, most of the silver ore at these early mining sites had been depleted,[261] and the boom-to-bust cycle which has since characterized Nevada's mining industry was begun.

Also in 1861, the Star Mining District (along Star Creek), also located just outside the Humboldt River Basin, was established when silver ore was discovered. Star City, located eight miles south of Imlay on the eastern slopes of the Humboldt Range, became the central mining town within the district. During the district's relatively brief boom years of 1864 and 1865, Star City boasted 1,200 residents, two hotels, three general stores, a Wells-Fargo office, a church and a dozen or more saloons. The (Queen of) Sheba Mine, located nearly two miles northeast of Star Peak (9,836 feet MSL), was the district's largest operation, producing about $5,000,000 in silver by 1868, at which time the rich ore began to run out. Three years later, only seventy-eight inhabitants remained in Star City. All that remains today are crumbling foundations and rusting mill equipment.[262]

In May 1862, the town of Austin, often referred to as the "mother town of mining camps" and located on the eastern side of the Reese River Valley, sprang into being after silver ore was discovered in nearby Pony Canyon. With this discovery, the Reese River Valley's largely pastoral existence was dramatically altered and a period of intense exploitation of the area's timber, mineral, rangeland and water resources began. A town called Clifton flourished briefly in Pony Canyon, but fast-growing Austin soon took over in prominence and became the county seat in 1863. Early in 1864, Clifton, Austin and Upper Austin were all combined and incorporated as the City of Austin. Before the local mines began to fail in the 1880's, Austin had become a substantial community boasting 10,000 residents.[263] From Austin, prospectors fanned out throughout the region to establish many other important mining camps.[264] In and around Austin, during its peak period, silver production was only second to that of the Eureka and Comstock mines. Estimates reveal that between 1862 and 1902, Austin area's mines produced approximately $50 million in silver.[265]

It did not take long for mining activities to result in conflicts with other Humboldt River Basin water users, as well as adversely affect the basin's wildlife. In August 1864, under the so-called "Humboldt [Water] Right", the Utica Bullion Mining Company boldly laid claim to use all the waters of the Humboldt River.[266] The mining company built a dam across the Humboldt River below the Humboldt lakes (Humboldt and Toulon Lakes) to process its ore. The dam became the focus of continuing controversy, flooding agricultural fields in the lower Lovelock Valley and preventing upstream migration of fish. The dam was eventually blown up in June 1884 by a party of masked men, after which the mining company's claim to any waters of the Humboldt River collapsed.[267]

In 1869, mining became one of the principal economic activities in the Ruby Mountains sub-basin when the Railroad Mining District, located west of Dixie Flats (Dixie Creek), was discovered and the mining camp of Bullion, located two miles northeast of Raven's Nest on the eastern slopes of the

Pinon Range, was established as its principal settlement. Between 1869 and 1887, some $3.2 million in silver, lead, copper and some gold was mined within the district.[268]

Despite the widespread mining activity, the early period of mining in the Humboldt River Basin never really produced the great mining booms or vast wealth of other areas in Nevada like Virginia City, Goldfield and Tonopah. However, based on the crucial importance of the Humboldt River Valley transportation corridor, especially after the completion of the transcontinental railroad in 1869, the basin's development greatly benefitted from mining activities just beyond its borders. Many of the basin's principal communities, such as Winnemucca, Battle Mountain, Carlin and Elko, grew up servicing the needs of mining districts, many of which were just outside the boundary of the Humboldt River Basin. For example, to the south, Elko's railroad depot, freight and stagecoach lines served the White Pine Mining District and mining camps like Hamilton, Treasure City and White Pine City, all of which lie within Nevada's Central Region. To the north, Elko's transportation and freight facilities served the Cope Mining District and the mines at Columbia, Cornucopia and Tuscarora, which all lie within the Snake River Basin.

Another form of early "mining" within the Humboldt River Basin was begun in October 1875. At that time the Elko Mining and Soap Deposit Company attempted to exploit the "soap" deposits located on the east bank of Huntington Creek above Twin Bridges, about one-half mile above Huntington Creek's confluence with the South Fork of the Humboldt River. These deposits had been identified as early as 1849 by the emigrants traveling down along Huntington Creek on the Hastings Cutoff route around the Ruby Mountains. While the final product was of high quality (in fact, winning a certificate of merit at the Columbian Exposition in Chicago in 1893), the mineral deposits ultimately proved too difficult to process and the operation never became a commercial success.[269]

By the early 1880's, mining throughout Nevada had fallen on hard times and as a consequence the state entered its Twenty-Year Depression (1880-1900). Over this period nearly one-third of the people left the state, reducing Nevada's population from a recorded 62,266 persons in 1880 to 42,335 persons by 1900.[270] As bad as things appeared for Nevada's struggling predominate silver mining industry, they actually worsened appreciably in 1893. In this year the Sherman Silver Purchase Act was repealed resulting in the demonetization of silver and the curtailment of its use for U.S. currency. This brought prospecting and mining activity in the Humboldt River Basin to a virtual standstill.[271] In this case, the Nevada mining industry's entry into a "bust" period was largely caused by external factors over which the state had virtually no control. This would not be the last time that this industry would be adversely affected by external factors and influences.

Toward the end of the 1800's, concerted efforts towards copper mining commenced within the Humboldt River Basin. Golconda, located 20 miles up the river from Winnemucca, was first settled in 1863 and was the by-product of the ill-fated and never completed Ginaca-Gintz Humboldt Canal. Later, in 1897, the town became the headquarters for the Golconda & Western Exploration Company, Ltd., which began to develop local copper deposits. At the height of the region's copper mining boom in 1899, the town boasted some 500 inhabitants, six hotels, a newspaper, several stores, many bars, a racetrack and a flourishing tenderloin district. The Golconda copper mining boom was short-lived, however. By 1900, because of difficulties in treating the Adelaide and Copper Canyon ores upon which the town had flourished, the mine, mill and narrow-gauge railroad to the mine site were all shut down.[272]

The Carlin Trend and the Era of Nevada's Modern Gold Mining

The era of modern gold (and silver) mining in the Humboldt River Basin began tenuously in the early 1900's when promising gold deposits were first discovered north of Carlin in northern Eureka County and western Elko County. In 1907, gold deposits were found in western Elko County in the Midas (Gold Circle) Mining District during the general resurgence in prospecting all over Nevada following the fabulous gold strikes at Tonopah and Goldfield. A rush ensued and a townsite – called Gold Circle at first, but later changed to Midas – was laid out, located just over 40 miles north of Battle Mountain. At its peak period of production from 1916 to 1921, Midas had a population of some 2,000 people. By the end of 1921, the district had produced almost $2.5 million in gold, silver and copper. After the Elko Prince Mill burned in 1922, Midas, which once hosted 21 saloons, a post office, a town water system, a newspaper, four general stores and several hotels and rooming houses, quickly lapsed into a near ghost town and is now visited only seasonally by hunters and curiosity seekers.[273]

In March 1913, the Big Six Mining Company laid out the town site of Lynn, located approximately 20 miles up Maggie Creek from Carlin. Gold was mined at the location in paying quantities and early estimates indicated the gold vein as being one of the largest and most lucrative in Nevada. However, this mining boom was quite short lived, even by Nevada's standards, and by December 1914 the company was experiencing severe financial difficulties.[274] Despite these early setbacks, the first major gold strikes in the area north of Carlin were indicative of far greater fortunes to come from this area. Not until the 1980's, however, would conditions be conducive for the development of this mineral-rich area. At that time, higher gold prices and the use of advanced technology in both ore extraction and milling would allow for the extensive development and cost-effective mining of this vast, but relatively low-grade body of gold ore running throughout this area of western Elko County and northern Eureka County. Only then would this region, now known as the "Carlin Trend", prove itself as the richest gold-producing region in the United States.

But before that eventuality, further gold discoveries continued to show the vast extent of the Humboldt River Basin's mineral wealth. In 1934 two large mines, the Riley and Getchell, located in eastern Humboldt County, were developed in the Potosi Mining District of the Osgood Mountains to exploit scheelite tungsten and gold-bearing ores. The Getchell Mine, located some 15 miles due north of Red House and the Humboldt River, was subsequently acquired in 1935 by George Wingfield and Noble Getchell, prominent Nevada mining men. At first, the mine was operated primarily for extraction of gold oxide ores; however, during World War II the gold mining operations were terminated and extraction was concentrated on tungsten ores, which had greater military value.[275] Later, following the withdrawal of the U.S. Government's tungsten purchase program in 1957,[276] gold operations were resumed at the Getchell mine site and would continue through to the present day. The district now ranks as an important producer of gold along an ore body called the Getchell Gold Trend, which intersects with the Carlin (Gold) Trend near the Midas mine site some 25 miles to the east.

Table 13, Nevada Mining Industry Analysis, 1985-1998, presents information and trends with respect to the total mineral valuation, gold and silver valuation, the number of mining workers, and the productivity of mining workers for Nevada and for the five principal counties within the Humboldt River Basin. The concept of mining worker productivity – a dollar measure of gross mining proceeds per mining worker – has important implications in assessing the financial feasibility and attractiveness of particular mining operations. The rapid and relatively recent (late 1980's) growth in overall mining in Nevada is clearly shown by the trends between 1985 and 1990. Over that relatively brief period, the valuation of total mineral production in Nevada more than quadrupled from $623 million in 1985 to over $2.6 billion by 1990.

The importance of gold mining is also shown in Table 13 by the fact that over the same 1985 to 1990 time period the valuation of gold (and silver) production in Nevada increased by a factor of nearly five times. From 1985 to 1990, the value of Nevada's gold production rose from nearly $481 million and 77 percent of the state's valuation of total mining proceeds to nearly $2.4 billion and 90 percent of Nevada's total mineral proceeds. Since 1990, statewide mineral production, based primarily on the trends in gold mining, has shown only modest gains and by 1998 gold and silver production continued to account for approximately 90 percent of Nevada's total value of all minerals produced. The more recent weakness in international gold prices has dramatically affected the trends in Nevada's gold mining industry. Statewide total mining employment, primarily reflecting the influence of increased gold production, rose by 8,240 workers or 136 percent between 1985 and 1990. Since 1990, however, job losses in Nevada's mining industry have totaled 1,085 workers, a decrease of 7.6 percent.

Since Nevada became a territory in 1861, mining has played a crucial role in terms of the Humboldt River Basin's settlement and development patterns. These influences have persisted to the present day. The basin's principal five counties[277] of Elko, Eureka, Humboldt, Lander and Pershing comprise five of the top six mineral and gold producing counties in Nevada.[278] Nevada is currently the largest gold producer in the United States with $2.66 billion in total gold production in 1998. Nevada also lays claim to having the largest underground gold mine (Barrick Goldstrike's Meikle Mine) and the largest surface (open pit) gold mine (Barrick Goldstrike's Betze-Post Mine) in the U.S. (which is also the nation's largest gold mine).[279] The total value of all mining activity in the state in 1998 came to nearly $3 billion, down only slightly from 1997's total mineral production of $3.12 billion. Gold and silver production in Nevada in 1998 was also down very slightly from $2.67 billion in gold production in 1997.

Table 13 – Nevada Mining Industry Analysis – 1985-1998

Gross Mineral Proceeds, Workers, Productivity of Humboldt River Basin Counties†

(Gross Mining Proceeds in Millions of Dollars; Productivity in Dollars per Worker per Year)

Mining – State/County	1985‡	1990	1995	1998	1990-98 Volume Change	1990-98 Percent Change
NEVADA						
Gross Mining Proceeds (Value) [1]	$623.63	$2,635.47	$2,991.62	$2,998.54	$363.07	13.8%
Gold and Silver Production (Value)	$480.83	$2,367.64	$2,740.84	$2,663.10	$295.46	12.5%
Number Mining Workers	6,081	14,321	13,187	13,236	-1,085	-7.6%
Mining Worker Productivity [2]	$102,554	$184,029	$226,862	$226,544	$42,515	23.1%
Elko County						
Gross Mining Proceeds	$102.35	$238.43	$183.47	$447.42	$208.99	87.6%
Gold and Silver Production	$97.53	$232.15	$169.60	$409.93	$177.78	98.2%
Number Mining Workers	774	1,289	1,295	1,223	-66	-5.1%
Mining Worker Productivity	$132,235	$184,970	$141,674	$365,835	$180,865	97.8%
Eureka County						
Gross Mining Proceeds	$114.88	$789.73	$1,412.68	$946.59	$156.86	19.9%
Gold and Silver Production	$108.23	$784.44	$1,405.12	$944.83	$160.39	20.4%
Number Mining Workers	636	3,599	3,927	4,079	480	13.3%
Mining Worker Productivity	$180,633	$219,432	$359,735	$232,064	$12,632	5.8%
Humboldt County						
Gross Mining Proceeds	$31.94	$356.96	$441.82	$365.45	$8.49	2.4%
Gold and Silver Production	$31.56	$353.13	$437.75	$360.16	$7.03	2.0%
Number Mining Workers	393	1,527	2,305	2,009	482	31.6%
Mining Worker Productivity	$81,272	$233,768	$191,681	$181,904	-$51,864	-22.2%
Lander County						
Gross Mining Proceeds	$96.22	$276.03	$279.94	$487.54	$211.51	76.6%
Gold and Silver Production	$86.68	$266.08	$258.49	$467.28	$201.20	75.6%
Number Mining Workers	845	1,360	1,082	1,106	-254	-18.7%
Mining Worker Productivity	$113,869	$202,961	$258,726	$440,816	$237,855	85.3%
Pershing County						
Gross Mining Proceeds	$16.12	$96.90	$111.60	$164.42	$67.52	69.7%
Gold and Silver Production	$3.76	$85.58	$99.69	$151.09	$65.51	76.6%
Number Mining Workers	195	683	682	799	116	17.0%
Mining Worker Productivity	$82,688	$141,869	$163,639	$205,776	$63,907	45.0%
Humboldt River Basin Counties						
Gross Mining Proceeds	**$361.51**	**$1,758.05**	**$2,429.51**	**$2,411.42**	**$653.37**	**37.2%**
Percent Statewide Total	**58.0%**	**66.7%**	**81.2%**	**80.4%**	**13.7pp***	**—**
Gold and Silver Production	**$327.76**	**$1,721.38**	**$2,370.65**	**$2,333.29**	**$611.91**	**35.5%**
Percent Statewide Total	**68.2%**	**72.7%**	**86.5%**	**87.6%**	**14.9pp***	**—**
Number Mining Workers	**2,843**	**8,458**	**9,291**	**9,216**	**758**	**9.0%**
Mining Worker Productivity	**$127,158**	**$207,856**	**$261,491**	**$261,656**	**$53,799**	**25.9%**

† Mineral values are for the total county and not necessarily for only those mines within the Humboldt River Basin.

‡ Due to reporting limitations at the time, gold and silver production valuation figures for 1985 may also contain relatively insignificant mineral valuations of other metals and metallic by-products, for example, lead and copper.

* pp = percentage point difference.

[1] Gross mining proceeds measures the market valuation of mineral sales made by the Nevada mining industry.

[2] Mining worker productivity measures the total state or county gross mining proceeds (including gold and silver production) divided by the respective average mining employment for that year; measured in dollars per mining worker per year.

Source Data: Nevada Department of Taxation, Centrally Assessed Properties, Division of Assessment Standards; Nevada Department of Employment, Rehabilitation and Training (DETR), Research and Analysis Bureau.

The five principal Nevada counties within the Humboldt River Basin accounted for just over 80 percent of Nevada's total mineral production in 1998 and nearly 88 percent of the state's total gold and silver production. These counties, in ranked order by their total 1998 mineral production, include:

Basin County	Percent Total State Mineral Production	Percent of Total Gold and Silver Mineral Production
Eureka	31.6%	35.5%
Lander	16.3%	17.6%
Elko	14.9%	15.4%
Humboldt	12.2%	13.5%
Pershing	5.5%	5.7%
Basin Counties Total	**80.4%**	**87.6%**

In addition, these five Humboldt River Basin counties also accounted for nearly 70 percent of the state's total mining jobs in 1998. Table 14, Humboldt River Basin Mining Employment Trends, 1997-1998, shows how the more recent declines in statewide total mining employment (jobs) have tended to be concentrated within the principal gold-producing counties making up the Humboldt River Basin. While Nevada experienced a total decline of 1,427 mining jobs from 1997 to 1998, the basin's five counties showed a cumulative decline of 1,083 mining jobs, meaning that 75.9 percent of the statewide decline in total mining jobs between 1997 and 1998 were concentrated within the basin's principal counties. While mining's impacts on statewide total employment appears slight, making up only 1.4 percent of total state employment, the importance of mining to the basin's overall employment patterns is far more crucial.

In 1998, the mining industry accounted directly for nearly 25 percent of all jobs in the Humboldt River Basin's principal counties, ranging from a high of almost 90 percent of total employment in Eureka County to a low of 6.2 percent of total employment in Elko County. Obviously, the greater the share of mining jobs, the more extensive the effects that changes in mining jobs will have on the local economy. In addition to the direct economic effects of changes in mining jobs within these counties, the indirect impact of such changes will result in secondary, or indirect economic impacts on other employment sectors,[280] and is also likely to have far-reaching effects on employment outside the county or region of origin.[281]

Due to more recent weakening prices in gold, economic trends within Nevada's mining industry have been generally downward since 1996 and have resulted in the curtailment of some aspects of the operations in Nevada's gold mines. Areas of operations that have been especially adversely affected have included the exploration for new ore deposits, investment in plant and equipment, mining-related construction activity, and employment. Table 14, Humboldt River Basin Mining Employment Trends – 1997-1998, shows that as a result of cutbacks in mining exploration, operations and investment, statewide total mining employment in 1998 of 13,236 workers was down 9.7 percent, or 1,427 workers, from a total of 14,663 mining workers in 1997.[282]

Table 14 – Humboldt River Basin Mining Employment Trends – 1997-1998

Mining Employment Trends in Counties† Comprising the Humboldt River Basin

County	1998 Total Employment	1997-98 Change in Total Employment	1998 Mining Employment	Percent Total Employment	1997-98 Change in Mining Employment	Percent of Mining Change‡ to Total Change
NEVADA	923,199	34,625	13,236	1.4%	-1,427	n.m.
Elko	19,894	-288	1,223	6.2%	-204	70.8%
Eureka	4,537	-317	4,079	89.9%	-191	60.2%
Humboldt	7,962	-592	2,009	25.2%	-442	74.7%
Lander	2,466	-242	1,106	44.8%	-184	76.3%
Pershing	2,274	-2	799	35.1%	-62	n.m.
Total Basin†	**37,133**	**-1,441**	**9,216**	**24.8%**	**-1,083**	**75.2%**

† The majority of mines and virtually all major towns and cities within these five counties lie within the Humboldt River Basin.
‡ Measures the change in mining jobs as a percent of the change in total jobs.
n.m. = not meaningful to either (1) compare percentage shares of decreases (negative numbers) with increases (positive numbers) or (2) the comparison of a very large change to a very small change.
Source Data: Nevada Department of Employment, Training and Rehabilitation (DETR), Research and Analysis Bureau.

Table 15, Nevada Gold and Silver Production and Average Prices, shows the historical production (in troy ounces[283]) and average market prices received for Nevada's two principal precious metals – gold and silver – for selected years from 1978 to 1998. The evident extreme price variability for gold, from a low of less than $194 per ounce in 1978 to a high of over $613 per ounce in 1980 (a recessionary period and a year of extremely high inflation and general economic uncertainty), reflects the metal's widespread use at that time as a "store of value" and "inflation hedge". Relatively stable gold prices during the early and mid-1990's, when its price remained within a relatively narrow range around $380-$390 per ounce, were largely responsible for the rapid expansion and prosperity of Nevada's gold industry over this period. At the source of the more recent decline in the Humboldt River Basin's mining operations has been declining gold prices, which have been trending downward since late 1996.

In 1997, the average price received for Nevada's gold production had fallen to $325 per ounce, and by 1998 the average price received by Nevada's mines for gold had declined further to only $294 per ounce.[284] By mid-1999, the price of gold had sunk even further to as low as $250 per ounce, and mine closings and job losses in Nevada had become more extensive. Since that time, however, considerable economic and political pressure has been brought to bear on responsible entities which have been involved in large open-market gold sales. By late summer 1999, these pressures helped persuade the International Monetary Fund (IMF) to hold off on planned gold sales that were supposed to benefit poor countries, and on September 26, 1999, 15 European central bankers promised to tightly limit gold sales over the next five years.[285] As a result, by October 1999, gold's "spot" market price had risen above $300 per ounce. The ultimate effects of these trends on Nevada's gold industry are unknown at this time, but could be profoundly negative if gold's price reverses and dips again well below the $300 per ounce level.

Table 15 – Nevada Gold and Silver Production and Average Prices†

Statewide Production and Prices of Gold and Silver for Selected Years 1978–1998

Precious Metal	**1978**	**1980**	**1985**	**1990**	**1995**	**1998**
Gold (troy ounces)	260,895	250,618	1,276,114	5,813,000	6,764,000	8,860,000
Silver (troy ounces)	804,000	167,000	4,947,000	21,529,000	24,602,000	21,500,000
Gold–Average Price per Ounce‡ (dollars)	**$193.55**	**$613.28**	**$317.66**	**$380.02**	**$384.09**	**$294.07**
Silver–Average Price per Ounce‡ (dollars)	$5.40	$21.54	$6.14	$5.00	$5.19	$5.55

Note: In 1998 gold and silver production comprised approximately 89 percent of total mineral valuation in Nevada.

† Average prices are not necessarily “spot market” prices, but instead the average prices actually received during the year for Nevada’s gold and silver production.

‡ Based on the troy ounce (12 ounces per pound).

Source Data: Nevada Bureau of Mines and Geology, *The Nevada Mineral Industry*, various issues and John l. Dobra, “The U.S. Gold Industry – 1998,” Special Publication 25, Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno, 1999, page 7.

The Mine Dewatering Issue

In addition to mining’s economic considerations, mining operations within the Humboldt River Basin have hydrologic implications as well. Nevada’s more recent gold surface mining operations have resulted in a number of large, open pit mines within the Humboldt River Basin. Many of these open-pit mines have extended below local groundwater levels and therefore require dewatering, or the pumping and surface water discharge, re-injection, or infiltration of groundwater in order to intercept groundwater and minimize groundwater flows into the pit. Dewatering operations consist of typically perimeter wells to preclude or minimize groundwater flows into the open pit and thereby allow for access to and extraction of the ore bodies.[286] Mine dewatering effectively creates a “cone of depression” near the extraction points which draws down the groundwater table. The pumping and lowering of the groundwater table may also have incidental effects on the flows of nearby springs, streams or other surface water bodies. The average ore grade for open pit mines along the Carlin Trend (approximately 0.06 ounce of gold per ton of earth removed) necessitates the removal of up to 17 tons or approximately 13 cubic yards of earth[287] for every ounce of gold produced. (Ore grades for underground gold mines are considerably greater than the average 0.06 ounce per tone for open pit mines.) Nevada’s extensive near-surface ore bodies lend themselves to the development of some very large and very deep open pits.

An example of the magnitude of one of these large open pit operations is the Betze-Post Mine, located in northern Eureka County along the Carlin Trend. When this pit is filled with water, it will contain an estimated 580,000 acre-feet of infiltrated groundwater, making it the largest pit lake in Nevada in terms of total volume, and the third largest body of water wholly contained within the state[288] (after Pyramid and Walker lakes).[289] In 1997 alone, Barrick Gold Corporation, owner of the Betze-Post Mine,[290] removed approximately 159 million tons of material from this pit,[291] equal to a equivalent volume of over 75,000 acre-feet of water.[292] Arguably, the scope of these pit excavations and the resultant size of the pit lakes that will be created could affect local groundwater and surface water conditions once dewatering operations cease and the pits begin to fill.[293]

The State of Nevada has recognized the potential effects that these open-pit mining operations may have on the region's hydrologic conditions. As a result, the State Engineer has established a mitigation process of preferred uses for the pumped groundwater from these surface mining operations. To every extent possible, this process attempts to either minimize or localize the effects of dewatering operations, or allow the water to substitute for other existing groundwater withdrawals (such as groundwater used for alfalfa irrigation). Consequently, as a first preference, the State Engineer has mandated that groundwater pumped that is in excess of ore processing requirements should be returned to the groundwater source through direct re-injection, if at all possible. Alternatively, if re-injection is not practical, then the water pumped from the mine pit may be stored in surface infiltration ponds. Depending on soil and rock strata conditions, this method can effectively dispose of water relatively quickly, but does increase losses due to surface water evaporation. However, this option may also tend to cause localized increases in groundwater levels (mounding)[294] and soil saturation immediately below and near these infiltration ponds.

As a third option, the State Engineer requires that where re-injection or infiltration are not possible or practical, then the mine can substitute the pumped groundwater for existing permitted beneficial uses of groundwater. Examples of this include mine water used for growing alfalfa on the TS Ranch in Boulder Flat (Betze-Post Mine)[295] and as a substitute for groundwater extracted for cooling the Valmy Power Plant in Humboldt County (Newmont's Lone Tree Mine). If no opportunities for beneficial use substitution exist, then the State Engineer would consider the creation of new, albeit temporary, beneficial uses for this water.[296]

As a last resort, if recharge, infiltration or beneficial use substitution are not possible, then the State Engineer will permit discharge of the pumped groundwater to existing stream systems, some of which eventually drain into the Humboldt River. However, for such surface water discharges, National Pollutant Discharge Elimination System (NPDES) permits are issued pursuant to the Federal Clean Water Act (CWA) and the Nevada Water Pollution Control Law. The Nevada Division of Environmental Protection (NDEP) Bureau of Water Pollution Control (BWPC) issues the NPDES permits which incorporate literally dozens of monitoring requirements pursuant to a multitude of site-specific and appropriate beneficial use standards such that no degradation to existing surface water quality conditions result.[297] For surface water discharges, NDEP's Bureau of Water Quality Planning (BWQP) has established Requirements to Maintain Existing Higher Quality (RMHQ's) and site specific Water Quality Standards for Nevada's major lakes, rivers and streams. Some of these standards include pH[298] levels and the amount of total dissolved solids (TDS).[299] Water temperature differentials may also be an issue and some pumped water from mines may initially have to be held in cooling ponds before eventual release to existing surface waters. NDEP's BWPC also issues water quality discharge permits for water that is infiltrated or injected to groundwater.[300]

The effects and concerns of mine dewatering in the Humboldt River Basin fall into two distinct time periods: (1) the current period (short-term) effects occurring during active dewatering operations; and (2) the long-term effects anticipated when dewatering operations have ceased, the mine pits begin to fill, and the resultant pit lake reestablishes equilibrium with the local groundwater table.[301] The short-term effects deal primarily with the disposal of the pumped groundwater, along with water quantity, quality and temperature issues. Also important here are the temporary opportunities and benefits that may be created by the use of this discharged water, such as increased recreational values and the maintenance or increase of instream flows for wildlife. In balance, some form of mitigation may become necessary where unforeseen effects create a situation of potential harm to the environment and existing water supplies. These effects appear to have been generally accommodated through the state's existing water right and water quality control permitting processes. In the process, efforts to more precisely determine the threats and benefits of mine dewatering operations have typically resulted in better research and understanding, as well as closer working relationships among the mine operators, local water users likely to be most affected, interested environmental groups, and state and federal regulatory and permitting agencies.

In October 1995 the USGS, in cooperation with the Nevada Department of Conservation and Natural Resources and the U.S. Bureau of Land Management, began an assessment of the regional water resources of the Humboldt River Basin. The assessment was undertaken in response to concerns over increasing demand for the limited water resources of the basin and the potential effects of mine dewatering during the past ten years. The assessment focused on 14 hydrographic areas[302] in the middle Humboldt River Basin which included areas of irrigated agriculture and most of the large gold mining operations in northern Nevada. The Humboldt River Basin Assessment was planned in two phases. Phase 1 of the studies were to be undertaken from October 1995 through September 1998 and consisted of the following tasks: (1) the compilation and dissemination of hydrologic data via the Internet (world wilde web) and a bibliography of reports pertinent to the middle basin; (2) a study of the hydrogeologic framework and groundwater levels; (3) water budgets for selected hydrographic areas; and (4) groundwater use.

Phase 2 studies of the Humboldt River Basin Assessment were to be conducted from October 1998 through September 2003 and consist of: (1) a continuation of studies related to groundwater use in the middle basin; (2) water budgets for the remaining hydrographic areas; and (3) development of a computer model of groundwater and surface water flow in the middle basin. Several mining companies with operations in the Middle Humboldt River Basin provided data, technical assistance and funding support for the project, including Barrick Goldstrike Mines Inc., Getchell Gold Corporation (subsequently acquired by Placer Dome), Newmont Gold Company, and Santa Fe Pacific Gold Corporation (subsequently acquired by Newmont).[303] All information, data, bibliographic references and progress reports are posted on the USGS Humboldt Hydrology website.[304]

The long-term effects of mine dewatering operations are, as yet, not well known. However, these issues are being given considerable attention by the mining industry, state and federal regulatory and permitting agencies, the USGS, geologists, hydrologists, environmentalists and the media. While the geology, hydrology and hydraulics[305] of the affected areas have been extensively studied,[306] the long-term effects of pit lake filling and groundwater stabilization are not known with certainty. Nearly one dozen large mine pits and many smaller ones will eventually become man-made lakes which will contain an estimated 1.5 to 2 million acre-feet of water. While some of these pit lakes will fill relatively quickly, i.e., within 5 to 10 years, others will fill over a longer period of time, typically in excess of 50 years.

The major hydrologic and environmental concerns during this long-term stabilization process are:

(1) the effects on local groundwater conditions[307] and land subsidence[308] during and after pit lake filling;

(2) the effects of evaporation[309] on both pit lake levels and the surrounding groundwater conditions;
(3) the quality of water flowing into the pits as well as the overall quality of the water within the pit lakes;[310]
(4) the effects on local springs and creeks and other surface waters during and after pit lake filling; and
(5) the long-term effects on the flows in the Humboldt River main stem from resultant changes in groundwater conditions and changes in tributary flows.

Agriculture and Its Importance to the Humboldt River Basin

[Notes to the presentation of agricultural-related data and analysis: The time periods used in this section differ from other sections in Part I as they are based on the agricultural census which occurs generally every five years and is defined by the U.S. Bureau of Census, Agriculture Division (e.g., 1974, 1978, 1982, 1987, and 1992). Irrigated acreage, and irrigation and livestock water withdrawal data for 1990 were developed by the U.S. Geological Survey (USGS) from 1992 agricultural census data. Acreage and water withdrawal estimates for 1997 were developed by the Nevada Division of Water Planning based on an extrapolation of forecasts as presented in the *1999 Nevada State Water Plan* (April 1999). That publication also provides an extensive review of the methodology used in this estimation and forecast process. Also, agricultural data is presented in two general coverages: (1) totals for the five principal counties making up the Humboldt River Basin (i.e., Elko, Eureka, Lander, Humboldt and Pershing); and (2) data for just the area contained within the basin itself. Due to reporting limitations, data on farm marketings and employment, in particular, is presented on a total county basis only and thus includes data for areas under cultivation which are inside a county's borders but outside the basin's borders. Water withdrawals and water use are terms used synonymously in this section; however, they differ from the concept of decreed water rights. Water withdrawals represent the total amount of water diverted to a field, whereas a water right is the water duty in acre-feet per acre per year times the decreed acreage.]

Overview

While fur trapping may have been the first business enterprise undertaken by Europeans within the Humboldt River Basin, agriculture has certainly been the basin's most enduring economic pursuit. Even while the basin's mining industry has shown several repetitions of boom and bust cycles, agriculture has persevered, servicing the mining industry during its boom periods and finding new markets outside the basin during mining's bust periods. The earliest agricultural-related demands within the basin were based on the expansive natural grasslands and lush meadows adjacent to the Humboldt River and its principal tributaries. The period of European emigration, commencing in 1841 with the Bartleson–Bidwell emigrant party and continuing essentially through the early 1870's, created new demands for agricultural commodities, both crops and livestock. The basin's mining boom, which began in the early 1860's, placed even greater demands on the basin's agricultural industry and began a period of land clearing and leveling, dam construction, canal building, irrigation diversions, wetland draining, agricultural cultivation and open-range grazing which have persisted to the present day.

Table 16 – Humboldt River Basin County† Irrigated Acres‡

Humboldt River Basin County Agricultural Data for Selected Years, 1974–1997

State / County	1974	1978	1982	1987	1990	1997
NEVADA						
Total Irrigated Acres	**777,510**	**881,151**	**829,761**	**766,968**	**728,350**	**732,833**
Elko County						
Irrigated Acres	234,838	224,624	256,932	235,188	210,150	215,296
Percent of Statewide Total	30.2%	25.5%	31.0%	30.7%	28.9%	29.4%
Percent Humboldt Basin Counties	49.2%	43.6%	49.7%	53.1%	46.5%	46.4%
Eureka County						
Irrigated Acres	31,247	49,806	33,372	28,606	44,700	38,230
Percent of Statewide Total	4.0%	5.7%	4.0%	3.7%	6.1%	5.2%
Percent Humboldt Basin Counties	6.5%	9.7%	6.5%	6.5%	9.9%	8.2%
Humboldt County						
Irrigated Acres	143,800	151,906	158,718	100,972	134,750	146,332
Percent of Statewide Total	18.5%	17.2%	19.1%	13.2%	18.5%	20.0%
Percent Humboldt Basin Counties	30.1%	29.5%	30.7%	22.8%	29.8%	31.5%
Lander County						
Irrigated Acres	31,994	48,474	28,820	35,663	31,200	34,736
Percent of Statewide Total	4.1%	5.5%	3.5%	4.6%	4.3%	4.7%
Percent Humboldt Basin Counties	6.7%	9.4%	5.6%	8.0%	6.9%	7.5%
Pershing County						
Irrigated Acres	35,681	40,286	38,837	42,796	31,100	29,389
Percent of Statewide Total	4.6%	4.6%	4.7%	5.6%	4.3%	4.0%
Percent Humboldt Basin Counties	7.5%	7.8%	7.5%	9.7%	6.9%	6.3%
Humboldt River Basin Counties†						
Total Irrigated Acres	**477,560**	**515,096**	**516,679**	**443,225**	**451,900**	**463,984**
Percent of Statewide Total	**61.4%**	**58.5%**	**62.3%**	**57.8%**	**62.0%**	**63.3%**

† Counties represent the five principal counties of the Humboldt River Basin. Agricultural irrigated acreage figures are for the total counties and include some irrigated acreage lying outside of the basin's boundaries. The majority of the irrigation in these counties, however, is along the Humboldt River main stem, within Lovelock Valley (Lovelock Reach sub-basin), Paradise Valley (Little Humboldt River sub-basin), Grass Valley (Sonoma Reach sub-basin), or in the Upper and Lower Reese River Valley (Reese River sub-basin). All these important agricultural areas lie within the Humboldt River Basin.
‡ Variations in irrigated acres are due more to the water available for irrigation than the land available for irrigation.
Source Data: Irrigated acreage figures for 1974, 1978, 1982 and 1987 are from the U.S. Bureau of the Census, Agriculture Division; irrigated acreage figures for 1990 are estimates from the U.S. Geological Survey (USGS); irrigated acreage for 1997 are based on estimates and forecasts made by the Nevada Division of Water Planning (NDWP) as extrapolated from information presented in the *1999 Nevada State Water Plan*.

Table 16, Humboldt River Basin County Irrigated Acres, presents information on estimated acreage currently and historically irrigated for the five principal counties within the Humboldt River Basin. The apparent wide variations in these figures are not necessarily due to the availability of irrigable acreage, but primarily represent variations in the amount of water actually available for irrigation during these census years. Water has tended to be the most crucial restraining factor in the agricultural industry over time. From Table 16, it may be seen that the basin's five principal counties contained an estimated 464,000 irrigated acres in 1997, accounting for over 63 percent of total irrigated acreage in the State of Nevada. Elko County alone, with over 215,000 irrigated acres, had the most irrigated acreage of any county in Nevada in 1997, accounting for over 29 percent of the statewide total and over 46 percent of all irrigated acreage among the basin's five counties.

Agriculture not only played an important role in the Humboldt River Basin's earliest settlement patterns and economic development, but also has important relationships to the hydrology of the basin. Agriculture is by far the largest user of surface water resources within the Humboldt River Basin. Consequently, no overview of the basin would be complete without some discussion of the hydrologic and economic consequences of this industry. In 1997, it was estimated that within the five principal counties in the Humboldt River Basin approximately 464,000 acres were irrigated using nearly 2 million acre-feet of water (see Table 18, Agricultural Water Use in the Humboldt River Basin Counties).[311] Solely within the Humboldt River Basin, there exists over 332,000 decreed water-righted acres of land which use approximately 817,000 acre-feet of decreed water rights each year (see Table 17, Humboldt River Basin Decreed Water Rights).[312] The USGS estimated that in 1990, a drought year in the basin, approximately 234,000 acres were irrigated with nearly 1,000,000 acre-feet of water, 75 percent of which represented surface water supplies.[313]

Table 17 – Humboldt River Basin Decreed Water Rights†

Decreed Acreage and Water Rights by Sub-Basin (Acres and Acre-Feet per Acre per Year)

Humboldt River Basin Sub-Basins	Decreed Lands (acres) Crop Land	Decreed Lands (acres) Pasture Land	Decreed Water Rights (af) Crop Land	Decreed Water Rights (af) Pasture Land
Mary's River	9,260	8,940	27,770	7,630
Ruby Mountains	78,575	12,080	235,260	11,490
North Fork Humboldt River	17,525	750	52,238	735
Maggie Creek	1,962	1,875	5,855	1,796
Elko Reach	15,000	6,800	45,000	6,700
Pine Valley	3,431	486	10,293	501
Reese River	19,900	—	21,600	—
Battle Mountain	14,790	41,760	46,730	43,510
Little Humboldt River	30,361	11,626	109,300	11,848
Sonoma Reach	8,940	7,920	26,810	7,430
Lovelock Reach	37,086	3,798	137,536	7,297
Total Humboldt River Basin	**236,830**	**96,035**	**718,392**	**98,937**
	Total Decreed Lands	**332,865**	**Total Decreed Rights**	**817,329**
Total Average Water Duty	2.5 Acre-Feet per Acre per Year			
Crop Land Average Water Duty	3.0 Acre-Feet per Acre per Year			
Pasture Land Average Water Duty	1.0 Acre-Feet per Acre per Year			

† Decreed water rights exist for specific lands for which a water use permit has been issued (vested), or for water rights which have been adjudicated by court decree. Water rights in terms of acreage and volumes are for the Humboldt River Basin only and differ from the total irrigated acreage and agricultural water use presented earlier which presented the total water use for the five principal Humboldt River Basin counties (i.e., Elko, Eureka, Lander, Humboldt and Pershing). Water duties are calculated figures and do not necessarily represent actual decreed values.

Source Data: *Humboldt River Basin, Nevada, Water and Related Land Resources*, Reports Number One through Twelve, Nevada Department of Conservation and Natural Resources and the U.S. Department of Agriculture, 1962-1966.

Agricultural activities in the Humboldt River Basin resulted in approximately $144 million in total farm marketings in 1997 (see Table 19, Humboldt River Basin County Farm Marketings) and created nearly 1,800 jobs in farming alone (see Table 20, Humboldt River Basin Agricultural-Related Employment). In addition, due to the "export" nature of much of the region's agricultural production, the industry results in multiple impacts on the local economy by bringing in new monies in payment for this agricultural output. While the economic effects of mining (especially since the 1980's) have been far greater than agriculture in terms of production valuation, employment, incomes and spending within the Humboldt River Basin, the nature of the agricultural industry has resulted in an underlying economic stabilizing force which has tended to smooth out, to some degree, the effects of mining's more typical boom-bust nature.

Table 17, Humboldt River Basin Decreed Water Rights, presents information on decreed (water-righted) lands for both crop lands and pasture lands and the respective decreed water allowed for these lands based on specific water duties for each of the eleven sub-basins within the Humboldt River Basin. These total figures for irrigated acreage differ from the total county irrigated acreage figures presented in Table 16, Humboldt River Basin County Irrigated Acres, as the irrigated acreage figures in Table 17 are solely for decreed water-righted lands and specific water duties for each defined sub-basin and only contained within the Humboldt River Basin.

Water Use Trends and Analysis

Table 18, Agricultural Water Use in the Humboldt River Basin Counties, presents estimates of total water withdrawals as well as irrigation and livestock water use for the five principal counties of the Humboldt River Basin. These estimates were based on estimates of irrigated acreage presented in Table 16 and a county-specific water duty, measured in acre-feet per acre per year, which was estimated from historical county water-use trends.[314]

Based on the agricultural water use estimation process used, the Humboldt River Basin counties showed total water withdrawals (a concept which differs from consumptive use which is the basis of the decreed water rights figures shown in Table 17) of nearly 2 million acre-feet in 1997, accounting for over 61 percent of the total water withdrawn in Nevada for agricultural purposes for that year. As expected, due to its ranking in total irrigated acreage, Elko County withdrew the most water for irrigation and livestock use in 1997, accounting for nearly 29 percent of all such withdrawals in the state and nearly 47 percent of such withdrawals among the Humboldt River Basin's five principal counties.

Table 18 – Agriculture Water Use in the Humboldt River Basin Counties†

Total Agricultural, Irrigation and Livestock Water Use for Selected Years (Acre-Feet per Year)

State and County	**1974**	**1978**	**1982**	**1987**	**1990**	**1997**
NEVADA						
Total Agricultural Water Use	3,390,594	3,842,555	3,618,452	3,344,622	3,176,215	3,193,696
Irrigation Water Use	3,383,716	3,834,761	3,611,112	3,337,837	3,169,772	3,187,137
Livestock Water Use	6,878	7,794	7,340	6,784	6,443	6,559
Elko County						
Total Agricultural Water Use	999,446	955,976	1,093,476	1,000,935	894,376	916,277
Percent of Statewide Total	29.5%	24.9%	30.2%	29.9%	28.2%	28.7%
Percent Humboldt River Basin‡	49.5%	44.0%	50.1%	53.3%	46.9%	46.8%
Irrigation Water Use	997,577	954,188	1,091,430	999,063	892,704	914,563
Livestock Water Use	1,869	1,788	2,045	1,872	1,673	1,714
Eureka County						
Total Agricultural Water Use	119,170	189,950	127,274	109,097	170,477	145,801
Percent of Statewide Total	3.5%	4.9%	3.5%	3.3%	5.4%	4.6%
Percent Humboldt River Basin	5.9%	8.7%	5.8%	5.8%	8.9%	7.4%
Irrigation Water Use	119,020	189,712	127,114	108,961	170,263	145,618
Livestock Water Use	149	238	160	137	214	183
Humboldt County						
Total Agricultural Water Use	605,702	639,845	668,538	425,306	567,582	616,368
Percent of Statewide Total	17.9%	16.7%	18.5%	12.7%	17.9%	19.3%
Percent Humboldt River Basin	30.0%	29.4%	30.6%	22.6%	29.8%	31.5%
Irrigation Water Use	605,069	639,177	667,840	424,861	566,989	615,724
Livestock Water Use	633	668	698	444	593	644
Lander County						
Total Agricultural Water Use	142,960	216,598	128,778	159,355	139,412	155,215
Percent of Statewide Total	4.2%	5.6%	3.6%	4.8%	4.4%	4.9%
Percent Humboldt River Basin	7.1%	10.0%	5.9%	8.5%	7.3%	7.9%
Irrigation Water Use	142,663	216,148	128,510	159,023	139,123	154,892
Livestock Water Use	297	450	268	331	290	323
Pershing County						
Total Agricultural Water Use	152,825	172,549	166,343	183,299	133,204	125,876
Percent of Statewide Total	4.5%	4.5%	4.6%	5.5%	4.2%	3.9%
Percent Humboldt River Basin	7.6%	7.9%	7.6%	9.8%	7.0%	6.4%
Irrigation Water Use	152,489	172,170	165,977	182,897	132,912	125,599
Livestock Water Use	336	379	366	403	293	277
Humboldt River Basin Counties						
Total Agricultural Water Use	**2,020,103**	**2,174,919**	**2,184,408**	**1,877,992**	**1,905,052**	**1,959,536**
Percent of Statewide Total	**59.6%**	**56.6%**	**60.4%**	**56.1%**	**60.0%**	**61.4%**
Irrigation Water Use	**2,016,818**	**2,171,395**	**2,180,872**	**1,874,805**	**1,901,990**	**1,956,397**
Livestock Water Use	**3,284**	**3,524**	**3,536**	**3,187**	**3,062**	**3,140**

† Represent the five principal counties of the Humboldt River Basin. Agricultural water use is for the total county and may include some acreage lying outside of the basin. Most of the irrigation in these counties, however, is along the Humboldt River main stem, within Lovelock Valley (Lovelock Reach sub-basin), Paradise Valley (Little Humboldt River sub-basin), Grass Valley (Sonoma Reach sub-basin), or in the Upper and Lower Reese River Valley (Reese River sub-basin). All these important agricultural areas lie within the Humboldt River Basin. Water use is equivalent to water withdrawals and is not the same as consumptive use.

‡ Percent is for Humboldt River Basin counties' total and not the basin-only total.

Source Data: Water use estimates based on estimates of irrigated acreage by U.S. Census Bureau (1974, 1978, 1982 and 1987), U.S. Geological Survey (1990), and Nevada Division of Water Planning (1997) times a water duty (acre-feet per acre per year) calculated for historical trends. Source data and explanation of methodology may be found in the Nevada Division of Water Planning's *1999 Nevada State Water Plan*.

Historical Perspective to Agriculture in the Humboldt River Basin

The agricultural potential of the Humboldt River Basin was first exploited during the wagon train era beginning in 1841 when the lush meadowlands and native grasses along the Humboldt River and its principal tributaries provided much-needed nourishment to the early emigrants' livestock. However, it was the basin's mining boom and its accompanying population influx that caused the rapid expansion of the basin's agricultural industry after 1860. Agricultural pursuits, and particularly livestock open-range grazing and intensive rangeland use, flourished in the Humboldt River Basin during the 1870's and 1880's.

Livestock raising in the Reese River sub-basin got its start in 1862 shortly after the start of Austin's mining boom. In this year, Lewis R. Bradley, who became Nevada's second Governor from1870-1878, moved to the upper Reese River Valley from California with 500 head of Texas longhorn cattle. Along with his son and two other partners, Bradley began the first large-scale ranching operation in the Humboldt River Basin, eventually stocking the lush meadows of the upper Reese River and the Toiyabe Canyons north and south of Austin with thousands of longhorn cattle.[315]

Very early on, the Lamoille Valley area at the foot of the Ruby Mountains was recognized for its excellent grazing conditions and was first permanently settled in 1865 by John Walker and Thomas Waterman. When heavy grazing by the emigrants' domestic livestock denuded the natural grasses near the Humboldt River, emigrant wagon trains used the meadows alongside Lamoille Creek as a welcome resting area, returning to the Humboldt River for their continued trek down river.[316] In 1866, livestock raising got its start in Mound Valley on Smith and Huntington Creeks (tributaries to the South Fork of the Humboldt River) when Lewis R. Bradley expanded his longhorn ranch from the Reese River Valley. Mr. Bradley continued to expand his operations until his cattle ranged all the way from Smith and Huntington Creeks in the east through Dixie Flats and further west to Pine Valley (Pine Creek) in the west, eventually becoming one of the state's largest cattle operations.[317]

Around 1870, Daniel Murphy took over and stocked with Texas longhorn cattle the area comprising the present Devil's Gate, Haystack and Rancho Grande ranches in the North Fork Humboldt River sub-basin. Dan Murphy was one of the sons of Martin Murphy, who was a member of the famous Stevens-Murphy-Townsend wagon train which had traversed the Humboldt River Basin in 1844 en route to California.[318] Also around this time, the firm of Sparks & Tinnen began cattle operations within the Mary's River sub-basin, eventually growing to arguably the greatest cattle ranching enterprise to ever operate in Nevada. The firm owned outright some 200,000 acres and through strategic land ownership along streams and around springs controlled many times that amount in terms of public domain lands (national land reserve), stretching from Humboldt Wells (present-day Wells) in the south to the Snake River in Idaho in the north. John Sparks was perhaps the first rancher in Nevada to introduce the Shorthorn and Hereford cattle breeds, which soon replaced the Texas longhorns on Nevada's open ranges.[319]

By 1872, the Horseshoe Ranch at Beowawe was established by Dr. George W. Grayson of San Francisco and Aaron Benson of Beowawe under the famous Horseshoe (branding) iron. Ultimately, Dr. Grayson and his various partners would come to own or control over 200,000 acres of grazing lands in Elko, Eureka and Lander counties and, in addition to the Horseshoe brand, operated under

26 other brands.[320] Also in 1872, Peter N. Marker made his first purchase of land in the lower Lovelock Valley. Eventually, his holdings would grow to 12,800 acres in the lower valley, along with additional acreage in the upper valley.[321] By 1873 cattle ranching began in earnest in Humboldt County when Frank Button and his uncle I.V. Button drove cattle into the Winnemucca area to begin ranching operations in the rich, fertile valleys of northern and eastern Humboldt County.[322]

Actual land ownership of many of these early cattle operations represented only a small portion of the land extent and rangeland use due to the nature of open-range grazing operations. By controlling the use of critical sources of water, many ranchers were able to effectively control ranges many times the size of their actual land holdings. Between 1862 to 1873, extensive farming, ranching and open-range cattle grazing operations had been established from virtually one end of the Humboldt River Basin to the other. Throughout the years, and particularly after the disastrous effects of "The White Winter" of 1889-90, many of these operations have changed ownership a number of times. In the process, ranches have been consolidated and livestock composition has changed, with sheep first replacing cattle and then cattle eventually replacing the sheep. Even so, the agriculture industry of the Humboldt River Basin has largely endured the passage of time and remains today vitally important to the economic welfare of this vast expanse of north-central Nevada.

The Impacts of Halogeton on Open-Range Grazing

Halogeton (*Halogeton glomeratus*) is a fleshy, annual, herbaceous and succulent plant that was inadvertently introduced into the rangelands of the western United States during the early twentieth century. The name halogeton was derived from the Greek *hals* (sea or salty) and *geiton* (habitat) and describes the invasive plant's ability to survive in high salt conditions characterizing the soil makeup of the Great Basin's lowland valleys and desert playas. No acceptable common name has been found for halogeton, although several common names have been proposed internationally: (1) U.S. – barilla; (2) English – cultivated saltwort; (3) French – haloget, barilla; (4) Spanish – barilla fina; (5) German – zahmes salzkraut; (6) Turkish – kalyofu; and (7) Arabic – guraynah.[323] The Russian common name for halogeton might be translated as "congested halogeton".[324] Beginning with its initial discovery in the Intermountain Area and the Humboldt River Basin near Wells, Nevada in 1934, and for at least the next 30 years, halogeton remained an important issue to open-range grazing throughout the West. Its toxicity to cattle and particularly sheep, both of which abounded on the open ranges of the Humboldt River Basin in the early 1900's, combined with the graphic publicity given to wholesale livestock die-offs of primarily sheep, were crucially important in bringing to the public's attention the degraded state of western rangelands, a condition which fostered the halogeton invasion.

Initially, halogeton was listed merely as an exotic nuisance weed which showed rather alarming rates of spread. The first report of halogeton's toxicity within Nevada came in the fall of 1942. Elko County sheep herder Nick Goicoa lost 160 sheep from a band that was grazing on the open range near Wells. A postmortem examination found considerable quantities of halogeton in the stomachs of the dead animals. Adding to the confusion of the toxicity issue was that sheep did not consistently prefer dry halogeton and often refused to eat it altogether. It was later determined that sheep that were not regularly salted during the winter months showed a preference for halogeton's leaves, which stored salt absorbed from the soil.[325] Further, the plant's toxicity tended to vary throughout the year, confusing the issue and initially delaying a more dramatic and urgent response to the potential harmful effects of halogeton.

The most significant event leading to the national recognition of halogeton's potential devastation to open-range sheep grazing on western rangelands occurred in Idaho. In November 1945, John Ward of Almo, Idaho, moved a band of 1,300 sheep to winter range in the Raft River bottoms near Bridge. The area was known to be infested with halogeton, but previous losses, from then unknown causes, had amounted to only a few head at a time. On this particular occasion, however, 1,000 sheep died from ingesting halogeton in just one day and the remainder died shortly thereafter. This staggering loss, coupled with subsequent widespread publicity of this incident and other similar livestock deaths,[326] was the catalyst that stirred public concern and prompted government agencies to begin to study and address the problem.[327] Ultimately, it was found that the most effective response to the halogeton problem proved to be biological suppression versus chemical, mechanical and biological control, which involve the use of herbicides and other costly rangeland restoration methods. Biological suppression consists of efforts to return the ecological balance to existing plant communities by establishing perennial species which naturally and effectively compete for moisture and nutrients required by such invasive annual weeds and toxic plants.[328]

Halogeton originated in the salt steppes of south Russia from the Ural and Aral-Caspian region up to the Kirgiz and Songarian Area and is also found in the deserts of Tibet. It is distributed from the north shore of the Caspian Sea east through the upper Irtysh River system, in the deserts and the foothills of the mountains eastward from the Caspian Sea to the Pamifs, and into Sinkiang and Mongolia.[329] Initial research and response to halogeton in the U.S. was greatly hampered due to the lack of English-language literature and the absence of documented references, in any language, alluding to halogeton's toxicity. From its sudden appearance in the Intermountain Area in the early 1930's, the plant's spread was nothing less than remarkable with an estimated area of infestation of over six million acres by 1954 and over 11 million acres by 1957. The spread of halogeton during the 1940's and 1950's was so spectacular, in fact, that it could not be definitively determined if the plant was actually spreading or whether it was merely being recognized at new locations for the first time.[330]

Considerable speculation continues to exist over halogeton's introduction into the Great Basin from Asia. Most theories on the plant's transport have concentrated on contaminated crested wheatgrass seed introductions,[331] halogeton seeds lodged in wool imported from this region, or seeds on the wool of Karakul sheep which were introduced into the Great Basin. The first specimens of halogeton found in North America were collected in June 1934 by Ben Stahmann and S.S. Hutchings, who were working for the Intermountain Forest and Range Experiment Station, U.S. Forest Service, Department of Agriculture (USDA) headquartered in Ogden, Utah. Stahmann's field notes indicated that the new plant, which actually would not be identified until 1936 when the specimens were sent to Washington, D.C., was abundant at the collection site near Wells, located in Elko County in the upper Humboldt River Basin, a location which is very near the geographic center of the Intermountain Area. Wells was a hub of sheep trails connecting summer and winter ranges in the region. During the 1890's and early 1900's, the open ranges of the Humboldt River Basin were subjected to widespread and intensive grazing by both cattle and sheep. These activities were essentially without any form of grazing management and resulted in severe competition and over use of the basin's winter (lowland) ranges, in particular. By the early 1930's, based on the effects of one-half century of intensive livestock grazing, these rangelands showed little resemblance to the sagebrush-bunchgrass vegetative cover which first greeted domestic livestock in the early 1870's and provided a fertile environment for the spread of exotic plants.

Figure 19 shows a drawing of halogeton in which sub-figure A shows a winged seed with bracts, B shows the entire halogeton plant, C depicts a leaf detailing the curved bristlelike hair on the leave tip, and D presents a leaf cluster.[332] Halogeton's adaptability to the growing conditions of the Great Basin, its phenomenal rate of spread, and its potentially lethal levels of toxicity are largely based on its tolerance to high concentrations of salts in the soil and the fact that many of the lower portions of the Great Basin represent salt-deserts left by the dessication of Pleistocene Epoch lakes, marshes and wetlands. Halogeton is a member of the goosefoot family, *Chenopodiaceae* (Chenopods), which are often adapted to soils that are saline, alkaline, or both.[333] Halogeton has leaves that resemble little grey-green sausages with a spine or bristly hair at the tip (Figure 19).

Halogeton plants vary greatly in size with mature plants attaining a height of nearly two feet and becoming covered entirely with flowers and then seeds. In dense stands, however, the plant rises only an inch or two off the ground, but still produces viable seeds in abundance. The nature of the plant's seeds are especially adapted to its survival and stymied early efforts at eradication. Two types of seeds are produced in prodigious quantities, black (actually a dark chocolate brown) and brown. At first it was believed that the brown seeds were merely non-viable (i.e., immature) black seeds. Later studies, however, clearly showed that the black seeds tended to germinate quickly while the brown seeds were viable, but remained dormant for a number of years. In this way the plant would still germinate after eradication efforts had ceased.[334]

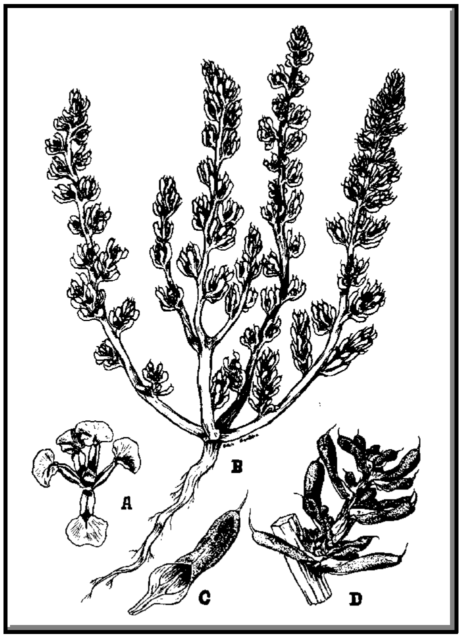


Figure 19 – Halogeton

Halogeton does most of its growing in midsummer when competition from other annuals, such as the exotic cheatgrass (*Bromus tectorum*), and native perennial grasses, is minimal. As a succulent, halogeton often uses the moisture from summer storms and has an ability to rapidly absorb soil moisture and store it for growth and seed production. Sodium, in the form of soluble sodium chloride (NaCl), in the soil is actually an essential element in the plant's mineral nutrition, as are high concentrations of chlorine. The sodium in halogeton's leaves is used primarily to form salts of oxalic acid,[335] and where the soil is high in sodium chloride, halogeton tends to be exceptionally vigorous and high in soluble oxalates. It is the soluble oxalates stored in halogeton's herbage that tend to be most toxic to grazing herbivores.

Halogeton's oxalate content has been found to be as high as 25 percent, with most livestock losses occurring when the oxalate content was 18 percent or greater. It was also found that the oxalate content of halogeton varies according to the plant's growth stage and certain climatic conditions, and that at least two-thirds of the oxalate content could leach out of the plant in a single snowstorm, thereby making the plant less dangerous, and sometimes entirely harmless, to grazing livestock. Consequently, most sheep losses have reportedly occurred in the fall and early spring, or during relatively dry winters when the plant tends to retain the oxalates in lethal concentrations. Losses are also heightened when sheep eat halogeton in large doses shortly after it is softened by a storm.[336] Research has also shown that sheep appear to relish the plant the first time they eat it and were it not for its variable and unpredictable toxicity, it would make an adequate forage plant with crude protein levels comparable to alfalfa.[337]

Halogeton's poisonous effects on gazing livestock are especially severe on sheep due to their less-roaming grazing nature. In fact, although halogeton was found to be even more toxic to cattle, due to their free-roaming grazing behavior, they seldom ingest lethal doses of the plant.[338] Some have argued that the effects of halogeton spelled the demise of the open-range sheep industry in the western U.S. In truth, this industry was already in demise and halogeton only hastened that eventuality, albeit somewhat more dramatically than otherwise. However, the effects of halogeton spread far beyond the sheep industry and focused the attention of livestock producers, land management agencies, range scientists and political groups on the larger problem of rangeland degradation. In effect, an entirely new body of science arose from this period which greatly expanded our knowledge of re-vegetation technology, basic plant and animal physiology, and on establishing the ecological basis for range weed control.[339]

By the 1980s's it had become apparent that halogeton was on the decline in the Great Basin. One primary reason for this remission was the virtual disappearance of the open-range sheep industry in the western portion of the Great Basin and particularly in the Humboldt River Basin. Another reason lies with the improved range management conditions which have positively affected the state of the region's salt-desert winter ranges. Another important contributing factor in halogeton's significant reduction throughout the Great Basin has been, ironically, the spread of cheatgrass to the very margins of the region's salt deserts. The competition provided by this even more vigorous invasive plant species has provided a strong biological restraint for halogeton on many open ranges.[340]

Tall Whitetop

Tall whitetop (*Lepidium latifolium* L.), a member of the mustard or *Brassicaceae* family and a noxious weed in Nevada, has become a severe ecological problem in many of Nevada's water sheds, including the Humboldt River Basin. No benefits have yet been found for this extremely competitive plant, and it has a number of particularly bad points. Specifically, the plant crowds out desirable native plant species, impairs scenic values and decreases biodiversity, degrades wildlife habitat, destabilizes river banks and increases erosion potential, lowers the quality of feed from the pastures and hay fields it infests, and threatens Nevada's agricultural industry with the potential for extensive economic losses. The potential ecological, environmental and economic damages from this invasive plant have been found to be so severe that in 1999 the Nevada State Legislature tasked the University of Nevada, Reno, Cooperative Extension, to mount a statewide attack on tall whitetop.[341]

Tall whitetop is native to southeastern Europe and southwestern Asia, and is believed to have been introduced into the western United States around 1900 in contaminated sugar beet seed. The first official sighting of tall whitetop in Nevada occurred as far back as the 1960's in Washoe County along Streamboat Creek, a tributary of the Truckee River originating in Washoe Valley. By the early 1970's, it was first referenced in research papers as having reached the Truckee River and by 1992 it had reportedly infested some 12,000 acres along the Truckee River's lower reaches. Since that time it has been found in the Carson, Walker and Humboldt River basins, several locations in Ely (White Pine County), and has extended as far south as Pahrump in Nye County. In 1999, a single siting was reported in Las Vegas (Clark County).[342]

The plant commonly grows to a height of two to four feet, but may reach up to eight feet in particularly wet areas. The plant forms tall whitetop monocultures that quickly dominate fields and riparian areas. The plant forms a semi-woody base stem with new growth emerging from the plant's woody crown. It also forms a course root structure with root diameters typically varying from one-quarter inch up to several inches. The weed expands prolifically from these creeping underground roots, which may grow from three feet to over ten feet long, sending up shoots along the way to form new plants. New plants can also sprout from fragments of perennial roots as small as one-tenth of an inch in diameter.

Small white flower clusters, with six to eight blossoms, bloom during June and July. Tall whitetop's flowers are so attractive that they are extensively used in fresh and dried flower arrangements, which inadvertently sometimes adds to the plant's spread. In addition to tall whitetop's spreading underground runners, the plant is especially prolific and capable of producing more than six billion seeds per acre.[343] Streambank erosion, flooding and irrigation field flooding help to disperse its seeds and broken root fragments both downstream and onto agricultural fields. Its potential for the contamination of Nevada's hay and alfalfa croplands is particularly serious and threatens the industry's export potential. Tall whitetop is sometimes confused with the noxious weed "hoary cress" or "whitetop" (*Carderia draba* L.), which is usually much shorter than tall whitetop and blooms in May.

Typically, tall whitetop initially infests sites along streams, rivers and wetlands. It then quickly spreads to native hay meadows, abandoned agricultural lands, pastures, hayfields, as well as residential areas and disturbed areas such as roadsides. The seeds are readily dispersed by a number of human-related activities such as vehicle traffic, road maintenance, site preparation, construction, agricultural activities and off-road recreational pursuits. Livestock and waterfowl have also been known to aid to the dispersal of tall whitetop seeds.

Due to its competitive nature in crowding out native species and its rapidly spreading roots and seed production, its complete eradication would not only be extremely expensive, but also unlikely. Consequently, present goals are oriented towards controlling its spread by using integrated weed management practices, which encompass a number of cultural, mechanical, biological and chemical coordinated weed control techniques. In terms of biological controls, thus far no insects or diseases have been found to kill or debilitate the plant. Also in this regard, caution must be exercised such that any biological controls used do not infest any of the 11 perennial *Lepidium* species in the mustard family which are native to the western United States.[344]

Interestingly, some effective suppression of tall whitetop has resulted from carefully managed intensive and continuous grazing by sheep or goats. In irrigated pastures, cattle will tend to avoid tall whitetop altogether even during drought periods when preferred forage plants are depleted. There is also some concern, now being tested more extensively, that tall whitetop may be toxic to grazing livestock. Current research is focusing on the use of herbicides for controlling tall whitetop. To be effective in the long-term, however, it is also recognized that successful management of the plant's spread must be combined with establishing competitive vegetation immediately after treatment. Beneficial plants which have proven to be highly competitive in this regard include tall wheatgrass (*Elytrigia elongata*), creeping wildrye (*Elymus triticolides*), and saltgrass (*Distichlis spicata*).

Tall whitetop was believed to have been introduced into the Humboldt River Basin in the 1960's, and possibly earlier, in either the Elko or Lovelock areas and was probably was brought into the region through contaminated forage or carried by livestock. Today, over 10,000 acres are estimated to have been infested within the Humboldt River system by this invasive weed with the most severe infestations occurring in Lovelock Valley along the Humboldt River and along irrigation canals and ditches. The Humboldt Sink area is also heavily infested with several thousand acres. Tall whitetop's spread currently extends from just east of Elko all the way to the Humboldt Sink and is estimated to be expanding at the rate of approximately 20 percent per year.[345]

Lovelock Valley and the Rye Patch Reservoir

The agricultural industry in Lovelock Valley, which is located in the lower Humboldt River Basin, is crucially dependent on water stored in Rye Patch Reservoir. Rye Patch Reservoir represents the only storage facility situated directly on the Humboldt River main stem and its importance to agricultural development in the lower basin was recognized very early. Considered in its entirety, the Humboldt River system represents a fairly "efficient" irrigation water conveyance and distribution mechanism in terms of water diversions and return flows. The irrigation water return flows and "reuse" concept has allowed for greater diversions from the river and its principal tributaries for agricultural purposes than could ever be supported based on existing instream flows.

But this river system has its limits. Agricultural water users along the Humboldt River benefit from a continuous process of water diversion, on-filed application, tailwater runoff, return flow and system reuse. Even so, the fact that the agricultural lands in the Lovelock Valley are situated some 250 to 300 miles from the Humboldt River's headwaters in the Ruby, Jarbidge and Independence mountains, has greatly strained the river's ability to deliver sufficient water to lower basin users, particularly during below-normal flow years.

Limitations to the capabilities of the Humboldt River water conveyance system became especially pronounced throughout the late 1800's as upstream diverters, relying on riparian water rights, increasingly limited water from ever reaching the lower basin. It was, in fact, this increased upstream consumptive use for agriculture purposes that intensified the conflicts over Humboldt River water rights issues, particularly between agricultural interests in Elko County and those in the lower basin in Lovelock Valley. The severe drought period of 1888-89 further exacerbated the situation. Immediately following that drought period, however, hydrologic conditions changed dramatically, and it was, in fact, the extreme "White Winter" of 1889-90 that severely increased the competition for the river's waters. The primarily effect of that event was to intensify upstream agriculture pursuits as ranchers began even greater diversions in order to grow more supplemental winter forage for their open-range grazing operations. The Humboldt River system adjudication process which ensued is detailed in a previous section to Part I ("Humboldt River Water Rights, Adjudication, and Related Court Decrees").

Before the rights to the Humboldt River's waters were legally adjudicated, it was generally recognized that a storage system was desperately needed to serve the lower basin agriculture interests, especially during low stream-flow conditions. In one early reference to this need for water storage which, in fact, prophesized the eventual construction of Rye Patch Reservoir, the *Tuscarora Times-Review* reported on February 27, 1900 that "The ranchers in the vicinity of Lovelocks [Lovelock] have spent over $100,000 in [water-related] litigation and this has not settled the water question and has not added a drop to the present supply. This sum spent in storage reservoirs would have settled the water question in short order, but possibly the ranchers didn't think of so simple a scheme as that."[346]

The location ultimately chosen for Rye Patch Reservoir was a site of some historical interest. On June 29, 1846, Jesse and Lindsay Applegate headed south from Willamette Valley, Oregon, seeking a less hazardous route to that region from the east. On July 21, coming by way of the Black Rock Desert into the Humboldt River Basin, they came to a large meadow (Lassen Meadows, but also referred to as Rye Patch Meadows) along the Humboldt River at a place called the "Great Bend",[347] located approximately forty miles downstream from present-day Winnemucca and just to the west of present-day Imlay. Thus they established the beginning of the Applegate Trail (also referred to as the Applegate-Lassen Cutoff at its juncture with the Humboldt River) at a point which would eventually be covered by the upper portion of what is now Rye Patch Reservoir.[348]

In 1891 national attention was brought to the rather unique water needs of arid and semi-arid western lands. In that year, Annual National Irrigation Congresses began to be held in major western cities in recognition that irrigation projects represented the salvation for the settlement of water-starved lands in the West. These meetings typically ended with a petition to the federal government to provide assistance in this reclamation effort, in a manner similar to the various Homestead Acts. It was strongly suggested that it was the federal government's obligation to provide water to these arid lands so that they could be settled and farmed on the same advantageous basis.[349] In the Humboldt River Basin, these efforts would eventually come to fruition with the construction of Rye Patch Dam and Reservoir in 1935 as part of the U.S. Bureau of Reclamation's "Humboldt Project".

But before that ultimate federal government solution to the lower Humboldt River Basin's water needs, local interests first attempted a solution. In 1910, Lovelock Valley (Big Meadows) agriculture interests began the area's first major water storage project in the form of the twin Pitt-Taylor Reservoirs, located approximately 35 miles upstream of Lovelock. These storage reservoirs had an initial total storage capacity of 48,000 acre-feet[350] and were situated just to the east of the present-day site of Rye Patch Reservoir. A diversion structure and canal leading to the reservoirs was constructed beginning about two miles upstream from Mill City. The principal movers behind the project were William C. Pitt, a prominent upper Lovelock Valley rancher, and John G. Taylor, an upper valley farmer and for many years Nevada's largest sheep rancher. The enterprise was conducted under the corporate name of the Humboldt-Lovelock Irrigation, Light and Power Company, with L.H. Taylor serving as the irrigation engineer in charge of construction, which was completed in 1913.[351] In order to fill the Pitt-Taylor Reservoirs then being constructed, in 1911 the company filed an application for 57,000 acre-feet of floodwater from the Humboldt River[352] as by 1900 virtually all of the basin's available surface waters had been appropriated.[353]

Even with the Pitt-Taylor Reservoirs, however, periodic drought years showed that a more sustainable water supply was still needed. In 1919, the Humboldt Project was designed. The Humboldt Project would include the construction of Rye Patch Dam and Reservoir on the Humboldt River near Rye Patch, Nevada, the acquisition and transfer of old upstream water rights near Battle Mountain, Nevada, and the use of these stored waters on approximately 30,000 acres of patented land near Lovelock.

In anticipation of the Humboldt Project, the U.S. Reclamation Service (renamed the U.S. Bureau of Reclamation in 1923) began preliminary investigations of reservoir sites along the lower reaches of the Humboldt River and conducted a study of the river's available runoff for such a storage facility. The finalization of these investigations in 1933 resulted in the selection of the Rye Patch Dam site, located approximately 22 miles upriver from Lovelock. Survey results indicated that a reservoir with a capacity of nearly 200,000 acre-feet could be constructed at this site.[354]

In the meantime, based on the drought years of the early 1920's, in 1926 the Lovelock Irrigation District was formed for the purpose of constructing a dam at Oreana, located almost 15 miles up the Humboldt River from Lovelock. After spending some $100,000 for engineering and legal services, the proposed structure was not built after it was determined that it could not provide sufficient storage capacity to warrant its construction. In 1929, the Lovelock Irrigation District changed its name to the Pershing County Water Conservation District and it was this organization that promoted the construction of the Rye Patch Reservoir. Construction on the reservoir eventually began in 1935 by the U.S. Bureau of Reclamation and was completed in 1936.[355]

Prior to construction of Rye Patch Reservoir, in 1931 water rights in the Lovelock Valley were adjudicated by the George A. Bartlett Decree and subsequent permits from the State Engineer's office. In general, the decreed rights provided for a flow of 0.81 cubic foot per second per 100 acres of decreed land, or at proportional rates for specific periods of time. Under this decree, and permits from the State Engineer, 33,300 acres of land within the Pershing County Water Conservation District were given water rights totaling 87,896 acre-feet per year. Subsequently, 867 acre-feet of water were transferred from 1,664 acres of land purchased for the Rye Patch Reservoir site.

To further augment the Humboldt Project's water supply for Rye Patch Reservoir, seven ranches totaling 32,182 acres (with water rights totaling 48,773 acre feet)[356] were purchased in the Battle Mountain area and stream channel improvements were made in that vicinity to facilitate water rights transfers to Rye Patch Reservoir and the Humboldt Project in Lovelock Valley.[357] Except for a relatively small amount of water which was used on limited acreage near Battle Mountain, where physical conditions rendered its transfer difficult, all this water was eventually transferred downstream to the Humboldt Project.[358]

On October 1, 1934, the Pershing County Water Conservation District entered into a contract with the U.S. Bureau of Reclamation (USBR) to repay the costs associated with the Humboldt Project over a term of 40 years without interest. Later, the repayment terms were modified to be 36 equal annual installments commencing in 1944. Ultimately, these construction costs assigned to the conservation district for repayment totaled $1,341,739.[359]

On January 31, 1935, construction began on Rye Patch Dam. The project was designed to provide seasonal and long-term regulation of the lower Humboldt River and to increase the amount of water available to downstream farmers and irrigators. Rye Patch Dam was completed and began storing water on June 1, 1936. It is an earthfilled structure with a height of 78 feet, a water level of 73 feet (raised by 3 feet in 1976) and a crest length of 1,074 feet. The outlet works can release water at a rate of up to1,000 cubic feet per second and the spillway can discharge at up to 20,000 cubic feet per second.[360]

The reservoir is approximately 20 miles long, has a surface area of 11,970 acres and has an official capacity, based on an enlargement in 1976, of 194,300 acre-feet, at its design surface water elevation of 4,136.38 feet above mean sea level (MSL). Irrigation water from Rye Patch Reservoir is distributed in Lovelock Valley through the six diversion structures there, with waters allocated on an acreage basis to all conservation district participants.[361] On January 15, 1941, operation and maintenance responsibilities for the Humboldt Project, including the operation of Rye Patch Dam and Reservoir, were transferred from the USBR to the Pershing County Water Conservation District.[362]

In an early test of the efficacy of this project, a wet-mantle flood event visited the Humboldt River Basin during the period of April 3 through May 1, 1942, producing the greatest flooding within the Humboldt River Basin since 1910. This was the first major flood in the basin with Rye Patch Reservoir in place. The reservoir proved generally effective at keeping flood waters from Lovelock Valley. It was also the first time that Rye Patch Reservoir, along with the Pitt-Taylor reservoirs, completely filled. However, the spillage from Rye Patch Reservoir was heavy enough to cause partial failure of the Young Dam (the farthest upstream in Lovelock Valley), which in turn was believed to have caused the destruction of the Rogers Dam as well.[363]

In 1945 the Pershing County Water Conservation District purchased the 1911 water rights obtained by the Humboldt-Lovelock Light & Power Company, consisting of 57,000 acre-feet of Humboldt River floodwaters for the Pitt-Taylor Reservoirs. Presently, the district uses the current safe storage capacity of this reservoir system of 36,600 acre-feet (increased in 1971 from 35,000 acre-feet) in conjunction with the waters stored in Rye Patch Reservoir.[364] The Pershing County Water Conservation District continues to play an active role in maintaining the structural integrity of this critical source of water supply for Lovelock Valley.[365]

Not all the impacts of Rye Patch Reservoir have been considered positive, however. In 1987, the Nevada State Museum published a comprehensive study of the archeology, geology and paleontology of the Rye Patch Reservoir site in Pershing County. It was noted that the construction of Pitt-Taylor Reservoirs in 1910 and Rye Patch Reservoir in 1935 flooded many archeological and paleontological sites. The study found that wave action has also destroyed some of these sites and has exposed buried deposits in other sites along the reservoir's shoreline. The study reported finding a total of

115 sites, including 30 in the reservoir bottom and 85 around the shoreline. These sites have yielded evidence of human occupation during the past 7,000 to 12,000 years, with continuous occupation beginning sometime after 6,900 B.P. (before present).[366]

Current Agricultural Trends – Farm Marketings

Table 19, Humboldt River Basin County Farm Marketings,[367] presents information for selected years on the value of farm marketings, i.e., the economic effects, of using the Humboldt River Basin's irrigable lands and available irrigation water. Total farm marketings, or the value of all agricultural products sold, were just over $144 million in 1997 for the Humboldt River Basin's principal counties of Elko, Eureka, Humboldt Lander and Pershing. This level of farm output comprised 43 percent of total farm marketings for the State of Nevada. Disaggregating total farm marketings into crop marketings and livestock marketings shows that the Humboldt River Basin counties' crop marketings totaled over $56 million in 1997, accounting for nearly 41 percent of Nevada's total crop marketings, while livestock marketings among the Humboldt River Basin counties were over $87 million, or nearly 45 percent of statewide total livestock marketings in 1997.

The Humboldt River Basin's five counties also accounted for 63.3 percent of statewide total irrigated acreage and 61.4 percent of total agricultural water withdrawals in 1997 (see Tables 16 and 18, respectively). From these relative share ratios of agricultural outputs (farm marketings) and resource inputs (irrigation and livestock water withdrawals), we can provide a means to assess agriculture's relative "efficiency" among regions (basins) and counties. This is done by calculating the ratio between the basin's or county's share of statewide total farm marketings and its share of statewide total irrigation and livestock water withdrawals.[368]

Obviously, the higher the ratio of farm marketing share to total water withdrawal share, the greater the efficiency to which that water is put. Using this simple ratio technique provides an "agricultural water efficiency factor" (rating) of 70.0 (percent) for the entire Humboldt River Basin, based on a 43 percent share of statewide total farm marketings and a 61.4 percent share of statewide total agricultural water withdrawals.

Table 19 – Humboldt River Basin County† Farm Marketings‡

Humboldt River Basin County Agricultural Data for Selected Years, 1974–1997
(Farm, Crop and Livestock Marketings in Thousands of Dollars)

State/Humboldt River Basin County	1974	1978	1982	1987	1990	1997
NEVADA						
Farm Marketings ($000s)	$145,458	$204,047	$250,610	$271,904	$326,889	$334,926
Crop Marketings	29,479	49,227	69,237	68,130	115,403	138,698
Livestock Marketings	115,979	154,820	181,373	203,774	211,486	196,228
Elko County						
Farm Marketings ($000s)	$24,438	$32,730	$40,456	$45,362	$53,071	$43,272
Crop Marketings	688	345	1,526	1,398	2,135	1,958
Livestock Marketings	23,750	32,385	38,930	43,964	50,936	41,314
Eureka County						
Farm Marketings ($000s)	$3,753	$7,210	$9,514	$8,996	$11,398	$12,222
Crop Marketings	752	1,813	3,575	3,914	7,346	7,873
Livestock Marketings	3,001	5,397	5,939	5,082	4,052	4,349
Humboldt County						
Farm Marketings ($000s)	$17,723	$35,389	$37,910	$38,371	$55,579	$52,740
Crop Marketings	11,293	12,726	22,879	18,756	37,132	36,037
Livestock Marketings	6,430	22,663	15,031	19,615	18,447	16,703
Lander County						
Farm Marketings ($000s)	$4,518	$6,170	$6,113	$8,257	$9,563	$6,621
Crop Marketings	524	863	992	1,464	3,096	3,695
Livestock Marketings	3,994	5,307	5,121	6,793	6,467	2,926
Pershing County						
Farm Marketings ($000s)	$14,975	$25,706	$29,124	$19,303	$27,874	$29,157
Crop Marketings	5,284	6,955	10,568	10,804	11,113	6,919
Livestock Marketings	9,691	18,751	18,556	8,498	16,761	22,238
Humboldt River Basin Counties†						
Farm Marketings ($000s)	**$65,407**	**$107,205**	**$123,117**	**$120,289**	**$157,485**	**$144,012**
Percent Statewide Total	**45.0%**	**52.5%**	**49.1%**	**44.2%**	**48.2%**	**43.0%**
Crop Marketings	**$18,541**	**$32,639**	**$39,540**	**$36,337**	**$60,822**	**$56,482**
Percent Statewide Total	**62.9%**	**66.3%**	**57.1%**	**53.3%**	**52.7%**	**40.7%**
Livestock Marketings	**$46,866**	**$74,566**	**$83,577**	**$83,952**	**$96,663**	**$87,530**
Percent Statewide Total	**40.4%**	**48.2%**	**46.1%**	**41.2%**	**45.7%**	**44.6%**

† Agricultural statistics are for Humboldt River Basin's principal counties and include county totals and are not necessarily limited only to those county areas within the basin.
‡ Farm Marketings consist of the current dollar value of all farm-related produce, both crops and livestock, which constitute a market transaction. It therefore excludes certain production used for on-farm use (e.g., seed production and domestic livestock forage) that does not constitute am "external" market transaction.
Source Data: U.S. Department of Commerce, Bureau of Economic Analysis (BEA), Regional Economic Information Service (REIS).

In 1997, Elko County accounted for 30.0 percent of the Humboldt River Basin counties' total farm marketings, but 46.8 percent of the basin counties' estimated total agricultural water withdrawals, for an agricultural water efficiency factor of 64.1 (i.e., 30.0 percent divided by 46.8 percent times 100). Eureka County accounted for 8.5 percent of the basin's total farm marketings in 1997 while using 7.4 percent of the basin's total agricultural water withdrawals, resulting in an efficiency factor of 114.9. Humboldt County accounted for 36.6 percent of the basin's total farm marketings and 31.5 percent of total agricultural water withdrawals in 1997, yielding an efficiency factor of 116.2. Lander

County accounted for 4.6 percent of the basin's total farm marketings in 1997 and 7.9 percent of total agricultural water withdrawals, for an efficiency rating of 58.2. And finally, Pershing County accounted for 20.2 percent of the basin counties' total farm marketings in 1997 while using an estimated 6.4 percent of the total agricultural water withdrawals of the basin's counties, resulting in the highest efficiency factor of any county within the basin at 315.6. Based on these water-use efficiency measures, it may be suggested that the higher water use efficiency factors evident in the lower Humboldt River Basin are, in large part, due to the benefits provided by Rye Patch Reservoir's irrigation water delivery system. This system has insured a more or less stable supply of water for irrigation purposes in the Lovelock Valley area of Pershing County.

Current Agricultural Trends – Farm Employment

Table 20, Humboldt River Basin County Agricultural-Related Employment, presents information on employment trends within the Humboldt River Basin's principal counties in the areas of farming and related activities (i.e., agricultural service workers in the fields of landscaping, forestry and fisheries). Of primary importance are the trends in farm employment which, over more recent years, have been generally declining for all five counties in the Humboldt River Basin. This follows a similar statewide trend which shows that Nevada's total farm employment peaked in 1978 at 5,639 workers and declined thereafter to a 1997 level of 4,732 workers engaged in farming activities statewide. This represented a statewide decline between 1978 and 1997 of 907 farm jobs, or 16.1 percent

Within the Humboldt River Basin counties, basin-wide total farm employment also peaked in 1978 at 2,274 workers, declining to 1,755 workers by 1997. This represented a reduction of 519 farming jobs, or 22.8 percent, among the five basin counties between 1978 and 1997. In 1974, the basin's five counties comprised 42.4 percent of the state's total number of farm workers. This figure declined to 37.1 percent of the statewide total number of farm jobs by 1997. By county, between 1978 and 1997, jobs in farming declined in each county by the following percentages:

Elko County: -13.4%
Eureka County: -44.8%
Humboldt County: -23.9%
Lander County: -19.6%
Pershing County: -34.4%

Table 20– Humboldt River Basin County† Agricultural-Related Employment

Humboldt River Basin County Agricultural Data for Selected Years, 1974–1997

State/Humboldt River Basin County	**1974**	**1978**	**1982**	**1987**	**1990**	**1997**
NEVADA						
Total Agricultural-Related Employment	5,895	7,728	7,863	10,033	11,487	16,460
Farm Workers	4,570	5,639	5,140	5,628	5,260	4,732
Agricultural Services Workers‡	1,325	2,089	2,723	4,405	6,227	11,728
Elko County						
Total Agricultural-Related Employment	859	1,005	922	1,186	1,085	1,038
Farm Workers	828	940	858	1,053	949	814
Agricultural Services Workers	31	65	64	133	136	224
Eureka County						
Total Agricultural-Related Employment	134	223	171	157	142	165
Farm Workers	134	223	171	157	118	123
Agricultural Services Workers	0	0	0	0	24	42
Humboldt County						
Total Agricultural-Related Employment	593	691	660	744	711	715
Farm Workers	566	619	537	591	539	471
Agricultural Services Workers	27	72	123	153	172	244
Lander County						
Total Agricultural Related Employment	165	179	129	145	139	141
Farm Workers	165	163	129	145	139	131
Agricultural Services Workers	0	16	0	0	0	10
Pershing County						
Total Agricultural Related Employment	243	329	258	230	257	238
Farm Workers	243	329	217	230	230	216
Agricultural Services Workers	0	0	41	0	27	22
Humboldt River Basin Counties†						
Total Agricultural Employment	**1,994**	**2,427**	**2,140**	**2,462**	**2,334**	**2,297**
Percent Statewide Total	**33.8%**	**31.4%**	**27.2%**	**24.5%**	**20.3%**	**14.0%**
Farm Workers	**1,936**	**2,274**	**1,912**	**2,176**	**1,975**	**1,755**
Percent Statewide Total	**42.4%**	**40.3%**	**37.2%**	**38.7%**	**37.6%**	**37.1%**
Agricultural Services Workers	**58**	**153**	**228**	**286**	**359**	**542**
Percent Statewide Total	**4.4%**	**7.3%**	**8.4%**	**6.5%**	**5.8%**	**4.6%**

† Agricultural statistics are for Humboldt River Basin's principal counties and include county totals and are not necessarily limited only to those county areas within the basin.

‡ Agricultural Services Workers include workers in areas such as gardening and landscaping, as well as workers in the forestry and fishery service areas.

Source Data: U.S. Department of Commerce, Bureau of Economic Analysis (BEA), Regional Economic Information Service (REIS).

Table 21, Humboldt River Basin County Agriculture Productivity, presents a comparison of the total dollar value of agricultural output per farm worker (as a gross measure of agricultural worker productivity) between all of Nevada (a statewide average) and the combined five principal counties comprising the Humboldt River Basin. This productivity measure is based on the total cash receipts from farm marketings divided by the respective number of farm workers. This analysis shows that over the selected years presented in Table 21, the productivity of farm workers in the Humboldt River Basin has exceeded the comparable statewide average farm worker productivity figures by nearly 21 percent, ranging from a low of 6.1 percent higher (index value of 106.1) in 1974 to 32.1 percent higher (index value of 132.1) in 1982.

Over the entire period of 1969 through 1997, this productivity figure for the Humboldt River Basin counties have averaged 22 percent. In 1997, agriculture's productivity among the Humboldt River Basin's principal counties was nearly 16 percent higher than the statewide average, $82,058 in farm output per worker in the Humboldt River Basin versus $70,779 per farm worker for all of Nevada.

Table 21 – Humboldt River Basin County† Agriculture Productivity‡

Humboldt River Basin County Agricultural Worker Productivity, Selected Years, 1974–1997

(Total Farm Marketings in Thousands of Dollars; Output per Worker in Dollars)

State/Humboldt River Basin	1974	1978	1982	1987	1990	1997
NEVADA						
Total Farm Marketings (000s)	$145,458	$204,047	$250,610	$271,904	$326,889	$334,926
Farm Employment	4,570	5,639	5,140	5,628	5,260	4,732
Farm Marketings per Worker (dollars)	$31,829	$36,185	$48,757	$48,313	$62,146	$70,779
Humboldt Basin Counties (Elko, Eureka, Humboldt, Lander and Pershing)‡						
Total Farm Marketings (000s)	$65,407	$107,205	$123,117	$120,289	$157,485	$144,012
Farm Employment	1,936	2,274	1,912	2,176	1,975	1,755
Farm Marketings per Worker (dollars)	$33,785	$47,144	$64,392	$55,280	$78,782	$82,058
As Percent Statewide Average (=100)*	106.1	130.3	132.1	114.4	126.8	115.9

† Counties represent total figures for the five principal counties of the Humboldt River Basin.

‡ Agriculture "productivity" measures the dollar value of the cash receipts from farm marketings divided by the number of farm workers, in essence, producing a current dollar measure of output produced per worker.

* Numbers are based on a base index value of the statewide average index value equals 100. Figures higher than this base measure the percent that a value exceeds the base; therefore, a value of 106.1 indicates that a value is 6.1 percent above the base value.

Source Data: U.S. Department of Commerce, Bureau of Economic Analysis (BEA), Regional Economic Information Service (REIS).

Livestock Grazing, Cheatgrass, Rangeland Wildfires, and Flooding

Overview

The ecosystem[369] of the Great Basin has varied considerably during the last 20,000 years. Year-round glaciers once covered mountain valleys which now only receive winter snow, while expansive lakes and marshes of the late Pleistocene Epoch[370] covered many of today's sagebrush-covered lowland valleys and playas. The vegetation communities of this period of time contained modern Great Basin plant species, but were comprised of many more species no longer found growing together today. Many of the animal species, particularly the large herbivores, began to decline during this time and eventually became either extinct or were extirpated by approximately 10,000 to 11,000 years ago.[371] By the late Pleistocene Epoch, the mastodon, mammoth, ground sloth, horse, camel, llama, diminutive pronghorn, mountain goat, shrub ox and musk ox had all disappeared from the Great Basin.[372] Climate variation was a primary cause for these changes and as climatic conditions continued to change over time so too did the region's plant and animal communities.[373]

About 10,000 years ago, during the early Holocene Epoch, a drying trend began throughout the Great Basin, although the climate then was still both cooler and wetter than it is today. Glaciers melted and many of the large lakes became shallow wetlands or playas. This change to a dryer climate effectively shaped Nevada's landscape and by about 4,500 years ago the vegetation and animal communities of the region began to look much as they do today. The sagebrush-grassland vegetation types which characterized much of the Great Basin of northern and central Nevada before European settlement had become less varied and therefore more susceptible to disturbance[374]. The general lack of moisture over much of this region and the accumulation of salts in the soil created a vegetative cover which lacked the resilience to cope with new concentrations of large herbivores and other human-induced disturbances to the land which typically accompanied early settlement and man's activities.

The arrival of European settlers initiated a more intensive use of the Great Basin's natural resources. This was especially true when mining activities accelerated throughout the Humboldt River Basin during the 1860's and 1870's. As a result, this delicate natural balance of climate, soil, plants and animals, which had persevered for at least the last 4,500 years, was suddenly shattered. The introduction of large herds of cattle and sheep on delicate and finely-balanced plant communities did not produce the adaptations necessary for the survival of many of the region's native species. As a consequence, invasive, more adaptive and less desirable plant species, such as cheatgrass (*Bromus tectorum*), were able to take hold when native plants proved less resilient[375] to the pressures that increased grazing and other settlement-related disturbances placed upon them.

The effects from man's arrival within the Humboldt River Basin, which occupies a large portion of the northern part of the Great Basin, were most pronounced in several areas, for example: (1) the changing nature of this region's grass-forb[376] understory[377] and sagebrush overstory[378]; (2) the acceleration of erosion and the increased effects of downstream flooding along over-grazed stream systems; and (3) the increased suppression of natural fires by man, eventually leading to the increased incidence, severity and return frequency of wildfires across vast expanses of the basin's open rangelands.

Trends in Nevada's Rangeland Wildfires

Nevada's 1999 fire season[379] represented by far the worst incidence of wildfires in the state's recorded history, and also produced the most extensive fire devastation ever recorded within the Humboldt River Basin. Throughout Nevada, primarily in its rural areas, approximately 1.6 million total acres were burned, equivalent to over two percent of Nevada's total surface area, representing twice the burned acreage caused by the previous "worst" fire. The previous worst fire season was in 1985 when approximately 885,000 total acres were burned throughout Nevada. The most devastating and far-reaching burns occurred during a relatively brief period in early August. The five counties included within the Humboldt River Basin absorbed the brunt of the fires's devastating effects. Specifically, Elko, Eureka, Lander, Humboldt and Pershing counties taken together accounted for nearly 1.39 million burned acres, or nearly 87 percent of the state's total burned acreage recorded during the 1999 fire season.

During the 1999 fire season, rangeland fires in Elko County destroyed approximately 331,803 acres (20.8 percent of the state's total burned acreage and 3.0 percent of Elko County's total land area). Another 213,142 acres (13.4 percent of the state's total burned area and 8.0 percent of the county's total land area) were burned in Eureka County; 264,167 acres (16.5 percent of the state's total burned area and 4.2 percent of the county's total land area) were burned in Humboldt County; 219,351 acres (13.7 percent of the state's total burned area and 6.1 percent of the county's total land area) were burned in Lander County; and 364,118 acres (22.8 percent of the state's total burned area and 9.6

percent of the county's total land area) were burned in Pershing County. The majority of the 1999 fire damage, or about 1.22 million acres and about 76 percent of the state's total burned area, were due to 25 major fires that were wholly or partially located within the Humboldt River Basin. These fires are listed in Table 22, Humboldt River Basin's 1999 Burned Acreage, and are broken out by the name of the fire, burned area, U.S. Bureau of Land Management (BLM) burned portion, the proportion within the Humboldt River Basin and county areas affected. Of this burned acreage affecting the Humboldt River Basin, nearly 905,000 acres, or nearly 75 percent of the basin's total, included lands which were managed by the BLM. Most of the other burned areas within the basin, comprising 22.5 percent of the basin's total area burned, were privately owned.[380]

While the 1999 fire season might be considered just an isolated event in terms of its extent and severity, this fire season more probably reflected a long-term intensification of potential rangeland destruction from fires which appear to be increasing in both severity and frequency. Admittedly, there were a number of somewhat unusual contributing factors in 1999 which, together, produced a potentially explosive situation unlike any in recent times. The five years preceding 1999 were particularly wet. This wetter than normal period, believed to be the result of the "El Niño"[381] phenomenon, produced optimal conditions for plant growth, particularly cheatgrass. The on-set of the "La Niña"[382] in 1999 at first produced near-drought conditions in southern Nevada and cooler and more moist conditions in northern Nevada.

By early summer, the prevailing La Niña conditions resulted in unusually high and persistent winds across much of northern Nevada, along with above normal temperatures and lower than normal fuel moisture. By late May and early June, the potential for wildfires had become extreme and was based on a combination of factors including high winds and temperatures, low relative humidity and fuel moisture, severe thunderstorm activity, and a high level of dead and dry fuels with low flash points carried over from prior good growing seasons. From a fuel-loading standpoint, fine flashy fuels, composed primarily of cheatgrass matted from prior years' growth, provided a situation where even fire retardant chemical drops from aircraft proved largely ineffective due to the fire's ability to burn under and through the matted fuels. In combination, these conditions resulted in severe conditions and sometimes "joining" fires with extreme and virtually uncontrollable rates of spread.[383]

Despite the relatively unique combination of conditions leading up to Nevada's worst recorded fire season, certain other factors have supported the potential for even greater conflagrations to come. In support of this assertion, forestry and rangeland experts have noted that prior to the arrival of the first settlers to the Great Basin, wildfires occurred at return intervals of approximately 32-70 years.[384] More recently, however, that fire frequency has been shortened to as little as 4-5 years.[385] This situation has tended to confirm a growing suspicion that human activities, both direct and indirect, may be major contributing causes of this alarming trend. Since initial settlement began in the Humboldt River Basin, significant changes have occurred in terms of the use of land, timber, vegetation and water resources.

Early economic pursuits such as fur trapping were essentially "non-invasive" activities, meaning that resource use and extraction did not significantly alter environmental conditions or significantly affect the region's long-term ecological balance. However, later economic endeavors within the Humboldt River Basin, particularly mining, ranching and open-range grazing activities, have had profound effects on the basin's river flows and diversions, grazing practices, vegetative composition and coverage, soil stability, destruction of natural firebreaks, and runoff characteristics.

Table 22 – Humboldt River Basin's 1999 Burned Acreage

Major (Named) Fires and Acreage Within or Contiguous to the Basin (Listed by Fire Size)

	BLM Fire Name	Total Burned Area (acres)	BLM Burned Area (acres)	BLM Affected Portion (percent)	Fire Portion Located within Humboldt River Basin	Counties Affected and Acreage
1	Poker Brown	244,049	163,889	67.2%	Mostly	Pershing
2	Sadler	199,204	166,535	83.6%	Mostly	Elko (167,156); Eureka (32,048)
3	Antelope	133,925	132,615	99.0%	Some	Churchill (598); Lander (133,327)
4	Slumbering Hills	103,640	73,590	71.0%	Little	Humboldt
5	Trail	74,137	69,378	93.6%	Slight	Eureka (49,570); Lander (24,567)
6	Clover	72,045	56,357	78.2%	Total	Elko (61,938); Humboldt (7,707)
7	Frenchie	54,679	26,898	49.2%	Total	Eureka
8	Rose 2	48,478	23,502	48.5%	Total	Eureka
9	Cosgrave	35,074	11,301	32.2%	Total	Pershing
10	Lone Butte	34,382	16,518	48.0%	Total	Humboldt
11	Chimney	32,774	31,063	94.8%	Mostly	Elko (27,533); Humboldt (5,240)
12	Izzenhood	28,592	16,207	56.7%	Total	Elko (15); Humboldt (14,768); Lander (13,810)
13	Unionville	23,599	13,602	57.6%	Partial	Pershing
14	Rain	21,731	17,021	78.3%	Total	Elko
15	Mule	18,003	13,072	72.6%	Total	Lander
16	Horse	17,867	17,201	96.3%	Mostly	Eureka
17	Rochester	13,321	9,616	72.2%	Partial	Pershing
18	Grass Valley One	12,443	11,243	90.4%	Total	Pershing
19	Blue Mountain	11,520	5,937	51.5%	Some	Humboldt
20	Cyanco	10,616	5,169	48.7%	Total	Humboldt
21	Cedar B	9,283	9,283	100.0%	Mostly	Lander
22	Piney	7,877	7,877	100.0%	Total	Eureka
23	Cedar A	3,466	3,459	99.8%	Mostly	Lander
24	Hunter	2,495	1,300	52.1%	Total	Elko
25	Grass Valley Two	2,231	2,205	98.8%	Some	Pershing
	TOTALS	**1,215,430**	**904,837**	**74.4%**		

Source Data: U.S. Bureau of Land Management (BLM), Nevada District Office, September 1999.

Early mining activities within the Humboldt River Basin prompted rapid population growth and intensified the need to produce agricultural food products for both livestock and people. In response to these requirements, much of the basin's upland wooded hillsides were denuded of usable timber for the mines, railroads, building construction and as a source of fuel. As early as 1862 the increased mining activity throughout much of the basin had caused many of the steep, thin-soiled slopes of upper basin watersheds to become exposed to sheet and gully erosion. The virtual explosion of mining and the rapid growth of numerous mining towns created a demand for building lumber that could only be satisfied by local stands of limber pine from high-altitude drainage areas. As a result, much of these high watershed soils were exposed, and while good second-growth stands have since come in at many of these locations, considerable topsoil losses have occurred due to effects of erosion. The denudation of the hillsides also encouraged the establishment of well-developed gully systems in these upper watersheds which reduced these areas' natural ability to hold moisture and mitigate and prolong the flows downstream onto the meadowlands below.[386]

Adding to the effects of erosion on changing the Humboldt River Basin's native landscape, early agricultural activities diverted natural flows out of established stream channels for irrigation purposes and to support large cattle operations. By the late 1800's, the effects on natural vegetation from the region's extensive open-range cattle grazing operations were exacerbated by extensive and far-ranging sheep herding. The resultant overuse of timber, shrub and natural perennial grasses, both in the basin's lowland meadows and upland watersheds, began an irreversible process of soil and channel erosion, elimination of natural meadows and native grasses, and the influx of invasive plant species[387] (e.g., cheatgrass) which was to accelerate changes to the region's ecology. This process not only dramatically changed the basin's vegetative state, but also made the land even more susceptible to future impacts from both floods and wildfires.

The Cheatgrass "Invasion"

Since the beginning of the European settlement of the western United States, approximately twenty species of *Bromus*, i.e., cheatgrass, have been introduced. Of these invasive grass species only two, cheatgrass (*Bromus tectorum*) and red brome (*Bromus madritensis* ssp. *rubens*, formerly *Bromus rubens*), have come to dominate large portions of western state rangelands. Within the Great Basin, and particularly within the Humboldt River Basin, cheatgrass has had the most profound impacts on rangelands and agricultural yields, while red brome has proliferated in lower elevation desert plant communities further to the south, particularly in parts of California, the Mojave Desert and southern Nevada.

Throughout this wide range, the extent of these cheatgrass species is primarily defined by altitude and latitude. Red brome tends to thrive best in the lower altitudes, typically below 4,000 feet MSL, hence limiting its range mostly to the southern portion of the Great Basin. Cheatgrass grows best at elevations up to about 6,000 feet MSL, which makes it ideally suited to much of the rangeland within the Humboldt River Basin. Cheatgrass was first recognized in the western United States in 1861 and its process of invasion (i.e., the state of attaining a "critical mass" of established plant communities) throughout this area was considered essentially "complete" by 1928.[388]

Cheatgrass, also known as downy chess, downy brome, junegrass, broncograss, and sometimes "railroad" grass, is now abundant as an understory plant throughout the Great Basin sagebrush zone and particularly within the Humboldt River Basin. It is especially well suited to dry disturbed soils, typically following man's activities and frequently turning entire landscapes purplish-brown for a few weeks in the spring and then straw-brown for the rest of the year. While the spread of cheatgrass is often associated with disturbances by man, it has also spread and come to dominate plant communities without human disturbance. With respect to cheatgrass invasion, human activities typically affect the "when" and not the "if".[389] Cheatgrass is less common in alkaline soils and at elevations above approximately 6,000 feet MSL.[390] Nonetheless, its range, tenacity and adaptability to a variety of growing conditions are impressive and cheatgrass infestations have occurred from the salt desert shrub community through the big sagebrush (*Artemisia tridentata*) zone and into the ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) zones.[391]

Cheatgrass is an annual grass species which was originally introduced from Eurasia, being native to the Mediterranean region eastward to the steppes of Russia, Kazakhstan, Mongolia and China. Unfortunately, it arrived in North America without natural diseases or predators to help keep it in check.[392] It has also been suggested that cheatgrass seeds arrived in contaminated seed grain shipments, which would help to better explain its rapid spread.[393] Cheatgrass tends to spread quickly, particularly after fire burns the native plants and grasses, as its seeds appear to be less affected by heat and also show remarkable post-burn recuperative abilities. Cheatgrass also tends to mature more quickly than other competing grass species, thereby robbing the soil of moisture, nitrogen and other nutrients necessary for later-developing native grasses.

As a forage plant, it can only be grazed upon for several weeks in early spring while it is still green, and once mature its seeds make the entire plant generally unusable by grazing animals. Cheatgrass tends to quickly crowd out other grasses which do not demonstrate similar characteristics of fire recovery, early germination and rapid growth. This "choking" effect will eventually turn diverse landscapes into cheatgrass monocultures which are highly vulnerable to the repetition of wildfires.[394]

Studies on the effects of fire on native and invasive grasses have shown that repeated burning every five years, or burns in the early summer, will tend to deplete perennial grasses and allow annual grasses, primarily cheatgrass, to increase its coverage dramatically. Once a sagebrush-grass community is depleted of its perennial grass cover, as in a wildfire, a secondary succession[395] begins which eventually results in the dominance of cheatgrass within five years.[396] Also, early summer burns are only a temporary setback for cheatgrass at a time of the year when climax[397] perennials are easily killed by fire. Consequently, under most burning conditions, the density of cheatgrass increases over time while fewer perennials survive after each fire.[398]

Further studies have also shown that burning followed by seeding will suppress some invasive species, but even this has not proven especially successful where cheatgrass is dominant. If a succession of perennials is desired after a fire, the cheatgrass infested areas must be chemically treated or plowed and then seeded, and fire alone, either wild or controlled, will not convert pure stands of cheatgrass to native perennial grasses.[399]

Cheatgrass also possesses other key attributes that tend to preclude or hinder the establishment of desirable grass species. Most important of these is that cheatgrass seeds are able to germinate under a wide range of temperatures, including conditions where day-time and night-time regimes fluctuate between 1°C to 15°C (34°F to 60°F). Seedlings that are able to establish themselves at such low temperatures have the distinct advantage in being able to utilize the typically more abundant soil moisture during warm periods in the winter and early spring months.

Furthermore, cheatgrass seedlings and young plants tend to grow extremely rapidly, typically producing roots up to 43 centimeters (17 inches) in length in only six weeks. In this regard, the roots of cheatgrass have been found to develop up to 50 percent faster than the root systems of most perennial grasses, such as bluebunch wheatgrass.[400] As a result, seedlings of only a very few grass species[401] have shown the ability to effectively compete with cheatgrass, particularly under the semiarid conditions prevalent in the Humboldt River Basin.[402]

In addition to its advantages in terms of early germination, rapid growth and disturbance (including fire) recuperative properties, the ability of cheatgrass to "carry" fire, both in terms of ignition and transference, has been frequently noted and all too often observed. The dead stems and plant litter of cheatgrass persist for a year or two and serve to carry fire across bare areas and between shrubs and trees. The accumulated fuel created by this annual grass species provides highly flammable tinder that results in more frequent fires, leading to the eventual replacement of sagebrush and native perennial grasses with pure stands of cheatgrass.

This fire-succession cycle increases the density of cheatgrass while significantly expanding its area of coverage, carrying the threat of greater and more frequent fires along with it.[403] The conversion of open rangelands from a sagebrush-bunchgrass vegetative state, which typically does not carry fire well, to the highly flammable "matted" cheatgrass vegetative state, has had obvious effects on increasing the frequency, severity and return intervals of wildfires across Nevada's rangelands.

The long-term effects of cheatgrass on native plant populations are not entirely understood; however, the results do tend to speak for themselves. A number of adaptations tend to make the species a particular threat to Nevada's rangelands. First, the root system of cheatgrass is fibrous and more spreading nearer the soil surface compared to the deeper and more vertical root systems of native perennial bunchgrasses found in the Great Basin. While this gives the native grasses an enhanced ability to weather the effects of drought, it also provides better growing conditions for cheatgrass during wetter to more "normal" water years.

The fact that precipitation conditions (i.e., snowpack water content) have been near "normal" in the Humboldt River Basin over the last five years of 1995-1999 (see Table 23, Northern Nevada Water Basin Snowpack Water Content) has greatly supported the more recent spread of this highly invasive grass species. The more rapid germination and maturation of cheatgrass makes it particularly well adapted to incidences of land disturbance, such as fire, rangeland grazing, erosion, land clearing and surface soil removal, use of off-road vehicles and recreational use of public lands.[404] In effect, man has perhaps been cheatgrass's greatest benefactor.

Historical Perspective of Open-Range Grazing

It was shortly after the initial surge in mining activity beginning in the early 1860's that the range and grazing potential of the Humboldt River Basin became widely recognized. Livestock grazing and intensive rangeland use became more pronounced in the Humboldt River Basin during the 1870's and 1880's. Between 1862 and 1873, extensive ranching and open-range cattle grazing operations had been established from virtually one end of the Humboldt River Basin to the other. The resultant adverse effects on the basin's perennial native grasses and upper watershed meadows and vegetation throughout the basin have proven to be significant.

By the late 1880's the Humboldt River Basin was visited by back-to-back severe and extreme (opposite) hydrologic events which were destined to dramatically reshape the basin's water use and vegetation conditions. In response to two years of severe drought in 1888 and 1889, the Humboldt River Basin's water resources became even more intensively diverted for irrigating livestock pasture and crop lands. Immediately thereafter, the Humboldt River Basin was subjected to the devastating effects of the "White Winter" of 1889-90. Livestock losses of up to 98 percent were reported by some cattle operators and many ranchers were forced into bankruptcy, resulting in fewer but considerably larger ranching operations requiring even more grazing lands. The incredibly severe winter of 1889-90 particularly affected open-range cattle grazing throughout the Humboldt River Basin and forced ranchers to supplement their grazing operations with greater irrigation diversions for growing winter feed supplies.[405] Exacerbating the grazing effects on the basin's natural vegetation was the introduction of sheep to the area. After the disastrous cattle losses from the "White Winter", large herds of sheep began to move into many of the Humboldt River sub-basins, intensifying the use of open grasslands and upper watershed meadowlands.

As one typical example of the extensive use of the basin's rangelands, after the winter of 1889-90 and continuing essentially until the passage of the Taylor Grazing Act in 1934, the lower and middle reaches of the Humboldt River Basin, particularly around Winnemucca, were reportedly visited by "countless thousands" of migrant sheep. These herds passed through Grass Valley (located just south of Winnemucca) on their route to and from their summer ranges in the Sonoma, Santa Rosa, East Range, Humboldt Range, and other higher elevation pastures. According to newspaper articles at the time, this continual procession of grazing sheep led to the trampling out or overuse of the once verdant native ryegrass meadows in Grass Valley, to the point where only a few scattered meadows remained. Also, the high summer ranges in the nearby mountains, particularly the Sonoma and Santa Rosa ranges, were grazed extensively by transient sheep operators. Many of the disastrous floods and the resultant erosion damage now clearly evident in the high mountain areas of the Humboldt River Basin has been attributed to this intensive past range and watershed grazing use.[406]

It was around 1900 that the exotic[407] cheatgrass began to replace the depleted climax perennial grass-forb understory throughout the Humboldt River Basin and take over large areas of the sagebrush overstory which had been thinned or eliminated by range fires or repeated grazing. In addition to its effects on erosion and wildfires, the invasion of this annual grass species would also have pervasive effects on the types of native animal species which could now be supported within the basin. As one example, sharp-tail and sage grouse, which relied on the natural grasses and sagebrush, have subsequently been largely replaced in many areas by the chukar partridge, which tends to thrive on cheatgrass.[408] Despite the growing threat of this exotic and practically worthless grass species, the rangeland abuses which fostered its relatively rapid replacement of much of the Humboldt River Basin's native grasses were actually intensifying.

By 1906 several large sheep outfits had bought, leased or homesteaded enough key acreage around springs or along streams to control the summer high mountain ranges in the areas formerly used by many cattle ranchers. The large numbers of sheep and cattle using many meadow grazing areas throughout the Humboldt River Basin eventually reduced them from a natural well-vegetated range covered with desirable perennial native grasses to relatively denuded state showing the effects of sheet and gully erosion.[409] The resultant effects on the basin's upland meadows were similar and led to increased erosion in the upper watersheds and the gullying and dessication (drying out) of once lush meadows. It also created ideal conditions for an opportunistic, adaptive and far less desirable invasive plant species like cheatgrass to thrive and spread. While livestock grazing in the Humboldt River Basin has continued to the present day, it is presently taking place on a reduced scale and, in concert with cooperative rangeland improvements, leading to improved rangeland conditions.

Historic and recent impacts from fire and past grazing and mining activities have resulted in significant acreage within the Humboldt River Basin that has been dominated with exotic weeds and introduced annual grasses. In addition, significant sagebrush types have been lost within the basin. Even so, the Bureau of Land Management's (BLM) yearly *Rangeland Inventory Reports* indicate that steady, gradual progress is being made toward improving the condition of the basin's rangelands. The majority of the rangelands are in fair to good condition with a little over two million acres being in excellent condition. Because of the slow pace of plant succession in the arid West, the long-term trend is a more meaningful measure of range management success. The BLM's *State of the Public Rangelands, 1990*, confirms a favorable trend over the past 50 years. At the time of that report, the trend showed stable to improving conditions on over 87 percent of the public rangeland in the West.[410] The extensive rangeland wildfires of August 1999, however, may have indicated that the natural rate of recovery as indicated here may not be quick enough.

Rangeland Grazing, Cheatgrass, Fires and Flooding

The federal government's initial efforts to protect the valuable watershed source areas from the growing threats of extensive grazing operations began in 1906 within the North Fork Humboldt River sub-basin. In this year the Independence Forest Reserve was established making possible the initiation of a grazing management program aimed at preventing further deterioration and degradation of the high water-yielding lands in the Independence Mountain Range.[411] Throughout the late 1800's and early 1900's, thousands of nomadic and unregulated bands of sheep grazed the upland areas of the Toiyabe and Shoshone Mountain ranges in the middle and upper Reese River sub-basin. Some of the destructive overuse of these upland watershed areas was curbed with the establishment in March 1907 of the 600,000-acre Toiyabe Forest Reserve, which later became part of the Toiyabe National Forest.[412] Following this, in 1908, the Independence Forest Reserve and the Ruby Mountains Forest Reserve (Ruby Mountains sub-basin) were consolidated into a new unit called the Humboldt National Forest.

Then in 1909 the Bruneau was added to the Humboldt National Forest, which covers the upper Mary's River sub-basin, in order to protect and administer land use in the vital watersheds of the Jarbidge Mountains.[413] In April 1911, in response to local opposition to sheep herds migrating from the Independence and Bruneau areas after they were established as national forests, President Taft created the Santa Rosa National Forest in the upland watershed of the Little Humboldt River.[414] In June 1912, the Ruby Division of the Humboldt National Forest was withdrawn, additional lands north of Overland (Hastings) Pass were added to these lands, and the new division was renamed the Ruby National Forest.[415] Then in June 1917, both the Ruby and Santa Rosa National Forests were combined within the present-day Humboldt National Forest.[416] Managed grazing programs for the remaining federal lands within the Humboldt River Basin, particularly the lower elevation meadows and open ranges where the cheatgrass invasion was most prevalent, did not occur until 1935 when the new Grazing Service (now the U.S. Bureau of Land Management) was established within the U.S. Department of the Interior.[417]

The effects of extensive open-range grazing throughout the Humboldt River Basin during the first half of the 1900's has tended to have two different, but nonetheless compounding effects on periodic natural disasters occurring within the basin. On the one hand, in the basin's lower elevations (4,000-6,000 feet) grazing by both domestic livestock and herds of wild horses has thinned native perennial grasses and supported the invasion of the annual cheatgrass, along with the potential for recurring fires and further cheatgrass succession on newly burned lands. On the other hand, within the basin's upper watersheds, the loss of native grasses, water-holding soils, and formerly lush meadowlands have had detrimental effects on the basin's flood potential. The loss of these areas' ability to hold soil moisture and attenuate and/or prolong runoff has increased the occurrence of "flash" flows along many Humboldt River stream systems, worsened channel erosion, and increased the effects of downstream flooding during both spring runoff and severe storm events. Although not fully documented, the more sudden flash flow nature of a number of the basin's stream systems may also tend to shorten effective irrigation periods along these stream systems. Furthermore, the heavy grazing of riparian areas,[418] combined with the down cutting of stream channels, has resulted in alterations to plant communities and moisture conditions along stream courses. As a result, natural fire breaks have been either narrowed or eliminated altogether from the landscape.

Extensive and severe flooding throughout the Humboldt River system during the February-April 1910 time period represented the basin's worst recorded flood event up to that time. It also arguably provided the first and most telling indication of how changes in upland watersheds, meadowlands and riparian vegetation conditions were destined to impact future runoff and flood events throughout much of the basin. The suddenness of the runoff from this event and the resultant severity of the downstream flooding in comparison to other storm and flood events tended to support the theory that the destruction of upper basin vegetative cover and the soil's diminished water holding capacity were important contributing factors to this flood's destructive effects. It is now generally believed that much of the susceptibility to erosion along many stream systems within the Humboldt River Basin began at this time.[419] Like the cheatgrass invasion and its impact on open-range wildfires, the condition of pervasive erosion within the Humboldt River Basin represents another virtually irreversible effect from repetitive livestock grazing on fragile ecosystems which have clearly proven to be unable to adapt to the pressures that human activities have placed upon them.

The Great Basin: A Fire-Related Assessment

The Bureau of Land Management's *State of the Public Rangelands, 1990,* which tended to indicate stable to improving rangeland conditions on a vast majority of the public rangeland in the West,[420] may have been overly optimistic when it came to the actual conditions within the Great Basin. The extensive rangeland wildfires of the 1999 fire season, which raged throughout northern Nevada and the Humboldt River Basin, supported a more austere picture of the vegetative state of the Great Basin. In fact, in April 2000 the BLM published a report entitled "The Great Basin: Healing the Land." This report was based on the effects of 1999's lightening-produced wildfires which had burned more than 1.7 million acres throughout the Great Basin, with a majority of the damage occurring in early August 1999.

The first sentence of that report perhaps best described the situation: "The Great Basin is in trouble." This overall assessment was of little surprise to researchers, ranchers, and resource conservationists who had been closely watching the long-term trends in the region's vegetative condition. The report noted that "Exotic annual grasses and noxious weeds are crowding out native vegetation. The invading species dry out quickly and are highly flammable. They carry wildland fire with devastating effectiveness. They are opportunistic, thriving in disturbed areas, particularly where fires burned. The cycle, once started, is difficult to break: fire follows annual grasses, and annual grasses follow fire."[421]

The BLM's April report was, in fact, based on an earlier November 1999 report "Out of Ashes, An Opportunity."[422] This preliminary assessment was published by a group of specialists who met in late August 1999 in Boise, Idaho, to discuss the Great Basin's recent wildland fires and what their consequences might be. Some of this group's conclusions were: (1) the Great Basin's ecological resiliency is failing as annual grasses and noxious weeds dominate the landscape; (2) traditional means of fighting invasive species and restoring native habitat are not enough to stop the downward spiral; (3) traditional, post-fire rehabilitation, which mostly addresses soil stability, is not sufficient to resolve the ecological problems associated with wildland fires. A restoration effort, unlike any other attempted on western rangelands, must begin; (4) such a restoration would be expensive, but the cost of doing nothing ultimately will be much higher, as non-native, invasive species dominate more land; (5) close cooperation with key individuals, local governments and agencies, and organizations is essential to successful restoration.

From this earlier report and other findings, the BLM formed their own conclusions which were then published in April 2000. The BLM assessment found that: (1) the Great Basin's ecological health and resiliency are in jeopardy. Exotic annual grasses and noxious weeds now dominate roughly one-third of the land in the Great Basin and are spreading at an alarming rate; (2) the wildland fires of 1999, which burned 1.7 million acres in the Great Basin, called attention to rangeland health issues and accelerated the need for restoration work. If the wildland fires heightened awareness of the serious situation in the Great Basin, then it could be argued they left the faintest of silver linings at the black edges of the burned land; (3) a restoration effort, on a scale never seen before in this country, needs to be undertaken to stop the downward ecological trends in the Great Basin. The opportunity to do so is brief; (4) restoration funding remains a huge question mark. No permanent account exists for restoration, which means funding may be allocated on an annual, piecemeal basis. That approach restricts the long-term planning and research critical to successful restoration; (5) pending sufficient funding, BLM can accommodate the structure needed to manage restoration with few changes in its current organization; (6) the consequences of relying on traditional rehabilitation methods to address the Great Basin's problems are severe in terms of cost, natural resource damage, effects on local economies, wildland fire intensity and occurrence, and public safety; (7) restoration of the Great Basin ecosystem is a monumental challenge, perhaps the single most demanding land-management task faced by BLM. Successful restoration will require the commitment of not only BLM, but also many other agencies, private organizations and other interests.[423]

The BLM's restoration objectives for the Great Basin restoration proposal included the following: (1) resolve the problems of the Great Basin from an ecosystem perspective rather than a programmatic or issue basis; (2) protect healthy, functioning ecosystems consisting of native plant communities; restore degraded landscapes with high potential; and restore decadent shrublands; (3) develop a common basis for an approach to problem identification and resolution; (4) develop criteria for prioritizing restoration work and funding; (5) leverage limited current capability by combining funding sources on priority areas identified through the restoration criteria; (6) capitalize on external partnerships to maximize restoration capability and success; and (7) promote scientific research and studies.[424]

The BLM's proposed program for Great Basin restoration included the following guiding principles: (1) restoration will encompass all landscapes in the Great Basin and not just those areas that burned in 1999; (2) restoration will be consistent with BLM's "Standards for Rangeland Health"; (3) decisions about restoration activities must be made, with involvement of local communities and tribes; (4) restoration work will be based on the best available science; (5) restoration must incorporate sound fire management strategies; (6) funds will be devoted to on-the-ground work to the extent possible; (7) native species should be given preference in seeding projects, pending seed availability, cost and chance of success; (8) all restoration projects will include monitoring, data evaluation and information sharing to improve restoration success in the future; (9) restoration activities must balance ecological needs with social, political and economic considerations; and (10) the Great Basin must be managed for no net loss of sagebrush habitat and salt desert shrub habitat.[425]

In addition to the obvious sense of urgency noted in the BLM document, what has made the BLM's proposals for the Great Basin singularly innovative is the recognition of having to resolve the pervasive rangeland problems on a more comprehensive, ecosystem basis. In the past, it was argued, restoration was effected for a single program (i.e., livestock grazing), or for a single issue (i.e., sage grouse), or for a given crisis on a site-specific basis (i.e., wildfire rehabilitation).[426] Consequently, the work that was undertaken was based on more short-term, immediate needs rather than long-term goals and needs of restoration. By contrast, the BLM's Great Basin restoration objectives were now calling for a unification of all rehabilitation and restoration efforts into a single, coordinated program both to improve the concentration of effort as well as to use available funding most effectively.

Humboldt River Basin Snowpack Water Content Analysis

For the Great Basin's river systems, the extent of the mountain snowpack is essential for downstream flows.[427] In fact, this snowpack water content natural "reservoir" constitutes the most important water storage component for these northern Nevada watersheds. Table 23, Northern Nevada Water Basin Snowpack Water Content,[428] presents an historical perspective of snowpack equivalent water content (and thereby a proxy measure of annual precipitation) levels in Northern Nevada's major water basins over the years 1980 through 1999. These measures are based on the percentage of average snowpack water content as of April 1 of each year (average, or "normal" year equal to 100 percent). This overall period of time is of special significance to the hydrology of northern Nevada as it included both the wettest year on record for the Sierra Nevada water basins (1983) and the Humboldt River Basin (1984), as well as the most severe drought period on record (1987-1994) for these same water basins. The trend in these figures clearly shows the extreme variations in snowpack water content from year to year.

For example, within the upper Humboldt River Basin (i.e., above Palisade, Nevada) snowpack readings have ranged from a low of 47 percent of normal snowpack water content in 1994 to a high of 227 percent of normal in 1984. Also, within the lower Humboldt River Basin (below Palisade), over a period of just four years, from 1981 to 1984, the snowpack water content readings varied from 30 percent of normal snowpack water content to 296 percent of normal. Due, in part, to its location between the storm systems affecting primarily the western Nevada watersheds (i.e., Truckee, Carson and Walker River Basins) and the more north-trending jet stream induced storm systems affecting primarily the watersheds of eastern Nevada (i.e., upper Humboldt River), the lower Humboldt River Basin has tended to show the greatest variation in its snowpack water content readings among all the watersheds of northern Nevada.

With respect to the trends shown in Table 23, despite the seemingly wide variations in the snowpack water content measures for the upper Humboldt River Basin, the (arithmetic) average snowpack water content for the 1980-99 period was reasonably close to the entire period of record average of 100 percent. Specifically, for the upper Humboldt River Basin, the average snowpack water content reading for this 1980-1999 period was 98 percent of normal,[429] which, when combined with a relatively low standard deviation (a measure of an individual year's variability from this average), indicates that while individual yearly values seem volatile, the overall pattern was approximately "average," i.e., close to 100 percent.

On the other hand, the average snowpack water content readings for the lower Humboldt River Basin over this 1980-1999 period showed far greater variability with an overall average value of 111 percent of normal.[430] Furthermore, the individual annual measures showed such a high standard deviation (variability) as to provide little statistical confidence that this value resembles the "true" mean (100 percent). These year-to-year variations, especially for the lower Humboldt River Basin, add support to concerns over using the concept of an "Average Water Year" for watershed forecasting and planning purposes, as there are so few such years in reality. In this regard, Rye Patch Reservoir, located in Lovelock Valley in the lower Humboldt River Basin, has contributed to smoothing out the surface water available (primarily from the upper basin) for irrigation.

Table 23 – Northern Nevada Water Basin Snowpack Water Content

Snowpack Water Equivalent (Content) as a Percent of Average (100%) – April 1, 1980-1999

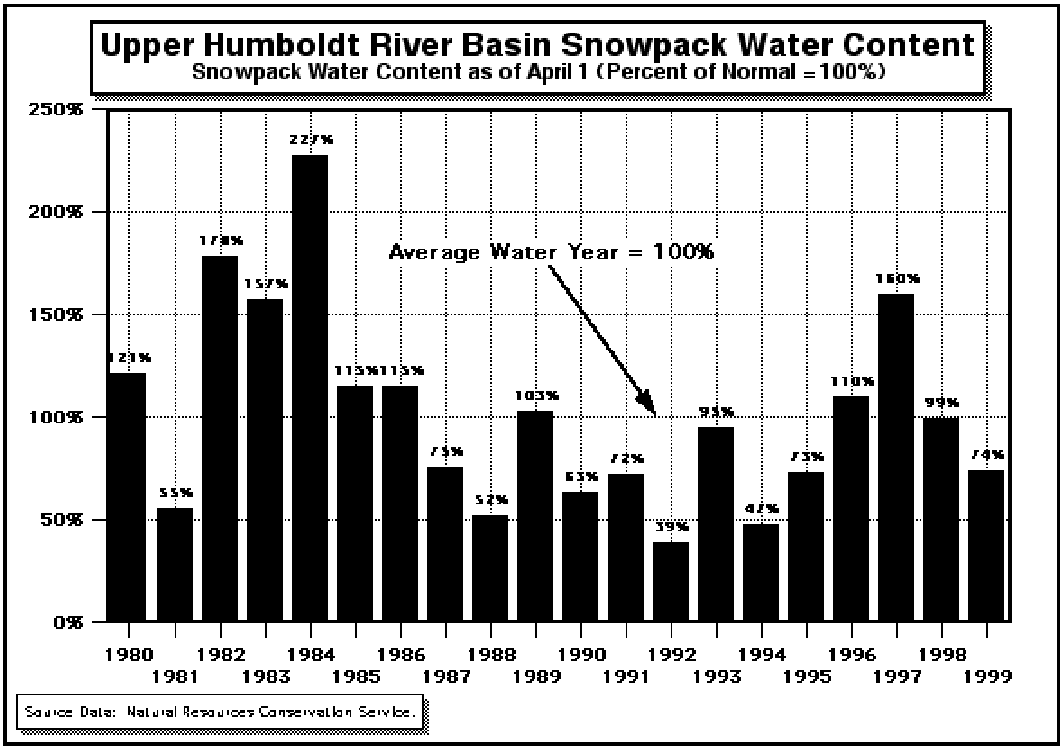
Water Year	Lake Tahoe Basin	Truckee River Basin†	Carson River Basin	Walker River Basin	Upper Humboldt River Basin	Lower Humboldt River Basin
1980	134%	134%	153%	170%	121%	131%
1981	62%	58%	70%	73%	55%	30%
1982	141%	149%	147%	156%	178%	173%
1983	202%	205%	206%	227%	157%	272%
1984	103%	100%	95%	106%	227%	296%
1985	90%	90%	85%	85%	115%	145%
1986	142%	134%	158%	170%	115%	115%
1987	56%	56%	48%	46%	75%	92%
1988	29%	32%	36%	40%	52%	44%
1989	93%	100%	87%	70%	103%	141%
1990	41%	50%	47%	47%	63%	45%
1991	64%	60%	63%	69%	72%	74%
1992	46%	45%	37%	54%	39%	33%
1993	149%	158%	123%	144%	95%	98%
1994	44%	50%	43%	46%	47%	36%
1995	168%	184%	157%	185%	73%	95%
1996	116%	121%	106%	113%	110%	107%
1997	93%	121%	87%	117%	98%	81%
1998	129%	138%	118%	142%	99%	123%
1999	133%	138%	103%	99%	74%	91%
Period Percent of Water Basin Average (Average = 100%) Wet Years (1982 - 1986); Drought Years (1987 - 1994); Wet Years (1995 - 1999):						
82 - 86	136%	136%	138%	149%	158%	200%
87 - 94*	65%	69%	61%	65%	69%	73%
95 - 99*	128%	140%	114%	131%	95%	101%
Accounting for Flood of January 1997 (Snowpack readings taken February 1, 1997):‡						
1997	181%	219%	187%	233%	160%	139%
95 - 99*	145%	160%	134%	154%	111%	115%

† Snowpack water content figures for the Truckee River Basin exclude the Lake Tahoe Basin and begin below the Lake Tahoe Dam at Tahoe City, California.

‡ Due to the effects of unusual weather conditions and an early runoff caused the extensive "wet-mantle" flooding in early January 1997 in northern Nevada, alternative peak snowpack readings are presented for February 1, 1997 (versus April 1) which more accurately reflected 1997's relatively extreme climatological conditions.

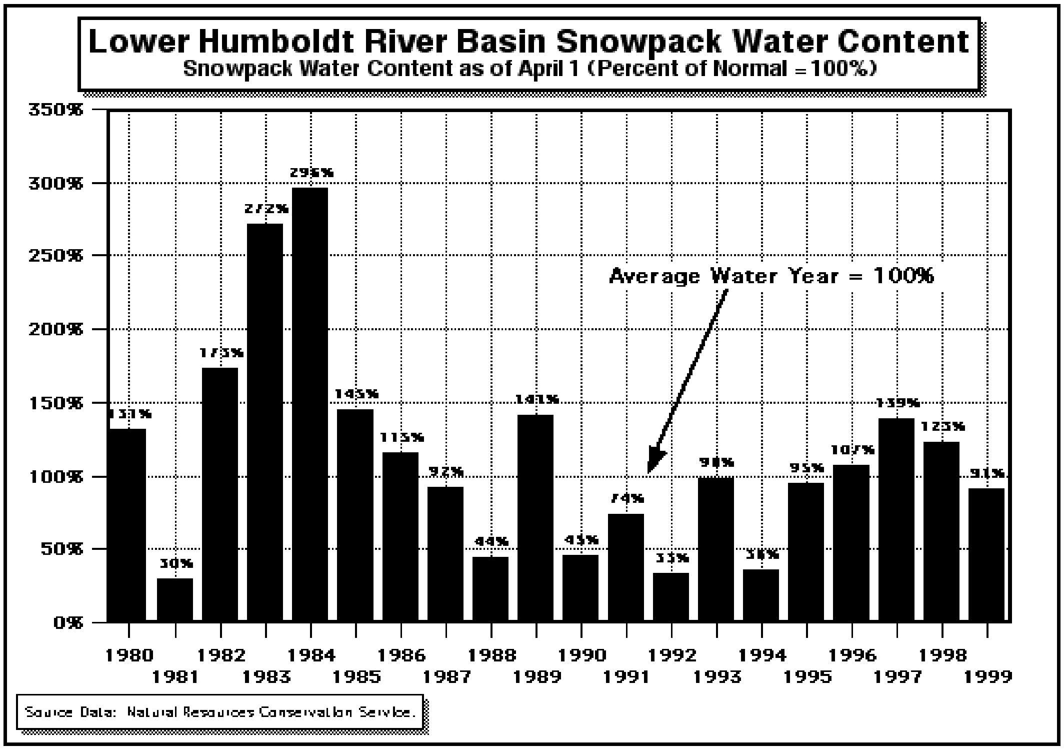
* Drought years for the upper and lower Humboldt River Basins extended from 1987-1995 and the most recent wet year extends from 1996-1999.

Source Data: "Nevada Basin Outlook Report", various issues, Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture, Reno, Nevada.



Source Data: Natural Resources Conservation Service.

Figure 20 – Upper Humboldt River Basin Snowpack Water Content



Source Data: Natural Resources Conservation Service.

Figure 21 – Lower Humboldt River Basin Snowpack Water Content

In addition to the relatively high variability of snowpack water content readings within each of these northern Nevada watersheds, closer analysis of Table 23 also shows how these watersheds are affected both similarly and uniquely by winter storm systems. From a more extensive analysis of this data, we may make several tentative propositions with respect to the effects of winter storms on regional hydrology. While the overall pattern in the snowpack water content readings appears to show marked correlation of the readings among all of northern Nevada's principal watersheds, more rigorous analysis also tends to indicate the presence of distinctly unique effects on specific watersheds. Furthermore, the apparent differences in the effects of the region's eastward tracking storm systems and the resultant variations in snowpack water content conditions exist primarily between western Nevada's watersheds (the Lake Tahoe Basin,[431] and the Truckee, Carson and Walker River Basins) and those of the upper and lower Humboldt River Basin.

The snowpack similarities and differences gleaned from Table 23 fall into three general categories:

> (1) years in which all the principal watersheds of northern Nevada have responded similarly (i.e., wet years or drought years) in terms of snowpack water content readings (e.g., 1980, 1981, 1988, 1990-1992, 1994 and 1996-1998);
> (2) years in which extremely heavy precipitation (i.e., "wet" storm systems) in the western Nevada watersheds were typically caused by the effects of a more southern-tracking jet stream "drawing" storm systems southward. These storm systems have tended to be "blocked" and depleted of their water content (the "rain shadow" effect) by the Sierra Nevada. These effects are not typically reflected in the snowpack conditions of the Humboldt River Basin, or at least not reflected in the upper Humboldt River Basin (e.g., 1983, 1986, 1993, 1995, 1997 [for a February 1, 1997 reading versus the normal April 1, 1997 reading], and 1999); and
> (3) years in which eastern Nevada and particularly the upper Humboldt River Basin, has been especially affected by Pacific storms systems being pushed first further north and east and then downward from the Pacific Northwest by a more northern-tracking jet stream. The more northern track of these systems has tended to cause them to largely by-pass the watersheds of western Nevada (e.g., 1982, 1984 and 1985, 1987 and 1989).

It has been proposed that the southern-tracking jet stream phenomenon supporting greater snowpack water content in western Nevada's watersheds is a characteristic of an El Niño event, while the more northern-tracking jet stream, which tends to push storms further to the north and then bring them down into eastern Nevada, is caused by a La Niña period or event.[432]

Table 23 also reveals important information specifically related to the unusual hydrologic conditions which occurred during the 1997 water year ("The Flood of 1997").[433] During this period, which lasted from late December 1996 to early January 1997, heavy rains produced extensive flooding in western Nevada and caused the Humboldt Sink to fill and then flow into the Carson Sink. Based on the normal April 1 recording of water basin snowpack water content measurements, the 1997 water year for both the upper and lower Humboldt River Basins was actually recorded as being below the long-term average. Specifically, the upper Humboldt River Basin showed snowpack water content of 98 percent of normal as of April 1, 1997 while the lower Humboldt River Basin was at 81 percent of normal. On the other hand, comparable period snowpack water content readings for the western

Nevada watersheds showed more mixed conditions, with some watersheds being slightly below average (the Lake Tahoe Basin and the Carson River Basin) and others just above average (Truckee and Walker River Basins).

The climatic conditions during this extreme storm and flood event were characterized by heavy snowfalls in December 1996, which were then followed in late December and early January by several days of warm torrential rains on heavy snowpack accumulation. At first, the rains virtually depleted the entire snowpack below 7,000 feet MSL, greatly exacerbating the effects of runoff and downstream flooding. Weather conditions then cooled appreciably, turning the rain to snow at the upper elevations and again restoring the snowpack to near-record levels. Temperatures then warmed significantly by early spring, greatly depleting the snowpack and resulting in snowpack water content measurements on April 1, 1997 which were, despite near-record flooding throughout all these water basins, indicative of only a "normal" water year.

The bottom portion of Table 23 has been modified to provide additional analysis of this 1997 period by changing the presumed date of maximum snowpack for these water basins. Specifically, this section of the table presents the snowpack water content readings for all of these watersheds taken on February 1, 1997 (versus April 1, 1997), which approximately corresponded to the peak snowpack water content readings for that water year recorded after recovery from the effects of the early January flooding. Even so, snowpack water content measures for 1997 provided poor estimates of the winter's "true" precipitation as by this time (February 1997) a significant portion of the period's overall precipitation, in terms of both rainfall and melted snowpack, had already flowed (actually flooded) to these basins' respective terminus locations.

Even so, throughout western Nevada's watersheds the differences between the snowpack water content readings taken on February 1, 1997 and those recorded later on April 1, 1997 were extreme. For example, within the Lake Tahoe Basin, snowpack water content measurements changed from 93 percent of normal recorded on April 1, 1997, to 181 percent of normal recorded previously on February 1, 1997. As this was a more typical El Niño "wet storm" event, and based on the previous discussion with respect to regional snowpack differences, the effects on the Humboldt River Basin were not quite so dramatic, but nonetheless significant. The snowpack water content readings of the upper and lower Humboldt River Basins changed from 98 percent and 81 percent of normal, respectively, recorded on April 1, 1997, to 160 percent and 139 percent of normal, respectively, recorded previously on February 1, 1997.

Climatic Changes and the Hydrology of the Great Basin

The hydrology of the region called the Great Basin was considerably different during the Wisconsin Age of the late Pleistocene Epoch of some 10,000 to 20,000 year ago. The Great Basin, which encompasses the entire Humboldt River Basin, effectively covers most of Nevada except the northern Nevada Snake River drainage flowing into the Columbia River Basin and the southern Nevada Colorado River drainage, which eventually flows into Mexico and the Gulf of California. During this last Ice Age period , the eastern portion of the Great Basin held the extensive 19,970 square mile Lake Bonneville while the western portion of the Great Basin contained the smaller, but still impressive, 8,660 square mile Lake Lahontan. This lake covered a vast and irregularly-shaped area of northwestern Nevada and extended into eastern California as well.

In addition, between these two vast bodies of water lay tall mountain ranges covered in glaciers, while interspersed among the mountains were many smaller Pleistocene lakes and marshes. Figure 22, Ice Age Lakes Lahontan and Bonneville,[434] shows the locations of these Ice Age lakes. Lake Lahontan occupied much of northwestern Nevada and extended into the Honey Lake sub-basin in eastern California. Lake Bonneville covered most of northwestern Utah and extended into the very eastern portion of Nevada.

The Great Basin's present topography has been some time in formation. Some 50 million years before present (B.P.), the Great Basin was believed to be considerably higher than today and more resembled the Andes Mountains of South America. Then the region began to stretch apart in an east-to-west direction, producing north-south faults near the current location of the California-Nevada Sierra Nevada in the west and Utah's Wasatch Range in the east. By 18 million years B.P., the trapped drainage between these boundary ranges, as characterized by the Great Basin's basin-and-range topography, began to form. By about 3 million years B.P., the Great Basin had assumed its current geologic form.

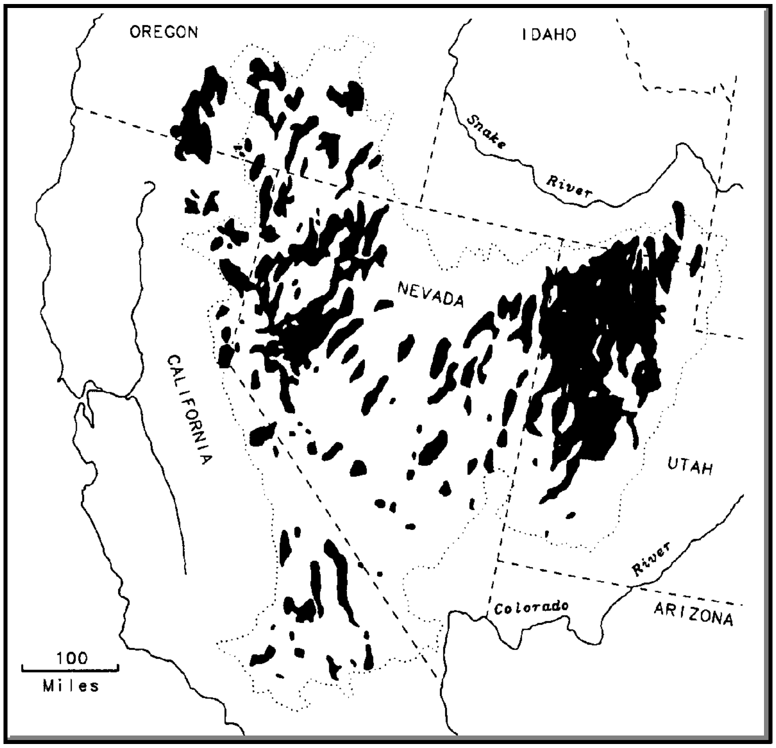


Figure 22 – Ice Age Lake Lahontan (Nevada) and Lake Bonneville (Utah)

Since the early Pleistocene Epoch beginning some 1.8 to 2 million years B.P., the Great Basin has proven to be an important archive of environmental change. As a closed basin, all rain and snow falling on the basin's surface remains within it, or it evaporates. Therefore, the ascensions (ups) and decensions (downs) of ancient lake levels provide reasonably accurate records of past climatic changes, with the detailed history of each individual lake basin stored within its layers of sediment. U.S. Geological Survey studies of the sediment in Pyramid Lake, for example, have revealed that between 52,000 to 10,000 years B.P. abrupt, dramatic climatic changes occurred every 1,000 to 3,000 years. These changes have also been correlated to changes revealed by Greenland ice and North Atlantic sediment, indicating that the changes recorded within the Great Basin are indicative of more global climatic patterns as well.[435]

Shoreline altitudes of several pluvial lakes in the northern and western Great Basin have recorded successively smaller lakes from the early to the late Pleistocene Epoch, or from approximately 2 million years B.P. to 10,000 years B.P. This decrease in lake size tends to indicate a long-term drying trend in the region's climate. Calculations based on differences in lake area suggest that the highest levels of these pluvial lakes occurring during the early Pleistocene would have required a regional increase in effective moisture of up to three times that effective moisture level estimated to have existed in the late Pleistocene. These previously unknown lake levels reflect significant changes in climate, tectonics and (or) drainage basin configurations and could have facilitated the more extensive migration of aquatic species in the Great Basin.[436]

Lake Lahontan 's early Pleistocene surface level of 4,590 feet MSL was estimated to be over 200 feet above its late Pleistocene shoreline (4,380 feet MSL), a surface elevation more typically recognized as this lake's approximate late Pleistocene highstand. At this higher elevation, Lake Lahontan would have extended its reach up the Humboldt River from the late Pleistocene highstand located just above Red House (about five miles above Comus) by another 45 miles to just above Argenta, thereby submerging Battle Mountain beneath nearly 70 feet of water. There is also evidence showing the possibility that at one time Lake Lahontan may have extended even further up the Humboldt River, by another 28 miles to the lower end of Palisade Canyon.[437]

Pyramid Lake, located in the Truckee River Basin in western Nevada, as well as Walker Lake, located nearly 80 miles to the south in the Walker River Basin, represent the last remaining major lake remnants of Ice Age Lake Lahontan. This ancient lake covered a highly irregular area throughout much of northwestern Nevada as recently as 12,500 years ago and experienced a number of fluctuations in its surface elevation and extent over the last 360,000 years.

The importance of this lake's fluctuations lies in the corresponding climatic conditions that fostered its rapid ascensions and descensions and, during intervening periods, the complete desiccation (drying up) of all its major sub-basins, with the exception of Pyramid Lake itself, which constituted the lowest point within the Lake Lahontan system. Core samples taken of Pyramid Lake's lake bottom do not indicate a brine concentration, as does Walker Lake, therefore suggesting that throughout Lake Lahontan's existence Pyramid Lake held water, although it was periodically severely restricted in size.[438]

Figure 23, Lake Lahontan's Sub-Basins and Sills,[439] show the seven principal sub-basins of Ice Age Lake Lahontan and the sills, or locations of spillover from one sub-basin to another. Lake Lahontan was fed by the Truckee, Carson, Walker, Humboldt, Susan, and Quinn Rivers. Lake Lahontan's extent consisted of seven major sub-basins in northwestern Nevada and eastern California. These sub-basins are presented below and are marked by Roman numerals in Figure 23:

(I) Smoke Creek/Black Rock Desert;
(II) Carson Desert;
(III) Buena Vista;
(IV) Walker Lake;
(V) Pyramid Lake;
(VI) Winnemucca Dry Lake; and
(VII) Honey Lake, located mostly in California.

Associated with each of these sub-basins was a primary "sill" or interbasin spillway defined as the lowest point on the divide between adjoining sub-basins. The sills were important because only at water elevations above these threshold levels would the waters of Lake Lahontan, originating in the basin's lowest point – Pyramid Lake – spill over into adjacent sub-basins. These sills and their approximate elevations above mean sea level are presented below and refer to the Arabic numbers in Figure 23:

(1) Pronto – Black Rock Desert (4,239 feet or 1,292 meters);
(2) Chocolate – Buena Vista (4,140 feet or 1,262 meters);
(3) Adrian Pass (Valley) – Walker Lake (4,291 feet or 1,308 meters);
(4) Darwin Pass – Carson Desert (4,150 feet or 1,265 meters);
(5) Mud (Winnemucca) Lake Slough – Winnemucca Dry (Mud) Lake (3,862 feet or 1,177 meters);
(6) Astor Pass – Honey Lake (4,009 feet or 1,222 meters); and
(7) Emerson Pass – Smoke Creek Desert (3,960 feet or 1,207 meters);.[440]

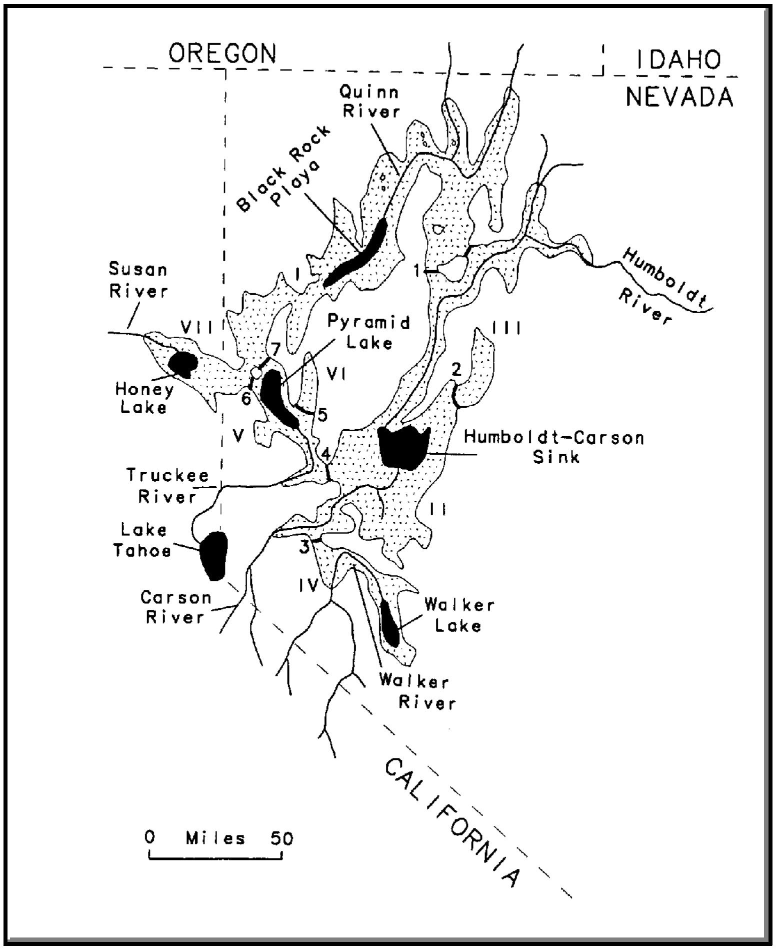


Figure 23 – Lake Lahontan's Sub-Basins and Sills

It was only at lake surface elevations above approximately 4,290 feet above mean sea level (MSL) that all the seven major sub-basins comprising Lake Lahontan were joined into one continuous, albeit highly irregularly-shaped, lake. This particular elevation represented the highest point within the Adrian Valley, a narrow pass, almost 10 miles in length, connecting the lower Carson River Basin in the north with Mason Valley and the Walker River Basin to the south. In its last stage towards full expansion, waters from an ascending Lake Lahontan flowed west up the Carson River towards the present-day site of Dayton, and south through the Adrian Valley and into the Walker River Basin. Once Lake Lahontan's waters emerged from the Adrian Valley and spread into the northern portion of Mason Valley, they then raced down Campbell Valley throught the site of present-day Weber Reservoir to fill Walker Lake and the Walker Lake sub-basin, continuing southward to beyond the present-day town of Hawthorne in Mineral County, Nevada. Once the Walker Lake basin was filed, waters then flowed up the Walker River, flooding Mason Valley up to the present-day location of the City of Yerington located in Lyon County, Nevada.

In the Humboldt River Basin, Lake Lahontan's late Pleistocene reach up the Humboldt River Valley effectively cut some 100 miles off the Humboldt River's present 300-mile length, covering the sites of Toulon and Humboldt Lakes by approximately 490 feet. Further upriver, Lake Lahontan submerged the present-day site of Lovelock by nearly 400 feet, and also submerged the Humboldt River's bed at the present-day site of Winnemucca by nearly120 feet. Just above Winnemucca, Lake Lahontan extended north and flowed up the Little Humboldt River drainage, covering the Sand Dunes formation and the southern portion of Paradise Valley, eventually reaching a point approximately 26 miles upriver from the Humboldt River main stem. From Winnemucca, Lake Lahontan's reach continued up the Humboldt River Valley for another 32 miles to a point about five miles above Comus to the present-day location of Red House. At this location a small and relatively shallow lake was formed of approximately 30 square miles in size.

Extensive evidence based on sophisticated X-ray diffraction petrographic and radiocarbon analyses, as well as detailed analysis of Walker Lake's lakebed core samples, indicates that Lake Lahontan and its various hydrographic sub-basins have been subject to extensive fluctuations over the last 40,000 years, and that most of Lake Lahontan's sub-basins have desiccated on numerous occasions.[441] This apparent repetitive cycle of ascension and descension, lake expansion and lake desiccation, and pluvial (wet) and inter-pluvial (dry) periods, has important implications on our own time period and the present hydrographic cycle, climatic conditions, and our expectations of natural versus man-caused hydrologic changes within the various hydrographic basins in northern Nevada.

As a general indication of climatic conditions within the Great Basin, evidence shows that between 15,000-13,500 years ago, Lake Lahontan went through a peaking enlargement (maximum stage), attaining a surface elevation of almost 4,380 feet MSL,[442] a surface area of approximately 8,600 square miles,[443] and all of its sub-basins were connected. Lake Lahontan's last highstand occurred some 12,500 years ago. By the end of the Pleistocene, between 11,000 and 10,000 years ago, climatic conditions again changed dramatically and the region entered what may be an inter-pluvial period. Since entering the Holocene Epoch, beginning about 10,000 years ago, generally warm and arid conditions have since prevailed throughout the Great Basin. At that time Lake Lahontan commenced a descension phase and all sub-basins except Pyramid Lake and Walker Lake essentially dried up.[444]

Appendix 1 – Humboldt River Basin Hydrographic Areas

Hydrographic Areas and Sub-Area by Name, Counties and Preferred Use Designations

Area Num.	Area Name	Size (sq. miles)	Size (acres)	Counties Included†	Designations‡
42	Mary's River	1,073	686,720	Elko	837–Designation (2/14/84); 838–Preferred Use: M&I, Domestic (3/20/84)
43	Starr Valley	332	212,480	Elko	867–Designation (7/10/85)
44	North Fork	1,110	710,400	Elko	744–Designation (5/28/80)
45	Lamoille Valley	257	164,480	Elko	869–Designation (7/18/85)
46	South Fork	99	63,360	Elko	870–Designation (7/18/85)
47	Huntington Valley	787	503,680	Elko, White Pine	865–Designation (7/10/85)
48	Dixie Creek-Tenmile Creek	392	250,880	Elko	848–Designation (9/6/84); 1120–Notice of Curtailment (portion) (4/2/96)
49	Elko Segment	314	200,960	Elko, Eureka	778–Designation (portion) (12/8/81); 782–Notice of Curtailment (1/3/81); 864–Designation (remaining portion) (7/10/85); 872–Designation (remaining portion): M&I, Domestic (7/18/85)
50	Susie Creek	223	142,720	Elko, Eureka	866–Designation (7/10/85); 872–Preferred Use: M&I, Domestic (7/18/85)
51	Maggie Creek	396	253,440	Elko, Eureka	863–Designation (7/10/85); 872–Preferred Use (portion): M&I, Domestic (7/18/85); 1055–Well Spacing (4/1/92)
52	Marys Creek	61	39,040	Eureka, Elko	868–Designation (7/18/85); 872–Preferred Use (portion): M&I, Domestic (7/18/85)
53	Pine Valley	1,002	641,280	Eureka, Elko	862–Designation (7/10/85)
54	Crescent Valley	752	481,280	Eureka, Lander	755–Designation (3/20/81); 1082–Well Spacing (10/6/83)
55	Carico Lake Valley	376	240,640	Lander	None
56	Upper Reese River Valley	1,138	728,320	Lander, Nye	None
57	Antelope Valley	452	289,280	Lander	276–Designation (portion) (8/5/64)
58	Middle Reese River Valley	319	204,160	Lander	276–Designation (portion) (8/5/64)
59	Lower Reese River Valley	588	376,320	Lander, Eureka	739–Designation (3/27/80); 839–Preferred Use: M&I, Domestic (3/20/84)
60	Whirlwind Valley	94	60,160	Eureka, Lander	799–Designation (10/5/82)
61	Boulder Flat	544	348,160	Eureka, Lander, Elko	799–Designation (10/5/82); 839–Preferred Use: M&I, Domestic (3/20/84); 1038–Well Spacing (3/29/91)

Area Num.	Area Name	Size (sq. miles)	Size (acres)	Counties Included†	Designations‡
62	Rock Creek Valley	444	284,160	Elko, Lander, Eureka	None
63	Willow Creek	405	259,200	Elko	None
64	Clovers Area	720	460,800	Humboldt, Lander, Elko	700–Designation (12/30/77); 839–Preferred Use (portion): M&I, Domestic (3/20/84); 1085–Well Spacing (1/21/94)
65	Pumpernickle Valley	299	191,360	Humboldt, Pershing	1086–Well Spacing (1/21/94)
66	Kelly Creek Valley	301	192,640	Humboldt, Elko	536–Designation (5/9/75); 1087–Well Spacing (12/30/93)
67	Little Humboldt Valley	975	624,000	Humboldt, Elko	None
68	Hardscrabble Area	167	106,880	Humboldt	None
69	Paradise Valley	600	384,000	Humboldt	408–Designation (portion) (10/22/71); 832–Notice of Curtailment (12/1/83)
70	Winnemucca Segment	435	278,400	Humboldt	464–Designation (7/24/72); 534–Extension of Designated Area (5/6/75)
71	Grass Valley	520	332,800	Pershing, Humboldt	464–Designation (7/24/72)
72	Imlay Area	771	493,440	Pershing	702–Designation (1/31/78)
73	Lovelock Valley	635	406,400	Pershing, Churchill	None
73A	Lovelock Valley/ Oreana Sub-Area	98	62,720	Pershing	369–Designation (2/25/69); 370–Notice of Curtailment Area and Preferred Use (portion): M&I (2/25/69); 1079–Expand Curtailment Area and Preferred Use (portion) (5/17/93)
74	White Plains	164	104,960	Churchill, Pershing	716–Designation (7/678

† Counties are listed in order of their respective area shares of the hydrographic area or sub-area.

‡ Designated = Designated groundwater basins (i.e., hydrographic areas or sub-areas) are basins where permitted ground water rights approach or exceed the estimated average annual recharge (or perennial yield) and the water resources are being depleted or require additional administration. Under such conditions, and in the interest of public welfare, the Nevada State Engineer, Division of Water Resources, Department of Conservation and Natural Resources, is authorized by statute (Nevada Revised Statute 534.120) and directed to designate a groundwater basin and declare preferred uses within such designated basin (e.g., municipal and industrial, domestic, agriculture, etc.). The State Engineer has additional authority in the administration of the water resources within a designated groundwater basin. Numbers refer to the State Engineer's Order number for specific designations.

Source Data: Office of the State Engineer, Nevada Division of Water Resources, Department of Conservation and Natural Resources, Carson City, Nevada.

Appendix 2 – Principal Humboldt River Basin Plant Species

Major Plant Species Presented in this Chronology – Listed Alphabetically by Common Name

aspen (*Populus tremuloides*)
Bailey greasewood (*Sarcobatus baileyi*)
big sagebrush (*Artemisia tridentata*)
bitterbrush (*Purshia tridentata*)
black sagebrush (*Artemisia nova*)
bluebunch wheatgrass (*Agropyron spicatum*)
bottlebrush squirreltail (*Sitanion hystrix*)
bristlecone pine (*Pinus aristata*)
bud sagebrush (*Artemisia spinescens*)
cheatgrass (*Bromus tectorum*)
chokecherry (*Prunus virginiana*)
cottonwood (*Populus fremontii*)
creeping wildrye (*Elymus triticoides*)
(black) greasewood (*Sarcobatus vermiculatus*)
Great Basin wildrye (*Elymus cinereus*)
halogeton (*Halogeton glomeratus*)
Idaho fescue (*Festuca idahoensis*)
Indian ricegrass (*Oryzopsis hymenoides*)
limber pine (*Pinus flexilis*)
littleleaf horsebrush (*Tetradymia glabrata*)
low sagebrush (*Artemisis arbuscula*)
juniper (*Juniperus utahensis*)
(curl-leaf) mountain mahogany (*Cercocarpus ledifolius*)
needlegrass (*Stipa spp.*)
Nevada bluegrass (*Poa nevadensis*)
(single-leaf) pinyon pine (*Pinus monophylla*)
rabbitbrush (*Chrysothamnus nauseosus*)
rockspirea (*Holodiscus discolor*)
saltgrass (*Distichlis stricta*)
Sandberg bluegrass (*Poa secunda*)
serviceberry (*Amelanchier alnifolia*)
shadscale (*Atriplex confertifolia*)
smallflower tamarisk (salt cedar) (*Tamarix parviflora*)
small rabbitbrush (*Chrysothamnus viscidiflorus*)
snowberry (*Symphoricarpos spp.*)
subalpine fir (*Abies lasiocarpa*)
tall whitetop (*Lepidium latifolium* L.)
white bark pine (*Pinus albicaulis*)
white fir (*Abies concolor*)
willows (*Salix spp.*)
winterfat (white sage) (*Krascheninnikovia lanata*)

Appendix 3 – Humboldt River Basin Gaging Station Records

U.S. Geological Survey Gaging Stations' Contiguous Periods of Record

Gaging Station Number	USGS Gage Name and Location	Gage Contiguous Period(s) of Record
10313400	Mary's River below Orange Bridge near Charleston, Nevada	October 1991 to current year (see "Note" below)
10315500	Mary's River above Hot Springs Creek near Deeth, Nevada	October 1943 to September 1980; October 1981 to current year
10315600	Mary's River below Twin Buttes near Deeth, Nevada	October 1991 to current year
10316500	Lamoille Creek near Lamoille, Nevada	May 1915 to May 1923; October 1943 to current year
10318500	Humboldt River near Elko, Nevada	June 1895 to October 1902; October 1944 to current year
10319900	South Fork Humboldt River above Tenmile Creek near Elko, Nevada	February 1989 to current year
1032000	South Fork Humboldt River above Dixie Creek near Elko, Nevada	October 1948 to September 1982; July 1988 to current year
10321000	Humboldt River near Carlin, Nevada	October 1943 to current year
10321590	Susie Creek at Carlin, Nevada	April 1992 to current year
10321925	Simon Creek near Highway 766 near Carlin, Nevada	November 1996 to current year
10321940	Maggie Creek above Maggie Creek canyon near Carlin, Nevada	January 1977 to current year
10321950	Maggie Creek at Maggie Creek Canyon near Carlin, Nevada	September 1989 to current year
10322000	Maggie Creek at Carlin, Nevada	July 1913 to December 1921; April to May 1922; April 1923 to September 1924; April 1992 to current year
10322150	Marys Creek at Carlin, Nevada	November 1989 to current year
10322500	Humboldt River at Palisade, Nevada	October 1902 to October 1906; July 1911 to current year
10323425	Humboldt River at Old U.S. Highway 40 Bridge at Dunphy, Nevada	February 1991 to current year
10324500	Rock Creek near Battle Mountain, Nevada	March 1918 to September 1925 (fragmentary from October 1923 to April 1925); March 1927 to May 1929 (fragmentary); October 1945 to current year
10324700	Boulder Creek near Dunphy, Nevada	February 1991 to June 1993; Seasonal records (i.e., January-June) since June 1993 to current year
10325000	Humboldt River at Battle Mountain, Nevada	May 1896 to December 1897; March 1921 to April 1924; October 1945 to September 1981; February 1991 to current year
10327500	Humboldt River at Comus, Nevada	October 1894 to December 1909; September 1910 to September 1926; October 1945 to current year
10329000	Little Humboldt River near Paradise Valley, Nevada	October 1921 to June 1928 (fragmentary); October 1943 to current year
10329500	Martin Creek near Paradise Valley, Nevada	October 1921 to current year

Gaging Station Number	USGS Gage Name and Location	Gage Contiguous Period(s) of Record
10333000	Humboldt River near Imlay, Nevada	June 1935 to December 1941; April 1945 to current year
10335000	Humboldt River near Rye Patch, Nevada	January 1896 to June 1898; June 1899 to December 1909; September 1910 to June 1917; September 1917 to September 1922; September 1924 to September 1930 (fragmentary); October 1930 to September 1932; October 1935 to September 1941; October 1943 to current year

Note: "Current year" refers to the water year ended September 30 1998.
Source Data: *Water Resources Data, Nevada, Water Year 1998* , Water-Data Report NV-98-1, U.S. Geological Survey, Water Resources Division, Department of the Interior, Nevada District Office, Carson City, Nevada, 1999, pages 195-231.

Index to Part I:

Notes to Part I:

1. Eakin, Thomas E., and Robert D. Lamke, *Hydrologic Reconnaissance of the Humboldt River Basin, Nevada*, Water Resources Bulletin No. 32, Nevada Department of Conservation an Natural Resources, Carson City, Nevada, 1966, page 17.

2. "Flood Control Survey Report on Humboldt River and Tributaries, Nevada," Department of the Army, Corps of Engineers, Sacramento District, Sacramento, California, September 15, 1948, page 4.

3. The approximate percentage shares of the Humboldt River Basin made up by these counties are as follows: Elko County – 42.2%; Lander County – 13.1%; Eureka County – 9.0%; Pershing County – 13.0%; Humboldt County – 20.3%; White Pine County – 1.6%; Churchill County 0.3%; and Nye County – 0.6%. The approximate percentage share of each county's total area which is contained within the Humboldt River Basin is as follows: Elko County – 40%; Lander County – 38%; Eureka County – 35%; Pershing County – 35%; Humboldt County – 34%; White Pine County – 3%; Churchill County 1%; and Nye County – 0.5%. See "Humboldt River Drainage Basin, A Cooperative State-Federal Report on Water Pollution Control," Nevada State Department of Health, Division of Public Health Engineering, Carson City, Nevada, June 1952, page 6.

4. The U.S. Geological Survey (USGS), Water Resources Division (WRD), and the Nevada Division of Water Resources, Department of Conservation and Natural Resources, have divided the state into discrete hydrologic units for water planning and management purposes. These have been identified as 232 Hydrographic Areas (256 areas and sub-areas, combined) within 14 major Hydrographic Regions or Basins. These hydrographic regions, areas and sub-areas are discussed more extensively in the Division of Water Planning's *Water Words Dictionary*, Eighth Edition, Nevada Division of Water Planning, Department of Conservation and Natural Resources, Carson City, Nevada.

5. A drainage area is defined as that area, measured in a horizontal plane, enclosed by a topographic (drainage) divide from which direct surface runoff from precipitation or snowpack runoff normally drains by gravity into the stream above the specified point. See *Water Words Dictionary, op. cit.*

6. These are referred to as designated groundwater basins (i.e., hydrographic areas or sub-areas) which are areas where permitted ground water rights approach or exceed the estimated average annual recharge (or perennial yield) and the water resources are being depleted or require additional administration. Under such conditions, and in the interest of public welfare, the Nevada State Engineer, Division of Water Resources, Department of Conservation and Natural Resources, is authorized by statute (Nevada Revised Statute 534.120) and directed to designate a groundwater basin and declare preferred uses within such designated basin (e.g., municipal and industrial, domestic, agriculture, etc.). The State Engineer has additional authority in the administration of the water resources within a designated groundwater basin. Source: Office of the State Engineer, Nevada Division of Water Resources, Department of Conservation and Natural Resources, Carson City, Nevada.

7. Houghton, Samuel G., *A Trace of Desert Waters: The Great Basin Story*, University of Nevada Press, Reno, Nevada, 1994 (reprint of Second Edition; First Edition printed in 1976), page 23.

8. In its most general sense, the term hydrographic area (or sub-area) may refer to an defined geographic area, sub-area, sub-basin, basin, region or watershed encompassing the drainage area or catchment area of a stream, its tributaries, or a portion thereof. Typically defined as a study area for analysis or planning purposes in which the land or undersea contours results in surface water flows or measures of elevation draining to a single point. At its smallest extent, a hydrographic area may encompass a single valley containing a single stream system, or a portion of a valley or stream system with distinctive drainage characteristics. At its greatest extent, a hydrographic area may encompass the entire drainage area of a major river system, e.g., the Mississippi River hydrographic area, including all tributary rivers, streams and other sources of surface water flow. Conventionally, a number of hydrographic sub-areas comprise a hydrographic area whereas a number of hydrographic areas comprise a hydrographic basin or region. See *Water Words Dictionary, op. cit.*

9. Padre Pedro Font gave the name Sierra Nevada to the mountain range on the eastern fringe of Spanish California in 1776. Sierra means mountains in Spanish and Nevada means snow-covered. Consequently, the name "Sierra Nevada" means snow-covered mountains and terms such as Sierra Nevada Mountains (snow-covered mountains mountains) or Sierra Mountains (mountains mountains) are redundant and therefore not strictly appropriate. The term Sierra Nevada range may also be used. Communication, Guy Rocha, Nevada State Historian, Carson City, Nevada, December 1999.

10. The Northwest Region covers 3,052 square miles (7,905 square kilometers or 1,953,280 acres) in Nevada consisting of northern Washoe and Humboldt counties and encompasses 16 hydrographic areas; also extends into the State of California to the west and the State of Oregon to the north.

11. The Black Rock Desert Region covers 8,632 square miles (22,357 square kilometers or 5,524,480 acres) in Nevada consisting of parts of Washoe, Humboldt, and Pershing counties and includes 17 valleys (hydrographic areas), two of which are divided into two hydrographic sub-areas each; also extends into the State of California to the west and the State of Oregon to the north.

12. The Humboldt River Basin covers over 16,843 square miles (43,623 square kilometers or 10,779,520 acres) in Nevada consisting of parts of eight counties—Elko, White Pine, Eureka, Humboldt, Lander, Nye, Pershing, and Churchill—and the largest stream (Humboldt River) wholly within Nevada. This basin contains 33 hydrographic areas and one hydrographic sub-area; this basin is one of only two hydrographic regions that are wholly contained within the State of Nevada.

13. The Great Salt Lake Basin covers 3,807 square miles (9,860 square kilometers or 2,436,480 acres) in Nevada consisting of the easternmost portions of Elko, White Pine, and Lincoln counties. It consists of eight hydrographic areas, one of which is divided into four hydrographic sub-areas; extends to the east into the State of Utah.

14. Grayson, Donald K. *The Desert's Past: A Natural Prehistory of the Great Basin*, Smithsonian Institution Press, Washington, D.C., 1993, page 18.

15. Brussard, Peter F., David A. Charlet, and David S. Dobkin, "Regional Trends of Biological Resources – Great Basin", *Status and Trends of the Nation's Biological Resources*, Volume 2, U.S. Geological Survey, U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C., 1998, page 506.

16. Grayson, *op. cit.*

17. Ricketts, Taylor H., Eric Dinerstein, David M. Olson, and Colby Loucks, "Who's Where in North America?", *BioScience*, Volume 49, Number 5, May 1999.

18. Brussard, *op. cit.*, pages 506.

19. *Ibid.*, pages 505-506.

20. *Ibid.*, page 507.

21. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, Ruby Mountains Sub-Basin, Nevada Department of Conservation and Natural Resources and the U.S. Department of Agriculture, May 1963, pages 7-9.

22. Grayson, *op. cit.*, page 46.

23. About 13,800 year ago, Lake Lahontan, covering a highly irregular portion of northwestern Nevada and spilling over into eastern California (Honey Lake Basin), attained a maximum surface elevation of approximately 4,380 feet (1,335 meters) above mean sea level (MSL), reached a maximum depth of about 900 feet (274 meters) at Pyramid Lake and a maximum surface area of some 8,665 square miles (5,545,580 acres or 22,440 square kilometers). See Grayson, *op. cit.*, pages 92 and 95.

24. About 16,000 year ago, Lake Bonneville in western Utah, and spilling over into eastern Nevada, attained a maximum surface elevation of approximately 5,090 feet (1,551 meters) above mean sea level (MSL) and a maximum surface area of some 19,970 square miles (12,780,750 acres or 51,720 square kilometers). See Grayson, *op. cit.*, pages 85, 88 and 90.

25. Brussard, *op. cit.*, page 507.

26. *Ibid.*, page 511.

27. USGS Gaging Station 10322500, Humboldt River at Palisade, Nevada — Location: Latitude 40°36'25", longitude 116°12'05", in SE 1/4 SE 1/4 section 35, T.32 N., R.51 E., Eureka County, Hydrologic Unit 16040101 [see explanation of USGS Hydrologic Units Part 1 of this chronology], on right bank, 0.2 miles downstream from Southern Pacific Railroad bridge, 0.5 miles downstream from Palisade, and 0.8 miles upstream from Pine Creek; Drainage Area: 5,010 square miles, approximately; Period of Record: October 1902 to October 1906, and July 1911 to current year. Monthly discharge only for some periods published in Water Resource Publication (WRP) 1314; Revised Records: WSP 1514, 1903-04, 1912, 1914; Gage: Water-stage recorder. Datum of gage is 4,825.55 feet above mean sea level. Prior to April 1, 1939, non-recording gages (water-stage recorder April 22 to June 3, 1935) at several sites within 0.5 miles of present site at various datums; Remarks: No estimated daily discharges. Records good. Diversions for irrigation above station. See schematic diagram [contained in this publication] of Humboldt River Basin; Extremes for Period of Record: Maximum discharge, 7,870 cfs, May 18, 1984, gage height, 10.08 feet. Minimum daily discharge, 2.0 cfs, August 25-28, 1931; Extremes Outside Period of Record: Maximum stage

known, about 17 feet above present datum, about February 28, 1910, from photographs and written statements of resident witnesses; discharge about 17,000 cfs; Extremes for Current [1998] Water Year: Maximum discharge, 3,320 cfs, June 12, 1998, gage height, 6.69 feet. Minimum daily discharge, 78 cfs, October 2, 1998. Source: *Water Resources Data, Nevada, Water Year 1998*, Water-Data Report NV-98-1, U.S. Geological Survey, Water Resources Division, Nevada District Office, U.S. Department of the Interior, Carson City, Nevada, 1999.

28. Eakin, *op. cit.*, pages 17-18.

29. The term "average" or "normal" water year denotes the average annual hydrologic conditions based upon an extended or existing period of record. Because precipitation, runoff, and other hydrologic variables vary from year to year, planners typically project future scenarios based on hydrologic conditions that generally include average, wet (high-water), and drought (low-water) years. See *Water Words Dictionary, op. cit.*

30. The Great Basin, whose unique inward-draining characteristics were first recognized by John C. Frémont, represents an area covering most of Nevada and much of western Utah and portions of southern Oregon and eastern California consisting primarily of arid, high elevation, desert valleys, sinks (playas), dry lake beds, and salt flats. The Great Basin is characterized by the fact that all surface waters drain inward to terminal lakes or sinks. For additional references on this region, see Grayson, Houghton, Fiero and Trimble.

31. Sometimes this easternmost reach of the Humboldt River above Halleck, Nevada, and the confluence with Lamoille Creek has been referred to as the East Fork of the Humboldt River. For purposes of this publication, this portion of the river below Wells is referred to simply as the Humboldt River (main stem).

32. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Four, *op. cit.*, pages 3-4.

33. Dam safety records, Office of the State Engineer, Nevada Division of Water Resources, Department of Conservation and Natural Resources, Carson City, Nevada, November 1999.

34. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Twelve, *op. cit.*, page 11.

35. Nevada State Demographer's Office, University of Nevada, Reno, July 1, 1998 township population estimates.

36. *Ibid*.

37. *Alternative Plans for Water Resource Use, Humboldt River Basin Area III*, prepared by State of Nevada, Division of Water Resources, State Engineer's Office, Carson City, Nevada, February 1974, page 8

38. For the Truckee, Carson and Walker River systems this represents a combined total of approximately 98,000 irrigated acres above these respective river's peak or maximum flow points as compared to between 150,000 to 200,000 irrigated acres on the Humboldt River above Palisade. See the section entitled "Humboldt River Basin Selected Gaging Station River and Stream Flows" later in this part. Also see Horton, *Truckee River Chronology*, *Carson River Chronology*, and *Walker River Chronology*.

39. *Nevada State Water Plan, 1999*, Nevada Division of Water Planning, Department of Conservation and Natural Resources, Carson City, Nevada, April 1999, Part 3, Section 1, pages 1C-1 through 1C-11. The 1999 water plan was published in five volumes: (1) Summary; (2) Part 1, Background and Resource Assessment; (3) Part 2, Water Use and Forecasts; (4) Part 3, Water Planning and Management Issues; and (5) Appendices.

40. Section 4 of Senate Bill 108 provided for the revision to NRS 533.370 by requiring that "In determining whether an application for an interbasin transfer of ground water must be rejected pursuant to this section, the state engineer shall consider: (a) Whether the application has justified the need to import the water from another basin; (b) If the state engineer determines that a plan for conservation of water is advisable for the basin into which the water is to be important, whether the applicant has demonstrated that such a plan has been adopted and is being effectively carried out; (c) Whether the proposed action is environmentally sound as it relates to the basin from which the water is exported; (d) Whether the proposed action is an appropriate long-term use which will not unduly limit the future growth and development in the basin from which the water is exported; and (e) Any other factor the state engineer determines to be relevant."

41. Cobourn, John, Wayne Johnson, Jean Ford, Mary Reid and Niel Allen, "Nevada's Water Future: Making Tough Choices, A Guide for Public Policy Dialogue," National/Nevada Issues Forums, University of Nevada, Reno, December 1992.

42. The Lahontan Basin refers to the drainage area of Lake Lahontan, an Ice Age which covered approximately 8,665 square miles in northwestern Nevada, eastern California and southeastern Oregon. Lake Lahontan's total drainage area covered about 45,000 square miles. See Coffin, Patrick D., and William F. Cowan, *Lahontan Cutthroat Trout Recovery Plan*, U.S. Fish and Wildlife Service, Region 1, U.S. Department of the Interior, Portland, Oregon, 1995, page 4.

43. Coffin, *op. cit.*, pages 1-2.

44. "Bring Back the Lahontan Cutthroat [Trout]," U.S. Fish and Wildlife Service, Nevada State Office, U.S. Department of the Interior, Reno, Nevada.

45. Houghton, Samuel G., *A Trace of Desert Waters: The Great Basin Story*, University of Nevada Press, Reno, Nevada, 1994, page 81.

46. Frémont, John Charles, *Report of the Exploring Expedition to the Rocky Mountains, 1842, and to Oregon and North California, 1843–44*, Washington, D.C., Gales & Seaton, 1845.

47. Extinction deals with the total removal of a species, while extirpation deals with its demise or removal from a particular area or habitat. Personal communication, Glenn Clemmer, Administrator, Nevada Natural Heritage Program, Department of Conservation and Natural Resources, Carson City, Nevada, October 1999.

48. Izaak Walton – 1593-1683. English biographer and author. Carried on draper's business in London (from 1614); retired from London to Stafford (circa 1650). Published biographies of John Donne (1640), Sir Henry Wotton (1651), Richard Hooker (1665), George Herbert (1670), and Bishop Robert Sanderson (1678). His masterpiece was *The Compleat Angler*, or *The Contemplative Man's Recreation* (1st edition, 1653; 5th edition, 1676), made up of dialogues between Piscator (angler), Venator (hunter), and Auceps (falconer), with anecdotes, quotations, country scenery, snatches of verse, enlarged by appending of part two by Charles Cotton on fly-fishing and making flies.

49. A common "fishing" practice was to divert the stream or river onto an adjoining field and then merely pick up the stranded fish both in the field and in the stream bed below the diversion.

50. McQuivey, Robert, "Nevada Environmental, Water, Habitat, Wildlife and Fisheries Historical Media Database," Reno, Nevada, 1999.

51. It is not certain that this name survived. Presently, three high peaks may be found near the Reese River headwaters: Arc Dome, 11,788 feet MSL; Toiyabe Dome, 11,353 feet MSL; and Mahogany Mountain, 11,165 feet MSL.

52. McQuivey, *op. cit.*

53. "Bring Back the Lahontan Cutthroat [Trout]," *op. cit.*

54. *Ibid.*

55. Personal communication, Doug Hunt, Habitat Bureau Chief, Nevada Division of Wildlife, Reno, Nevada, January 26, 2000.

56. NDOW Briefing Paper, July 19, 1999, *op. cit.*

57. *Central Nevadan*, Battle Mountain, July 25, 1889, from McQuivey, *op. cit.*

58. *Central Nevadan*, Battle Mountain, May 7, 1891, from McQuivey, *op. cit.*

59. The actual date of the original repayment contract between the U.S. Bureau of Reclamation and the Pershing County Water Conservation District, Contract IIr-774, was October 1, 1934. The Humboldt Project was authorized pursuant to the National Industrial Recovery Act of June 16, 1933 and the National Reclamation Act of 1902. The project's major component, Rye Patch Reservoir, was completed in 1936. Personal communication, Mike Andrews, U.S. Bureau of Reclamation, Lahontan Region Projects Office, Carson City, Nevada, July 6, 2000.

60. The water rights obtained for the Humboldt Project came largely from the purchase of ranches owned by the Aldous family (purchased on January 17, 1935) and the Fillipini family (purchased on January 26, 1935). Water rights from five other ranches were also purchased in the Battle Mountain area, but those owners retained the surface water rights. The issue of ownership of the Battle Mountain Community Pasture has repeatedly surfaced, particularly most recently with the efforts of the Pershing County Water Conservation District to obtain ownership of the Humboldt Project. With respect to the purchase of these ranches, the PCWCD's original role was to negotiate prices and secure options to purchase from the landowners. All options to purchase were assigned to the U.S. Government and the deeds have been recorded with the U.S. Government. The original 1934 contract between the U.S. Bureau of Reclamation and PCWCD was not a contract-for-deed, and therefore, according to BOR sources, the BOR has no authority to transfer title; only Congress and the President can effect that. Personal communication, Mike Andrews, *op. cit.*

61. Rawlings, *op. cit.*, page 47.

62. An alternative source has placed the area of this particular marsh at 2,040 acres. See *Battle Mountain Bugle*, September 3, 1996.

63. An alternative source has placed the area of this particular marsh at 560 acres. See *Battle Mountain Bugle*, September 3, 1996.

64. Plat Maps, Survey General's Office, State of Nevada, May 12, 1869, *op. cit.*

65. Rawlings, *op. cit.*, page 47.

66. While the issue of the disposition of the Community Pasture was already contentious in the 1960's (the U.S. Bureau of Reclamation had even considered the idea of surplusing the property to GSA for disposal), the Pershing County Water Conservation District did not actually make their final payment on the original contract until fiscal year 1978. Personal communication, Mike Andrews, *op. cit*.

67. U.S. Bureau of Reclamation Rehabilitation & Betterment Contract, August 22, 1975, personal communication, Mike Andrews, *op. cit*.

68. The firm hired was HYA Consulting Engineers, a Dames & Moore Company based in Sacramento, California. See *Lovelock Review-Miner*, December 12, 1996.

69. *Battle Mountain Bugle*, October 29, 1996.

70. The principal participants (aside from the U.S. Bureau of Reclamation, Pershing County Water Conservation District and the Nevada Division of Wildlife) included the following (in alphabetical order): Argenta Marsh Committee, Battle Mountain Shoshone Tribe, Coalition for Nevada's Wildlife, Ducks Unlimited, Elko County conservation Association, Great Basin Bassers, Great Basin Bird Observatory, Intermountain West Joint Venture, Lahontan Audubon Society, Lahontan Valley Wetlands Coalition, Lander County Commission, (The) Nature Conservancy, Nevada Bighorns Unlimited, Nevada Farm Bureau, Nevada State Council of Trout Unlimited, Nevada Wildlife Federation, Newmont Gold Company, Rocky Mountain Elk Foundation, Sierra Club and Truckee River Fly Fishers. Source: Personal communication, Doug Hunt, Habitat Bureau Chief, Nevada Division of Wildlife, Reno, Nevada, February 11, 2000.

71. NDOW Briefing Paper, July 19, 1999, *op. cit*.

72. The only project lands that the Pershing County Water Conservation District would actually be entitled to under current title transfer policy would be the *acquired* lands, unless PCWCD wanted to purchase some of the *withdraw*n lands (lands withdrawn from the public domain for project purposes) at fair market value. That issue would have to be addressed in legislation. Personal communication, Mike Andrews, *op. cit*.

73. Personal communication, Doug Hunt, Habitat Bureau Chief, Nevada Division of Wildlife, January 24, 2000.

74. The "average water year flows" represents a term denoting the average annual hydrologic conditions based upon an extended or existing complete period of record. Also referred to as the "Average Water Year". See *Water Words Dictionary, op. cit*.

75. The "Low Water Year" represents the lowest total annual volume (in acre-feet per year) and the corresponding lowest annual average rate of flow (in cubic feet per second) recorded at a specific gaging station location over a specific period of record. See *Water Words Dictionary, op. cit*.

76. The "High Water Year" represent the highest total annual volume (in acre-feet per year) and the corresponding highest annual average rate of flow (in cubic feet per second) recorded at a specific gaging station location over a specific period of record. See *Water Words Dictionary, op. cit*.

77. It should be noted that the years of record indicated in these tables for each gaging station are inclusive full years and are not necessarily reflective of continuous gaging periods. For example, while the period of record for the Humboldt River gage at Battle Mountain (USGS gage number 10325000) is listed as 1897 through 1998, the actual record is May 1896 to December 1897, March 1921 to April 1924, October 1945 to September 1981, and February 1991 to the current (1998) year. See *Water Resources Date, Nevada, Water Year 1998*, Water-Data Report NV-98-1, U.S. Geological Survey, page 222.

78. The "peak" or "maximum" flow concept used here is not to be confused with any high water or flood year flow measure. The average year peak flow represents the river's maximum rate of flow along its entire reach for a normal or average water year period of record. In essence, this location on the river represents the point after which river flows begin to decrease (attenuate) due to lack of tributary inflows, evaporation, seepage, infiltration, diversions, evapotranspiration, etc.

79. Taken at USGS gage 10311000, Carson River at Carson City, period of record 1940-1998. Actually, USGS gage 10311400, Carson River at Deer Run Road near Carson City, has shown a significantly greater average year peak flow (389,500 acre-feet per year); however, this gage's period of record is only for 1979-1998, making its record less representative of actual, long-term average-year Carson River flow conditions.

80. Taken at USGS gage 10293000, East Walker River near Bridgeport, California, below Bridgeport Reservoir (107,150 acre-feet per year), for period of record 1922-1998, and USGS gage 10296500, West Walker River near Coleville, California, above Topaz Reservoir (203,440 acre-feet per year), for period of record 1903-1998.

81. Taken at USGS gage 10350000, Truckee River at Vista, Nevada, just downstream from entrance of Steamboat Creek (and the outflows from Truckee Meadows Water Reclamation Facility), for period of record 1899-1998.

82. This figure was derived by taking the combined water productivity coefficient for the western Nevada watersheds of 136.7095 acre-feet of peak flows per square mile of total surface area (1,211,930 acre-feet divided by 8,865 square miles) and dividing it by the Humboldt River Basin's water productivity coefficient of 17.2796 acre-feet of peak flows per square mile of total surface area (291,040 acre-feet divided by 16,843 square miles), yielding a ratio of 7.9116.

83. This figure was derived by dividing the combined western Nevada watershed's adjusted water productivity ratio of 414.3350 acre-feet per year per square mile of actual drainage area (1,211,930 acre-feet divided by 2,925 square miles of actual upstream drainage area) by the Humboldt River's adjusted water productivity factor above Palisade of 58.0918 acre-feet per year per square mile of actual drainage area (291,040 acre-feet divided by 5,010 square miles of upstream drainage), resulting in a ratio of 7.1324.

84. Blakemore, Thomas E., H.W. Hjalmarson, and S.D. Waltemeyer, *Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States*, U.S. Geological Survey Water-Supply Paper 2433, 1993, page 122.

85. *Ibid.*, page 142.

86. Calculated by multiplying the total surface area in square miles, times 640 acres per square miles, times precipitation in feet, thereby providing an estimate of surface precipitation in acre-feet.

87. For the Truckee River, irrigation diversions above the peak flow point are made within the Truckee Meadows for less than 20,000 acres; within the Carson River, diversions are made above the peak flow point within Carson Valley for just over 30,000 acres; and within the Walker River system, diversion are made above the East Fork's peak flow point in Bridgeport Valley above Bridgeport Reservoir for about 28,000 acres and above the West Fork's peak flow point in Antelope Valley for about 20,000 acres. This represents a combined total of approximately 98,000 irrigated acres above these respective river's peak flow points. See Horton, *Truckee River Chronology*, *Carson River Chronology*, and *Walker River Chronology*.

88. Included are totals for the Mary's River sub-basin, Ruby Mountains sub-basin, North Fork Humboldt River sub-basin, Maggie Creek sub-basin and the Elko Reach sub-basin. *Humboldt River Basin, Nevada, Water and Related Land Resources*, various reports, *op. cit.*

89. Consumptive use is that portion of water withdrawn from a surface or groundwater source that is consumed for a particular use (e.g., irrigation, domestic needs, and industry), and does not return to its original source or another body of water. See *Water Words Dictionary, op. cit.*

90. The irrigation leaching requirement is the theoretical amount of irrigation water that must pass (leach) through the soil beyond the root zone to keep soil salinity within acceptable levels for sustained crop growth. See *Water Words Dictionary, op. cit.*

91. Water withdrawal measures presented in these estimates include return flows and water reuse, while decreed water rights are generally for a specified water duty applied to decreed land and typically represent consumptive use only. Actual water diversions for irrigation will normally include a "leaching" requirement in addition to the consumptive use requirement. Also, these latter figures are somewhat over-stated as a relatively small portion of the Elko County acreage and irrigation figures are for areas lying entirely outside the Humboldt River Basin or are within the Battle Mountain sub-basin of western Elko County and are located in drainage areas below the Palisade gage.

92. See "Nevada Water Supply and Use," U.S. Geological Survey Water-Supply Paper 2350 and other issues, U.S. Department of the Interior, Water Resources Division, Carson City, Nevada; *U.S. Census of Agriculture, 1987*, Volume 1, Geographic Area Series, Nevada and County Data, U.S. Department of Commerce, Bureau of the Census, Agriculture Division, Washington, D.C., June 1989; and *Nevada State Water Plan*, Nevada Division of Water Planning, Department of Conservation and Natural Resources, Carson City, Nevada, April 1999.

93. Palisade Canyon, just downstream from the present-day site of Carlin, was a major impediment to early emigrant wagon trains. Most of the early wagon trains detoured around this rugged canyon to the north over part of the Tuscarora Range along a trail which now parallels present-day Interstate Highway 80. John Hawkins Clark noted in his diary in 1852: "The mountains we are crossing [Tuscarora Range] today stands at right angles with our road and cuts the valley of the Humboldt [River] into two separate divisions, making an upper and lower Humboldt [River] Valley." See Curran, Harold, *Fearful Crossing – The Central Overland Trail Through Nevada*, Great Basin Press, Reno, Nevada, 1982, pages 88-89.

94. The Federal Emergency Management Agency (FEMA) has estimated that the peak flood discharge of the Reese River, at 8,620 cubic feet per second for a 100-year flood event (the recurrence interval), is nearly 15 percent larger than that flood discharge of the Humboldt River at the Battle Mountain gaging station, which was estimated to be 7,510 cubic feet per second for a 100-year flood event. FEMA has estimated that the peak discharges for these two river systems for different predicted recurrence intervals are as follows: (1) Reese River, drainage area – 2,330 square miles; peak discharge: 10-year flood – 3,960 cfs; 50-year flood – 6,870 cfs; 100-year flood – 8,620 cfs; and 500-year flood – 12,600 cfs. (2) Humboldt River at the Battle Mountain gage, drainage area – 8,870 square miles; peak discharge: 10-year flood – 3,680 cfs; 50-year flood – 6,270 cfs; 100-year flood – 7,510 cfs; and 500-year flood – 10,700 cfs. See "Flood Insurance Study," Lander County, Nevada (Unincorporated Areas), Federal Emergency Management Agency, July 15, 1988, page 10.

95. Eakin, *op. cit.*, page 36.

96. Cohen, Philip, *Water in the Humboldt River Valley Near Winnemucca, Nevada*, Water Resources Bulletin No. 27, Department of Conservation and Natural Resources, State of Nevada, Prepared in Cooperation with the U.S. Geological Survey, Department of the Interior, Carson City, Nevada, 1964, page 30.

97. USGS gaging station number 10329000, Little Humboldt River near Paradise Valley, Nevada.

98. USGS gaming station number 10329500, Martin Creek near Paradise Valley, Nevada.

99. Personal communication, Jack L. Boyd, Halleck, Nevada, May 22, 2000.

100. Due to their relatively shorter periods of record (1935-1998 and 1936-1998, respectively), readings for the Imlay and Lovelock Valley USGS gages tend to be overstated, i.e., they should be smaller as their periods of record do not include the extreme drought period of the early 1930's. The readings for these two gages do, however, correspond to the period of construction of Rye Patch Reservoir.

101. See Seaber, Paul R., F. Paul Kapinos, and George L. Knapp, *Hydrologic Unit Maps*, USGS Water-Supply Paper 2294, U.S. Geological Survey, U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C., 1987.

102. These eleven sub-basin definitions, derived from the 12-volume study referenced below, generally follow, but are not always exactly the same as, the defined Nevada hydrographic areas, which constitute smaller hydrologic units within Nevada's fourteen hydrographic regions or basins, of which the Humboldt River Basin is Hydrographic Basin 4. Where differences existed between these sub-basin classifications and the defined Nevada hydrographic areas, the hydrographic area boundaries were used instead. See the 12-volume series *Humboldt River Basin, Nevada, Water and Related Land Resources,* based on a cooperative survey by the Nevada Department of Conservation and Natural Resources and the United State Department of Agriculture and prepared by the USDA's Economic Research Service, Forest Service and Soil Conservation Service, in the bibliography.

103. Mary's River was one of the first names assigned to the Humboldt River (after "Unknown River") by Peter Skene Ogden and was named after the Indian wife of one of Ogden's trappers.

104. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Four, *op. cit.*, page 11.

105. Young, James A., Philip C. Martinelli, Richard E. Eckert, Jr., and Raymond A. Evans, *Halogeton: A History of Mid-20th Century Range Conservation in the Intermountain Area,* Miscellaneous Publication Number 1553, Agricultural Research Service, U.S. Department of Agriculture, August 1999, page 1.

106. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Twelve, *op. cit.*, page 15.

107. *Ibid.*, pages 3-4.

108. *Ibid.*

109. The Ruby Mountains got its name in September 1854 when a member of Colonel E.J. Steptoe's detachment searching for a feasible military route across central Nevada found "rubies" (actually garnets) in his gold pan while prospecting one of the streams above Ruby Valley (east side of the Ruby Mountain range) near Hastings Pass (later renamed Overland Pass). The range was then named the Ruby Mountains by Colonel Steptoe, replacing the name Humboldt Mountains assigned by John C. Frémont in 1845 during his Great Basin expedition. See *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 2.

110. Some local historians believe that the 1841 Bartleson-Bidwell Party actually crossed the Ruby Mountains not at Harrison Pass, but instead used a trail some two miles north of this location, first called Trail Pass and now Road Pass. (Personal conversation, Cliff Gardner, Ruby Valley, August 1999.)

111. Frémont's first expedition west was conducted in 1842 and left from St. Louis, Missouri, but only got just beyond South Pass in the northern Rocky Mountains of Wyoming. See Grayson, *op. cit.*, pages 3–4.

112. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 2.

113. *Ibid.*

114. *Ibid.*, pages 6-7.

115. *Ibid.*, page 9.

116. *Ibid.*, pages 10-11.

117. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Five, *op. cit.*, page 1.

118. *Ibid.*, page 3.

119. *Ibid.*, pages 1-2.

120. *Ibid.*, page 4.

121. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 4.

122. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Five, *op. cit.*, pages 4-5.

123. *Ibid.*, page 9.

124. *Ibid.*, pages 9-10.

125. *Ibid.*, pages 11-12.

126. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Six, *op. cit.*, page i.

127. *Ibid.*, page 1.

128. Nevada Historical Marker 112, “Carlin,” and *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Six, *op. cit.*, pages 1-2.

129. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Six, *op. cit.*, page 2.

130. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 2.

131. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Six, *op. cit.*, page 2.

132. *Ibid.*

133. *Ibid.*, page 3.

134. *Ibid.*, page ii and pages 5-6.

135. *Ibid.*, page 6.

136. *Ibid.*, pages 6-7.

137. On this, the fifth of his Snake Country Expeditions, Ogden was adhering to his Company’s “scorched earth” policy. This policy had a three-fold objective: (1) combat the American fur trappers on their home grounds, including the Great Basin, instead of the Company’s lands farther north; (2) deplete the Snake and the Great Basin areas of their fur resources before the final settlement of the boundary line between the United States and Canada restricted these areas to the Hudson’s Bay Company; and (3) relieve for awhile the trapping pressure on the Company’s own trapped-out holdings in western Canada. See *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, page 1.

138. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, pages 1-3.

139. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Seven, *op. cit.*, page 2.

140. *Ibid.*, page 47.

141. Hulse, James W., *The Nevada Adventure*, Sixth Edition, University of Nevada Press, Reno, Nevada, 1990, pages 49-52.

142. Curran, Harold, *Fearful Crossing – The Central Overland Trail Through Nevada*, Great Basin Press, Reno, Nevada, 1982, page 41.

143. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Seven, *op. cit.*, pages 1-6.

144. *Ibid.*, pages 10-12.

145. *Ibid.*, pages 3-5.

146. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Two, *op. cit.*, page 6.

147. *Ibid.*, pages 6-8.

148. *Ibid.*, pages 2-3.

149. *Ibid.*, pages 3-5.

150. *Ibid.*, page 3.

151. “Wet-mantle events” typically occur in the winter months (December through February) and generally consist of heavy rainfall under the following conditions: (1) rain on snow causing either flow through or snowpack metldown; (2) rain on frozen ground; (3) rain on saturated soils; or (4) some combination of these conditions.

152. While the gaging periods appear to be almost identical for these two USGS gages, i.e., 1897-1998 for the Battle Mountain gage and 1895-1998 for the Comus gage, there exist a number of discontinuous and different gaging periods for each site. For example, by continuous period of record, the Battle Mountain gage shows continuous flow readings from May 1896 to December 1897, March 1921 to April 1924, October 1945 to September 1981, and February 1991 to the current year. The Comus gage, on the other hand, shows a continuous period of record from October 1894 to December 1909, September 1910 to September 1926, and October 1945 to the current year. Interestingly, and disappointingly, both gages were not in operation during the February-April 1910 extreme flood period. Had they been in operation at that time, this surely would have been each gage’s high water (flood) record year (versus 1971 for the Battle Mountain gage and 1984 for the Comus gage). Also, with a 1910 reading a both gaging station sites, a more accurate measure could have been obtained for the 1910 record flood outflow from the Reese River. *Water Resources Data, Nevada, Water year 1998*, *op. cit.*, pages 222 and 224.

153. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eight, *op. cit.*, page 1.

154. *Ibid.*, page 2.

155. Nevada Historical Marker 95, “Battle Mountain.”

156. As of July 1, 1998, Austin’s resident population was estimated at 871 persons. (Source: Nevada State Demographer, University of Nevada, Reno, February 22, 1999.)

157. Nevada Historical Marker 8, “Austin.”

158. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eight, *op. cit.*, page 6.

159. *Ibid.*, pages 11-12.

160. *Ibid.*, pages 13-17.

161. Rock Creek typically flows year-round past its USGS gaging station, which is located some 22 miles northeast of Battle Mountain, Nevada, and the Humboldt River. This location is where Rock Creek emerges from the Sheep Creek Mountains. From that point to is confluence with the Humboldt River, flows are not generally perennial, i.e., year round, and generally dissipate on Boulder Flat (Valley).

162. Seasonal streams are defined as those streams which flow only at certain times of the year when it receives water from springs, rainfall, or from surface sources such as melting snow. Ephemeral streams are defined as those streams which flow only in direct response to precipitation and whose channel is at all times above the water table. See *Water Words Dictionary*, *op. cit.*

163. Hulse, *op. cit.*, page 125.

164. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Nine, *op. cit.*, page 2.

165. Curran, *op. cit.*, pages 43-44.

166. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Nine, *op. cit.*, pages 2-3.

167. *Ibid.*, page 3.

168. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Six, *op. cit.*, page 2.

169. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Nine, *op. cit.*, page 4.

170. *Ibid.*, pages 4-7.

171. *Ibid.*, page 13.

172. *Ibid.*, pages 14-20.

173. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, page 1.

174. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Twelve, *op. cit.*, page 5.

175. *Ibid.*, page 5.

176. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number One, *op. cit.*, page 6, and Nevada Historical Marker 89, “Paradise Valley.”

177. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number One, *op. cit.*, page 102.

178. *Ibid.*, page 102.

179. *Ibid.*, page 103.

180. *Ibid.*, page 104.

181. *Ibid.*

182. *Ibid.*, page i.

183. *Ibid.*, page 4.

184. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, pages 1-3.

185. Curran, *op. cit.*, page 41.

186. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, page i.

187. Nevada Historical Marker 2, "Pioneer Memorial Park."

188. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, page 4.

189. *Ibid.*, pages i and 5.

190. *Ibid.*, page 4.

191. Nevada Historical Marker 164, "Button Point."

192. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, page 4.

193. *Ibid.*, page 7.

194. *Ibid.*, pages 10-11.

195. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page i.

196. *Ibid.*

197. Curran, *op. cit.*, page 125.

198. *Ibid.*, pages 128-129.

199. Ibid., page 137.

200. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Twelve, *op. cit.*, page 8.

201. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 4.

202. *Ibid.*, page 8.

203. *Ibid.*, page 9.

204. *Ibid.*, page 4.

205. *Ibid.*, page 13.

206. *Ibid.*, pages 19-20.

207. Ibid., pages 21-26.

208. An adjudication is a court proceeding to determine all rights to the use of water on a particular stream system or within a specific groundwater basin. See *Water Words Dictionary, op. cit.*

209. A hydrographic basin (basin, area or sub-area) is considered closed with respect to surface water flow if its topography prevents the occurrence of visible surface water outflow. It is closed hydrologically if neither surface nor underground water outflow can occur. See *Water Words Dictionary, op. cit.*

210. The exception to this is the adjudication of the water rights of E.C. and H.L. Lye whose property lies along Indian Creek in the Little Humboldt River sub-basin. The Lye property was granted certain rights under Suit No. 1383, known as the Bonnifield Decree. This Decree grants the Lyes a prior right to the use of 16 cubic feet per second of Indian Creek water over the rights of the Dooley, Recanzone and Harvey properties. The Decree does not hold against any others within the Little Humboldt River system. The Lye property consists of 270.96 acres of harvest crop land and 26.57 acres of pasture land irrigated by Indian Creek from the Section Line ditch; 510.30 acres of harvest crop land and 173.69 acres of pasture land irrigated by Indian Creek from the Haviland ditch; and 214.30 acres of crop land irrigated by Indian Creek by means of the Silve ditch. In addition, the Lyes also obtained the M. Dooley property consisting of 59.01 acres of pasture land irrigated with Indian Creek waters via the Nos. 1, 2 and 3 ditches. See *Abstract of Claims Little Humboldt River*, In the matter of the Determination of the Relative Rights in and to the Waters of the Little Humboldt River and its Tributaries in Humboldt and Elko Counties, Office of the

State Engineer, State of Nevada, 1929, pages 11, 19 and 27, and Muth, Edmund, Deputy State Engineer, "Field Investigation: Water Distribution Report and Recommendations on Little Humboldt River and Tributaries in Nevada," Office of the State Engineer, Department of Conservation and Natural Resources, State of Nevada, Carson City, Nevada, 1943, page 18.

211. A vested water right is a right to use either surface or ground water acquired through more or less continual beneficial use prior to the enactment of water law pertaining to the source of the water. These claims become final through adjudication, i.e., a judicial process. See *Water Words Dictionary, op. cit.*

212. Within the Reese River drainage, only Silver Creek water rights have been adjudicated consisting of 345 acres and 1,635 acre-feet of water. Elsewhere within the total Reese River sub-basin, in Carico Lake Valley two streams, Carico Creek and Crum-Wilson Creeks, have been adjudicated for a total of 966 acres and 2,227 acre-feet of water. On all streams the adjudications provide for varying quantities of water per acre, ranging from 1.5 to 6 acre-feet per acre per year (season). See *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eight, *op. cit.*, page 23.

213. As previously noted, the Palisade location, and particularly the U.S. Geological Survey Palisade gage (number 10322500) has historically been considered as the Humboldt River's dividing point between an upper and lower Humboldt River Basin. Above this point the Humboldt River's flows are generally considered to be increasing and below this point, due to considerably reduced tributary inflows, the Humboldt River's flows are generally considered to be decreasing. Also, tributary streams and sub-basins above this point are considered to be in the upper portion of the basin and those flowing into the Humboldt River main stem below this point to be in the lower Humboldt River Basin. In the Bartlett and Edwards decrees, this concept was extended to use the Palisade location as a dividing point to indicate differences in climate and length of irrigation seasons between the upper and lower Humboldt River basins.

214. Hennen, George W., *Humboldt River Water Distribution*, Part 1 – Problems, Part II – Priority Tables, Division of Water Resources, Department of Conservation and Natural Resources, State of Nevada, April 1964, page 9.

215. See *(The) Humboldt River Adjudication, 1923 – 1938*, Compiled by Gray Mashburn, Attorney General and W.T. Mathews, Deputy Attorney General, State Printing Office, Carson City, Nevada, 1943, Section No. 1, Findings of Fact, Conclusions of Law, and Decree of Judge George A. Bartlett, Known as the Barlett Decree, and Section No. 3, Findings of Fact, Conclusions of Law and Decree of Judge H.W. Edwards, Known as the Edwards Decree.

216. More specifically, to secure the benefit of the doctrine of relation, there must be posted a notice of appropriation (which must be recorded), there must be a bona fide intention to use the water for a beneficial purpose, there must be diligence in the construction work, and the work must be completed (i.e., the waters conducted to the place of intended use). Actual application of the water is not a prerequisite to the vesting of the right. The right is complete when possession has been taken. When these requisites have been completed the right to the water relates back to the date of posting notice, in order to determine priority between conflicting claims. See Malone, George, W., State Engineer of Nevada, "Humboldt River Distribution and Different Features Affecting These Deliveries for the Years 1927 to 1931, Inclusive," State Printing Office, Carson City, Nevada, 1932, pages 12-13.

217. A water right has several characteristics, one of which is the location of where the water will be put to beneficial use. An "appurtenant water right" is a water right that belongs to the legal owner of the land described as the place of use of the water right. See *Water Words Dictionary, op. cit.*

218. Hennen, *op. cit.*, page 10.

219. Ibid., pages 9-10.

220. Shamberger, Hugh A., *Evolution of Nevada's Water Laws, as Related to the Development and Evaluation of the State's Water Resources, From 1866 to About 1960*, Water Resources Bulletin 46, Prepared by the U.S. Department of the Interior, Geological Survey in cooperation with the Nevada Division of Water Resources, Department of Conservation and Natural Resources, 1991, page 5.

221. The prior appropriation date, or priority date, is the date of establishment of a water right; the officially recognized date associated with a water right. The rights established by application have the application date as the date of priority. Relative to other water rights, the priority date may make a water right senior (predating other rights) or junior (subordinate to other rights). See *Water Words Dictionary, op. cit.*

222. The prior appropriation doctrine is based on the concept of "First in Time, First in Right". The first person to take a quantity of water and put it to beneficial use has a higher priority of right than a subsequent user. Under drought conditions, higher priority users are satisfied before junior users receive water. Appropriative water rights can be lost through nonuse; they can also be sold or transferred apart from the land. See *Water Words Dictionary*,

op. cit.

223. Riparian water rights are the rights of the owners of lands on the banks of watercourses, relating to the water, its use, ownership of soil under the stream, accretion, etc. The term is generally defined as the right which every person through whose land a natural watercourse runs has to the benefit of the stream as it passes through his land for all useful purposes to which it may be applied. See *Water Words Dictionary*, *op. cit.*

224. Young, James A., and B. Abbott Sparks, *Cattle in the Cold Desert*, Utah State University Press, Logan, Utah, 1985, page 143.

225. The primary contentions questioning the law's constitutionality were first, that as a special law it applied to only particular rights to the use of water and embraces only a part of the territory of the State. Second, it took away vested rights of property without due process of law and without giving the owner an opportunity to be heard. Third, it granted rights and imposed burdens upon some of the citizens of the State, which are not granted to or imposed upon others. And fourth, it delegated the law-making power to the Governor and clothed him with power to create water districts and the discretion to extend to or withhold from the people of the State the provisions of a statute law. See Grace Dangberg, *Conflict on the Carson*, Carson Valley Historical Society, Minden, Nevada, November 1975, pages 90–91.

226. Young, *op. cit.*, 1985, pages 143-144.

227. *Biennial Report of the State Engineer, 1909–1910*, State of Nevada, State Printing Office, Carson City, Nevada, 1911, page 3.

228. Shamberger, *op. cit.*, page 20.

229. Ibid., page 21.

230. Ibid., pages 23–28.

231. The date of establishment of a water right; the officially recognized date associated with a water right. The rights established by application have the application date as the date of priority. Relative to other water rights, the priority date may make a water right senior (predating other rights) or junior (subordinate to other rights). See *Water Words Dictionary, op. cit.*

232. *(The) Humboldt River Adjudication, 1923 – 1938, op. cit.*, Section No. 1, page 3.

233. *Ibid.*

234. *Ibid.*, page 5.

235. On this point it was noted that "The Court finds that the growing season in Lovelock [Valley] and the lower reaches of the Humboldt River is more than thirty days earlier than the growing season in Elko County, and that the temperatures in the upper reaches are lower than in Lovelock. The Court further finds that the temperature varies between Battle Mountain and Lovelock, as well as between Lovelock and Elko. The Court finds from the evidence that there is a difference in the irrigation season between Battle Mountain and Lovelock of approximately three weeks and a difference in the irrigation season between Winnemucca and Lovelock of approximately ten days; that the Battle Mountain District irrigates approximately 20 days earlier than the Elko District. The evidence shows the most economical method of irrigation on the Humboldt River is to begin irrigation at Lovelock in the earlier spring and progress up stream to the Elko District. Such a system of irrigation is the most economical and the only system that will serve the proper priorities on the entire stream system, and the Court finds from the evidence that this was the system under which the water rights along the Humboldt River were initiated and used since the first irrigation of said stream system." See *(The) Humboldt River Adjudication, 1923 – 1938, op. cit.*, Section No. 1, page 29.

236. *Ibid.*, pages 9-11.

237. *Ibid.*, page 29.

238. The rate of flow in District No. 1 was based upon an irrigation system of the following approximate lengths: 180 days for Class A lands, 90 days for Class B lands, and 45 days for Class C lands. That in District No. 2 was 120 days for Class A lands, 60 days for Class B lands, and 30 days for Class C lands. Further, the water duty of the cultured areas was established as follows: Harvest Crop lands (Class A) 3 acre-feet; Meadow Pasture (Class B) 1.5 acre-feet; and Diversified Pasture, 0.75 acre-feet. See *(The) Humboldt River Adjudication, 1923 – 1938, op. cit.*, Section No. 1,, pages 52 and 242-243

239. *(The) Humboldt River Adjudication, 1923 – 1938, op. cit.*, Section No. 2, page 3.

240. *Ibid.*, pages 4-5.

241. *Ibid.*, pages 6-12.

242. *Ibid.*, pages 13-14.

243. *Ibid.*, pages 15-16.

244. *Ibid.*, pages 17-18.

245. *Ibid.*, pages 19-20.

246. *Ibid.*, pages 21-22.

247. *Ibid.*, pages 11-12.

248. *Abstract of Claims Little Humboldt River*, In the matter of the Determination of the Relative Rights in and to the Waters of the Little Humboldt River and its Tributaries in Humboldt and Elko Counties, Office of the State Engineer, State of Nevada, 1929.

249. *Proposed Findings of Fact, Conclusions of Law and Decree*, in the District Court of the Sixth Judicial District of the State of Nevada, in and for the County of Humboldt, No. 3157, In the Matter of the Determination of the Relative Rights in and to the Waters of the Little Humboldt River and Its Tributaries in Humboldt and Elko Counties, January 24, 1935 [E.P. Carville Decree], pages 73-74.

250. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number One, *op. cit.*, page 9.

251. *(The) Humboldt River Adjudication, 1923 – 1938*, *op. cit.*, Section No. 2, pages 1-105.

252. Hennen, *op. cit.*, page 9.

253. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 18.

254. *(The) Humboldt River Adjudication, 1923 – 1938*, *op. cit.*, Section No. 4, pages 1-6.

255. Hennen, *op. cit.*, page 3.

256. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 18.

257. The exception to this being that the water rights of E.C. and H.L. Lye within the Little Humboldt River sub-basin (Indian Creek) were determined by the Bonnifield Decree. See Muth, *op. cit.*

258. Correspondence, U.S. Bureau of Reclamation, Lahontan Basin Area Office, Carson City, Nevada, July 1999.

259. Some disagreement continues to exist over whether it was Nevada's mineral wealth or its electoral votes that facilitated its admission to the Union. Admittedly, both were important issues to the Union's Civil War effort at the time.

260. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Twelve, *op. cit.*, page 8

261. Nevada Historical Marker 145, "Unionville."

262. Nevada Historical Marker 231, "Star City."

263. As of July 1, 1998, Austin's population was estimated at 871 persons. (Source: Nevada State Demographer, University of Nevada, Reno, February 22, 1999.)

264. Nevada Historical Marker 8, "Austin."

265. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eight, *op. cit.*, page 4.

266. Actually, it was later determined that Poker Brown (see 1862 chronology entry in Part II) was apparently the only rancher who had been granted permission by the mining company to use the waters of the lower Humboldt River. (See *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, pages 8-9.)

267. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 8.

268. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 2.

269. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 3.

270. Nevada Historical Society, University of Nevada, Reno.

271. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Twelve, *op. cit.*, page 8.

272. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, pages i and 5.

273. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Nine, *op. cit.*, page 5.

274. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Six, *op. cit.*, page 3.

275. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Nine, *op. cit.*, page 6.

276. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Twelve, *op. cit.*, page 11.

277. In addition to the counties of Elko, Eureka, Humboldt, Lander and Pershing counties, the Humboldt River Basin also includes relatively small portions of Churchill County (Humboldt Sink), Nye County (upper Reese River Valley) and White Pine County (upper Huntington Valley).

278. In addition to the five principal counties of the Humboldt River Basin, the sixth major mineral producing county is Nye County in central Nevada (Central Hydrographic Region). In 1998, Nye County had $241.26 million in total valuation of mineral proceeds, of which $227.47, or 94.3 percent was gold and silver production. Source: "Net Proceeds of Minerals", Nevada Department of Taxation, Division of Assessment Standards, Centrally Assessed Properties, State of Nevada, Carson City, Nevada, April 20, 1999.

279. The Meikle Mine in Elko County, owned by Barrick Goldstrike, is the largest underground gold mine in the United States, producing 847,313 ounces of gold in 1998. The open-pit Betze-Post Mine in Eureka County north of Carlin, also owned by Barrick, is the single largest gold mine in the United States, producing 1,498,683 ounces of gold in 1998. Source: "The Nevada Mineral Industry in 1998", Special Publication MI-1998, Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno, 1999.

280. For example, Professor John L. Dobra, Natural Resource Industry Institute, University of Nevada, Reno, has estimated that for every four jobs in the mining industry, another three jobs are created in other industry sectors in the local economy, equivalent to an employment 'multiplier' of 1.75 (the ratio of total jobs, 7 [4 + 3], to mining jobs, 4). Using this employment (job) impact estimate, the 9,216 jobs in mining in the Humboldt River Basin counties in 1998 were responsible for an additional 6,900 jobs. Furthermore, the decline in mining jobs of 1,083 from 1997 to 1998, should result in the further employment contraction within the region of 800 jobs in other industry sectors.

281. As one example of these far-reaching effects on employment in other industries and areas outside the county where mining is conducted, mining-related jobs in Washoe County, which consist primarily of administrative, exploration and laboratory jobs in support mining operations in the rural counties, have declined from a peak of 1,513 jobs in 1990 to 656 jobs in 1997 and then to only 513 mining-related jobs in 1998. Source Data: Nevada Department of Employment, Training and Rehabilitation (DETR), Research and Analysis Bureau, September 1999.

282. In addition, mining employment accounted for 1.4 percent of all workers in Nevada in 1998 as compared to 1.7 percent of the state's total employment in 1997. In 1998, the Nevada mining industry paid $699.18 million in total payrolls to its workers, down 4.4 percent from $731.75 million in total payrolls in 1997. In 1998, the mining industry's payrolls accounted for 2.5 percent of statewide payrolls as compared to 2.9 percent of total payrolls in 1997. Some trends, however, reflected the continuation of mining and milling higher grade ore bodes or existing bodies of reserves, while laying off exploration and other workers in the process. The result of these actions was the retention of more skilled (and higher paid) mine workers and higher levels of productivity in terms of dollar-valued output per worker. For example, mining jobs averaged $52,824 per worker in annual wages in 1998, up 5.8 percent from an average annual wage of $49,905 per worker in 1997. Mining workers' average wage was 74.9 percent higher than the average all-industry Nevada wage of $30,195 in 1998. Productivity measures were also affected as efforts were made to maintain production levels while using fewer workers. For example, on average, the mining worker in Nevada produced $226,544 in gross proceeds in 1998, up from $212,650 in gross proceeds in 1997. This productivity level for 1998 effectively covered the average mining wage for that year by 4.3 times.

283. The troy weight is a system of units of weight in which the grain is the same as in the avoirdupois weight system and the pound contains 12 ounces, 240 penny weights, or 5,760 grains. See *Water Words Dictionary, op. cit.*

284. In an effort to off-set this 9.5 percent price decline and attempt to maintain revenues from gold sales, Nevada's gold mines actually increased gold production in 1998, from 7.828 million ounces in 1997 to 8.860 million ounces in 1998, an increase of 13.2 percent. Since 1995, however, despite a 31 percent increase in gold production, the value of the of the state's total gold production has risen by only 0.3 percent, due entirely to a 23.4 percent decline in gold's price (from $384.09 per ounce received in 1995 to $294.04 per ounce in 1998).

285. *BusinessWeek*, McGraw-Hill Companies, New York, New York, October 11, 1999, page 43.

286. Mine dewatering applies to surface (open-pit) mines as well as underground mines.

287. The conversion from weight (tons) to volume (cubic yards) was estimated at 1.3 tons per cubic yard. Source: Nick Horning, President, Nevada Hydrocarbon, Lockwood, Nevada, July 1999.

288. Shaw, W. Douglass, "Gold Mining in the Humboldt River Basin of Nevada," Department of Applied Economic and Statistics, College of Agriculture, University of Nevada, Reno, 1998, page 5.

289. In November 1997 Hydrologic (Colorado) Consultants, Inc. (HCI) published a report for Newmont Gold Company which estimated current and proposed dewatering activities for a number of mining operations in the Humboldt River Basin. In total, seven mining operations were listed showing existing or proposed (Leeville Mine) groundwater pumping (dewatering) operations amounting to nearly 250,000 gallons per minute (gpm), or over 400,000 acre-feet per year. In addition to an analysis of the mines' dewatering operations and the effects on river flows, the HCI report also estimated the ultimate size of the mine pit lakes which would form once pumping operations ceased. In total, it was estimated that the twelve mine lakes analyzed would fill with nearly 1,370,000 acre-feet of groundwater. Based on a total surface area of 2,952 acres, an estimated 11,300 acre-feet would be evaporated from the pit lakes each year. (This estimate is based on a total surface area of 2,952 acres and an average annual rate of evaporation of 46 inches, or approximately 3.83 feet per year.) See "Preliminary Assessment of Cumulative Impacts on Humboldt River Streamflow from Mining Operations in Humboldt River Basin," HCI-1718, Hydrologic Colorado Consultants, Inc., Lakewood, Colorado, November 1997.

290. The Betze-Post Mine is technically owned by Barrick Goldstrike Mines Inc., which is a wholly-owned subsidiary of Barrick Gold Corporation.

291. *Annual Report 1997*, Barrick Gold Corporation, Toronto, Canada, page 16.

292. At an average conversion of 1.3 tons per cubic yard, 159 million tons is equivalent to 122,308,000 cubic yards which is equivalent to a water-equivalent volume of 75,810 acre-feet.

293. Much controversy exists over the potential magnitude of the impacts that mine dewatering operations will have on groundwater conditions and surface water flows. However, it should be noted that in three Draft Environmental Impact Statements (DEIS's) on projects on the Carlin Trend – the Gold Quarry expansion, Betze-Post and Leeville – sophisticated hydrologic modeling indicated that the maximum impact on flows in the Humboldt River will be less than 8 cubic feet per second. These studies also concluded that there are very few areas where surface springs will be affected.

294. Commonly, groundwater mounding is an outward and upward expansion of the free water table caused by shallow re-injection, percolation below and impoundment, or other surface recharge method (essentially, the reverse of the cone of depression effect created by a pumping well). Mounding can alter groundwater flow rates and direction; however, the effects are usually localized and may be temporary, depending upon the frequency and duration of the surface recharge events. See *Water Words Dictionary, op. cit.*

295. This represents a joint operation between Barrick and Newmont with the water coming from a Barrick mine and being used for irrigation on farmlands owned by Newmont Gold Mining.

296. Bathker, Colleen, "Technical Issue Paper: Mine Dewatering in the Humboldt River Basin," Unpublished manuscript, Nevada Division of Water Planning, Department of Conservation and Natural Resources, Carson City, Nevada, September 1995, pages 1-6.

297. Correspondence, Leo Drozdoff, P.E., Chief, Bureau of Water Pollution Control, Nevada Division of Environmental Protection (NDEP), December 14, 1999.

298. A term indicating the hydrogen ion concentration of a solution, i.e., a measure of the solution's acidity. The term (from French, pouvoir hydrogène, or literally, "hydrogen power") is defined as the negative logarithm of the concentration of H+ ions (protons): $pH = -\log10\ [H^+]$, where $[H^+]$ is the concentration of H^+ ions in moles per liter. Acid solutions have a pH ranging from 6 (for a weak acid) to 1 (for a strong acid). Inversely, a basic solution has a low concentration of H_3O^+ ions and an excess of OH^- ions, and the pH ranges from 8 (for a weak base) to 14 (for a strong base). See *Water Words Dictionary, op. cit.*

299. A measure of the amount of material dissolved in water (mostly inorganic salts). Typically aggregates of carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, etc. of calcium, magnesium, manganese, sodium, potassium, and other cations which form salts. The inorganic salts are measured by filtering a water sample to remove any suspended particulate material, evaporating the water, and weighing the solids that remain. An important use of the measure involves the examination of the quality of drinking water. Water that has a high content of inorganic material frequently has taste problems and/or water hardness problems. As an example, water that contains an excessive amount of dissolved salt (sodium chloride) is not suitable for drinking. High TDS solutions have the capability of changing the chemical nature of water. High TDS concentrations exert varying degrees of osmotic pressures and often become lethal to the biological inhabitants of an aquatic environment. The common and synonymously used term for TDS is "salt". Usually expressed in milligrams per liter. See *Water Words Dictionary, op. cit.*

300. Personal communication, Leo Drozdoff, *op. cit.*, December 20, 1999.

301. Bathker, *op. cit.*, page 8.

302. The 14 hydrographic areas included: (1) 53 – Pine Valley; (2) 54 – Crescent Valley; (3) 55 – Carico Lake Valley; (4) 56 – Upper Reese River Valley; (5) 57 – Antelope Valley; (6) 58 – Middle Reese River Valley; (7) 59 – Lower Reese River Valley; (8) 60 – Whirlwind Valley; (9) 61 – Boulder Flat; (10) 62 – Rock Creek Valley; (11) 63 – Willow Creek; (12) 64 – Clovers Area; (13) 65 – Pumpernickel Valley; and (14) 66 – Kelly Creek Valley.

303. "Humboldt River Basin Assessment Briefing Paper, Phase One Progress, Phase Two Plans," U.S. Geological Survey, Water Resources Division, U.S. Department of the Interior, Carson City, Nevada, December 1998.

304. Website address: < http://nevada.usgs.gov/humbl >

305. The branch of physics having to do with the mechanical properties of water and other liquids in motion and with the application of these properties in engineering. See *Water Words Dictionary, op. cit.*

306. For example, see Crompton, E. James, "Potential Hydrolgoic Effects of Mining in the Humboldt River Basin, Northern Nevada," Water-Resources Investigation Report 94-4233, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1995; Maurer, Douglas K., Russell W. Plume, James M. Thomas, and Ann K. Johnson, "Water Resources and Effects of Changes in Ground-Water Use Along the Carlin Trend, North-Central Nevada, Water-Resources Investigation Report 96-4134, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1996; Plume, Russell, W., "Water Resources and Potential Effects of Ground-Water Development in Maggie, Marys, and Susie Creek Basins, Elko and Eureka Counties, Nevada," Water-Resources Investigations Report 94-4222, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1995; and Plume, Russell, W., and David A. Ponce, "Hydrologic Framework and Ground-Water Levels, 1982 and 1996, Middle Humboldt River Basin, North-Central Nevada," Water-Resources Investigations Report 98-4209, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1999.

307. Here a principal concern is that the "cone of depression" exerted by the "draw" of the pit during filling may well alter the groundwater gradient, i.e., flow, from established routes and courses. This could affect nearby springs and stream flows and water right holders who use those waters.

308. A sinking or lowering of a large area of the earth's crust. Typically this may result from the over-pumping of a basin's water table and the inability of the soils to re-absorb water from natural or artificial injection. Also frequently results from overdrafts of the aquifer and its inability to fully recharge, a process termed aquifer compaction. See *Water Words Dictionary, op. cit.*

309. Most of these open pits lie in an evaporation band of 44-46 inches per year, meaning that nearly four feet of surface water evaporation will occur annually once groundwater is used to fill the pit lakes.

310. When the pits are allowed to fill with water, rocks comprising the pit lake walls will have the opportunity to interact with the water under newly aerobic (in the presence of air or free oxygen) conditions. This may allow acidic compounds to form, changing the original water chemistry and potentially impacting surrounding groundwater, as well as wildlife which may be drawn to the newly-formed pit lake. See *Bathker, op. cit.*, page 9.

311. *Nevada State Water Plan, 1999*, Nevada Division of Water Planning, Department of Conservation and Natural Resources, Carson City, Nevada, April 1999.

312. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Reports Number One through Twelve, Nevada Department of Conservation and Natural Resources and the U.S. Department of Agriculture, 1962-1966.

313. Crompton, E. James, "Potential Hydrolgoic Effects of Mining in the Humboldt River Basin, Northern Nevada," Water-Resources Investigation Report 94-4233, U.S. Geological Survey, U.S. Department of the Interior, Carson City, Nevada, 1995.

314. For more information on the methodology of using estimated irrigated acreage times and estimated county-specific irrigation water use factor or coefficient (acre-feet per acre per year) to estimate total irrigation (and livestock) water withdrawals, see the Nevada Division of Water Planning's *1999 Nevada State Water Plan*, Part 2 – Water Use and Forecasts, Section 5 – Technical Supplement, Water Use Coefficient and Related Forecast Factor Development and Applications.

315. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eight, *op. cit.*, page 6.

316. Nevada Historical Marker 109, "Lamoille Valley."

317. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, pages 2-3.

318. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Five, *op. cit.*, page 4.

319. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Four, *op. cit.*, page 2.

320. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Nine, *op. cit.*, page 3.

321. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 9.

322. Nevada Historical Marker 164, “Button Point.”

323. Young, *op. cit.*, 1999, page 3.

324. *Ibid.*, page 4.

325. *Ibid.*, page 8.

326. The July 15, 1951 issue of Life Magazine, in particular, had an article (pages 55-56) on the “Sheep-Killing Weed” with graphic photographs of dead and dying sheep strewn across the salt desert while another sheep nibbled away on an innocent-looking halogeton plant. The article commented that halogeton could be suppressed through proper range management techniques. See Young, *op. cit.*, 1999 page 48.

327. Young, *op. cit.*, 1999, page 14.

328. *Ibid.*, page vi.

329. *Ibid.*, pages 3-4.

330. *Ibid.*, page 9.

331. Crested wheatgrass was introduced in North America in 1897 by the South Dakota botanist N.E. Hansen, who worked as a plant explorer for the U.S. Department of Agriculture. Hansen obtained his seed from V.S. Bogden at the Valuiki Experiment Station on the Volga River in southern Russia. Even though Bogden may have collected crested wheatgrass seed from areas where halogeton was present, given the plant’s requirement for sodium chloride, it is doubtful that the weed would have flourished in the black soil belt of Russia. See Young, *op. cit.*, 1999, page 18.

332. Young, *op. cit.*, 1999, page 10.

333. Saline soils are those containing common salt, or sodium chloride, but also refer to those soils specifically containing any of the salts of the alkali metals, e.g., sodium, calcium, potassium or magnesium. Strictly speaking, saline soils are nonalkali soils containing soluble salts in such quantities that they interfere with the growth of most plants. Alkaline soils contain an amount of alkali substances sufficient to raise the pH value above 7.0 and be harmful to the growth of crops. Generally, the term alkaline is applied to water with a pH greater than 7.4. Generally, alkali refers to any strongly basic (high pH) substance capable of neutralizing an acid, such as soda, potash, etc., that is soluble in water and increases the pH of a solution greater than 7.0. But this term may also refer to soluble salts in soil, surface water, or groundwater. See *Water Words Dictionary, op. cit.*

334. Young, *op. cit.*, 1999, pages 20-23.

335. Oxalates constitute a salt or ester of oxalic acid. An acid, $C_2H_2O_4$, or $(CHO_2)_2$, existing in oxalis as acid potassium oxalate, and in many plant tissues as sodium or calcium oxalate. Oxalic acid is obtained as a white crystalline compound containing two molecules of water, by the action of nitric acid on sugar, starch, etc. It has a strong acid taste and is poisonous in large doses.

336. Young, *op. cit.*, 1999, page 7.

337. *Ibid.*, page 27.

338. *Ibid.*, page 31.

339. *Ibid.*, page vi.

340. *Ibid.*, page 17.

341. Donaldson, Susan, and Wayne Johnson, “The War Against Tall Whitetop,” Fact Sheet FS 99-95, University of Nevada, Reno, Cooperative Extension, January 1999, page 1.

342. *Ibid.*, pages 1-2.

343. *Ibid.*, page 1.

344. *Ibid.*, page 3.

345. Fact Sheet: Tall Whitetop in the Humboldt River, Martin Larraneta, Nevada Department of Agriculture, Winnemucca, Nevada, February 7, 2000.

346. McQuivey, *op. cit.*

347. “Emigrant Trails in the Black Rock Desert”, Technical Report No. 6, Bureau of Land Management, U.S. Department of the Interior, Nevada State Office, Reno, Nevada, April 1980, page 16.

348. Nevada Historical Marker 49, “Applegate-Lassen Trail Cutoff.”

349. Rowley, William D., "The Newlands Project: Crime or National Commitment," *Dividing Desert Waters*, Nevada Public Affairs Review, Number 1, 1992, Senator Alan Bible Center for Applied Research, University of Nevada, Reno, page 39.

350. With the completion of Rye Patch Reservoir in 1936, the Pitt-Taylor Reservoirs have only been used to store water during high flow years when it is apparent that Rye Patch will not hold the total flow. Current capacity of these reservoirs is only 25,000 acre-feet, although these reservoirs are authorized to hold a total of 36,600 acre-feet by the Nevada State Engineer. It has been reported that due to heavy evaporation losses, only approximately one-half of the water diverted into these reservoirs can be made available for release to Rye Patch Reservoir. See *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 27.

351. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 13.

352. "Humboldt Project Briefing Paper," U.S. Bureau of Reclamation, Mid-Pacific Region, Lahontan Basin Area Office, Carson City, Nevada, U.S. Government Printing Office, Washington, D.C., 1972.

353. Crompton, *op. cit.*

354. "Humboldt Project Briefing Paper," *op. cit.*

355. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 13.

356. *Ibid.*, page 31.

357. "Humboldt Project Briefing Paper," *op. cit.*

358. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 31.

359. "Humboldt Project Briefing Paper," *op. cit.*

360. Interestingly, although construction on Rye Patch Dam had already begun the previous January, on November 1, 1935, the Humboldt Project was officially found feasible by the Secretary of the Interior and subsequently approved by the President on November 6, 1935, approximately ten months after construction reportedly had begun. See "Humboldt Project Briefing Paper," *op. cit.*

361. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, pages 8, 13 and 27.

362. "Humboldt Project Briefing Paper," *op. cit.*

363. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eleven, *op. cit.*, page 51.

364. "Humboldt Project Briefing Paper," *op. cit.*

365. In continuing support of the Humboldt Project and moving upstream water to Rye Patch Reservoir as efficiently as possible, on October 6, 1955, the Pershing County Water Conservation District signed a contract to repay the costs of rehabilitation and betterment of the Battle Mountain water development and collection system with the amount of the obligation not to exceed $123,000, to be repaid in 20 equal annual installments. The notice of completion of work and statement of final cost set the actual contract amount at $122,998. See "Humboldt Project Briefing Paper," *op. cit.*

366. *System Plan, 1997*, Nevada Division of State Parks, Department of Conservation and Natural Resources, Carson City, Nevada, 1997, page 4-52.

367. Data on farm marketings are compiled and published by the U.S. Department of Commerce, Bureau of Economic Analysis (BEA), Regional Economic Information Service (REIS).

368. Here total agricultural water withdrawals, including both irrigation and livestock water withdrawals, are used as both crops and livestock production comprise total farm marketings.

369. An ecosystem is a complex grouping of interacting plants and animals with their physical surroundings. Ecosystems are isolated from each other by boundaries which confine and restrict the movement of energy and matter, for example, an ecosystem could be recognized at a watershed level by designating an area of common drainage (i.e., topography determines movement of water). See *Water Words Dictionary*, *op. cit.*

370. The Pleistocene Epoch designated the geologic time, rock series, and sedimentary deposits of the earlier of the two epochs of the Quaternary Period and was characterized by the alternate appearance and recession of northern glaciation and the appearance of the progenitors of human beings. Also commonly referred to as the Ice Age, the Pleistocene immediately preceded the present Holocene Epoch and occurred from about from 2 million years ago

to 10,000 years ago. See *Water Words Dictionary*, *op. cit*.

371. Tausch, Robin J., Peter E. Wigand, and J. Wayne Burkhardt, "Viewpoint: Plant Community Thresholds, Multiple Steady States, and Multiple Successional Pathways: Legacy of the Quaternary?", *Journal of Range Management*, Volume 46, September 1993, page 441.

372. A more complete list of extinct or extirpated late Pleistocene mammals known from the Great Basin include Jefferson's ground sloth (*Megalonyx*), Shasta ground sloth (*Nothrotheriops shastensis*), Harlan's ground sloth (*Glossotherium*), Short-faced skunk (*Brachyprotoma brevimala*), Giant short-faced bear (*Arctodus simus*), Sabertooth cat (*Smilodon fatalis*), American lion (*Panthera leo*), American cheetah (*Miracinonyx trumani*), Horses (*Equus* species) Flat-headed peccary (*Platygonus*), Yesterday's camel (*Camelops hesternus*), Large-headed llama (*Hemiauchenia macrocephala*), Diminutive pronghorn (*Capromeryx*), Harrington's mountain goat (*Oreamnos harringtoni*), Shrub ox (*Euceratherium*), Harlan's muskox (*Bootherium bombifrons*), American mastodon (*Mammut americanum*) and Columbia mammoth (*Mammuthus columbi*). The American lion and Harrington's mountain goat still exist in North America. See Grayson, *op. cit.*, page 159.

373. While climatic warming and drought at the beginning of the Holocene interglacial period and the loss of Pleistocene plant communities certainly contributed to the demise and/or extirpation of mega-fauna species, others have noted that human arrival in the Great Basin and extensive hunting also possibly contributed to the disappearance of these animal species. See Tausch, *op. cit.*, page 441.

374. A disturbance is a discrete event or process which kills or removes vegetation. From an ecological and hierarchical perspective, disturbance is a change in the minimal structure of an ecosystem caused by a factor external to the reference structure, for example, fire, activities by man, etc. See *Water Words Dictionary*, *op. cit*.

375. Resilience assesses the ability of an ecosystem to maintain or restore biodiversity, biotic integrity, and ecological structure and processes following disturbance. See *Water Words Dictionary*, *op. cit*.

376. A forb is any herbaceous flowering plant, other than a grass; especially one growing under range conditions. (Herbaceous: With the characteristics of an herb; having the texture and color of a foliage leaf; a plant with no persistent woody stem above ground.) See *Water Words Dictionary*, *op. cit*.

377. The understory includes plants growing beneath the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or shrub overstory, or, in the case of the Great Basin, grasses growing beneath a sagebrush overstory. See *Water Words Dictionary*, *op. cit*.

378. The uppermost or tree part of a forest, formed by tree crowns; canopy. Also, the highest plant community within a given area, which in a sagebrush-grassland setting would be the sagebrush. See *Water Words Dictionary*, *op. cit*.

379. While not precisely defined such as a "water year" (October 1 through September 30), the "fire year" or fire season generally begins in April, or even late March in southern Nevada, when moisture conditions are such that timber and grasses are prone to the effects of ignition. From this time, the fire season moves northward in latitude and upward in elevations from valley floors to the mountain ranges as drying conditions increase, until around October when moisture conditions increase sufficiently and most of the danger of fire has passed. Much of this definition is derived from an operational point of view as the time when the various fire suppression agencies (i.e., BLM, Forest Service, BIA, etc.) hire temporary workers and put fire crews on alert or standby. Source: Oral communication, Mark O'Brien, U.S. Bureau of Land Management (BLM), Nevada Office, September 13, 1999.

380. All figures related to burned areas were obtained from source data supplied by the U.S. Bureau of Land Management (BLM), Nevada Office, September 1999.

381. Derived from the Spanish for "child" (i.e., the "Christ child" due to its occurrence near Christmas), the name given to a southward-flowing ocean current off the coast of Peru causing an irregularly occurring flow of unusually warm surface water along the western coast of South America that is accompanied by abnormally high rainfall in usually arid areas and that prevents upwelling of nutrient-rich cold deep water causing a decline in the regional fish population. It typically results in a warm inshore current flowing along the coast of Ecuador and about every seven to ten years it extends southward down the coast of Peru with frequently devastating effects on weather, crops, and fishing (due to adverse effects on plankton). El Niño's warm and nutrient-poor waters cause great damage to the fishing industry and also to the birds feeding there, which are an important source of guano. The climatic effects of large-scale El Niño disturbances also cause flooding and drought conditions over a wide area, sometimes extending as far as the southern Pacific Ocean, Europe, Africa, and Asia. Such disturbances have taken place in 1953, 1957-58, 1972-73, 1976, 1982-83, 1992 and over an extended period of 1995-1999. It is also believed that this condition (the "El Niño effect") has more far-reaching effects on climatological patterns in the Western Hemisphere and also has influenced storm patterns in the western Atlantic Ocean region (Caribbean and Gulf of Mexico). It has generally been found that the presence of El Niño tends to reduce hurricane activity while the

presence of La Niña, or cool eastern Pacific waters, tends to increase hurricane activity. See *Water Words Dictionary, op. cit.*

382. Derived from the Spanish for the "little girl", the name given to the weather phenomenon characterized by abnormally cold ocean surface water temperatures in the eastern Pacific Ocean near the equator. According to the National Oceanic and Atmospheric Administration (NOAA), during a La Niña occurrence temperatures are typically warmer than normal in the southeast United States and cooler than normal in the northwest, bringing drier than normal conditions to southern California and the Southwest. With the cold water in the Pacific tropics characterizing a La Niña event, the chill, west-to-east high-altitude winds known as the jet stream no longer move southward attracted by the temperature differential which exists during the El Niño warm-water event. Therefore, instead of being "pulled" downward as the jet stream hurls across the United States, it tends to shift northward, producing unusually wet springs in the Northwestern U.S. and summer droughts in the mid-Atlantic region. It also means that there are no strong upper elevation winds in the middle Atlantic to blow the tops off of any big tropical storms forming, consequently allowing for the formation of more hurricanes. See *Water Words Dictionary, op. cit.*

383. Stewart, Robert, "Summary, May-August 10, 1999 Nevada Fire Season," U.S. Bureau of Land Management (BLM), Nevada Office, September 1999.

384. Pellant, Mike, "History and Applications of the Intermountain Greenstripping Program," Paper presented at the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands, Boise, Idaho, May 18-22, 1992.

385. Murphy, Patrick M., Deputy State Forester for Resource Management, Correspondence, Nevada Division of Forestry, Department of Conservation and Natural Resources, Carson City, Nevada, October 7, 1996.

386. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eight, *op. cit.*, page 49.

387. Invasive species are alien or exotic (i.e., not native to a particular ecosystem) plants or animals whose introduction does or is likely to cause economic or environmental harm or harm to human health. See *Water Words Dictionary, op. cit.*

388. Hunter, Richard, "*Bromus* Invasions on the Nevada Test Site: Present Status of *B. Rubens* and *B. Tectorum* with Notes on Their Relationship to Disturbance and Altitude," *Great Basin Naturalist*, 51(2), 1991, pages 176-178.

389. Goodrich, Sherel, and Natalie Gale, "Cheatgrass Frequency at Two Relic Sites within the Pinyon-Juniper Belt of Red Canyon, Utah," Proceedings: Ecology and Management of Pinyon-Juniper Communities within the Interior West, Provo, Utah, September 15-18, 1997.

390. Cronquist, Arthur, Arthur H. Holmgren, Noel H. Holmgren, James L. Reveal, Patricia K. Holgren, *Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A.*, Volume Six, Columbia University Press, New York, 1977, pages 199-200.

391. Monsen, Stephen B., "The Competitive Influences of Cheatgrass (Bromus tectorum) on Site Restoration," Paper presented at the Symposium on Ecology, Management, and Restoration of Intermountain Annual Rangelands, Boise, Idaho, May 18-21, 1992.

392. Morefield, James D., Ph.D., Botanist, Correspondence, Nevada Natural Heritage Program, Department of Conservation and Natural Resources, Carson City, Nevada, September 26, 1996.

393. Monsen, *op. cit.*, 1992.

394. Invasive Plant Species Records, Nevada Natural Heritage Program, Department of Conservation and Natural Resources, Carson City, Nevada.

395. Succession represents the ecological process of sequential replacement by plant communities on a given site as a result of differential reproduction and competition. See *Water Words Dictionary, op. cit.*

396. One early study (1951) concluded that the conversion of sagebrush-grass ranges to annual weeds progresses through three distinct plant communities. Barren or burned areas are first occupied by Russian thistle (*Salsola pestifer*), then by mustards (*Descurainia sophia*) and tumble mustard (*Sisymbrium altissimum*), and finally by cheatgrass (*Bromus tectorum*). Russian thistle dominates the first two years, mustards the third and fourth years, and cheatgrass from the fifth year on. These changes occur irrespective of weather differences. The communities thrive and reproduce within the limits of available moisture. Once cheatgrass has gained control, however, the successive patterns are not repeated if the site is again disrupted. Consequently, disturbed sites can be much more successfully seeded when Russian thistle or mustards are present than when cheatgrass has assumed control. See Monsen, Stephen B., and E. Durant McArthur, "Factors Influencing Establishment of seeded Broadleaf Herbs and Shrubs Following Fire," Paper presented at the Symposium on Rangeland Fire Effects, Boise, Idaho, November 27-29, 1984.

397. The state of a biotic community attained when constituent species' populations fluctuate rather than exhibit successional replacement and thereby self-perpetuate as long as climatic, edaphic (soil), and biotic conditions continue. See *Water Words Dictionary*, *op. cit.*

398. Wright, Henry A., Arthur W. Bailey, *Fire Ecology, United States and Southern Canada*, John Wiley & Sons, New York, N.Y., 1982, pages 166-167.

399. *Ibid.*, page 171.

400. Monsen, *op. cit.*, 1992.

401. In this regard, the success of 'Hycrest' crested wheatgrass (*Agropyron desortorum*) and mountain rye (*Secale montanum*) has been most notable. Seeds of mountain rye germinate at slightly cooler temperatures than cheatgrass, and the growth rate of this perennial has been found to even exceed that of cheatgrass. When grown in direct competition, the perennial grass prevails. Few other perennial species have shown similar characteristics. See Monsen, Stephen B., and Dale Turnipseed, "Seeding Forage Kochia onto Cheatgrass-Infested Rangelands," Paper presented at the Symposium on Cheatgrass Invasion, Shrub Die-Off, and Other Aspects of Shrub Biology and Management, Las Vegas, Nevada, April 5-7, 1989.

402. Monsen, *op. cit.*, 1989.

403. Monsen, *op. cit.*, 1992.

404. Hunter, *op. cit.*, page 181.

405. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Nine, *op. cit.*, page 4.

406. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Ten, *op. cit.*, page 7.

407. Exotic species are non-native or non-indigenous species, usually introduced as the result of human activities. See *Water Words Dictionary*, *op. cit.*

408. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Seven, *op. cit.*, page 41.

409. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Five, *op. cit.*, page 4.

410. Correspondence (JoLynn Worley), Bureau of Land Management (BLM), Nevada District Office, Reno, Nevada, December 23, 1999.

411. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Five, *op. cit.*, page 5.

412. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Eight, *op. cit.*, page 6.

413. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Four, *op. cit.*, page 3.

414. "Fact Sheet: The Santa Rosa National Forest, 1911-17," Santa Rosa Ranger District, U.S. Forest Service, U.S. Department of Agriculture, Winnemucca, Nevada, September 1999.

415. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 4.

416. *Ibid.*

417. *Ibid.*

418. Riparian areas represent transitional ecosystem located between aquatic (usually riverine) and terrestrial (upland) environments. Riparian ecosystems are identified by distinctive soil characteristics and vegetation communities that require free, i.e., flowing, water. See *Water Words Dictionary*, *op. cit.*

419. *Humboldt River Basin, Nevada, Water and Related Land Resources*, Report Number Three, *op. cit.*, page 23.

420. JoLynn Worley, *op. cit.*

421. "The Great Basin: Healing the Land," Bureau of Land Management, U.S. Department of the Interior, April 2000, page 1.

422. *Ibid.*, page 3.

423. *Ibid.*, page 35.

424. *Ibid.*, pages 7-8.

425. *Ibid.*, pages 17-19.

426. *Ibid.*, page 7.

427. Beginning in 1901, Dr. James Edward Church, Professor of Classics at the University of Nevada, Reno, and an enthusiastic outdoorsman, first began studies and measurements of snowpack water content on the summit of Mount Rose (10,778 feet MSL) in the Carson Range of the Sierra Nevada near Reno, Nevada, and thereby pioneered the science of snow surveying. His research showed that figures indicating the snowpack water content over a wide melting area could be used to forecast with considerable accuracy the likelihood and degree of flood or drought in

the drainage area below the measurement area during the following season of runoff. Dr. Church formulated a simple mathematical expression, which he called the “Percentage Method,” involving water content measurements taken over a “snow course” annually on April 1st and weighted for both soil moisture on that date and precipitation on the snowfield during the period of melting. While new techniques and more modern equipment have been implemented since that time, the fundamental relationships developed by this imaginative scientist remain accepted to this day. Closely associated with the work of Dr. Church and long in charge of the Nevada Cooperative Snow Surveys and the University of Nevada, Reno, was Dr. H.P. Boardman. Both men retired in 1939 and continued to study and publish in this area of research for almost 20 years. See Houghton, *op. cit.*, page 58.

428. The snowpack water content figures measure the water equivalent of a specific volume (depth) of snow. The measures are based on a percent of average for the particular time of year for which the reading is taken, with 100 percent being the total period average. The Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture, maintains a number of SNOTEL, or snowpack telemetry sites throughout the Great Basin and particularly in the upper watersheds of the Humboldt, Truckee (Lake Tahoe), Carson and Walker River basins. These sites are used to estimate and forecast potential runoff from the existing snowpack for planning and emergency preparation purposes and serve a wide range of uses to include flood planning, reservoir releases, diversions for irrigation and agricultural needs, and water anticipated to be available for municipal and industrial uses. The basin average is the composite reading of a number of individual site readings which are taken monthly, generally from November 1 through April 1 of each year. It is the April 1 figure that determines the year’s assumed maximum snowpack reading; however, in certain years, e.g., 1997, unique climatologic and hydrologic conditions warranted a different reference period which approximated the maximum annual snowpack water content conditions. This analysis used an alternative reading date of February 1, 1997, in addition to the April 1 date, for comparative calculations presented in the accompanying table.

429. This average period figure reflected a standard deviation, as a measure of variability about the calculated mean or average value, of 46 percentage points, yielding a *t-value* of 2.16 (the mean divided by the standard deviation), indicating that within a confidence range of 90-95 percent, 98 percent represented the “true” mean of the series. Using the February 1, 1997 snowpack figure to account for unusual weather patterns in that year, this series mean was 102 percent, standard deviation of 47 percentage points, yielding a *t-value* of 2.14, also statistically significant at a 90-95 percent confidence interval.

430. This average period figure reflected a standard deviation of 70 percentage points, yielding a *t-value* of only 1.59, indicating little confidence that 111 percent of average snowpack figure represented the true mean of the series. Accounting for the unusual snowpack conditions of 1997 and using February 1, 1997 for snowpack measurements yielded an average of 114 percent, standard deviation of 70 percent, and t-value of 1.64, again indicating little statistical confidence in this value. One possible explanation of the larger variability of the lower Humboldt River Basin’s snowpack water content readings was its location between the storm systems which tend to affect primarily the western Nevada watersheds and the more north-trending jet stream storm which mainly affect the eastern Nevada and the upper Humboldt River Basin. This leaves the lower Humboldt River Basin between these occurrences and being affected, to varying degrees, by the severity and conditions of each.

431. The Lake Tahoe basin actually constitutes the upper portion of the overall Truckee River Basin, but for NRCS snowpack water content data, it has been segregated. Results for the Truckee River Basin also exclude the Lake Tahoe Basin.

432. According to the National Oceanic and Atmospheric Administration (NOAA), during a La Niña occurrence temperatures are typically warmer than normal in the southeast United States and cooler than normal in the northwest, bringing drier than normal conditions to southern California and the Southwest. With the cold water in the Pacific tropics characterizing a La Niña event, the chill, west-to-east high-altitude winds known as the jet stream no longer move southward attracted by the temperature differential which exists during the El Niño warm-water event. Therefore, instead of being “pulled” downward as the jet stream hurls across the United States, it tends to shift northward, driving winter storms northward and producing unusually wet springs in the Northwestern U.S. See *Water Words Dictionary, op. cit.*

433. For a more extensive analysis of this flood event, see Horton, *The Flood of 1997 – Final Report: An Analysis of Snowpack Water Content and Precipitation Changes in the Waterbasins of Western Nevada and the Effects on Runoff and Stream Flows, December 16, 1996—January 6, 1997*, Nevada Division of Water Planning, Department of Conservation and Natural Resources, Carson City, Nevada, January 1997, updated and revised May 1997.

434. Grayson, *op. cit.*, page 86.

435. *Salt Lake Tribune*, September 21, 1997, reporting on a symposium held in Salt Lake City of more than 80 geoscientists, biologists and archaeologists to discuss what the Great Basin region can teach us about global climate change and the structure and movement of the Earth's crust.

436. Reheis, Marith, "Highest Pluvial-Lake Shorelines and Pleistocene Climate of the Western Great Basin," *Quaternary Research*, 52, 1999, page 196.

437. *Ibid.*, page 197.

438. Benson, Larry V., "Fluctuation in the Level of Pluvial Lake Lahontan During the Last 40,000 Years," *Quaternary Research*, Volume 9, Number 3, University of Washington, 1978, pages 314–315.

439. Grayson, *op. cit.*, page 93.

440. Benson, Larry V., "Preliminary Paleolimnologic Data for the Walker Lake Sub-Basin, California and Nevada," *Water Resources Investigations Report 87–4258*, U.S. Geological Survey, U.S. Department of the Interior, Denver, Colorado, 1988, page 2.

441. Benson, *op. cit.*, 1978.

442. Houghton, *op. cit.*, page 73.

443. Benson, *op. cit.*, 1978, page 316.

444. Benson, *op. cit.*, 1988, page 1.