Water Quality in Lahontan Cutthroat Trout Streams. A baseline study was conducted in 1997 by AATA International, Inc. (1998a) to monitor water quality and flow data for stream reaches in the Rock Creek and Willow Creek drainages that support Lahontan cutthroat trout (LCT) (*Onchorhynchus clarki henshawi*). Selected streams supporting LCT were upper Rock Creek, Nelson Creek, Toe Jam Creek, Lewis Creek, and Frazer Creek (see Figure 3.6-1 and Appendix B, Table B-4). The monitored streams supporting LCT are classified by the Nevada Department of Environmental Protection (1997) as Class A waters. According to Nevada Administrative Code 445A.124, Class A waters are located in areas of minimal human habitation, no industrial development, and no intensive agriculture. In addition, the watershed is relatively undisturbed by human activities. Nevada Division of Environmental Protection water quality standards are, therefore, protective of these relatively pristine waters.

A summary of the generated stream water quality database for LCT streams is provided in Table B-4. The LCT streams were a calcium or calcium-sodium bicarbonate water type. Streamflow ranged from less than 0.1 to 0.29 cfs. Concentrations of TDS ranged from 90 mg/L in upper Rock Creek to 150 mg/L in Lewis Creek. Values of pH ranged from 7.6 in Lewis Creek to 8.6 in Nelson Creek, and water temperatures ranged from 14.2 °C in upper Rock Creek to 23.3 °C in Nelson Creek. The dissolved oxygen standard in upper Rock Creek and water temperature standard in Nelson Creek were not met during the sampling event (Table B-4).

3.2.1.3 Humboldt River Study Area

Humboldt River Water Uses

For purposes of examining potential impacts to the Humboldt River from mine dewatering discharges, the Humboldt River study area was defined as extending from the USGS stream gage at Carlin, Nevada (10321000) to the Humboldt Sink downstream. The river study area is shown in Figure 1-6 (Basin Boundaries and Humboldt River Features).

In addition to Barrick's Goldstrike Mine data, major sources of flow and water quality data for the region included the USGS; the Nevada Department of Conservation and Natural Resources - Division of Water Resources, Division of Water Planning, Division of Environmental Protection and Division of Wildlife; the Natural Resources Conservation Service; Pershing County Water Conservation District; and the U.S. Fish and Wildlife Service.

Throughout its length, the Humboldt River has historically supported diverse water demands and beneficial uses. In addition to recreational uses and providing aquatic and wildlife habitats, the river supplies water for commerce and domestic uses. Primary water development sectors within the basin have been agricultural (irrigated crops and livestock), mining, and municipal uses. Data and projections regarding dominant uses of the river are shown by county in Appendix C. It should be noted that projected uses can change dramatically from one analysis to the next; for example, estimates of future agricultural demand and consumption vary substantially from the 1992 projections (increasing) to the 1996 projections (decreasing) (Nevada Division of Water Planning 1992a, b, 1998). Graphical summaries of demands and consumption in the Humboldt River basin are depicted in Figures C-1 and C-2 in Appendix C. These data show that the irrigation and livestock sector is by far the largest use of water in the basin. The proportion of mining and municipal uses is projected to vary over time.

Actual water use data for 1995 for the five-county area that comprises the Humboldt River basin is summarized in Table C-3 in Appendix C. These data show that 87.5 percent of water withdrawal was for irrigation/livestock use. Mining was the next largest water user at 10.7 percent, followed by municipal/industrial (1.7 percent) and domestic (0.1 percent). Elko and Humboldt counties had the majority of irrigation and livestock water use whereas Eureka and Humboldt counties had most mining-related water withdrawal. Total water withdrawn in the Humboldt River basin in 1995 was relatively evenly divided between ground water and surface water sources. In addition, approximately 50 percent of all water withdrawn in 1995 was consumed (Table C-4 in Appendix C). A considerable amount of the consumed water is due to evaporation from the ditches and reservoirs, as well as evapotranspiration by the plants that are irrigated.

Tables C-3 and C-4 in Appendix C indicate that total water withdrawal in 1995 for the five specific counties in the Humboldt River basin was approximately 2.2 million acre-feet, half of which came from ground water sources and the other half from surface water sources. Table C-4 shows that the average consumptive use in 1995 for the same five-county area was approximately 49 percent of the total water withdrawal. Total consumptive water use for both surface and ground water in 1995 for the five-county area was approximately 1.1 million acre-feet. It generally can be estimated that consumptive use of surface water was on the order of 540,000 acre-feet for the year, which is less than the decreed and permitted water usage of approximately 667,000 acre-feet per year for the Humboldt River.

It should be noted that the water demands and consumption in the counties listed are not all made directly on Humboldt River surface flows; a substantial amount of demand is met by ground water sources or surface water sources tributary to the river. However, the data generally indicate the relative magnitudes of past and projected water uses in the basin. An additional wildlife use of Humboldt River water is at wildlife management areas at the Humboldt and Carson sinks and in habitats along the river.

Agricultural Irrigation Uses. As shown in Appendix C, agricultural uses dominate the demands on Humboldt River flows. Table 3.2-8 illustrates an approximate seasonal distribution of the annual irrigation demands that were used to evaluate potential changes in the surface water environment of the Humboldt River from Palisade to the Comus gage. Additional published estimates were used downstream of Comus (Eakin 1962; Eakin and Lamke 1966). The general monthly irrigation demands shown in Table 3.2-8 were approximated from seasonal requirements to meet priorities as described by the Nevada Department of Conservation and Natural Resources (NDCNR) (1964). According to the NDCNR, approximately 48 percent of the annual decreed diversion occurs from March 15 through April 28, approximately 29 percent of the annual decreed diversion occurs from April 28 through June 13, and approximately 23 percent of the annual decreed diversion occurs from June 13 through September 15. Additional diversions based on older permits may occur before or after these dates.

Irrigation Efficiency, Return Flow Pattern, and Return Location. Irrigation return flow is the portion of diverted water that is not consumed by evapotranspiration and returns later to the stream system. The amount of water returned and the timing of its return vary in complex ways according to agricultural water management systems, the type of crop grown, and the nature of lands under irrigation. The general rate at which used irrigation water returns to the system can be expressed regionally as a percentage of the original diversions over time. Regional returns often lag the original diversions by some period of time and may extend over several months. Estimates of the overall fraction of irrigation return flow range from 20 percent (Nevada State Engineer's Office 1997) to 40 percent (NDCNR 1964) of the water diverted. For quantitative evaluations of the Humboldt River upstream of Comus, the average return flow percentage was assumed to be 30 percent.

The return flow pattern used to evaluate the changes in the surface water environment of the Humboldt River was developed from a Glover analysis (Glover 1978). The Glover parameters assumed in determining the return flow pattern are believed to be applicable to the irrigated areas along the Humboldt River (hydraulic conductivity = 10 feet/day, voids ratio = 0.20, and distance to stream = 1,000 to 5,000 feet). Based on the Glover analysis, the fraction of irrigation water returning to the stream system was assumed to return over a 5-month period. As a percentage of the total return flow, it is assumed that approximately 75 percent of the return flow would occur in the first month after diversion, 17 percent in the second month, 5 percent in the third month, 2 percent in the fourth month, and 1 percent in the fifth month.

It is assumed for purposes of the impact analyses that the return flow quantities are represented in the USGS gage data. It also is assumed that return flows for the reach between Palisade and Battle Mountain are reflected in the Battle Mountain gage data, that return flows between Battle Mountain and Comus are reflected in the

Table 3.2-8
General Seasonal Irrigation Demand Estimates
(acre-feet)

Reach	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Palisade to Battle Mountain	0	0	8,572	17,145	11,357	8,133	5,666	5,666	3,461	0	0	0	60,000
Battle Mountain to Comus	0	0	5,165	10,329	6,287	4,322	2,358	2,360	1,179	0	0	0	32,000

Comus gage data, and so on downstream. Again, without an in-depth analysis of specific diversions and irrigation practices, this represents a reasonable assumption for subsequent impact analysis.

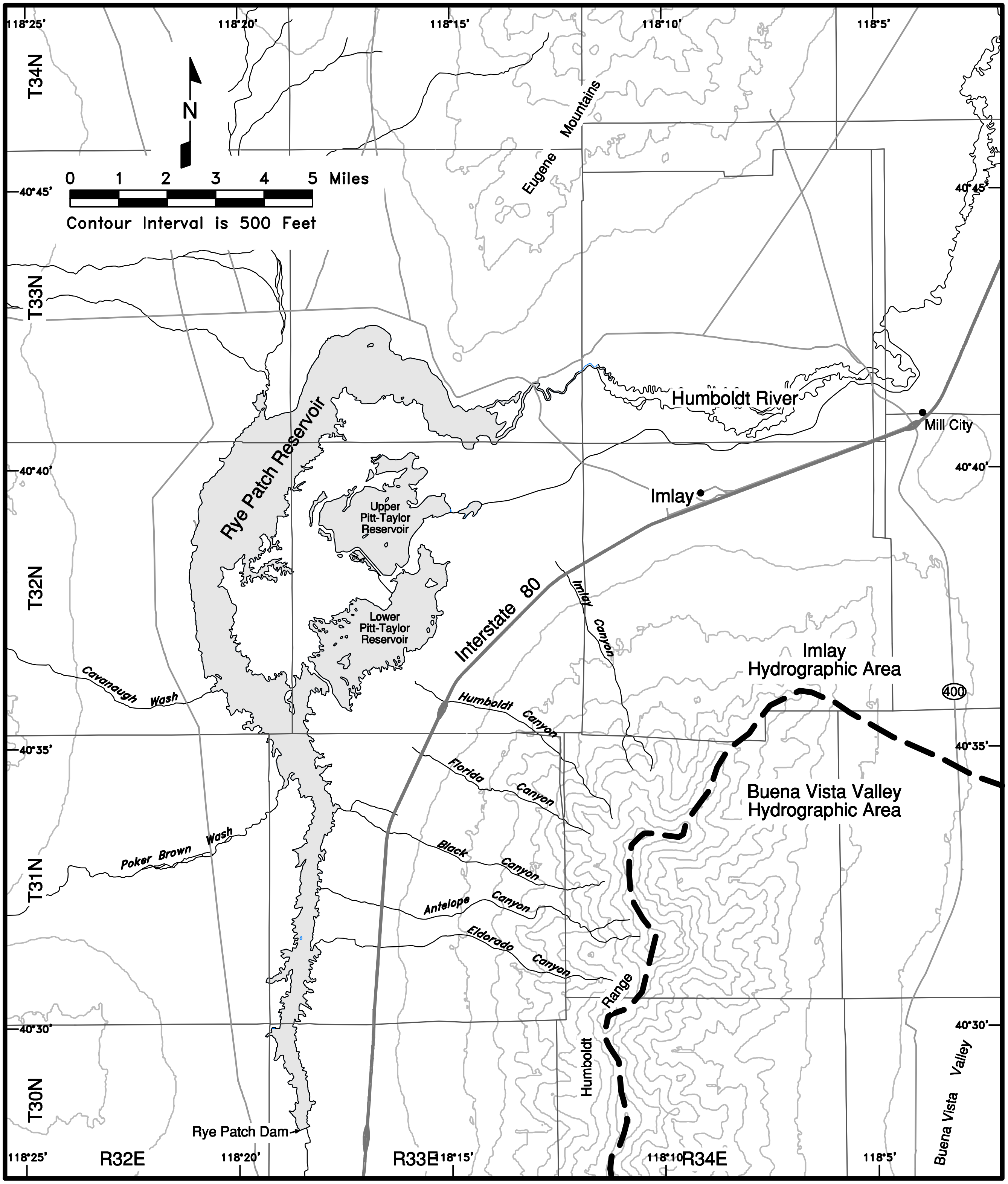
The Humboldt Project and Pitt-Taylor Reservoirs. Water from the Humboldt Project is used to irrigate approximately 40,000 acres, mostly in hay, in the Lovelock Valley. Operation and maintenance of the Humboldt Project, which consists of Rye Patch Dam, Rye Patch Reservoir, and associated outlets and conveyances, are conducted by the Pershing County Water Conservation District. Return flows from irrigation are directed to the Humboldt Sink area (Toulon Lake or Humboldt Lake) immediately downstream of the Lovelock Valley via agricultural drains.

Rye Patch Reservoir and the Pitt-Taylor reservoirs are the largest surface water impoundments on the Humboldt River (Figure 3.2-16). They are located between Winnemucca and Lovelock approximately 100 miles downstream of the Barrick Goldstrike property. Rye Patch Dam is located on the river, and was completed in the mid-1930s. Rye Patch Reservoir can control approximately 194,300 acre-feet of water storage (USGS 1998a). It is generally an elongated narrow reservoir, somewhat wider and shallower at the upstream end. When full, its surface area is approximately 11,200 acres (17.5 square miles).

The Pitt-Taylor reservoirs (lower and upper) provide relatively shallow off-channel storage of water diverted from the river via the Pitt-Taylor Canal. These features are owned by the Pershing County Water Conservation District, and are not part of the federal Humboldt Project. A long dam on higher ground separates these reservoirs from Rye Patch Reservoir. Depending on storage, the total surface area of the Pitt-Taylor reservoirs may be up to approximately 4,600 acres (7.2 square miles). Evaporative losses from Rye Patch and Pitt-Taylor reservoirs are generally estimated at 20,000 acre-feet/year (Eakin 1962).

Municipal and Other Water Uses. Water use estimates for the 1990-2020 period by other demand sectors in the five-county area of the Humboldt River basin are presented in Table C-5 in Appendix C. Total water use projected for municipal water suppliers in this period ranges from approximately 12,000 to 26,000 acre-feet/year. Much of the water used in the basin originates from ground water sources, as shown in Appendix C, Table C-4. Most municipal water use in the basin is by the City of Elko (6,000 to 15,000 acre-feet/year for the period 1990-2020). Currently available water supplies for the communities included in Table C-5 is expected to be adequate beyond the year 2020. Another water user in the Humboldt River basin is the Valmy Power Station, which consumes approximately 5,000 acre-feet/year, some of which is supplied by wells and by excess water from the Lone Tree Mine dewatering system. Active National Pollutant Discharge Elimination System (NPDES) permits for Elko, Eureka, Humboldt, Lander, and Pershing counties are presented in Table C-6 in Appendix C. A total of six discharges are permitted, four of which go to the Humboldt River. All of the Humboldt River discharges are from mining operations (Goldstrike, Lone Tree, and Gold Quarry). Total permitted discharge from these mines is approximately 300 cfs or 217,000 acre-feet/year (Table C-6). The remaining two permitted discharges are from the town of Lovelock (this waste water goes to Toulon Lake) and the Nevada Division of Wildlife's Gallagher Fish

\A305\DWG\305RYE.DWG REVISION: 3/17/2000



Legend

- Roads
- Interstate 80
- River or Stream
- Hydrographic Sub-Area Boundary

Figure 3.2-16

Rye Patch and Pitt-Taylor Reservoirs

Hatchery in Elko County (this waste water goes to Ruby Marsh).

Table C-7 in Appendix C shows the release of water from public sewage treatment facilities in 1990 for the five-county Humboldt River basin area. These discharges totalled approximately 6,200 acre-feet/year and generally are disposed of via infiltration basins. Some of this water, therefore, likely recharges the Humboldt River.

Flow Regime

Humboldt River flow within the hydrologic study area has been measured over several decades by the USGS at gaging stations near Carlin, Palisade, Argenta, Valmy, Battle Mountain, Comus, Winnemucca, Rose Creek, Imlay, Rye Patch, and below Lovelock (Figure 1-6). An additional gage was established at Dunphy in February 1991. Daily flows are presented in the USGS records for these gaging stations. The gages at Argenta, Valmy, Winnemucca, Rose Creek, and below Lovelock have been discontinued. They have differing periods of record. The upstream gage at Carlin is located approximately 5.5 miles upstream of the Maggie Creek confluence. Barrick's dewatering outfall on the Humboldt River is located between the Dunphy gage and the former Argenta gage. The gage at Comus is located approximately 9 miles east of Golconda and 50 miles downstream of Barrick's outfall. Discharges from Newmont's Lone Tree Mine enter the main branch of the river approximately 1 mile upstream of the Comus gage. As shown on Figure 1-6, the Imlay gage is immediately upstream of Rye Patch Reservoir, and the Rye Patch gage is immediately downstream of the reservoir. Because of this, the flows at the Rye Patch gage strongly reflect reservoir operations. During the 1950s, the Lovelock gage was located approximately 10 miles downstream of Lovelock and 8 miles upstream of Humboldt Lake. Flow measurements at that location were highly affected by reservoir operations and irrigation diversions and returns. Gaging below Lovelock was discontinued in 1959 and re-established by the USGS in 1998.

Cultivated lands and water management structures lie along the Humboldt River main stem and its tributaries, except where narrow canyons, deep channel networks, or unsuitable soils prohibit cropland uses. The dominant crop grown is native meadow hay, and the total amount of irrigable land has not changed dramatically over the past 40 years (Natural Resources Conservation Service 1997). The drainage area and the area potentially under irrigation from river diversions are shown cumulatively for each gage in Table 3.2-9. The actual area irrigated varies tremendously from year to year, depending on the availability of water from the river.

In addition to agriculture, mining operations in the area use a large volume of water. Nearly all of the water used for mining is ground water that is pumped from the mine areas. Several mining operations in the hydrologic study area pump more ground water for mine dewatering than they can use for mine processes and dust control. Four of these mines discharge (or will discharge) excess ground water to the Humboldt River. These mines are Newmont's Gold Quarry and Lone Tree mines, the proposed Leeville Mine, and Barrick's Goldstrike Mine. Primarily as a result of mining activity in the region, Humboldt River flow data have been recently analyzed by several investigators (Hydrologic Consultants, Inc. 1997a; JBR 1997; Maurer et al. 1996; RTi 1998; Simons & Associates, Inc. 1995b, 1997; and Zimmerman 1992b).

USGS daily stream gage records were used to assess the streamflow conditions on the Humboldt River for the periods January 1946 through May 1990 and June 1990 through December 1996 (RTi 1998). The period from January 1946 through May 1990 was chosen to establish the baseline (prior to dewatering) conditions. The June 1990 through December 1996 period was selected to coincide with the start of pumping for the Goldstrike Mine. Streamflow data were requested from the USGS in Carson City, Nevada, for each of the following stations: Carlin, Palisade, Battle Mountain, Comus, and Imlay. The data received from the USGS are considered provisional for the period October 1994 through December 1996 but remained in the analysis as the best data available. Provisional data have been finalized and additional data have become available since the time of the original streamflow data analysis (RTi 1998). These data show substantially higher streamflow averages for recent years (1991

Table 3.2-9
Areas Upstream of Humboldt River Gages
(square miles)

Gage	Cumulative Drainage Area	Cumulative Irrigated Area[1]	Incremental Irrigated Area[1]
Carlin	4,310	223	
Palisade	5,010	231	8
Dunphy	7,470	unknown	unknown
Argenta	7,490	unknown	unknown
Battle Mountain	8,870	303	72
Comus	12,100	>322[2]	>19
Imlay	15,700	>345	23
Lovelock	16,600	>448	103

Source: USGS 1998a.
[1] Incremental irrigated area is the area under irrigation from one stream gage to the next. For example, there are 8 square miles of irrigated lands between Carlin and Palisade. The cumulative irrigated area is the total amount of irrigated land upstream of the gage. For example, above Carlin there are 223 square miles of irrigated land. Above Palisade, there are 223 + 8 = 231 cumulative square miles of irrigated land.
[2]Additional irrigated lands beyond those recorded under the Humboldt River Decree occur in this subarea.

through 1998) than are depicted in the following tables due, in part, to precipitation increases since 1995. However, the essential points of the tables are still pertinent to the discussion: that a drought occurred in the late 1980s and early 1990s, and more importantly, that streamflow data for short periods can vary dramatically from long-term averages. Comparison of the hydrographs also indicates that peak flows are reduced from upstream to downstream on the river system.

The stations at Carlin, Palisade, Comus, Imlay, and Rye Patch have continuous data for the entire study period, including January 1946 through December 1996. The stations at Battle Mountain and Argenta have discontinuous records for the period of interest. Missing data at Battle Mountain and Argenta were synthesized for the periods of interest (through 1996) by means of statistical correlation with the gage data from Carlin, which showed the best fit with existing data. This approach yielded regression coefficients of 0.90 or above for most months.

The station at Dunphy has no historical record prior to mine dewatering, but does have data during the recent period of mine discharges to the Humboldt River. This makes it useful for comparisons to recent river conditions in the outfall locale, but it does not have the period of record for long-term historical or regional analysis. Substantial irrigation withdrawals as well as channel losses and gains occur in the reach from Comus to Imlay, and from Rye Patch Reservoir to the Humboldt Sink. These lower reaches were examined qualitatively. The gage at Rye Patch was not used for river flow analysis because it is downstream of Rye Patch Reservoir and is highly influenced by reservoir storage and operation. The gage data for Valmy, Winnemucca, Rose Creek, and Lovelock were not incorporated into the quantitative flow analysis due to their relatively short periods of record and because they were discontinued several decades prior to this assessment. Average annual flow hydrographs for the selected stations are shown in Figure 3.2-17 (RTi 1998).

Except for its lower reaches near Lovelock, the Humboldt River is generally perennial throughout its length within the study area. Flows are highly variable and nearly cease during some low-flow periods. High flows in the river typically occur during the months of April, May, and June as a result of snowmelt; low flows usually occur in August, September, and October. Low flow is defined herein as streamflow during the period when minimal effects from man-made diversions and return flows, storm and snowmelt runoff, and evapotranspiration occur. Low flows for this study have been assessed as flow conditions in September, when irrigation diversions and evapotranspiration are still occurring.

The average flow on a yearly basis for January 1946 through May 1990 and June 1990 through December 1996 is summarized for the selected long-term Humboldt River gages in Table 3.2-10. Further data summaries for the gages are shown for the pre-pumping period (1946-1990) in Appendix C, Table C-8.

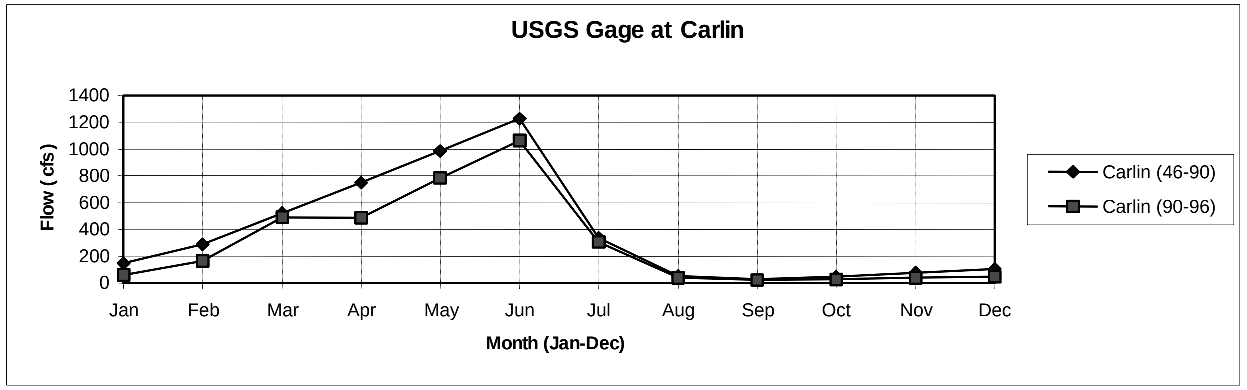
USGS records (and annual hydrographs developed from them) indicate that the highest flows on the river typically occur during June. Average high flows for the peak runoff month (June) for the periods from January 1946 through May 1990, and for June 1990 through December 1996, are summarized in Table 3.2-11. Average low flows for the month of September are shown in Table 3.2-12 for the two periods of interest.

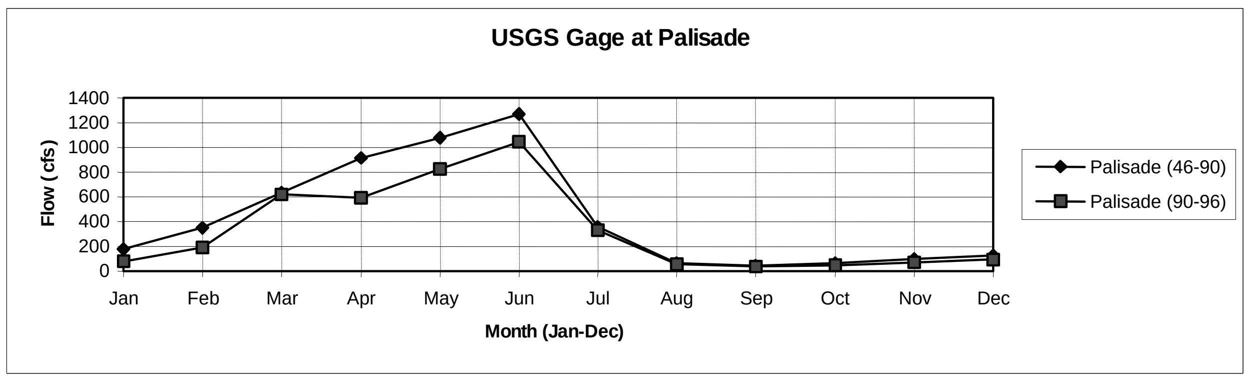
It is important to note that the previous tables and discussions of flow conditions are based on averages representing a historical period of approximately 50 years. It is also important to note that wide variations in precipitation and snowfall occur in time and space throughout the region. As a result, wide variations in natural streamflows also occur, and these are masked by presenting data averages for the purposes of a general discussion. For example, from Table 3.2-11 the average peak flow (June flow) at Argenta from 1946 to mid-1990 is 1,146 cfs; the standard deviation for the same month over the same period is 1,037 cfs (RTi 1998). A standard deviation is a statistical characteristic that summarizes how much the data values vary from their average. These particular values indicate a very high level of variation. From Table 3.2-12, the average low flow (September flow) at Argenta is 16 cfs; the standard deviation for this is 27 cfs. At Palisade, the average June flow is 1,270 cfs, and the standard deviation is 1,007 cfs (RTi 1998). Also at Palisade, the average low flow is 41 cfs, and the standard deviation is 37 cfs (RTi 1998).

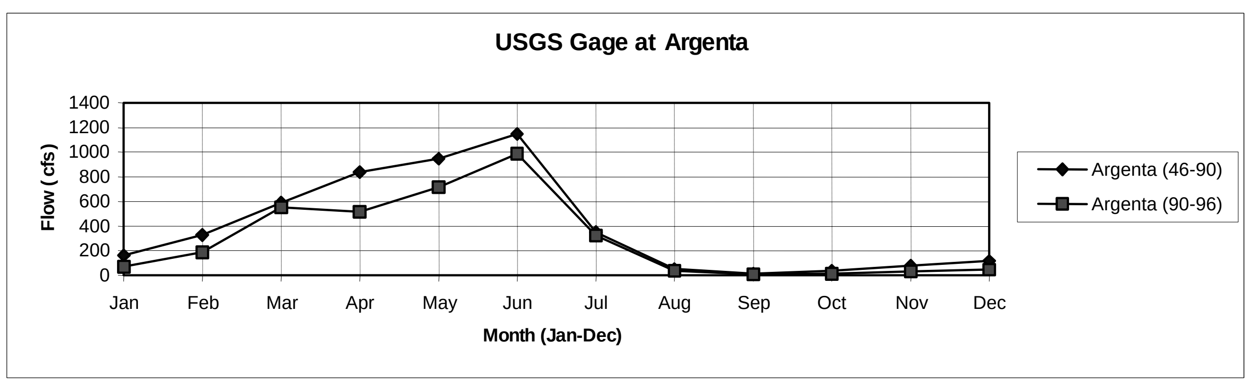
As another illustration, over the long term, peak monthly flows on the river typically occur in June. That is, the highest flow over 1 month predominantly occurs in June. However, it also should be noted that high flows, sometimes as high or higher than June flows, occasionally occur in other months such as March, April, or May. For example, 1979 was an average flow year at Argenta. The average flow for the month of June that year was 1,006 cfs. For May, it was higher - 1,129 cfs. For March, the average flow was 995 cfs - 1 percent less than June. Peak daily flow for June of that year was 2,050 cfs on June 1. The same daily flow occurred on May 31. In addition, 1,660 cfs occurred on March 12; 1,760 cfs occurred on February 16; and the highest daily flow all year was 2,350 cfs on January 14. Four days earlier the river carried 87 cfs.

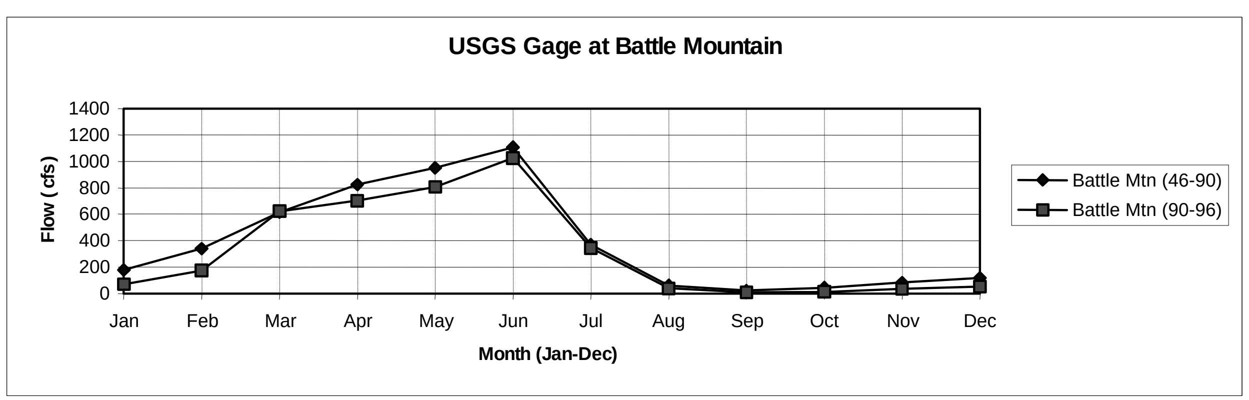
Average monthly flows on the river are exceeded between 20 and 40 percent of the time. In June at Argenta, for example, the average monthly flow is 1,146 cfs for the period 1946 through mid-1990. June flows were higher than that in approximately 39 percent of those years. The average June flow in those exceeding years was approximately 2,000 cfs. September flows average 16 cfs at Argenta during the same period; this was exceeded in 22 percent of the years. The average September flow in those exceeding years was approximately 54 cfs. Similarly, substantially lower than average flows also occur much of the time. Clearly, wide variations in flow occur on the river through time. The average values presented herein are included as a means of generally depicting the flow conditions on the river, and to aid in a conceptual understanding of conditions as the river traverses the study area. Table 3.2-13 presents the estimated average annual gains and losses for the periods of interest at each of the selected Humboldt River gages. Long-term gains and losses are determined by comparing the average annual flows between successive stream gages.

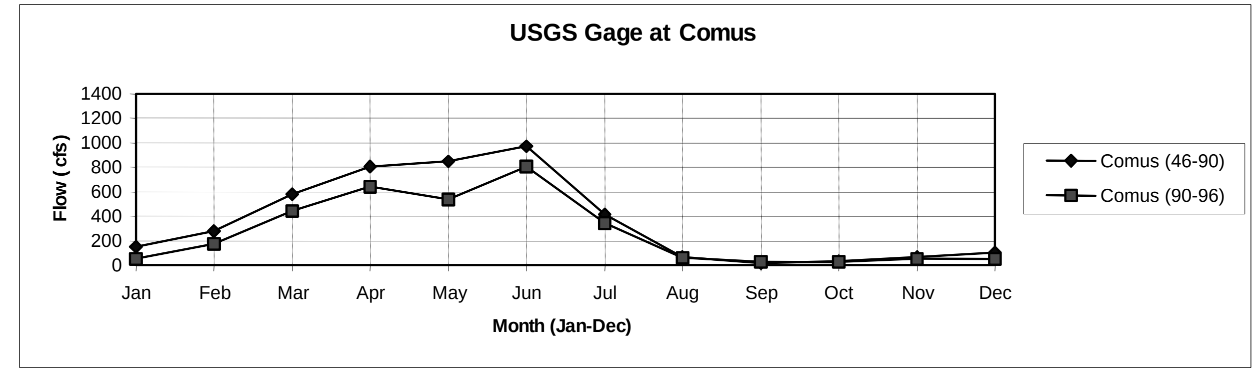
As can be seen in Table 3.2-13, the river reach from Carlin to Palisade is a gaining reach on an annual basis. This is primarily due to additional runoff as well as ground water discharge into the channel from the alluvial and bedrock aquifers along the reach. In contrast, data indicate that on an annual basis the river has losing reaches historically from Palisade to Argenta and from Battle Mountain to Comus. Water loss along these reaches is due to agricultural withdrawals,

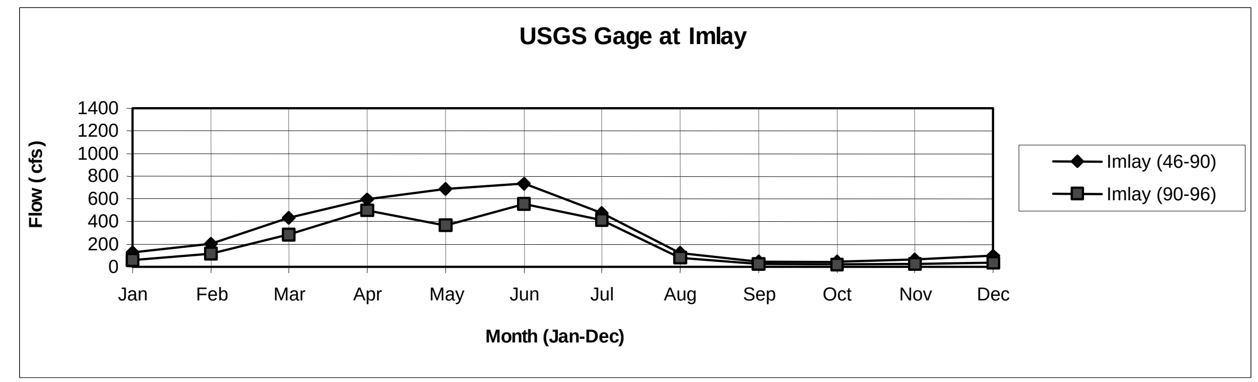












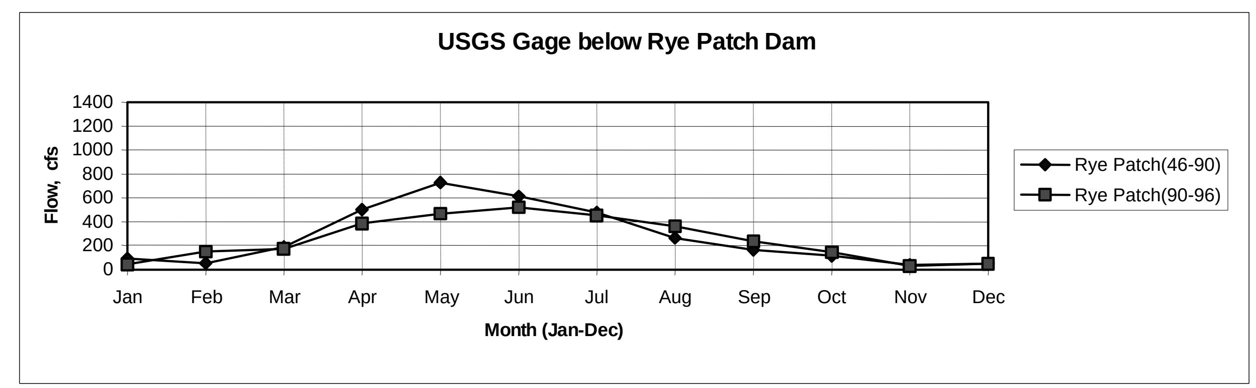


Figure 3.2-17

Long-term Average Annual Streamflows for the Humboldt River at USGS Gage Stations

Table 3.2-10
Average Annual Humboldt River Flows (cfs)

January 1946 - May 1990		June 1990 - December 1996	
Gage	**Flow**	**Flow**	**Percent of 1946 - 1990 Flow**
Carlin	383	269	70
Palisade	434	345	79
Argenta	391	262	67
Battle Mountain	395	279	71
Comus	365	232	64
Imlay	305	174	57

Table 3.2-11
Average June Humboldt River Flows (cfs)

Gage	January 1946 - May 1990	June 1990 - December 1996	
	Flow	**Flow**	**Percent of 1946 - 1990 Flow**
Carlin	1,228	1,064	87
Palisade	1,270	1,046	82
Argenta	1,146	988	86
Battle Mountain	1,108	1,023	92
Comus	970	808	83
Imlay	732	555	76

Table 3.2-12
Average September Humboldt River Flows (cfs)

Gage	January 1946 – May 1990	June 1990 - December 1996	
	Flow	**Flow**	**Percent of 1946 - 1990 Flow**
Carlin	27	20	74
Palisade	41	37	90
Argenta	16	10	63
Battle Mountain	23	11	48
Comus	17	27[1]	159
Imlay	48	23	48

[1] The June 1990 through December 1996 flows at Comus may have been affected by dewatering discharges from Newmont's Lone Tree Mine, and therefore are not particularly representative of a natural occurrence.

Table 3.2-13
Mean Annual Humboldt River Gains and Losses (cfs)

River Reach	January 1946 - May 1990 Flows	June 1990 - December 1996 Flows
Carlin to Palisade	+51	+76
Palisade to Argenta	-43	-83
Argenta to Battle Mountain	+4	+17
Battle Mountain to Comus	-30	-47
Comus to Imlay	-60	-58

Source: RTi 1998.

evapotranspiration, and infiltration into the alluvial aquifer. Between Argenta and Battle Mountain, the river historically shows no major net gain or loss on an annual basis. Maurer et al. (1996) generally concur with these results, finding that the river gains flow from Carlin to Palisade and dominantly loses flow from Palisade to Battle Mountain.

Baseflow gains and losses have been estimated between selected Humboldt River gages by Zimmerman (1992b). Using October flows, Zimmerman indicates that a gaining reach occurs between Carlin and Palisade, such that baseflows at Palisade are approximately 19 cfs greater than flows at Carlin. This is consistent with Maurer et al. (1996). Between Palisade and Argenta, the river loses approximately 22 cfs. From Argenta to Battle Mountain, a slight gain occurs. From Battle Mountain to Comus, the river loses baseflows of approximately 10 cfs.

Similar values are shown for the periods of record identified in Table 3.2-14. The two periods used reflect similar values upstream of Argenta. Downstream of Argenta, the differences in the data may be partially caused by the effects of statistical streamflow data synthesis used for impact analyses, but are more likely due to increasing irrigated area and other discharge factors, which vary from year to year in the basin.

Maurer et al. (1996) used gage data from October 1946 through September 1981 to conduct flow duration analyses for the Humboldt River at Carlin, Palisade, Argenta, and Battle Mountain. The Battle Mountain gage was used for similar calculations by Simons (Simons & Associates, Inc. 1995b). The results of these analyses indicate that a flow of approximately 1,000 cfs is equaled or exceeded only 10 percent of the time. Similarly, a flow of approximately 2,800 cfs is equaled or exceeded only 1 percent of the time. The median flow is approximately 120 cfs, indicating that flows are greater than this half of the time, and less than this half of the time. By examining the results in Maurer et al. (1996), it can reasonably be assumed that these results closely fit the Argenta data as well, except for the lowest flows (less than 1 or 2 cfs).

In Table 3.2-13, it can be seen that substantial flow losses are typical downstream of Battle Mountain. Downstream of the Comus gage, substantial losses in river flows also occurred in a majority of the years specifically investigated in USGS studies. Between the Comus gage and the Pershing County line (see Figure 1-6), the average annual loss was 17,000 acre-feet for the period 1949-1962 (Cohen 1964). Spring and summer losses were higher than the annual average due to irrigation withdrawals, seepage to ground water, and evapotranspiration. Flow losses in the river for February though June averaged 28,000 acre-feet between Comus and the Pershing County line. Flows increased somewhat in the river from July through January as a result of irrigation returns and ground water contributions. Downstream of the Pershing County line to the Imlay gage (see Figure 1-6), approximately 5,000 acre-feet/year were lost from the river during the period 1951-1962 (Eakin 1962). Flow losses or gains varied widely in individual years for both of the reaches described above, but it can be seen that on the order of 22,000 acre-feet/year were lost between the Comus gage and the upstream end of Rye Patch Reservoir. With an additional 20,000 acre-

Table 3.2-14
Mean October Gains and Losses in the Humboldt River (cfs)

River Reach	January 1946 - May 1990 Mean October Flows	June 1990 - December 1996 Mean October Flows
Carlin to Palisade	18.4	+20.6
Palisade to Argenta	29.7	-30.1
Argenta to Battle Mountain	5.1	1.2
Battle Mountain to Comus	9.7	12.3
Comus to Imlay	14.4	4.5

Source: RTi 1998.

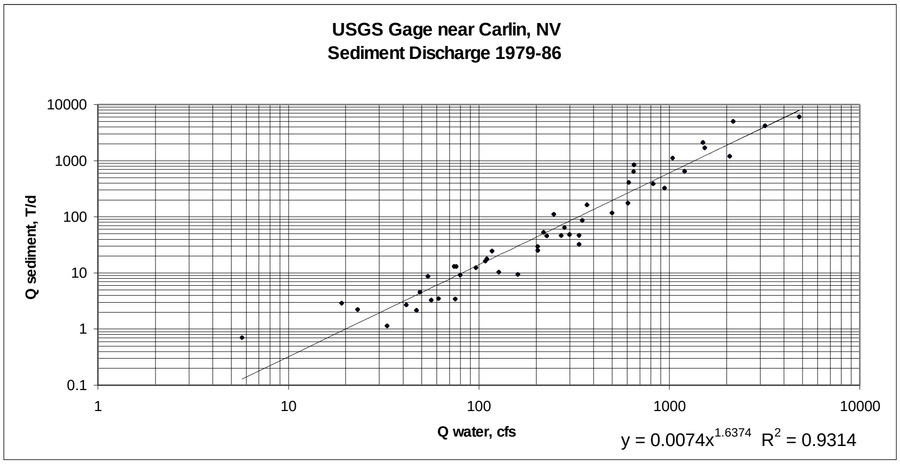
feet/year estimated to evaporate from Rye Patch and Pitt-Taylor reservoirs, it can be seen that on average a substantial amount of river flow was lost from the surface water system between Comus and the USGS gage near Rye Patch. This general concept is supported by more extensive gaging data depicted in Table 3.2-13.

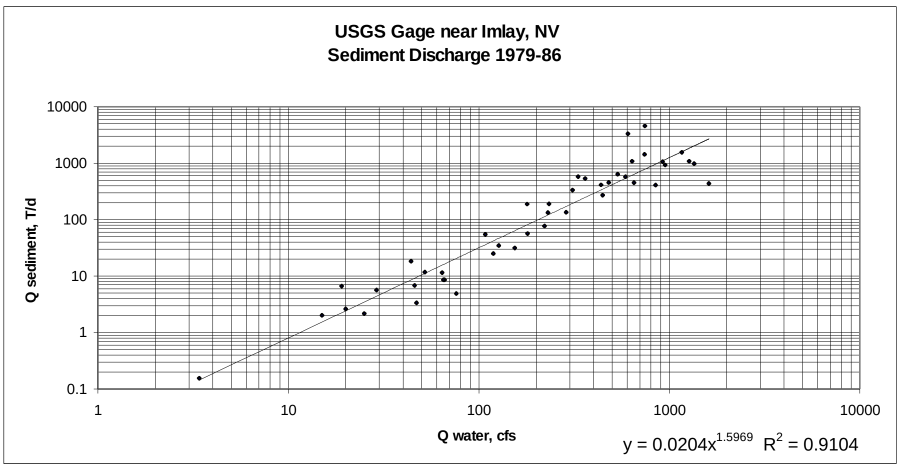
Existing Mining Discharges. Since 1992, two mines have operated dewatering operations that affect surface water along the Humboldt River prior to Barrick's mine dewatering discharges. These mines are Newmont's Gold Quarry and Lone Tree mines. The Gold Quarry Mine is located in the Maggie Creek drainage and discharges into Maggie Creek, which enters the Humboldt River just upstream of the Palisade gage (see Figure 1-6); the Gold Quarry Mine was issued a surface water discharge permit in April 1994. The Lone Tree Mine is located downstream of Battle Mountain just upstream of the Comus gage (see Figure 1-6); the Lone Tree Mine was issued a surface water discharge permit in May 1992. Further information on these discharges is presented in the Cumulative Impact Analysis report (BLM 2000b).

Sediment Discharges. Humboldt River sediment discharge data from the USGS were examined for the gage locations in the study area that have reasonable periods of record. These gages include the Humboldt River near Carlin, near Imlay, and near Rye Patch (Figure 1-6). Essentially no sediment discharge data exist in the Palisade to Comus area. Sediment discharge data for the period of record common to the gages was plotted, and a line of best fit was determined to relate sediment discharge to flow rate in the river (Figure 3.2-18).

There is considerable variation in the data, even at a single station for a given river flow. However, general relationships can be seen at a single station and between stations. Between Carlin and Imlay, a general increase in sediment discharge for a given water flow can be identified from the graphs. For example, the general sediment discharge for a flow of 100 cfs is about 14 tons/day at Carlin, and about 32 tons/day at Imlay. For 1,000 cfs in the river, the general sediment discharge rates are about 605 tons/day and 1,260 tons/day at Carlin and Imlay, respectively. This is likely due to the increased sediment supply from the additional drainage area and channel length at Imlay versus Carlin. Substantially less sediment discharge occurs for a given flow at the Rye Patch gage in comparison to either Carlin or Imlay. This is due to the sediment trapping effects of Rye Patch Reservoir, which is between the Imlay and Rye Patch gages. The estimated sediment discharges at the Rye Patch gage are about 9 tons/day for a flow of 100 cfs, and about 80 tons/day for a flow of 1,000 cfs.

With regard to data variations, it can be seen that for flows of about 55 cfs at Carlin, the sediment discharges range from about 3.5 to 8.5 tons/day. For flows on the order of 1,000 cfs, sediment discharges range from 325 to 1,120 tons/day. Similar variation exists in the Imlay and Rye Patch data. It should be noted that sediment discharge data portray a synthesis of all the random and instantaneous sediment-related events in the watershed upstream of the monitoring point. Thus, one point in the Carlin data reflects cropland uses, grazing activity and other land uses, the amount and timing of rainfall and snowmelt, re-entrainment of sediment that may have been stored along the channel for





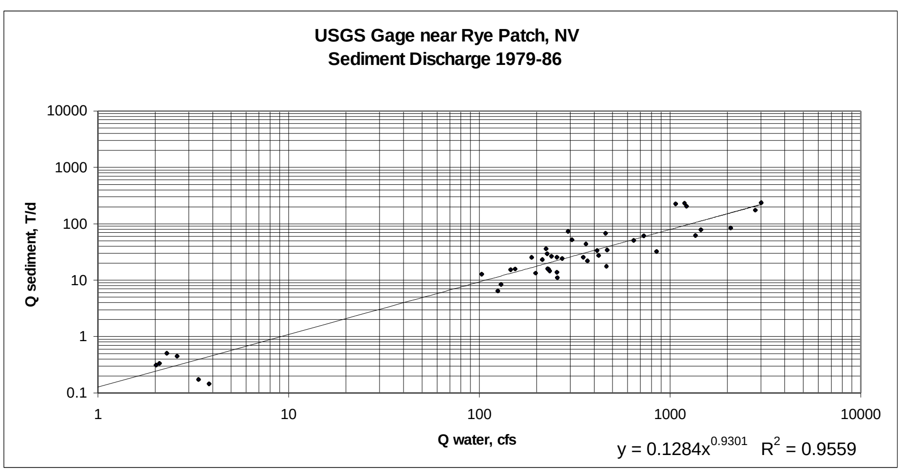


Figure 3.2-18

Humboldt River Sediment Discharges

years, and other incidental disturbances along the river for the entire upstream watershed. Accounting for this multitude of factors historically is unrealistic. The same limitation exists at Imlay and Rye Patch. Therefore, although general statements can be made for data averaged over a period of time, the data do not allow specific causes and effects to be separated at specific times or flow events.

Regional River Channel Geometry. The configuration and habitat associations of the Humboldt River have been intensively examined over much of the study region by the Nevada Division of Wildlife (Rawlings and Neel 1989; Bradley and Neel 1990; Bradley 1992; Neel 1994). In particular, these studies included quantification of river length and sinuosity from the Dunphy area to near Rye Patch Reservoir. Sinuosity is the ratio of river length to valley length, and it is commonly used as a measure of river meandering. Higher sinuousity values indicate a higher degree of meandering. Changes in the river over time are shown in Table 3.2-15 for general non-continuous locations in the cumulative study area. The data used to develop Table 3.2-16 are nearly continuous over the length of the river indicated. Small gaps do exist in the data; however, they are reasonably representative of channel conditions along the section from Dunphy to Imlay. The measurements were made from USGS topographic quadrangles, historical aerial photographs, and additional aerial photos taken in 1985 when the investigation was initiated. The date of the historical information used in the analysis is shown in the second column. The 1985 data were used for comparison.

Table 3.2-15 indicates that a net loss of approximately 13.4 miles of river length has occurred between the Dunphy area and the Imlay area over the 2 to 3 decades represented by the data. Substantial loss of river length and sinuosity has occurred in the Dunphy and Argenta area and downstream of Winnemucca. In other locations, such as near Comus and at or slightly upstream of Winnemucca, the river has apparently both increased and decreased its length. Little or no change is shown over much of the river, particularly where the historical data represent conditions only 2 or 3 years prior to 1985. Differences of less than 0.1 mile in river length may be caused by small measurement errors on the maps and photos. From the date of the baseline data, it can be seen that channel changes have occurred to different degrees at different locations. Whether the changes occurred gradually over time or resulted from a few isolated events is not known. A mixture of both long-term and short-term factors probably contributed to the river conditions. However, it is clear that the river geometry has been in flux historically, prior to mining discharges. Some river locations have undergone substantial adjustment, while others are relatively unchanged.

A number of factors must be considered when reviewing Humboldt River channel characteristics. First of all, the concept of stability may have different meanings when applied to a dynamic natural river system. The distinction is between the balance of flow and sediment transport processes within a system in motion versus the immobility of a river's position in relationship to civil boundaries or structures.

Variables such as channel gradient, length, width, depth and sinuosity refer to conditions that may be balanced (dynamic equilibrium) or not as a stream channel migrates or otherwise adjusts itself within an alluvial valley system. From a geomorphic viewpoint, a river can be thought of as being in balance if these relationships are maintained, even though the river may migrate widely across its floodplain. In short, changes in channel position do not necessarily imply instability within the river system. In contrast, efforts to stabilize or maintain the channel position at a given location often promote imbalances elsewhere, both upstream and downstream.

Within the past several decades, several major activities have taken place along the Humboldt River that have affected its position and geometry. These include several miles of federal channel straightening in the 1950s near Argenta and east of Comus. In addition, construction began on what is now the Interstate 80 system in the early 1960s. In combination with railroad structures and a narrow valley, the highway bridges at Dunphy have maintained the channel location there. The river position fluctuates upstream and downstream. In recent decades, several irrigation structures have been built

Table 3.2-15
Historical Changes in Humboldt River Configuration

General Study Location	Historical River Length, miles (date)	1985 River Length, miles	Total Change, miles	Total Percent Change	Historical Channel Sinuosity	1985 Channel Sinuosity	Change
Dunphy	19.7 (1965)	15.1	-4.6	-23.4	1.62	1.25	-0.370
Argenta/Rock Creek	15.5 (1957)	13.7	-1.8	-11.6	1.26	1.11	-0.150
Battle Mountain Area	3.8 (1957)	3.7	-0.1	-2.6	1.69	1.64	-0.050
Valmy	20.1 (1954)	16.3	-3.8	-18.9	2.53	2.05	-0.480
Valmy	6.0 (1976)	5.2	-0.8	-13.3	2.06	1.79	-0.270
Valmy	3.4 (1965)	3.1	-0.3	-8.8	1.10	1.06	-0.040
Valmy	3.5 (1965-66)	3.5	0.0	0.0	1.17	1.17	0.000
Valmy	18.6 (1965)	17.8	-0.8	-4.3	1.58	1.57	-0.010
Comus	5.4 (1965)	5.3	-0.1	-1.9	1.28	1.26	-0.020
Comus	5.0 (1945, 1965)	5.3	0.3	6.0	1.85	1.96	0.110
Golconda	1.5 (1965, 1983)	1.6	0.1	6.7	1.50	1.60	0.100
Golconda	20.5 (1965)	20.1	-0.4	-2.0	1.71	1.68	-0.030
Winnemucca	7.6 (1983)	8.4	0.8	10.5	1.81	1.74	-0.070
Winnemucca	3.6 (1983)	3.5	-0.1	-2.8	1.16	1.13	-0.030
Winnemucca	4.7 (1983)	4.7	0.0	0.0	2.35	2.35	0.000
Winnemucca	3.5 (1982-83)	3.5	0.0	0.0	1.84	1.84	0.000
Winnemucca	5.3 (1982-83)	5.3	0.0	0.0	2.41	2.41	0.000
Winnemucca	5.8 (1976)	5.7	-0.1	-1.7	2.23	2.19	-0.040
Below Winnemucca	11.7 (1976)	10.3	-1.4	-12.0	2.21	1.94	-0.270
Imlay	17.4 (1976, 1982)	17.1	-0.3	-1.7	1.66	1.63	-0.030
TOTAL	**182.6**	**169.2**	**-13.4**	**-7.3**			

Source: Bradley and Neel 1990; Bradley 1992; Neel 1994.

Table 3.2-16
Humboldt River Channel Sinuosity Over Time, Dunphy to Mosel

Reach	1979	1982	1983	1994
Upstream	1.82	1.59	1.53	1.48
Downstream	1.40	1.21	1.20	1.35

across the river as well. Over a longer time, railroad and municipal embankments have been built and maintained, and streamside vegetation has been altered as a result of various land use conversions (Rawlings and Neel 1989).

In 1984, extremely high flows occurred naturally in the Humboldt River. The highest recorded instantaneous peak flow at the Comus gage occurred on April 24 of that year, and was 9,900 cfs. The highest recorded daily mean flow occurred the next day, and was 9,640 cfs (USGS 1999). On the basis of data gathered since 1946, these flows were roughly 10 times the peak flow for an average year at the Comus gage. The extreme flows cut across meanders, eroded banks, scoured the existing bars and terraces, and created new sediment deposits either as bars or thin veneers over the lower terraces.

It is probable that over several decades, alterations and infrastructure development all along the river have essentially anchored several locations into place and caused other reaches to continually adjust. Preliminary USGS information for the gage at Comus indicates that between

1988 and 1997, the river channel has widened and filled such that the general bottom elevation was between 0.5 feet and 1.5 feet higher in 1997 than in 1988 (USGS 1999). In addition, aerial photographs indicate that several meanders have been cut off immediately upstream of the gage since the 1960s. Extensive lateral migration of the river channel also has occurred historically in the Dunphy area near Barrick's outfall.

Local River Channel Characteristics. Aerial photography and photo-based topographic maps were inspected for the river reach near Barrick's outfall for the years 1979, 1982, 1983, and 1994. The Humboldt River is a sinuous point-bar channel over the area examined in detail, which extends approximately 8 miles upstream and downstream of Barrick's outfall. It has maintained this overall configuration since 1979, through both the drought years and the highest flows on record. Tectonic influences on the river in the last 20 years or so are unknown. However, the river grades to a sinuous braided channel for a short reach just upstream of the Dunphy Road bridge, approximately 2.5 to 3 miles upstream of Barrick's outfall.

USGS topographic quadrangles for the area were developed from aerial photography taken in 1982. Based on these maps, main channel sinuosities (river length divided by straight air length) range widely between Whirlwind Valley (just north of Beowawe, Figure 1-6) and the Argenta area. Main channel sinuosity is high in Whirlwind Valley itself, typically approximately 2.0. As the river leaves the valley, the value drops to 1.3 for approximately 2 miles above the Interstate 80 bridge. From Interstate 80 to just below Barrick's outfall (approximately 3.5 miles) the value increases to 1.6. Below the outfall, sinuosity decreases again to approximately 1.2 down to the TS Ranch bridge, except for a short stretch approximately 1 mile above the bridge with sinuosity of 1.6. As shown in 1994 aerial photographs, the main channel in the latter area has naturally straightened to match the rest of the locale since the topographic mapping was completed. Below the bridge, sinousity increases slightly to 1.3 for a couple of miles and then decreases again to 1.1 or even less at Argenta. Long, straight sections of the river occur in the Argenta area, probably caused by a combination of natural and man-made factors.

Based on the 1982 topography, channel bed slope in Whirlwind Valley is approximately 1.4 feet per mile. Above the Interstate 80 bridge, the main channel slope averages approximately 3.7 feet per mile. From the bridge to approximately 0.5 mile above Barrick's outfall, the slope averages approximately 6.4 feet per mile. From there, the main channel slope flattens gradually, reaching approximately 4 feet per mile in the Argenta vicinity. These values are approximate; somewhat steeper and flatter sections are interspersed throughout the river length. The slope of the reach that straightened out approximately 1 mile above the TS Ranch bridge was considerably flatter in 1982 than the reaches on either side of it. Main channel slope and meander adjustments such as this occur regularly in the area. The slope of the low-flow channel is probably somewhat flatter in general than the values presented since general map contours were used to determine these slopes, and typically the low-flow channel meanders somewhat within the wider channel shown on maps.

Channel banks are typically steep to nearly vertical. Bank erosion has been an active agent historically over much of the area studied and presently continues. Bank materials in the outfall locale demonstrate some degree of cohesion, and samples contain 80 to 90 percent very fine sand, silt, and clay (Simons & Associates, Inc. 1997). Bed materials in the locale consist primarily of gravel and sand, with minor amounts of cohesive materials (Simons & Associates, Inc. 1995d). Mean grain size in the bed is approximately 20 millimeters (gravel) in most sampled locations. Point bars occur on the inside of most bends, and have relatively gentle slopes with a mixture of material sizes.

Floodplain width ranges from approximately 2,000 to 4,000 feet, depending on the location. Within this width, numerous and extensive abandoned meanders and subsidiary channels exist. Anabranches occur in the form of narrow, highly sinuous side channels that are common in Whirlwind Valley and at other locations downstream. Historically, the main channel has migrated frequently and widely throughout its floodplain.

Levees, spoil banks, and other river controls, such as bridges, dams, and railroad grades, occur extensively throughout the portion of the river from lower Whirlwind Valley to Argenta. These features provide varying degrees of control on river position and consequently influence river adjustments over much of the flow range. At or near Dunphy, three bridges cross the river. An additional bridge crosses at Mosel, and a network of levees and spoilbanks occur in combination with a concrete overflow spillway in the Argenta area. These features persisted through the highest recent flow year (1984). The Argenta gage washed out and was not replaced following 1983; however, based on statistical relationships with other gages (RTi 1998), the peak monthly discharge at Argenta in late May of 1984 was approximately 6,300 cfs.

A relatively stable reach occurs downstream of the former USGS gage site above the TS Ranch bridge at Mosel. Another occurs upstream of the Interstate 80 bridge above Dunphy and on into Whirlwind Valley. Between these locations, the river has historically modified its course a number of times in different locations within the last 20 years or so. Examples of this can be seen in Figure 3.2-19. Barrick's outfall is located within this more active stretch of the river. Changes in river position are shown over a 4-year period (1979 to 1983) in Figure 3.2-19. Changes over a 15-year period (1979 to 1994) are shown in Figure 3.2-19. Channel shifts for an intermediate 11-year period (1983 to 1994) can be seen by comparing the relevant traces between the two diagrams for a particular location. While the river has not dramatically migrated across the width of its floodplain during these years, it can still be seen that substantial shifts in channel position have occurred naturally between Mosel and the Interstate 80 bridge near Dunphy. Continuing channel shifts near Dunphy in 1995 and1996 are further illustrated by on-site photographs in the JBR Humboldt River baseline monitoring report (JBR 1997).

Historical changes in sinuosity were examined for the reaches immediately above and below the Barrick outfall. Although variations in channel sinuosity occur within short distances over the entire length of the river from Whirlwind Valley to Battle Mountain, longer reaches can be generalized. For comparative purposes, two reaches were selected visually, based on apparent similarity in general river configuration as shown on the 1982 photo-based topographic quadrangles. The upstream reach extended from a straight section approximately 2,000 feet below the Interstate 80 bridge, to a point approximately 800 feet below the outfall. The downstream section extended from the latter location to a point just above the pair of high-amplitude meanders halfway to Mosel. (These positions can be seen in Figure 3.2-19). The overall sinuosity values through time for the two selected reaches are shown in Table 3.2-16. As can be seen from the table, the upstream reach has consistently straightened since 1979. In contrast, the downstream reach has fluctuated over time. Nearer the outfall, the downstream reach has actually become more sinuous in recent years than the table indicates.

<u>Regional Features and Conveyance Structures</u>

In addition to water management systems associated with mining and municipal uses, numerous flow structures and conveyances occur within the study area. These are primarily used for agricultural purposes and form a complex system of diversions and returns on the Humboldt River and its tributaries. Notable diversion features from east to west along the main Humboldt River channel are listed for the study reach in Table 3.2-17. Additional ditches and controls interconnect river tributaries throughout the study area. White House Ditch, Blue House Ditch, and Rock Creek Ditch are examples of these structures in Boulder Valley. Occasionally, man-made links between the river and its tributaries have been made at locations other than the natural confluences. Examples of this occur in the Battle Mountain locale along the Reese River and Rock Creek.

Historically, an area of wetlands, abandoned channels, and associated wildlife habitats existed in the Argenta area in Lander County about half way between Battle Mountain and Dunphy near the former Argenta stream gage (see Figure 1-6). This area was informally known in the region as the Big Slough. Its size ranged between 1,500 acres and 5,000 acres, depending on the source of the information (Elko Daily Free Press 1997). It formed part of the Community Pasture

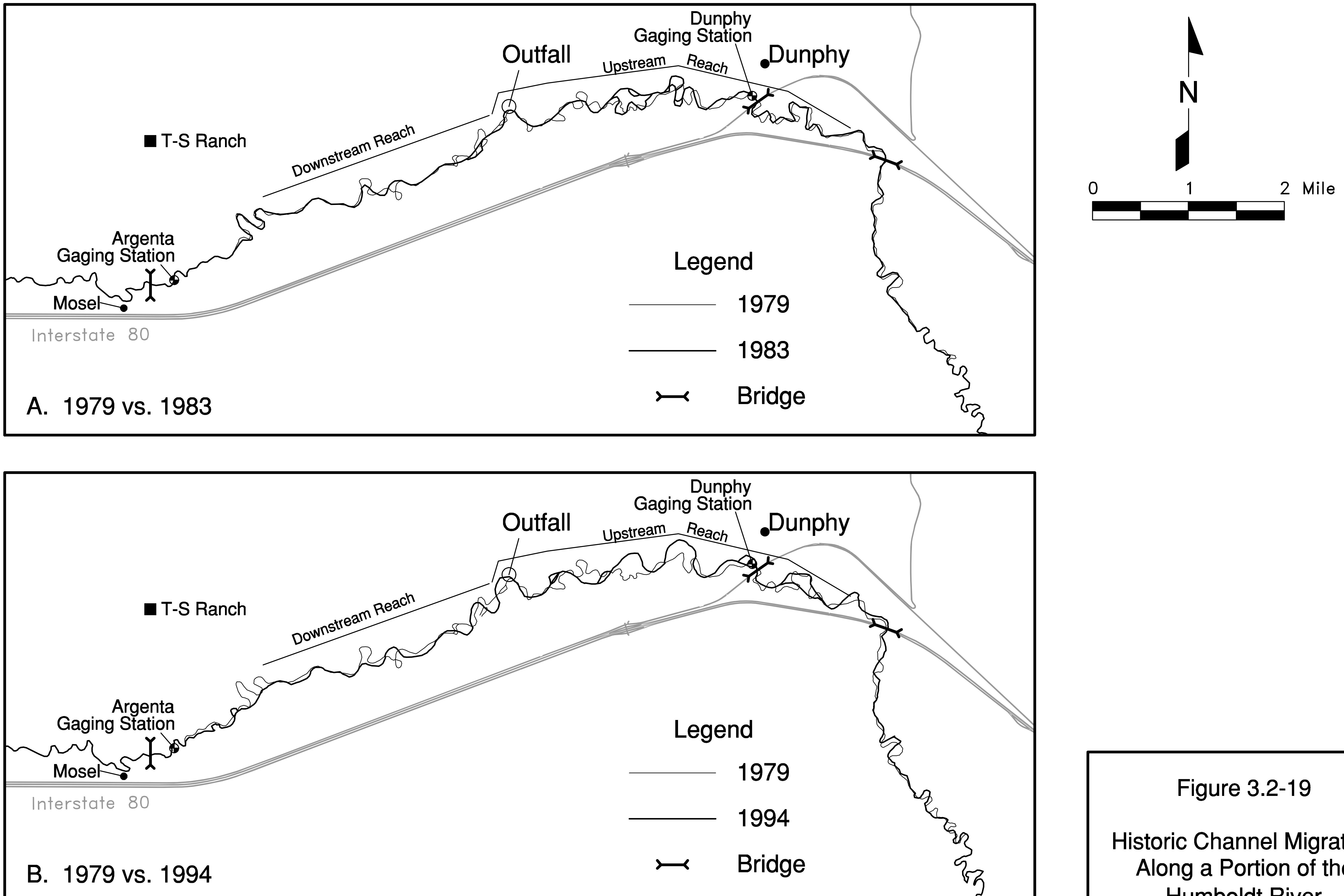


Figure 3.2-19

Historic Channel Migration Along a Portion of the Humboldt River

Table 3.2-17
Major Conveyance Structures Within the Humboldt River Study Area

Structure	Approximate Location
Diversion flumes	1 mile southwest of Carlin
Diversion dam and ditch system	Harney, 8 miles east of Beowawe
Anderson-Highline Canal takeout	3 miles southeast of Beowawe
Corbett Canal takeout	2 miles southeast of Beowawe
Merchant Canal system takeout	Beowawe
Westside Ditch takeout	Beowawe
Rose Canal takeout	3.5 miles southeast of Dunphy
White House Dam	Dunphy
Bluehouse Ditch	3 miles east of Dunphy
Ditch	3 miles east of Battle Mountain
25 Ranch ditch system	7 miles northwest of Battle Mountain
Ditch	Ellison Ranch
The Dike	2 miles south of White House Ranch
Ditch	White House Ranch
Dam	Red House
Dam	2 miles west of Red House
Dam	1.5 miles southeast of Comus
Stahl Dam and French Canal diversion	2 miles east of Golconda
CS Dam	3 miles southeast of Button Point
Various dikes, headgates, and ditches	Button Point vicinity
Reinhart Dam	1.5 miles north of Winnemucca
Diversion dams and ditch system	2 miles northeast of Rose Creek
Pitt-Taylor Diversion Canal takeout	1.5 miles north of Mill City
Pitt-Taylor Dam and reservoirs	2.5 miles west of Humboldt
Rye Patch Dam and reservoir	1.5 miles northwest of Rye Patch
Young Dam, levees and diversion takeout	2 miles north of Colado
Pitt Dam	4.5 miles northeast of Lovelock
Irish-American Dam	3.5 miles northeast of Lovelock
Rogers Dam	1.5 miles northeast of Lovelock
Numerous gates, canals, ditches, and flumes	Lovelock area and downstream

bought by the U.S. Bureau of Reclamation in the 1930s in an effort to acquire water rights for Rye Patch Reservoir. The reservoir, pasture, and associated irrigation and water management infrastructure collectively form the Humboldt Project, which was approved by Congress in the 1930s. Water rights for the Community Pasture lands were transferred downstream to support the project, which is operated and paid for by the Pershing County Water Conservation District. Until the late 1950s, the marsh area supported extensive zones of willow and other riparian and wetland communities that, in turn, provided habitat for large numbers of waterfowl, as well as shorebirds, upland game birds, deer, and antelope (McColm 1994).

During the late 1950s, the area was drained by a Federal river channelization project, which straightened the course of the river for several miles through the Argenta vicinity and elsewhere along the river. The purpose of the channelization project was to conserve water in the river by reducing seepage and evapotranspiration, and ultimately to ensure that the water rights purchased by the U.S. Bureau of Reclamation actually resulted in additional water being supplied to the reservoir. The channelization was devised and undertaken by the U.S. Bureau of Reclamation, as a result of a directive from the Nevada Department of Conservation and Natural Resources to demonstrate that the amount of water acquired was actually available at Rye Patch and downstream.

In recent years, this area has been referred to as the former Argenta Marsh. Having complied with the Humboldt Project reimbursement schedule for decades, the Pershing County Water Conservation District has recently applied to the Federal government to receive title to the Humboldt Project properties. This process has generated public comment and involvement concerning the use and management of project lands. The concept of restoring water to the Argenta Marsh and improving habitats there has been supported by the Nevada Division of Wildlife and other public and private organizations, although the actual mechanisms for doing so require further definition and examination. Conceivably, mine discharge water could be diverted into the area through an old system of irrigation ditches. The feasibility of marsh restoration, water rights issues, and the long-term maintenance of marsh habitats after mine discharges cease are ongoing topics of discussion between the Pershing County Water Conservation District and other entities in the region.

The Humboldt River terminates at the Humboldt Sink approximately 15 miles southwest of Lovelock. The sink consists of two shallow lakes, Humboldt Lake and Toulon Lake, and a large area of alkali flats (Figure 3.2-20). The extent of the lakes varies widely from year to year, depending on the amount of water flowing into them from the river and agricultural drains. The total land area at the sink is on the order of 40 square miles.

The river is channelized for several miles upstream of the sink. Other major drains near the sink include the Toulon, Army, Lovelock Irrigation and the Graveyard drains, which primarily route agricultural return flows. Ultimately the drainages combine so that the Toulon Drain, Army Drain, and the Humboldt River form the major surface water conveyances into the Humboldt Sink.

When water is available, the Humboldt Drain at the southwestern end of Humboldt Lake allows conveyance of water out of the Humboldt Sink to the nearby Carson Sink through an area of alkali flats and the Humboldt Slough. Recent USGS data indicate that flows between approximately 550 to 950 cfs passed through the Humboldt Drain toward the Carson Sink in the late summer of 1998 (USGS 1999b). The USGS gage near Carlin exhibited nearly average flows for that period as did the gages at Imlay and Rye Patch. It is not known if the flows through the Humboldt Drain in 1998 are representative of average conditions or how much of that flow actually reached the Carson Sink.

The USGS operated a streamflow gaging station on the Humboldt River downstream of Lovelock from 1950 to 1959, and has conducted new gaging and sampling at the location in 1998 and 1999 (USGS 1999b; Thodal 2000). Flows in the latter period include recent high flow years as well as possible effects from mine dewatering. They are within the range of flows exhibited at the gage from 1950 through 1959. The 1950s were comprised of both high flow years and low flow years on the river, but are somewhat lower in overall average compared with the periods of record at other gages used in this assessment. However, the earlier period (1950 through 1959) reflects conditions prior to flow contributions from mine dewatering and, as such, these data have been used to characterize baseline (existing) conditions for the purposes of impact assessment.

Based on these limited flow measurement data, approximately 42,000 acre-feet of water per year flowed into the sink via the river below Lovelock. A very general assumption for the average annual diversion rate for the Lovelock Valley can be estimated by subtracting the river flows past Lovelock (available for 1950 through 1959) from the Rye Patch gage flows for the same period. This indicates that on the order of 105,000 acre-feet/year were diverted for use in the Lovelock Valley. Both high and low flows are represented in this period, although the Rye Patch average for the period is only about 75 percent of the 1946-90 average. Assuming a 30 percent return from the

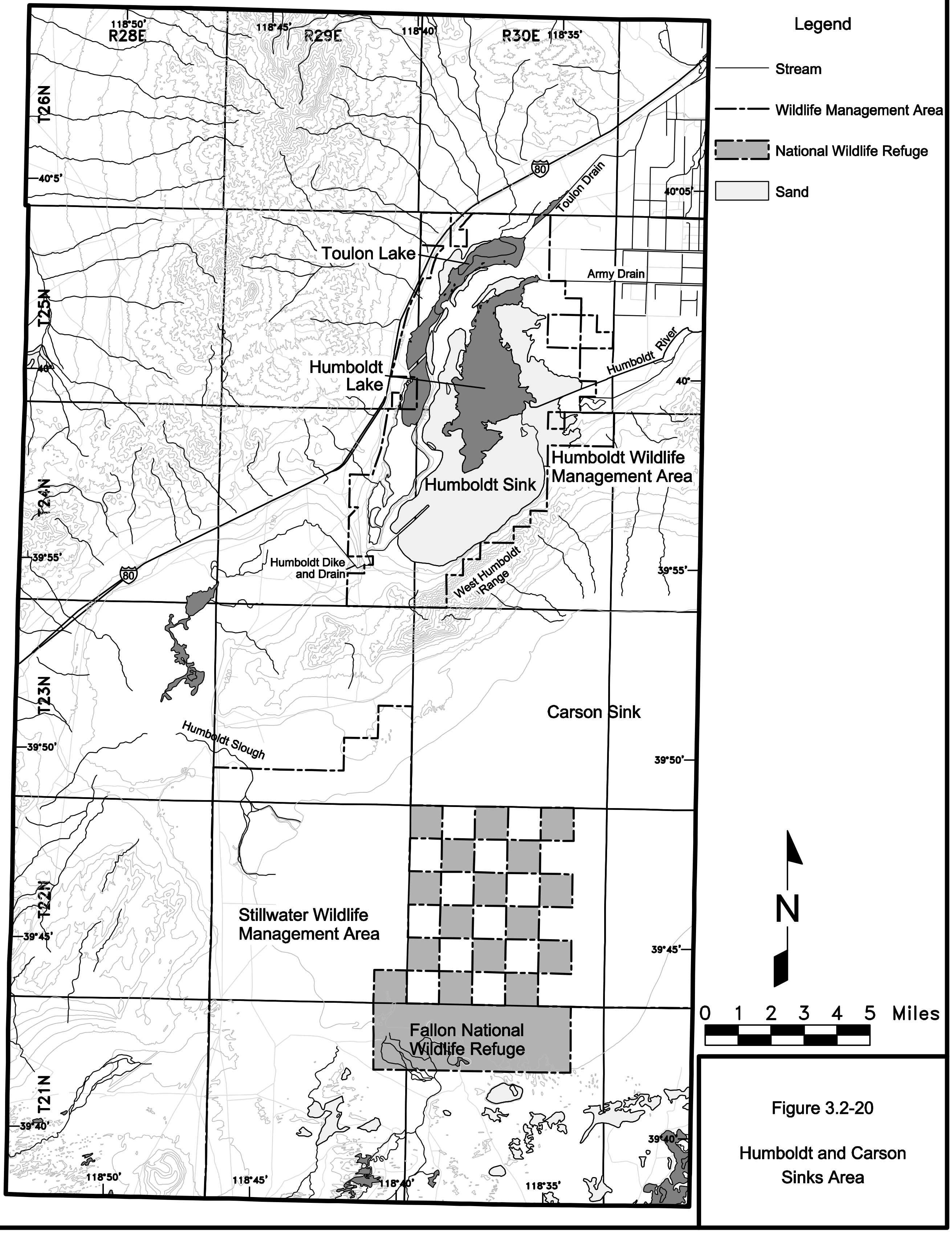


Figure 3.2-20

Humboldt and Carson Sinks Area

105,000 acre-feet/year diversion, 31,500 acre-feet/year also flowed to the sink through seepage and drains as a general estimate. Coincidentally, with the 42,000 acre-feet per year flowing in the river, these figures sum to the approximate value (74,000 acre-feet/year) of surface and ground water outflow from the Humboldt basin into the sink as indicated by Eakin and Lamke (1966). Normalizing these values to the 1946 through 1990 period of record used for other premining flow analyses, approximately 56,500 acre-feet/year flowed into the sink through the lower river, and 42,500 acre-feet/year of agricultural return flows entered the sink through drains and seepage, as broad estimates.

Mean annual rainfall in the sink area is approximately 5.4 inches (National Oceanic and Atmospheric Administration - Cooperative Institute for Environmental Sciences 1999). With approximately 40 square miles of area, on the order of 11,500 acre-feet/year are contributed to the sink by direct precipitation. Combined with the inflows, on the order of 110,000 acre-feet/year are lost at the Humboldt Sink by evaporation, transpiration, and occasional overflow to the Carson Sink. Note that this is a very general approximation based on limited data and simplifying assumptions; the actual contributions and losses at the sink vary widely from year to year.

Humboldt River Surface Water Rights

Many surface water rights exist within the Humboldt River study area, some dating from the early 1860s. Hundreds of rights are held for diversion of river water, and additional rights exist along the tributaries. A listing of all these would be too large to include in this document, but a summary is presented Table 3.2-18 below (Hennen 1964). Table 3.2-18 indicates the amount of water on the lower Humboldt (generally below Palisade) that was decreed and permitted by the State Engineer as of calendar year 1963, and can serve as an approximation for characterizing potentially affected resources. In the entire Humboldt River basin, there are approximately 667,000 acre-feet of decreed and permitted water on approximately 266,000 acres of land (Hennen 1964). A concise listing of surface water rights and a discussion of related issues for the Humboldt River is presented in *Humboldt River Water Distribution* (Hennen 1964), although changes have occurred since its publication. Humboldt River surface water rights above Palisade are administered under the Edwards Decree of 1935. The Bartlett Decree of 1931 applies to and is used in the distribution of river water below Palisade. Additional information is publicly available from the Nevada Department of Conservation and Natural Resources, Division of Water Resources, in Carson City.

Humboldt River Water Quality

Available water quality information was compiled for all Humboldt River stations located between Carlin and the Humboldt Sink. Water quality data exist for most of the monitoring sites shown in Figure 1-6. Since mining-related discharges to the river began in early 1991, however, only the data collected from approximately 1970 to 1990 was applicable for describing premine water quality conditions. Based on review of the database, it was determined that the most representative data for premine water quality in the Humboldt River was USGS data collected near Carlin (USGS Gage 10321000) and near Rye Patch (USGS Gage 10335000).

Data from other water quality stations were much less complete and were not considered in this evaluation. The Carlin site was also selected for evaluation since it represents conditions in the upstream reach of the Humboldt River study area. The Rye Patch site was selected to represent conditions in the lower portion of the river immediately above the Lovelock agricultural development. Below the Rye Patch gage, a large percentage of the river flows are diverted for irrigation. The Humboldt River and the Army Drain are the primary sources of flow to Humboldt Lake; the Toulon Drain is the primary source of flow to Toulon Lake. Only a few samples are available to define the water quality for each of these three sources for the premine discharge period (prior to 1991).

Surface Water Quality Standards. Surface water quality standards have been established by the State of Nevada for designated beneficial uses associated with the Humboldt River. These standards are prescribed in Nevada Administrative Codes 445A.144 and 445A.203 to 445A.208, inclusive. Beneficial uses for the

Table 3.2-18
Approximate Five-county Acreage with Humboldt River Water Rights, and Annually Decreed and Permitted Water on the Lower River[1]

County	Acreage	Acre-feet of Water
Elko	4,726	8,702
Eureka	20,235	34,427
Lander	27,633	42,085
Humboldt	23,950	46,980
Pershing	40,884	144,833
TOTAL	**117,428**	**277,027**

Source: Hennen 1964.

[1] In this tabulation, the area on the main stem and on Maggie Creek west of the Eureka-Elko county line is also credited to the lower river (below Palisade). The actual acreage and acre-feet of water decreed and permitted on the river is somewhat different, due to changes over the years, duplications in the decree, and the occurrence of permits issued by the State Engineer that are not included in the data given by the decree (Hennen 1964).

Humboldt River are defined in Nevada Administrative Code 445A.202 and include irrigation; livestock watering; contact and non-contact water recreation; industrial, municipal, and domestic supply; propagation of wildlife; and propagation of aquatic life including warm-water fisheries. Beneficial uses and water quality standards for the Humboldt River near Palisade and Woolsey are also listed in Table 3.2-19. Water quality standards for the Palisade control point are applicable to data collected from the Humboldt River USGS Gage near Carlin (Figure 1-6). Likewise, standards for the Woolsey control point apply to data collected from the Humboldt River USGS Gage near Rye Patch (Figure 1-6).

General Surface Water Quality. Water quality data summaries from the USGS gages near Carlin and Rye Patch are listed in Table 3.2-20. For January 1970 through April 1991, streamflows in the Humboldt River near Carlin ranged from 5.7 to 8,130 cfs and from 0.3 to 3,010 cfs near Rye Patch. Average flow values decreased from 473 cfs near Carlin to 334 cfs near Rye Patch. The decrease in flow through the river section is likely the result of diversions out of the river and evaporative losses. It is also likely that flow losses due to evapotranspiration, and sources providing additional constituent loads, contributed to an increase in average TDS concentration calculated through the river section. Average concentrations of TDS increased from 294 mg/L near Carlin to 548 mg/L near Rye Patch.

An average water temperature of 12°C and dissolved oxygen concentration of approximately 10 mg/L was calculated for both monitoring locations (Table 3.2-20). In addition to temperature and dissolved oxygen, average pH values were similar near both Carlin (8.4) and Rye Patch (8.5). As illustrated by the average values, measurements of pH were only slightly higher in the Humboldt River near Rye Patch, with two measurements during the period of record exceeding the propagation of wildlife standard (9.0).

Average concentrations of total suspended solids near Rye Patch (43.4 mg/L) were less than average concentrations near Carlin (159 mg/L). Likewise, the average turbidity was less near Rye Patch (13.6 NTU) than near Carlin (36.9 NTU). While 16% of the measurements near Carlin exceeded the turbidity standard of 50 NTU, no exceedances were measured near Rye Patch. Additionally, for the period of record, the total suspended solids standard near Carlin (annual median value less than 80 mg/L) was exceeded in 42 percent of the years with available total suspended solids data (1979 through 1990). No total suspended solids standard exceedances were measured near Rye Patch. These results likely reflect the ability of Rye Patch Reservoir to settle suspended particles from river flows.

The average total phosphorus value for the Humboldt River near Carlin (0.16 mg/L as P) was greater than the standard for the propagation of aquatic life including warm-water fisheries (0.1 mg/L as P seasonally from April through

Table 3.2-19

Water Quality Standards for the Humboldt River at Palisade and Woolsey Control Points

Constituent	Units	Municipal or Domestic Supply	Propagation of Aquatic Life (warm water)			Propagation of Wildlife	Water Contact Recreation	Irrigation	Watering of Livestock
			Single Value Limit	1-hour Avg.	96-hour Avg.				
Physical and Aggregate Properties									
Alkalinity	mg/L as $CaCO_3$		(a)			30-130			
Color	color units	NAE							
TDS	mg/L @180°C	500[1,3]/ 1000[2,3]							3000
Temperature	°C						15-34		
Temperature (ΔT)	°C						2		
TSS	mg/L @103-5C		80[4]						
Turbidity	NTU		50						
Inorganic Nonmetallic Constituents									
Ammonia, unionized	mg/L as NH_3		0.02						
Chloride	mg/L as Cl	250							
Cyanide	mg/L as CN	0.2		0.022	0.0052				
Dissolved Oxygen	mg/L as O_2		≥5.0						
Fluoride	mg/L as F							1.0	2.0
Nitrate	mg/L as N	10							
Nitrite	mg/L as N	1.0							
pH	standard units					6.5-9.0	6.5-9.0		
ΔpH	standard units		±0.5						
SAR	ratio	8[3]						8[3]	
Sulfate	mg/L as SO_4	250							
Total Phosphorus	mg/L as P				0.1[5]				
Metals and Semi-metals[6]									
Antimony	µg/L as Sb	146							
Arsenic (total)	µg/L as As	50						100	200
Arsenic (III)	µg/L as As			342[7]	180[7]				
Barium	µg/L as Ba	2000							
Beryllium	µg/L as Be	0						100	
Boron	µg/L as B							750	5,000
Cadmium	µg/L as Cd	5		5.3[7,8]	1.3[7,8]			10	50
Chromium (total)	µg/L as Cr	100						100	1,000
Chromium (III)	µg/L as Cr			2,057[7,8]	245[7,8]				
Chromium (VI)	µg/L as Cr			15[7]	10[7]				
Copper	µg/L as Cu			22.1[7,8]	14.2[7,8]			200	500
Iron	µg/L as Fe		1,000					5,000	
Lead	µg/L as Pb	50		68.4[7,8]	1.3[7,8]			5,000	100
Manganese	µg/L as Mg							200	
Mercury	µg/L as Hg	2		2[7]	0.012				10
Molybdenum	µg/L as Mo		19						
Nickel	µg/L as Ni	13.4		1,699[7,8]	189[7,8]			200	
Selenium	µg/L as Se	50		20	5.0			20	50
Silver	µg/L as Ag		6.9[7,8]						
Thallium	µg/L as Tl	13							
Zinc	µg/L as Zn			140[7,8]	127[7,8]			2,000	25,000

Source: Nevada Administrative Code 445A.144, 445A.204, and 445A.208.
[1]Applicable to Palisade control point.
[2]Applicable to Woolsey control point.
[3]Annual average.
[4]Annual median.
[5]Seasonal water quality standard from April to November.
[6]The standards for metals are expressed as total recoverable, unless otherwise noted.
[7]Standard applies to the dissolved fraction.
[8]Hardness-derived standard (Nevada Administrative Code 445A.144). Values calculated assuming a hardness of 150 mg/L as $CaCO_3$.
(a) = Less than 25 percent change from natural conditions; TDS = total dissolved solids; TSS = total suspended solids; SAR=sodium adsorption ratio; NAE=No Adverse Effects; single concentration limits and 24-hour average concentration limits must not be exceeded; 1-hour average and 96-hour average concentration limits may be exceeded only once every 3 years.

Table 3.2-20
Humboldt River Water Quality
(January 1970 through April 1991)

Constituent	Units	Carlin Gage (USGS 10321000)				Rye Patch Gage (USGS 10335000)			
		n	Min.	Max.	Avg.[1]	n	Min.	Max.	Avg.[1]
Stream Discharge	cfs	97	5.7	8130	473	121	0.3	3010	334
Physical and Aggregate Properties									
Alkalinity	mg/L as CaCO3	37	143	280	210	121	185	295	248
Hardness	mg/L as CaCO3	79	80	219	162	134	116	217	171
Temperature	°C	95	0.0	26	12	178	2.5	25	12
TDS	mg/L @ 180°C	77	178	414	294	95	407	774	548
TSS	mg/L @ 103-5 °C	75	10	2440	159	106	14	136	43.4
Turbidity	NTU	79	0.8	640	36.9	67	0.7	48	13.6
Inorganic Nonmetallic Constituents									
pH	standard units	75	7.6	8.9	8.4	149	7.6	9.6	8.5
Dissolved Oxygen	mg/L as O2	71	6.7	15.2	10.4	67	7.4	16.1	9.9
Nitrite	mg/L as N	28	<0.01	0.08	0.02	64	<0.01	0.06	0.01
Nitrate	mg/L as N	23	<0.01	0.30	0.06	62	<0.01	0.1	0.03
Phosphorous, Total	mg/L as P	79	<0.01	1.2	0.16	121	0.01	0.31	0.09
Cyanide	mg/L as CN	0	- - -	- - -	- - -	0	- - -	- - -	- - -
Chloride	mg/L as Cl	78	6.9	40	17.0	137	43	230	101.1
Sulfate	mg/L as SO4	77	11	60	33.5	130	40	100	74.5
Fluoride	mg/L as F	79	<0.1	1.3	0.5	105	0.4	1.2	0.8
Metals and Semi-metals (dissolved)									
Antimony	µg/L as Sb	0	- - -	- - -	- - -	0	- - -	- - -	- - -
Arsenic	µg/L as As	49	3	14	7.2	44	16	60	31
Barium	µg/L as Ba	48	49	140	89	31	25	82	45
Beryllium	µg/L as Be	34	<0.5	0.7	<0.5	12	<0.5	0.5	<0.5
Boron	µg/L as B	2	120	180	150	7	260	580	471
Cadmium	µg/L as Cd	48	<1	2	<1	39	<1	2	<1
Chromium	µg/L as Cr	48	<1	7	1.1	44	<1	20	2.0
Copper	µg/L as Cu	49	<1	13	3.2	44	<1	9	3.6
Iron	µg/L as Fe	49	<3	130	22	44	<3	70	15
Lead	µg/L as Pb	47	<1	10	1.9	40	<1	11	1.5
Manganese	µg/L as Mn	49	<1	56	12	43	<1	40	7.8
Mercury	µg/L as Hg	49	<0.1	0.5	<0.1	44	<0.1	1.8	0.2
Molybdenum	µg/L as Mo	34	<10	10	<10	12	<10	20	<10
Nickel	µg/L as Ni	47	<1	6	1.7	25	<1	9	2.1
Selenium	µg/L as Se	49	<1	1	<1	44	<1	1	<1
Silver	µg/L as Ag	49	<1	1	<1	32	<1	<1	<1
Zinc	µg/L as Zn	48	<3	130	11	44	<3	25	6.3

Source: USGS streamflow monitoring data.
[1]For concentrations reported to be below detection, a value of one-half the detection limit was used for calculating averages. For each constituent, detection limits may have varied between sampling events.
TDS = total dissolved solids; TSS = total suspended solids; NTU = nephelometric turbidity units.
n = number of concentration results available.
Min. = lowest value of available results.
Max. = highest value of available results.
Avg. = calculated average of available results (calculations used one-half the detection limit for non-detected values; if calculated average was less than the detection limit).