5.3.4 Surface Water Quality

5.3.4.1 Affected Environment

This section describes the historical water quality conditions of the surface water bodies in the states of Utah and Arizona that could be affected from construction and operation of the LPP Project. The beneficial use protection classifications and historical water quality conditions are summarized for the surface water bodies. The historical water quality conditions for surface water bodies within Utah and Arizona are reviewed in conjunction with the surface water quality numeric criteria. A comprehensive review of the historical water quality data against the surface water quality numeric criteria for all sampled water quality constituents is beyond the scope of this chapter. Therefore, the review of historical water quality is limited to parameters such as pH, total dissolved solids (TDS), total suspended solids (TSS), temperature, metals, and pollution indicators such as total coliform.

5.3.4.1.1 Beneficial Use Designations for Utah.

In Utah, water quality protection standards are based on designated state beneficial uses which are defined and classified in the Utah Administrative Code, Rule 317-2 Standards for Quality of Waters of the State (UAC R317-2) (UAC 2016). Use designations are provided in UAC R317-2-6 and include the classifications shown in Table 5-26.

The portions of the Proposed Action in Utah would involve the following surface water features:

- Proposed Action Intake and Water Conveyance Systems: Paria River
- Proposed Action Hydro System: Kanab Creek and, Sand Hollow Reservoir
- Transmission Line Alignments: Paria River

Beneficial use protection classifications for major rivers and reservoirs in the LPP vicinity are displayed in Table 5-27. Beneficial use designations for many ephemeral washes in the LPP Project area of potential effect are not provided in UAC R317.

Table 5-26
Beneficial Use Protection Classifications for Surface Waters of the State of Utah

Classification	Definition
1C	Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water.
2A	Protected for frequent primary contact recreation where there is a high likelihood of ingestion of water or a high degree of bodily contact with the water. Examples include, but are not limited to, swimming, rafting, kayaking, diving, and water skiing.
2B	Protected for infrequent primary contact recreation. Also protected for secondary contact recreation where there is a low likelihood of ingestion of water or a low degree of bodily contact with the water. Examples include, but are not limited to, wading, hunting, and fishing.
3A	Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
3B	Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.
3C	Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.
3D	Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.
3E	Severely habitat-limited waters. Narrative standards will be applied to protect these waters for aquatic wildlife.
4	Protected for agricultural uses including irrigation of crops and stock watering.
5	Special category for the waters of the Great Salt Lake.

Table 5-27
Beneficial Use Protection Classifications Designated for Major Rivers and Reservoirs in the LPP Area of Potential Effect, UAC R317-2-13

Water Body	Classifications
Colorado River	1C, 2B, 3B, 4
Kanab Creek (lower)	2B, 3C, 4
Lake Powell	1C, 2A, 2B, 3B, 4
Paria River	2B, 3C, 4
Quail Creek	1C, 2B, 3A, 4
Quail Creek Reservoir	1C, 2A, 2B, 3B, 4
Virgin River (above Quail Creek Diversion)	1C, 2B, 3C, 4
Virgin River (below Quail Creek Diversion)	2B, 3A, 4

5.3.4.1.2 Historical Water Quality Conditions for Utah.

Water quality data for the relevant surface water bodies were obtained from the EPA STORET data system. Water quality data for the water bodies listed in Table 5-27 are summarized in this section. Water quality data should be reviewed in conjunction with factors such as flow rates, the number of samples, and the frequency and period of sampling. Averages were calculated based on an assumed concentration of zero for samples reported as "non-detect" (ND) because of variations in the method detection limits for the reported data. It should be noted that the average concentration values may not be representative of typical conditions because of the presence of outlier events. For example, the average TDS concentration of a water body may be significantly elevated in response to increased runoff during a 100-year storm event (an outlier event).

Historical water quality for the relevant surface waters in Utah is summarized in the following tables. In general, all water bodies exhibited concentrations for total coliform, TDS, and TSS in excess of their numeric water quality criteria. Recorded values for pH were within the specified numeric range for the majority of samples. Metals were detected in all water bodies. For the Virgin and the Paria rivers, metals were detected in concentrations that were in excess of their numeric water quality criteria.

5.3.4.1.2.1 Kanab Creek.

In southwest Utah, Kanab Creek drains a narrow valley from north to south with peak elevations nearing 8,000 feet. Downstream of Kanab in Kane County, Utah, Kanab Creek flows into Arizona near Fredonia. In Arizona it flows through the Kaibab-Paiute Indian Reservation of the Kaibab Band of Paiute Indians onto BLM-administered land, and through Kanab Creek Wilderness (on National Forest System land) before its confluence with the Colorado River in Grand Canyon National Park. Peak flows occur in spring and low flows occur during the summer months. The characterization of Kanab Creek water quality is based upon water quality data obtained at three sampling stations (listed in Table 5-28). Key water quality parameters and numeric criteria at each of the stations are summarized in Table 5-29.

Table 5-28
Kanab Creek Water Quality Sample Station Locations

Station ID	Station Name	Sampling Period	Latitude	Longitude
4951810	Kanab Creek at US89 Crossing	1978 to 1982, 1993 to 2006	37.10083	-112.547
4951830	Kanab Creek at Falls Crossing East of Glendale	1978 to 1980, 1996 to 2008	37.29111	-112.492
4951750	Kanab Creek below Kanab WWTP at the State Line	1976 to 1993, 2001 to 2003	37.00611	-112.536

Source: Utah Department of Environmental Quality

Numeric water quality criteria for Kanab Creek vary based on the different beneficial uses. Table 5-29 presents the most stringent numeric criteria for Kanab Creek for the relevant water quality parameters.

Table 5-29
Numeric Water Quality Criteria for Kanab Creek

Constituent-Units	Numeric Criteria
Aluminum-µg/L	750
Cadmium-µg/L	2
Chromium (VI)-µg/L	16
Copper-µg/L	13
Dissolved Oxygen-mg/L[1]	5 3
Iron-µg/L	1,000
pH-Standard Units	6.5-9.0
Solids, Total Dissolved-mg/L	1,200
Temperature, water-degrees C	27
Total Coliform- MPN[2]/100ml	206
Turbidity - NTU[3]/(increase of)	10
Zinc- µg/L	120

[1] 30-day average and minimum
[2] Most Probable Number (MPN)
[3] Nephelometric Turbidity Units

Historical water quality data for Kanab Creek at the station locations listed in Table 5-28 are summarized in Tables 5-30, 5-31 and 5-32.

5.3.4.1.2.2 Paria River.

The Paria River flows from the headwaters in Bryce Canyon National Park and Dixie National Forest through private agricultural lands in Garfield County, Utah and south through GSENM (in Kane County, Utah) into Arizona and the Colorado River below Glen Canyon Dam. The river flows through the Grand Staircase region, a series of multi-colored cliffs which begin at the rim of the Grand Canyon, and ascend over 5,000 feet across GSENM to the headwaters at the cliffs in Bryce Canyon. Section 303(d) and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130), require that States report waterbodies (i.e., lakes, reservoirs, rivers, and streams) that do not support their designated beneficial use(s). In compliance with this requirement, segments of the Paria River are categorized as impaired for total dissolved solids, suspended solids, and *E. coli* (EPA 2006 and 2008). The characterization of water quality in the Paria River is based upon water quality data obtained at three sampling stations (listed in Table 5-33). Key water quality parameters and numeric criteria at each of the stations are summarized in Table 5-34.

Numeric water quality criteria for the Paria River vary based on the different beneficial uses. Table 5-34 presents the most stringent numeric criteria for Paria River for the relevant water quality parameters.

Table 5-30
Summary of Historical Water Quality at Kanab Creek (Station ID 4951810)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Aluminum-µg/L	ND[(1)]	880	76	32	The numeric criterion for aluminum (1 hour average of 750 µg/L) was exceeded in one sample (3% of samples). Aluminum was detected in 11 samples (34% of samples).
Copper-µg/L	ND	42	3	47	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in four samples (9% of samples). Copper was detected in 7 samples (15% of samples).
Iron- µg/L	ND	1,850	102	42	The numeric criterion for iron (1 hour average of 1,000 µg/L) was exceeded in two samples (5% of samples). Iron was detected in 23 samples (55% of samples).
pH-Standard Units	7.3	8.8	8.3	324	All samples were within the 6.5-9.0 range of the criterion.
Solids, Total Dissolved-mg/L	216	1,360	364	174	The numeric criterion for TDS (1,200 mg/L) was exceeded in 1 sample (<1% of samples). Approximately 82% of the samples measured had TDS concentrations less than 400 mg/L. A TDS concentration of 1,000 mg/L was exceeded in two samples (1% of samples).
Solids, Total Suspended (TSS)-mg/L	<1	9,744	558	160	Approximately 80% of the samples had TSS concentrations less than 500 mg/L. Approximately, 11% of the samples had concentrations in excess of 1,000 mg/L.
Specific Conductance, umho/cm	197	1,672	570	324	Approximately 81% of the total samples had a specific conductance that ranged between 400 umho/cm and 600 umho/cm. Approximately 8% of the total samples had a specific conductance that was greater than 800 umho/cm.
Temperature, water-degrees C	0	31	15	157	The numeric criterion for temperature (27˚C) was exceeded in 9 samples (6% of samples).
Total Coliform- Most Probable No. (MPN)/100ml[(2)]	23	9,300	2,510	11	The numeric criterion for total coliform (206 MPN/100 ml) was exceeded in 10 samples (91% of samples).
Turbidity-NTU	0.7	10,276	430	172	Numeric criterion is based on an increase as a result of discharge.
Zinc- µg/L	ND	140	19	48	The numeric criterion for zinc (1 hour average of 120 µg/L) was exceeded in one sample (2% of samples). Zinc was detected in 15 samples (31% of samples).

Source: Summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
(1) ND – non-detect.
(2) Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-31
Summary of Historical Water Quality at Kanab Creek (Station ID 4951830)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Copper-µg/L	ND[1]	30	4	15	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in three samples (20% of samples). Copper was detected in 5 samples (33% of samples).
pH-Standard Units	7.2	9.2	8.2	200	The numeric criterion for pH was exceeded in one sample (<1% of samples).
Solids, Total Dissolved-mg/L	372	2,262	1,302	111	The numeric criterion for TDS was exceeded in 65 samples (59% of samples). Approximately 25% of the samples had TDS concentrations between 1,000 mg/L and 1,500 mg/L. Approximately 42% of the samples had TDS concentrations greater than 1,500 mg/L.
Solids, Total Suspended (TSS)-mg/L	<1	31,980	795	95	Approximately 70% of the measured TSS concentrations were lower than 200 mg/L. All measured concentrations in excess of 1,000 mg/L occurred after year 1999. TSS concentrations in excess of 5,000 mg/L were recorded during the months of July and August in year 2001 and year 2006.
Specific conductance-umho/cm	171	2,495	1,613	204	Approximately 80% of the sampled values were between 1,000 umho/cm and 2,000 umho/cm.
Temperature, water-degrees C	0	29	11	93	The numeric criterion for temperature (27˚C) was exceeded in 3 samples (3% of samples).
Turbidity-NTU	1	6,979	256	110	The numeric criterion is based on an increase as a result of discharge.

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
[1] ND – non-detect.

Table 5-32
Summary of Historical Water Quality at Kanab Creek (Station ID 4951750)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Cadmium-µg/L	ND[1]	20	<1	82	The numeric criterion for cadmium (1 hour average of 2 µg/L) was exceeded in five samples (6% of samples). Cadmium was detected in 8 samples (10% of samples).
Chromium(VI)-µg/L	ND	100	8	15	The numeric criterion (1 hour average of 16 µg/L) for chromium was exceeded in one sample (7% of samples). Chromium was detected in 7 samples (47% of samples).
Copper-µg/L	ND	925	22	86	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in 18 samples (21% of samples). Copper was detected in 30 samples (35% of samples).
pH	6.2	9.5	8.1	200	The numeric criterion for pH was exceeded in one sample (<1% of samples).
Solids, Total Dissolved-mg/L	230	1,494	988	123	The numeric criterion for TDS (1,200 mg/L) was exceeded in 38 samples (31% of samples).
Solids, Total Suspended (TSS)-mg/L	<1	28,700	1,354	118	Approximately 60% of the samples had a TSS concentration lower than 300 mg/L. Approximately 20% of the samples had a TSS concentration that ranged between 1,000 mg/L and 5,000 mg/L. Approximately 6% of the samples had concentrations in excess of 5,000 mg/L.
Specific conductance-umho/cm	13	2,800	1,312	224	Approximately 70% of the measured values varied between 1,000 umho/cm and 2,000 umho/cm. Approximately 42% of the measured values varied between 1,500 umho/cm and 2,000 umho/cm
Temperature, water-degrees C	0.7	32.4	13	118	The numeric criterion for temperature (27˚C) was exceeded in 5 samples (4% of samples).
Total Coliform-MPN/100ml[3]	23	724,000	40,719	39	The numeric criterion for total coliform (206 MPN/100 ml) was exceeded in 34 samples (87% of samples).
Turbidity-NTU	0.35	3,164	153	115	The numeric criterion is based on an increase as a result of discharge.

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
[1] ND – non-detect.
[3] Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-33 **Paria River Water Quality Sample Station Locations**				
Station ID	**Station Name**	**Sampling Period**	**Latitude**	**Longitude**
4951850	Paria River at US89 Crossing	1976 to 1988, 1998 to 2008	37.1075	-111.906
4951860	Paria River at Kodachrome Basin Road Crossing	2000 to 2004	37.52814	-112.043
5994550	Paria River at Old Town Site	1998 to 2008	37.2505	-111.954
Source: Utah Department of Environmental Quality				

Table 5-34 **Numeric Criteria for Paria River**	
Constituent-Units	**Numeric Criteria**
Aluminum-µg/L	750
Cadmium-µg/L	2
Chromium (VI)-µg/L	16
Copper-µg/L	13
Dissolved Oxygen-mg/L(1)	5 3
Iron-µg/L	1,000
Lead-µg/L	65
pH-Standard Units	6.5-9.0
Solids, Total Dissolved-mg/L	1,200
Temperature, water-degrees C	27
Total Coliform- MPN/100ml	206
Turbidity - NTU (increase of)	10
(1)30-day average and minimum	

Historical water quality data for the Paria River at the station locations listed in Table 5-33 are summarized in Tables 5-35, 5-36, and 5-37.

Table 5-35
Summary of Historical Water Quality at Paria River Station ID (4951850)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Aluminum-µg/L	ND(1)	708	131	8	The numeric criterion for aluminum (1 hour average of 750 µg/L) was not exceeded in any sample. Aluminum was detected in 4 samples (50% of samples).
Cadmium-µg/L	ND	5	<1	28	The numeric criterion for cadmium (1 hour average of 2 µg/L) was exceeded in one sample (4% of samples). Cadmium was detected in 8 samples (29% of samples).
Chromium(VI)-µg/L	ND	25	3	8	The numeric criterion for hexavalent chromium (1 hour average of 16 µg/L) was exceeded in the only sample where chromium was present (13% of samples); all other samples were non-detect.
Copper-µg/L	ND	425	26	29	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in 10 samples (34% of samples). Copper was detected in 14 samples (48% of samples).
Iron-µg/L	ND	6,650	742	14	The numeric criterion for iron (1 hour average of 1,000 µg/L) was exceeded in 10 samples (71% of samples). Iron was detected in 9 samples (64% of samples).
Lead-µg/L	ND	250	13	30	The numeric criterion for lead (1 hour average of 65 µg/L) was exceeded in five samples (17% of samples). Aluminum was detected in 12 samples (40% of samples).
pH-Standard Units	7.0	9.7	8.2	131	The numeric criterion for pH (range of 6.5 – 9.0) was exceeded in four samples (3% of samples).
Solids, Total Dissolved-mg/L	504	2,744	1,188	73	The numeric criterion for TDS (1,000 mg/L) was exceeded in 56 samples (77% of samples). Approximately 60% of the collected samples had TDS concentrations that ranged from 1,000 mg/L to 1,500 mg/L.

Table 5-35
Summary of Historical Water Quality at Paria River Station ID (4951850)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Solids, Total Suspended (TSS)-mg/L	12	142,500	7,662	75	Approximately 45% of the samples had TSS concentrations lower than 500 mg/L. Approximately 30% of the samples had concentrations in excess of 1000 mg/L. There were several peaks throughout the sampling period where the TSS concentrations exceeded 10,000 mg/L. Approximately, 10% of the samples had TSS concentrations in excess of 10,000 mg/L.
Specific conductance-umho/cm	255	3,070	1,552	136	Specific conductance measured in over 50% of the collected samples ranged from 1,000 umho/cm to 1,500 umho/cm.
Temperature, water-degrees C	0	33	14	66	The numeric criterion for temperature (27˚C) was exceeded in 5 samples (8% of samples).
Total Coliform-MPN/100ml[(2)]	23	43,000	7,144	9	The numeric criterion for total coliform (206 MPN/100 ml) was exceeded in seven samples (78% of samples).
Turbidity-NTU	9	52,208	2,253	66	The numeric criterion is based on an increase as a result of discharge.

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
[(1)] ND – non-detect.
[(2)] Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-36
Summary of Historical Water Quality at Paria River Station ID (4951860)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Aluminum-µg/L	35	62	49	4	The numeric criterion for aluminum (1 hour average of 750 µg/L) was not exceeded in any sample.
Chromium-µg/L	5	10	7	5	The numeric criterion for chromium (1 hour average of 16 µg/L) was not exceeded in any sample.
Iron-µg/L	50	142	85	4	The numeric criterion for chromium (1 hour average of 1,000 µg/L) was not exceeded in any sample.
pH-Standard Units	7.0	8.6	8.1	33	All samples were within the 6.5-9.0 range of the criterion.
Solids, Total Dissolved-mg/L	838	4,030	1,726	18	The numeric criterion for TDS (1,000 mg/L) was exceeded in 12 samples (67% of samples). Approximately 62% of the samples have TDS concentrations lower than 1,500 mg/L.
Solids, Total Suspended (TSS)-mg/L	6	87,440	6,321	16	Approximately 40% of the samples had a TSS concentration lower than 100 mg/L. The high TSS of 87,440 mg/L represented an isolated event over the sampling period. The average TSS is 916 mg/L if that sampling event is excluded.
Temperature, water-degrees C	0	28	11	15	The numeric criterion for temperature (27˚C) was exceeded in 1 samples (7% of samples).
Turbidity-NTU	2	54,380	3,404	18	The numeric criterion is based on an increase as a result of discharge.

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.

Table 5-37
Summary of Historical Water Quality at Paria River Station ID (5994550)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Aluminum-µg/L	ND[1]	2,200	429	11	The numeric criterion for aluminum (1 hour average of 750 µg/L) was exceeded in two samples (18% of samples). Aluminum was detected in only three samples (27% of samples).
Cadmium-µg/L	ND	2.2	<1	11	The numeric criterion for cadmium (1 hour average of 2 µg/L) was exceeded in the only two samples in which it was detected (18% of samples).
Chromium-µg/L	ND	24	4	12	The numeric criterion for chromium (1 hour average of 16 µg/L) was exceeded in one sample (8% of samples). Chromium was detected in only two samples (17% of samples.
Copper-µg/L	ND	17,100	1425	12	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in one sample (8% of samples). Copper was detected in only two samples (17% of samples).
Iron-µg/L	ND	5,310	599	14	The numeric criterion for iron (1 hour average of 1,000 µg/L) was exceeded in two samples (14% of samples).
Lead-µg/L	ND	574	53	11	The numeric criterion for lead (1 hour average of 65 µg/L) was exceeded in one sample (9% of samples).
pH-Standard Units	7.3	8.9	8.2	186	All samples were within the 6.5-9.0 range of the criterion.
Solids, Total Dissolved-mg/L	504	2,350	957	102	The numeric criterion for TDS (1,000 mg/L) was exceeded in 34 samples (33% of samples). Approximately 70% of the samples collected had TDS concentrations that ranged between 500 mg/L and 1,000 mg/L.
Solids, Total Suspended (TSS)-mg/L	4	188,100	6,039	95	Approximately 30% of the samples had TSS concentrations lower than 100 mg/L. Approximately 10% of the samples had TSS concentrations in excess of 10,000 mg/L.

Table 5-37
Summary of Historical Water Quality at Paria River Station ID (5994550)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Specific conductance-umho/cm	677	2,920	1,275	185	For approximately 82% of the samples, the specific conductance ranged between 1,000 umho/cm and 1,500 umho/cm.
Temperature, water-degrees C	0	31	16	84	The numeric criterion for temperature (27˚C) was exceeded in 13 samples (15% of samples).
Turbidity-NTU	1	19,212	1,606	101	The numeric criterion is based on an increase as a result of discharge.

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
(1) ND – non-detect.

5.3.4.1.2.3 Virgin River.

Bound by mountains with elevations reaching over 10,000 feet, the Virgin River lies within the lower Colorado River basin. The lowest elevation in Utah is about 2,500 feet where the Virgin River crosses the Utah- Arizona state line. Most Virgin River streamflow originates as snow, the runoff results in high flows from March through May. The greatest water producing area is the headwaters of the North Fork of the Virgin River. The headwaters of the Virgin River are located in the high mountains of southern Utah, north and east of Zion National Park. The river flows through Utah and Arizona before entering Nevada near the City of Mesquite. The river is intermittent within Nevada, having no flow in some reaches during certain times of the year. The river flows southwesterly for about 25 miles through the unincorporated towns of Bunkerville and Riverside before emptying into the Overton Arm of Lake Mead.

Segments of the Virgin River are categorized on the Section 303(d) list as impaired for temperature, total phosphorus, selenium, iron, manganese, suspended solids, dissolved oxygen, total dissolved solids, silver, and total ammonia (EPA 2006 and 2008). The characterization of Virgin River water quality is based upon water quality data obtained at nine sampling stations (listed in Table 5-38). Key water quality parameters and numeric criteria for each of the stations below the Quail Creek diversion are summarized in Table 5-39.

Table 5-38
Virgin River Water Quality Sample Station Locations

Station ID	Sampling Period	Latitude	Longitude
4950010	1976-1983	37.00000	-113.703
4950020	1984-2008	37.02014	-113.672
4950120	1977, 1989-2006	37.05222	-113.600
4950130	1976-1984, 1999	37.07306	-113.580
4950200	1975-1985, 1996-2007	37.08639	-113.556
4950260	1982-1983	37.11611	-113.500
4950300	2000-2002, 2004-2007	37.16278	-113.395
4950320	1976, 1982-2002, 2006-2007	37.16278	-113.395

Source: Utah Department of Environmental Quality

Numeric water quality criteria for the Virgin River vary based on the different beneficial uses. Table 5-39 presents the most stringent numeric criteria for the Virgin River for the relevant water quality parameters.

Table 5-39
Numeric Criteria for Virgin River (Below Quail Creek Diversion)

Constituent-Units	Numeric Criteria
Aluminum-µg/L	750
Arsenic-µg/L	10
Barium-mg/L	1
Boron-µg/L	0.75
Cadmium-µg/L	2
Chromium (VI)-µg/L	16
Copper-µg/L	13
Dissolved Oxygen-mg/L(1)	6.5 8.0/4.0
Iron-µg/L	1,000
Lead-µg/L	65
Mercury-µg/L	2.4
Nickel-µg/L	468
pH-Standard Units	6.5-9.0
Selenium-µg/L	18.4
Silver-µg/L	1.6
Solids, Total Dissolved-mg/L	1200
Temperature, water-degrees C	20
Total Coliform-MPN/100ml	206
Turbidity-NTU (increase of)	10
Zinc-µg/L	120
(1)30 day average; minimum when early life stages are present; minimum when all other life stages are present	

Historical water quality data for the water bodies at the station locations listed in Table 5-38 are summarized in Tables 5-40 through 5-48.

Table 5-40
Summary of Historical Water Quality at Virgin River Station ID (4950010)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Arsenic-µg/L	2	15	10	4
Boron-mg/L	650	695	677	3
Copper-µg/L	ND[1]	30	8	4
Iron-µg/L	1	2	2	4
Lead-µg/L	ND	30	8	4
Manganese-µg/L	50	325	191	4
Nickel-µg/L	ND	25	14	3
pH-Standard Units	7.9	8.4	8.1	5
Solids, Total Dissolved-mg/L	1,334	1,734	1,525	4
Solids, Total Suspended (TSS)-mg/L	97	612	380	3
Specific conductance- umho/cm	1,910	2,620	2,240	8
Temperature, water-degrees C	3	18	14	5
Total Coliform-MPN/100ml[2]	4,600	4,600	4,600	1
Turbidity-NTU	29	300	175	4

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
[1] ND – non-detect.
[2] Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-41
Summary of Historical Water Quality at Virgin River Station ID (4950020)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Aluminum-µg/L	ND(1)	5,780	218	33	The numeric criterion for aluminum (1 hour average of 750 µg/L) was exceeded in two samples (6% of samples). Aluminum was detected in 9 samples (27% of samples).
Arsenic-µg/L	ND	23	9	128	The numeric criterion for arsenic (10 µg/L) was exceeded in 49 samples (38% of samples). Arsenic was detected in 117 samples (91% of samples).
Boron-mg/L	231	2,710	909	9	The numeric criterion for boron (0.75 mg/L) was exceeded in five samples (56% of samples).
Cadmium-µg/L	ND	35	1	101	The numeric criterion for cadmium (1 hour average of 2 µg/L) was exceeded in three samples (3% of samples). Cadmium was detected in 9 samples (9% of samples).
Copper-µg/L	ND	90	5	103	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in 14 samples (14% of samples). Copper was detected in 17 samples (17% of samples).
Iron-µg/L	ND	1,160	2	53	The numeric criterion for iron (1 hour average of 1,000 µg/L) was exceeded in only one sample (2% of samples). Iron was detected in 26 samples (49% of samples).
pH-Standard Units	6.6	9.0	8.2	352	All samples were within the 6.5-9.0 range of the criterion.
Selenium-µg/L	ND	5	1	125	The numeric criterion for selenium (1 hour average of 18.4 µg/L) was not exceeded in any sample. Selenium was detected in 51 samples (41% of samples).
Solids, Total Dissolved-mg/L	472	3,990	1,856	187	The numeric criterion for TDS (1,200 mg/L) was exceeded in 158 samples (84% of samples). Approximately 88% of the samples collected exceeded the numeric criterion for TDS.

Table 5-41
Summary of Historical Water Quality at Virgin River Station ID (4950020)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Solids, Total Suspended (TSS)-mg/L	4	14,580	736	184	Approximately 43% of the samples had TSS concentrations lower than 100 mg/L. Approximately 20% of the samples had TSS concentrations in excess of 500 mg/L.
Specific conductance-umho/cm	203	8,730	2,560	368	Approximately 75% of the samples had specific conductance in excess of 2,000 umho/cm.
Temperature, water-degrees C	2	34	17	187	The numeric criterion for temperature (20˚C) was exceeded in 72 samples (39% of samples).
Total Coliform-MPN/100ml(2)	49	18,500	3,967	6	The numeric criterion of total coliform (206 MPN/100 ml) was exceeded in two samples (33% of samples).
Turbidity-NTU	29	300	175	4	The numeric criterion is based on an increase as a result of discharge.
Zinc-µg/L	ND	180	15	104	The numeric criterion for zinc (1 hour average of 120 µg/L) was exceeded in two samples (2% of samples). Zinc was detected in 42 samples (40% of samples).

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
(1) ND – non-detect.
(2) Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-42
Summary of Historical Water Quality at Virgin River Station ID (4950120)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Aluminum-µg/L	ND[1]	85,900	3,089	28	The numeric criterion for aluminum (1 hour average of 750 µg/L) was exceeded in one sample (4% of samples). Aluminum was detected in 10 samples (36% of samples).
Arsenic-µg/L	ND	44	9	72	The numeric criterion for arsenic (10 µg/L) was exceeded in one sample (1% of samples). Arsenic was detected in 62 samples (9% of samples).
Barium-µg/L	35	203	84	42	The numeric criterion for barium (1 mg/L) was exceeded in one sample (2% of samples).
Boron-mg/L	219	1,190	768	6	The numeric criterion for boron (0.75 mg/L) was exceeded in four samples (67% of samples).
Cadmium-µg/L	ND	4	<1	49	The numeric criterion for cadmium (1 hour average of 2 µg/L) was exceeded in the one sample where it was detected (2% of samples).
Chromium-µg/L	ND	9	1	50	The numeric criterion for chromium (1 hour average of 16 µg/L) was not exceeded in any sample. Arsenic was detected in 5 samples (10% of samples).
Copper-µg/L	ND	39	4	48	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in eight samples (17% of samples). Copper was detected in 9 samples (19% of samples).
Iron-µg/L	ND	195	30	36	The numeric criterion for iron (1 hour average of 1,000 µg/L) was not exceeded in any sample. Iron was detected in 20 samples (56% of samples).
pH-Standard Units	7.2	8.5	8.0	126	All samples were within the 6.5-9.0 range of the criterion.

Table 5-42
Summary of Historical Water Quality at Virgin River Station ID (4950120)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Selenium-µg/L	ND	4	2	69	The numeric criterion for selenium (1 hour average of 18.4 µg/L) was not exceeded in any sample. Selenium was detected in 41 samples (59% of samples).
Solids, Total Dissolved-mg/L	488	3,216	1,988	40	The numeric criterion for TDS (1,200 mg/L) was exceeded in 34 samples (85% of samples).
Solids, Total Suspended (TSS)-mg/L	6	25,450	899	62	Approximately, 90% of the samples had TSS concentrations lower than 500 mg/L.
Specific conductance-umho/cm	362	4,867	2,651	124	None
Temperature, water-degrees C	4	33	16	90	The numeric criterion for temperature (20˚C) was exceeded in 30 samples (33% of samples).
Total Coliform-MPN/100 mL(2)	200	240,000	36,513	8	The numeric criterion of total coliform (206 MPN/100 ml) was exceeded in six samples (75% of samples).
Turbidity-NTU	4	630	87	36	The numeric criterion is based on an increase as a result of discharge.
Zinc-µg/L	ND	413	18	51	The numeric criterion for zinc (1 hour average of 120 µg/L) was exceeded in one sample (2% of samples). Zinc was detected in 14 samples (27% of samples).

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
(1) ND – non-detect.
(2) Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-43
Summary of Historical Water Quality at Virgin River Station ID (4950130)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Arsenic-µg/L	2	16	9	12	The numeric criterion for arsenic (10 µg/L) was exceeded in five samples (42% of samples).
Boron-mg/L	445	1,375	790	3	The numeric criterion for boron (0.75 mg/L) was exceeded in one sample (33% of samples).
Chromium(VI) -µg/L	ND[(1)]	4	1	3	The numeric criterion for chromium (1 hour average of 16 µg/L) was not exceeded in any sample. Chromium was detected in 1 sample (33% of samples).
Copper-µg/L	ND	20	8	11	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in five samples (45% of samples). Copper was detected in 5 samples (45% of samples).
Iron-µg/L	5	5,300	1,231	14	The numeric criterion for iron (1 hour average of 1,000 µg/L) was exceeded in five samples (36% of samples).
Lead-µg/L	ND	50	8	11	The numeric criterion for lead (1 hour average of 65 µg/L) was not exceeded in any sample. Lead was detected in 5 samples (45% of samples).
Nickel-µg/L	ND	26	9	9	The numeric criterion for nickel (1 hour average of 468 µg/L) was not exceeded in any sample. Copper was detected in 5 samples (56% of samples).
pH-Standard Units	7.0	8.7	8.1	24	All samples were within the 6.5-9.0 range of the criterion.
Selenium-µg/L	ND	1	<1	11	The numeric criterion for selenium (1 hour average of 18.4 µg/L) was not exceeded in any sample. Selenium was detected in 2 samples (18% of samples).
Silver-µg/L	ND	15	2	12	The numeric criterion for silver (1 hour average of 1.6 µg/L) was not exceeded in both of the two samples that silver was detected (17% of samples).

Table 5-43
Summary of Historical Water Quality at Virgin River Station ID (4950130)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Solids, Dissolved-mg/L	272	3,560	1,388	14	The numeric criterion for TDS (1,200 mg/L) was exceeded in seven samples (50% of samples).
Solids, Total Suspended (TSS)-mg/L	<1	9,999	1,618	20	Approximately 60% of the samples have TSS concentrations lower than 200 mg/L.
Specific conductance-umho/cm	434	4,180	1,893	23	None
Temperature, water-degrees C	1	35	11	20	The numeric criterion for temperature (20˚C) was exceeded in 4 samples (20% of samples).
Total Coliform-MPN/100 ml(2)	930	46,000	18,926	10	The numeric criterion of total coliform (206 MPN/100 ml) was exceeded in all samples.
Turbidity-NTU	11	800	226	12	The numeric criterion is based on an increase as a result of discharge.
Zinc-µg/L	ND	50	14	11	The numeric criterion for zinc (1 hour average of 120 µg/L) was not exceeded in any sample. Zinc was detected in 7 samples (64% of samples).

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
(1) ND – non-detect.
(2) Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-44
Summary of Historical Water Quality at Virgin River Station ID (4950200)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Arsenic-µg/L	2	20	9	57	The numeric criterion for arsenic (10 µg/L) was exceeded in 18 samples (32% of samples).
Barium-mg/L	37	600	123	15	The numeric criterion for barium (1 mg/L) was exceeded in nine samples (60% of samples).
Cadmium-µg/L	ND(1)	20	2	36	The numeric criterion for cadmium (1 hour average of 2 µg/L) was exceeded in nine samples (25% of samples). Cadmium was detected in 12 samples (33% of samples)
Copper-µg/L	ND	45	9	44	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in 11 samples (25% of samples). Copper was detected in 25 samples (57% of samples).
Iron-µg/L	10	95	33	25	The numeric criterion for iron (1 hour average of 1,000 µg/L) was exceeded in five samples (20% of samples).
Lead-µg/L	ND	90	10	38	The numeric criterion for lead (1 hour average of 65 µg/L) was exceeded in one sample (3% of samples). Lead was detected in 18 samples (47% of samples)
pH-Standard Units	6.4	8.8	8.0	208	All but one sample was within the 6.5-9.0 range of the criterion (<1% of samples outside of criterion range).
Selenium-µg/L	ND	5	1	48	The numeric criterion for selenium (1 hour average of 18.4 µg/L) was not exceeded in any sample. Selenium was detected in 26 samples (54% of samples)
Silver-µg/L	ND	30	3	38	The numeric criterion for silver (1 hour average of 1.6 µg/L) was not exceeded in 11 samples (29% of samples). Silver was detected in 12 samples (32% of samples)
Solids, Dissolved-mg/L	424	4,072	1,964	103	The numeric criterion for TDS (1,200 mg/L) was exceeded in 83 samples (81% of samples).

Table 5-44
Summary of Historical Water Quality at Virgin River Station ID (4950200)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Solids, Total Suspended (TSS)-mg/L	1	9,999	476	104	Approximately 87% of the samples collected had TSS concentrations lower than 500 mg/L.
Specific conductance-umho/cm	214	5,550	2,645	189	None
Temperature, water-degrees C	1	35	15	115	The numeric criterion for temperature (20˚C) was exceeded in 37 samples (13% of samples).
Total Coliform-MPN/100 mL [(2)]	4	240,000	15,937	63	The numeric criterion of total coliform (206 MPN/100 ml) was exceeded in 58 samples (92% of samples).
Turbidity-NTU	1	1,600	109	91	The numeric criterion is based on an increase as a result of discharge.
Zinc-µg/L	ND	1,900	67	42	The numeric criterion for zinc (1 hour average of 120 µg/L) was exceeded in one sample (2% of samples). Zinc was detected in 32 samples (76% of samples).

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
[(1)] ND – non-detect.
[(2)] Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-45
Summary of Historical Water Quality at Virgin River Station ID (4950260)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Arsenic-µg/L	3	13	9	6
Chromium-µg/L	ND[1]	30	6	6
Copper-µg/L	ND	40	15	6
Iron-mg/L	<1	4	2	6
Lead-µg/L	ND	11	6	6
Magnesium-mg/L	27	61	41	6
Manganese-µg/L	90	660	363	6
Nickel-µg/L	ND	115	24	6
pH-Standard Units	7.6	8.6	8.2	10
Solids, Total Dissolved-mg/L	488	1,610	1,016	6
Solids, Total Suspended (TSS)-mg/L	4	1,566	600	6
Specific conductance-umho/cm	280	2,300	1,442	12
Temperature, water-degrees C	6	34	16	6
Total Coliform-MPN/100 mL[2]	300	50,000	13,740	5
Turbidity-NTU	4	882	384	6
Zinc-µg/L	ND	70	32	6

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
[1] ND – non-detect.
[2] Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-46
Summary of Historical Water Quality at Virgin River Station ID (4950300)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Arsenic-µg/L	15	15	15	1
Boron-µg/L	793	793	793	1
Iron-µg/L	25	25	25	1
pH-Standard Units	7.8	8.4	8.1	6
Selenium-µg/L	3	3	3	1
Solids, Total Dissolved-mg/L	1,898	2,098	1,998	2
Solids, Total Suspended (TSS)-mg/L	26	40	33	2
Specific conductance-umho/cm	2,756	3,534	3,142	6
Temperature, water-degrees C	7	32	21	4
Total Coliform-MPN/100 mL(1)	57	961	409	3
Turbidity-NTU	6	8	7	2

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
(1)Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-47
Summary of Historical Water Quality at Virgin River Station ID (4950320)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Arsenic-µg/L	ND[(1)]	255	18	113	The numeric criterion for arsenic (10 µg/L) was exceeded in 78 samples (69% of samples). Arsenic was detected in 108 samples (96% of samples)
Barium-mg/L	ND	0.7	0.1	65	The numeric criterion for barium (1 mg/L) was not exceeded in any sample. Barium was detected in 48 samples (74% of samples).
Cadmium-µg/L	ND	20	<1	103	The numeric criterion for cadmium (1 hour average of 2 µg/L) was exceeded in one sample (1% of samples). Cadmium was detected in 9 samples (9% of samples)
Chromium-µg/L	ND	50	1	103	The numeric criterion for chromium (1 hour average of 16 µg/L) was exceeded in two samples (2% of samples). Chromium was detected in 12 samples (12% of samples).
Copper-µg/L	ND	150	5	105	The numeric criterion for copper (1 hour average of 13 µg/L) was exceeded in 15 samples (14% of samples). Copper was detected in 19 samples (18% of samples).
Iron-µg/L	ND	70	13	41	The numeric criterion for iron (1 hour average of 1,000 µg/L) was not exceeded in any sample. Iron was detected in 14 samples (34% of samples).
Lead-µg/L	ND	50	2	103	The numeric criterion for lead (1 hour average of 65 µg/L) was not exceeded in any sample. Lead was detected in 9 samples (9% of samples).
Nickel-µg/L	ND	22	11	10	The numeric criterion for nickel (1 hour average of 468 µg/L) was not exceeded in any sample. Nickel was detected in 7 samples (70% of samples).
pH-Standard Units	6.8	9.2	8.0	304	The numeric criterion for pH was exceeded in one sample (<1% of samples).

Table 5-47
Summary of Historical Water Quality at Virgin River Station ID (4950320)

Parameter-Units	Minimum	Maximum	Average	Number of Samples	Remarks
Selenium-µg/L	ND	6	1	113	The numeric criterion for selenium (1 hour average of 18.4 µg/L) was not exceeded in any sample. (Selenium was detected in 31 samples (27% of samples).
Solids, Total Dissolved-mg/L	362	2,964	1,484	161	The numeric criterion for TDS (1,200 mg/L) was exceeded in 109 samples (68% of samples).
Solids, Total Suspended (TSS)-mg/L	<1	32,550	640	165	Approximately 83% of the samples had concentrations lower than 500 mg/L.
Specific conductance-umho/cm	209	4,410	2,212	325	None
Temperature, water-degrees C	2	31	15	169	The numeric criterion for temperature (20˚C) was exceeded in 38 samples (23% of samples).
Total Coliform-MPN/100 mL [(2)]	9	46,000	7,401	7	The numeric criterion of total coliform (206 MPN/100 ml) was exceeded in five samples (71% of samples).
Turbidity-NTU	1	9,100	192	161	The numeric criterion is based on an increase as a result of discharge.
Zinc-µg/L	ND	170	12	104	The numeric criterion for zinc (1 hour average of 120 µg/L) was exceeded in one sample (1% of samples). Zinc was detected in 35 samples (34% of samples).

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Utah Department of Environmental Quality.
(1) ND – non-detect.
(2) Most Probable Number (MPN); value shown as "average" represents the geometric mean of the samples.

Table 5-48
Summary of Virgin River Water Quality – All Stations

Parameter-Units	Minimum	Maximum	Number of Samples	Criterion	Remarks
Arsenic-µg/L	ND	255	393	10	Most values near criterion
Copper- µg/L	ND	90	321	13	Mostly in compliance with water quality objectives
Iron- µg/L	ND	5,300	180	1,000	Mostly in compliance with water quality objectives
pH-Standard Units	6.6	9.2	1035	6.5-9.0	Almost always in compliance with water quality objectives
Solids, total dissolved-mg/L	272	4,072	517	1200	Often exceeds criterion
Solids, total Suspended (TSS)-mg/L	<1	32550	546	-	
Specific conductance-umho/cm	203	8,730	1055	-	
Temperature, water-degrees C	0	35	596	20	Often exceeds criterion
Turbidity-NTU	1	882	316	10	Mostly in compliance with water quality objectives

5.3.4.1.3 Beneficial Use Designations for Arizona.

In the state of Arizona, water quality protection standards are based on designated state beneficial uses which are defined and classified in the Arizona Administrative Code (AAC) R18-11-105. Use designations are provided in Title 18, Chapter 11 and include the classifications shown in Table 5-49.

Table 5-49
Beneficial Use Protection Classifications for Surface Waters of the State of Arizona (R18-11-105)

Designated Uses	Definition
A&Wc	Aquatic and Wildlife cold water
A&Ww	Aquatic and Wildlife warm water
A&We	Aquatic and Wildlife ephemeral
A&Wedw	Aquatic and Wildlife effluent dependent water
FBC	Full-body Contact
PBC	Partial-body Contact
DWS	Domestic Water Source
FC	Fish Consumption
AgI	Agricultural Irrigation
AgL	Agricultural Livestock Watering
U	Unique Water
EDW	Effluent-dependent Water
WWTP	Agricultural Livestock Watering

Beneficial use protection classifications for major rivers in the vicinity of the LPP alignments passing through the State of Arizona are provided in Table 5-50. There are numerous ephemeral washes along the proposed pipeline alignments. Beneficial use designations for these ephemeral washes in the LPP vicinity are not provided in AAC R18-11-105.

Table 5-50
Beneficial Use Protection Classifications Designated for Major Rivers and Reservoirs in the LPP Area of Potential Effect, AAC R317-2-13

Water Body	Classifications
Kanab Creek (lower)	A&Ww, FBC, DWS, FC, AgL
Paria River	A&Ww, FBC, FC

5.3.4.1.4 Historical Water Quality Conditions for Arizona.

Water quality data for the relevant surface water bodies were obtained from the EPA's STORET data system. Water quality data for the water bodies listed in Table 5-50 are summarized in the following sections. Trends in historical water quality are not described because of the limited availability of data for the water bodies in Arizona.

5.3.4.1.4.1 Kanab Creek.

Water quality data were obtained for the relevant water downstream of Kanab in Kane County, Utah, where Kanab Creek flows into Arizona near Fredonia. It flows through the Kaibab-Paiute Indian Reservation onto BLM-administered land, and through the Kanab Creek Wilderness (on National Forest System land) before its confluence with the Colorado River in Grand Canyon National Park. Kanab Creek forms the county line between Mojave County and Coconino County, Arizona. The characterization of Kanab Creek water quality is based upon water quality data obtained at one sampling station (listed in Table 5-51).

Table 5-51
Kanab Creek Water Quality Sample Station Locations

Station ID	Station Name	Sampling Period	Latitude	Longitude
100576	Unknown	June 6, 1994	36.96125	-112.529305
Source: Arizona Department of Environmental Quality				

Numeric water quality criteria for Kanab Creek in the State of Arizona vary based on the different beneficial uses. Table 5-52 presents the most stringent numeric criteria for the Kanab Creek for the relevant water quality parameters.

Table 5-52
Numeric Criteria for Kanab Creek (Arizona)

Constituent-Units	Numeric Criteria
pH	6.5-9.0
Temperature, water-degrees C (increase)	3
Total Coliform-MPN/100ml (single sample)	235
Dissolved Oxygen (mg/L)	6
Source: Arizona Department of Environmental Quality	

Historical water quality data for Kanab Creek in Arizona are summarized in Table 5-53

Table 5-53
Summary of Historical Water Quality at Kanab Creek Station ID (100576)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Iron-µg/L	160	160	160	1
pH-Standard Units	8.2	8.8	8.5	2
Solids, Total Dissolved-mg/L	1,070	2,430	1,750	2
Solids, Total Suspended (TSS)-mg/L	10	10	10	1
Specific conductance-umho/cm	168	168	168	1
Temperature, water-degrees C	23	23	23	1
Turbidity-NTU	6	8	7	2
Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.				

5.3.4.1.4.2 Paria River.

The Paria River flows from its headwaters in Bryce Canyon National Park and Dixie National Forest through private agricultural lands in Garfield County, Utah and south through GSENM (in Kane County, Utah) into Arizona and the Colorado River below Glen Canyon Dam. In Arizona, the Paria River flows through Coconino County. The characterization of Paria River water quality is based upon water quality data obtained at nine sampling stations (Table 5-54).

Table 5-54
Paria River Water Quality Sample Station Locations

Station ID	Sampling Period	Latitude	Longitude
100617	2004-2005	36.87264	-111.6
100743	1990-2004	36.86472	-111.588
101073	1999-2001	36.86433	-111.596
101074	1999-2001	36.93189	-111.664
101075	1999-2001	36.95658	-111.743
101076	1999-2001	36.99519	-111.793
101077	1999-2001	37.0008666	-111.864255
101078	1999-2001	37.0019133	-111.8646433
101079	April 14, 2000	37.00143	-111.866
Source: Arizona Department of Environmental Quality			

Numeric water quality criteria for Paria River in the State of Arizona vary based on the different beneficial uses. Table 5-55 presents the most stringent numeric criteria for the Paria River for the relevant water quality parameters.

Table 5-55
Numeric Criteria for Paria River (Arizona)

Constituent-Units	Numeric Criteria
pH	6.5-9.0
Temperature, water-degrees C (increase)	3
Total Coliform-MPN/100ml (single sample)	235
Dissolved Oxygen (mg/L)	6
Source: Arizona Department of Environmental Quality	

Historical water quality data for the water bodies at the station locations listed in Table 5-53 are summarized in Tables 5-56 through 5-65.

Table 5-56
Summary of Historical Water Quality at Paria River Station ID (100617)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Arsenic, Inorganic-µg/L	12	29	18	4
Cadmium-µg/L	1	5	3	3
Copper-µg/L	3	110	39	6
Lead-µg/L	<1	75	32	6
Manganese-µg/L	1,300	5,500	2,900	4
Mercury-µg/L	3	5	4	3
pH-Standard Units	7.4	8.4	8.1	8
Selenium-µg/L	14	14	14	1
Solids, Total Dissolved-mg/L	510	1,400	893	8
Solids, Total Suspended (TSS)-mg/L	52	20,000	6,108	12
Specific conductance-umho/cm	796	1,960	1,332	8
Temperature, water- degrees C	10	23	14	4
Zinc-µg/L	130	360	195	4

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.

Table 5-57
Summary of Historical Water Quality at Paria River Station ID (100743)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Aluminum-µg/L	ND[(1)]	64	4	49
Antimony-µg/L	<1	3	1	4
Arsenic, Inorganic-µg/L	ND	3	1	162
Cadmium-µg/L	<1	16	2	14
Copper-µg/L	1	19	3	69
Iron-µg/L	1	1,800	40	85
Lead-µg/L	1	10	2	13
Manganese-µg/L	1	120	6	47
Mercury-µg/L	<1	1	<1	2
Molybdenum-µg/L	4	20	5	25
Nickel-µg/L	1	8	2	51
pH-Standard Units	7.2	8.4	8.0	197
Selenium-µg/L	1	14	2	152
Silver-µg/L	2	2	2	1
Solids, Total Dissolved-mg/L	386	656	506	182
Solids, Total Suspended (TSS)-mg/L	1	13	4	48
Specific conductance-umho/cm	637	1,010	816	164
Strontium-µg/L	594	1,000	745	79
Temperature, water-degrees C	7	13	10	112
Turbidity-NTU	<1	2	1	90
Uranium-µg/L	3	4	3	23
Zinc-µg/L	1	20	6	57

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.
(1)ND – non-detect.

Table 5-58
Summary of Historical Water Quality at Paria River Station ID (101073)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Boron-µg/L	ND[(1)]	120	60	2
Iron-µg/L	3,800	3,800	3,800	1
Magnesium-mg/L	25	47	36	2
Manganese-µg/L	ND	60	30	2
pH-Standard Units	8.3	8.4	8.3	3
Solids, Total Dissolved-mg/L	390	700	545	2
Solids, Total Suspended (TSS)-mg/L	32	280	156	2
Specific conductance-umho/cm	530	1,011	778	4
Temperature, water-degrees C	22	25	23	2
Turbidity-NTU	32	331	153	3

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.
(1)ND – non-detect.

Table 5-59
Summary of Historical Water Quality at Paria River Station ID (101074)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Iron-mg/L	1	1	1	1
Magnesium-mg/L	22	22	22	1
pH-Standard Units	8.3	8.5	8.4	2
Solids, Total Dissolved-mg/L	350	350	350	1
Solids, Total Suspended (TSS)-mg/L	16	250	133	2
Specific conductance-umho/cm	480	1,035	680	3
Temperature, water-degrees C	15	19	17	2
Turbidity-NTU	50	475	263	2

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.

Table 5-60
Summary of Historical Water Quality at Paria River Station ID (101075)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Iron-mg/L	1	1	1	1
Magnesium-mg/L	22	22	22	1
pH-Standard Units	8.4	8.4	8.4	2
Solids, Total Dissolved-mg/L	320	320	320	1
Solids, Total Suspended (TSS)-mg/L	28	260	144	2
Specific conductance-umho/cm	460	1,069	672	3
Temperature, water-degrees C	22	23	22	2
Turbidity-NTU	400	400	400	1

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.

Table 5-61
Summary of Historical Water Quality at Paria River Station ID (101076)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
pH-Standard Units	8.3	8.4	8.3	2
Solids, Total Dissolved-mg/L	240	240	240	1
Solids, Total Suspended (TSS)-mg/L	26	250	138	2
Specific conductance-umho/cm	360	1,143	629	3
Temperature, water-degrees C	10	15	13	2
Turbidity-NTU	26	492	287	3
Iron-mg/L	1	1	1	1
Magnesium-mg/L	17	17	17	1

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.

Table 5-62
Summary of Historical Water Quality at Paria River Station ID (101077)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Barium-mg/L	<1	<1	<1	2
Beryllium-µg/L	ND[1]	1	<1	6
Iron-mg/L	1	1	1	1
Magnesium-mg/L	21	21	21	1
Manganese-mg/L	<1	<1	<1	1
pH-Standard Units	8.4	8.5	8.4	2
Solids, Total Dissolved-mg/L	390	390	390	1
Solids, Total Suspended (TSS)-mg/L	22	440	231	2
Specific conductance-umho/cm	460	1,445	790	3
Temperature, water-degrees C	11	15	13	2
Turbidity-NTU	817	817	817	1

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.
[1] ND – non-detect.

Table 5-63
Summary of Historical Water Quality at Paria River Station ID (101078)

Parameter-Units	Minimum	Maximum	Average	Number of Samples
Beryllium-µg/L	ND[1]	1	<1	6
Boron-mg/L	<1	<1	<1	1
Iron-mg/L	<1	<1	<1	1
Magnesium-mg/L	55	55	55	1
Manganese-mg/L	<1	<1	<1	1
pH-Standard Units	8.1	8.5	8.3	2
Solids, Total Dissolved-mg/L	910	910	910	1
Solids, Total Suspended (TSS)-mg/L	34	490	262	2
Specific conductance-umho/cm	1,100	1,448	1,243	3
Temperature, water-degrees C	11	14	12	2
Turbidity-NTU	752	752	752	1

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.
(1) ND – non-detect.

Table 5-64 summarizes the historical water quality for Paria River at Station ID 101079.

Table 5-64
Summary of Historical Water Quality at Paria River Station ID (101079)

Parameter-Units	Measured Value	Number of Samples
Barium-µg/L	120.0	1
Magnesium-mg/L	14.0	1
Manganese-mg/L	0.1	1
Solids, Total Dissolved-mg/L	200.0	1
Specific conductance-umho/cm	310.0	1

Source: Data summarized from EPA's STORET database. Water quality sampling and analysis were completed by the Arizona Department of Environmental Quality.

5.3.4.1.5 Lake Powell.

Lake Powell is the reservoir impounded by Glen Canyon Dam as described in Section 5.1.4. Lake Powell primarily provides water storage for use in meeting the delivery requirements to the Lower Colorado River consistent with the *Law of the River* – the numerous compacts, federal laws, court decisions and decrees, contracts, and regulatory guidelines that apportion and regulate the use of Colorado River water among the seven basin states and Mexico. Releases are also timed for hydropower production. Lake Powell is an important regional resource for water-based recreation. A comprehensive description of Lake Powell's water quality is presented in *Technical Memorandum 5.13 A Review of Water Quality and Treatment Issues* (MWH 2008). A summary of Lake Powell water quality is presented in Table 5-65.

Table 5-65 Summary of Raw Water Quality – Lake Powell	
Parameter	**Untreated Lake Powell Water**
Ammonia (mg/L as N)	< 0.03
Calcium (mg/L as Ca)	60 to 80
Calcium Carbonate Precipitation Potential (CCPP) (mg/L as $CaCO_3$)	3
Chloride (mg/L)	50 to 80
Conductivity (umhos/cm)	800 to 1100
Dissolved Oxygen (mg/L)	saturated
Langlier Saturation Index (LSI)	0.15
Magnesium (mg/L as Mg)	20 to 28
Nitrate (mg/L as N)	< 0.6
pH – std units	7.8 to 8.2
Potassium (mg/L)	2.5 to 4.0
Silica (mg/L as SiO_2)	7 to 9
Sodium (mg/L)	65 to 90
Sulfate (mg/L)	210 to 280
TDS (mg/L)	540 to 680
Temperature (degrees C)	7 to 16
Total Alkalinity (mg/L as $CaCO_3$)	135 to 180
Total Hardness (mg/L as $CaCO_3$)	240 to 320
Total Organic Carbon (mg/L)	2.0 to 3.0
Source: MWH 2008	

In general, water quality in Lake Powell is better than the surface water quality of the water bodies in the vicinity of the proposed project facilities. In addition, Lake Powell acts as a large sedimentation basin which allows for the settlement of large suspended solids. Therefore, the concentration of suspended solids of the water to be delivered via the LPP Project is reduced. This also reduces the amount of sediment transport into the receiving waters.

5.3.4.1.6 Sand Hollow Reservoir.

Sand Hollow Reservoir is a 50,000 acre-foot storage facility located about 5 miles southwest of Hurricane, Utah. The reservoir was constructed by WCWCD in 2002, is owned by WCWCD and used for M&I raw water supply for WCWCD customers. Water to fill the Sand Hollow Reservoir is delivered from the Virgin River in the same pipeline serving Quail Creek Reservoir. The reservoir has an active pool of about 30,000 acre-feet and a drought pool of 20,000 acre-feet that would provide water supplies in an extreme drought. Sand Hollow Reservoir also serves as a groundwater recharge facility for the Navajo sandstone aquifer. There are no beneficial use designations in the UAC for the Sand Hollow Reservoir.

Historical water quality data for the Sand Hollow Reservoir were obtained from a report produced by the USGS titled *Assessment of Managed Aquifer Recharge at Sand Hollow Reservoir, Washington County, Utah, Updated to Conditions through 2007*. Measured DO levels are susceptible to variation resulting from turbulence at the air-water interface, slow equilibration after a change in atmospheric conditions, algal photosynthetic activity, as well as possible measurement discrepancies associated with electrochemical type instruments. For reference, saturation DO levels have an inverse relationship with water temperature, and a proportional relationship with hydrostatic pressure experienced with increasing depth. A summary of the historical water quality is presented in Table 5-66.

Table 5-66 **Summary of Historical Water Quality – Sand Hollow Reservoir**							
Date sampled	**Water temperature (°C)**	**Specific conductance (µS/cm)**	**pH (standard units)**	**Dissolved Oxygen (mg/L and percent saturation)**	**Chloride (mg/L as Cl)**	**Bromide (mg/L as Br)**	**Arsenic (µg/ L as As)**
9/10/2002	24.2	1,000	8.8	2.3(30%)	76	0.02	2
12/18/2002	7.9	860	8.4	10.2(99%)	-	-	-
3/20/2003	11.1	830	8.2	8.4(100%)	-	-	0.9
5/6/2003	17.6	820	-	3.1(38%)	-	-	-
6/10/2003	23.6	850	8.2	8.8(115%)	-	-	-
8/6/2003	26	930	7.6	3.6(50%)	-	-	2
10/7/2003	21.9	910	8.4	-	79.5	0.03	2.3
1/8/2004	7.1	870	8.4	11.7(110%)	-	-	1.2
5/5/2004	17.3	710	8.2	8.5(101%)	50	0.01	1.1
9/22/2004	18.9	770	8.5	7.2(86%)	-	-	-
2/10/2005	8.3	860	8.4	11.3(106%)	56	0.02	1.5
1/18/2006	6.9	820	8.5	11.9(108%)	44.8	0.04	1.4
2/14/2007	5.1	760	8.1	11.6(101%)	50.4	0.05	1.8
Source: USGS, 2007							

Dissolved oxygen data collected by WCWCD near the dam on the north side of Sand Hollow Reservoir indicate concentrations ranging from 8 to 12.5 mg/L throughout the year from the surface to approximately 50 feet deep. Dissolved oxygen concentrations decrease below 8 mg/L between 50 and 70 feet deep during the summer months when the reservoir stratifies. Figure 5-93 shows the dissolved oxygen concentrations measured at various depths in Sand Hollow Reservoir. The dissolved oxygen data were collected during 2006, 2007 and 2008.

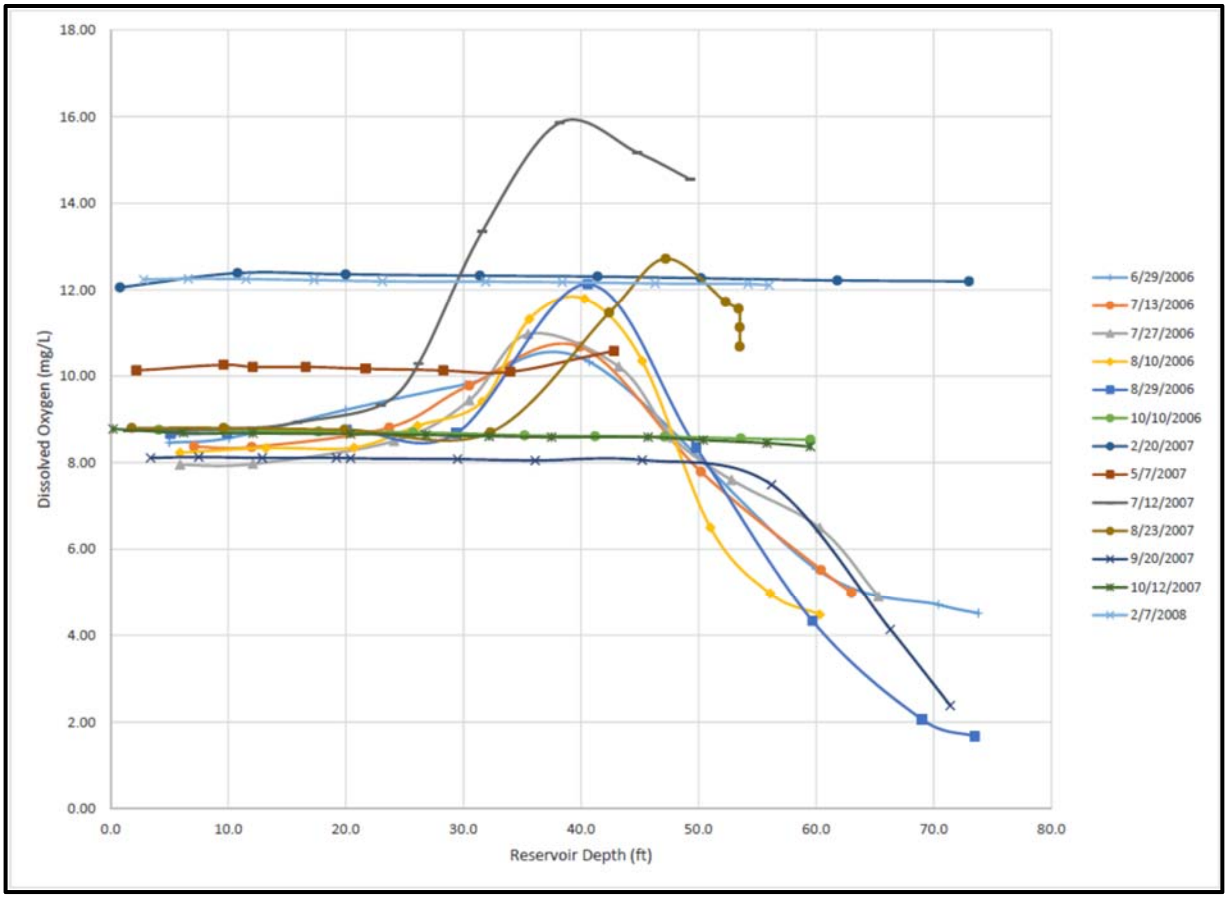

Figure 5-93
Dissolved Oxygen Concentrations in Sand Hollow Reservoir Near the North Dam

Temperature data collected by WCWCD at various depths near the north dam of Sand Hollow Reservoir indicate water temperatures ranging from 61 to 84°F from the surface to 50 feet during the summer months, with water temperatures down to 57°F between 50 and 70 feet deep. The temperature profile with depth indicates thermal stratification occurs during the summer months and matches the dissolved oxygen profile shown in Figure 5-93. Water temperatures during the fall and winter periods are nearly uniform with depth, indicating complete turnover and mixing following the summer period. The temperature data were collected during 2006, 2007 and 2008 (UDWRe 2016c).

TDS data collected by WCWCD at various depths near the north dam of Sand Hollow Reservoir indicate TDS concentrations ranging from 497 to 519 mg/L from the surface to 70 feet during the summer months. The TDS concentrations during fall and winter periods are nearly uniform with depth and indicate complete turnover and mixing following the period of summer stratification. The TDS data were collected during 2006, 2007 and 2008 (UDWRe 2016c).

5.3.4.2 Environmental Effects

This section presents the potential effects on surface water quality that would be caused by construction and operation of the Proposed Action and alternatives. The major surface water streams in the area of potential effect include Kanab Creek, Paria River, and Virgin River. Major surface water reservoirs in the area of potential effect include Quail Creek Reservoir, Sand Hollow Reservoir, and Lake Powell. In addition, there are numerous ephemeral washes that could be affected by the proposed LPP construction and operation.

New facilities proposed under the LPP Project include: intake facilities in Lake Powell, large diameter water conveyance pipelines, booster pump stations, large diameter penstocks, hydro generating stations, and power transmission lines. Potential effects on water quality from the proposed facilities include:

- Sediment transport and introduction of pollutants from equipment used during construction
- Sediment transport and introduction of pollutants from pipeline discharges during operation
- Changes in total dissolved solids from the addition of large volumes of Lake Powell water to Sand Hollow Reservoir
- Changes in water quality from volume changes (Lake Powell and downstream in the Lower Colorado River)

5.3.4.2.1 Significance Criteria.

Effects on water quality are considered significant if construction, operation or maintenance activities would result in any of the following conditions:

- Violation of applicable surface water quality standards
- Substantial degradation of surface water quality
- Substantial alteration of the existing drainage pattern of the site or area, including through alteration of a stream or river course in a manner resulting in substantial erosion or siltation on- or off-site

Criteria for evaluating water quality in the surface water bodies in the vicinity of the proposed pipelines are based on beneficial uses and water quality objectives as determined by the Utah Administrative Code R317-2 and the AAC R18-11-105. Water quality effects on the surface water bodies in the vicinity of the proposed project facilities are qualitatively described in this section.

5.3.4.2.2 Proposed Action.

Effects on surface water quality could occur from Proposed Action construction and from operations and maintenance activities. The Proposed Action pipeline and penstock share common segments with the alignment alternatives between the intake at Lake Powell and delivery at Sand Hollow Reservoir. The Proposed Action and alignment alternatives are spatially different in the area through and around the Kaibab-Paiute Indian Reservation. The Proposed Action extends south around the Kaibab-Paiute Indian Reservation. The Existing Highway Alternative follows Highway 389 through the southeast corner of the Kaibab-Paiute Indian Reservation. The Southeast Corner Alternative follows the Navajo-McCullough Transmission Line corridor across the southeast corner of the Kaibab-Paiute Indian Reservation. Effects on water quality during Proposed Action and alternative alignment construction and operation would be common for all alignment alternatives because they all cross the major surface water features described in the affected environment (Section 5.3.4.1).

5.3.4.2.2.1 Construction Effects.

Construction of the proposed pipelines, penstocks and other project facilities would require extensive earthwork with the potential to significantly affect natural surface water features in the area of potential effect. In addition to the proposed pipelines and penstocks, the project includes construction of booster pump stations, hydro generating stations, and power transmission lines. Staging areas for equipment and personnel and creation of temporary construction roadways, would further disturb surface soils and create the potential for water quality effects.

Clearing and Grading

Clearing and grading would reduce vegetation along the cleared sections of the right-of-way thereby increasing the exposure of underlying soils to erosion. Excavated loose soil could be transported into adjacent water bodies via wind and stormwater runoff. The use of heavy equipment for construction could result in increased compaction of the underlying soils which would have the potential to increase runoff into surface water bodies. The increased runoff could transport the sediment into the water bodies, resulting in increased turbidity levels and sediment recruitment rates in the receiving water body. An increase in the suspended sediments would increase turbidity, reduce light penetration, and potentially reduce photosynthesis and oxygen production. Dissolved oxygen can be further reduced in affected areas from oxygen consumption by the organic components of the sediment matter.

Open-Cut Crossings

There would be several open-cut crossings of surface waters along the LPP. Open-cut pipeline installation offers lower cost, greater continuity of pipeline installation, and less risk of encountering unknowns during construction compared to trenchless construction techniques.

Construction of open-cut crossings disturbs channel banks and sediments and could increase sediment loading downstream, ultimately adversely affecting receiving waters. The extent of the effect would depend on the volume of sediments disturbed, composition of channel materials including sediment particle size, and volume of storm flows during construction activity. These factors would determine the density and downstream extent of sediment migration. Open-cut construction activity can also dislodge and transport channel bed sediments which could cause changes in downstream bottom contours and stream flow dynamics that could cause additional erosion and downstream sedimentation. Construction of open-cut crossings in areas with shallow groundwater may require trench dewatering and surface discharge operations that may degrade surface water quality of the receiving waters.

Typically, open-cut pipeline installation would be restricted to surface water bodies with intermittent or seasonal flows and construction would occur in dry conditions. However, in cases where continuous flow must be maintained in a waterway and an open-cut installation is proposed, a temporary culvert, pipeline and/or pumping system could be used to divert flows around the pipeline trench and discharge flows downstream. Diversions designed to allow fish passage must maintain suitable temperature and dissolved oxygen conditions for the length of the diversion.

Trenchless Construction Techniques

Trenchless crossing for LPP pipeline construction would be marginally feasible at the Paria River. The Paria River pipeline crossing site would be a minimum of 500 feet long and could be more than 800 feet long, which is the feasible limit for most trenchless pipeline construction techniques. The east bank of the Paria River has limited topography for a driving or receiving pit; the west bank of the Paria River is a riparian area that runs parallel to the pipeline alignment for approximately 0.25 mile. Although the Paria River is classified as a perennial stream, it flows intermittently at the Highway 89 crossing during the summer and fall months, and the high cost of installing the pipeline using a trenchless construction technique would be unnecessary when an open-cut installation could be scheduled during a no flow period. Therefore, it is not expected that the Utah Division of Water Rights would require compliance with Utah Administrative Code Section R655 National Resources, Water Rights, which requires trenchless crossings of natural streams with year-round flows.

Trenchless crossings involve costly underground construction methods that avoid surface effects above the pipe crossing. Five trenchless methods have been considered for LPP construction of stream crossings: conventional bore and jack, pipe ramming, microtunneling, horizontal directional drilling, and blasting. All except blasting consist of tunneling an oversized casing below the waterbody to be crossed, using two temporary vertical access shafts on each side of the crossing. The vertical access shafts would be constructed of sheet piles, soldier piles and lagging, caissons or trench boxes – or unsupported if located in firm rock. When groundwater is present, watertight shoring such as sheet piles must be used along with a dewatering system.

Depending upon the type of trenchless construction, substantial volumes of soils may be excavated and large areas may be required for the staging of the tunneling equipment. Therefore, trenchless construction could reduce direct effects on surface waters but would result in increased erosion potential related to earthwork for vertical access points, soil stockpiles, and equipment staging areas and discharges from dewatering.

Intake and Discharge Construction

Construction of the intake structure at Lake Powell would have minor effects on surface water quality. The intake construction would be performed by constructing vertical shafts in the Navajo sandstone rock adjacent to Lake Powell, and then boring horizontal tunnels from inside the shafts toward the vertical cliff face in the reservoir. Each tunnel would be advanced toward the lake, with the excavated rock removed through the tunnel and up out of the vertical shafts for upland disposal. The upland disposal (of what would be the settled sand-sized particles of Navajo sandstone) would occur on the water intake site which is a previously-disturbed construction materials storage area used to construct Glen Canyon Dam. When each tunnel construction would reach the cliff face, a small quantity of ground-up Navajo sandstone pieces would fall into Lake Powell, which is not expected to change the turbidity in the reservoir and would not violate the water quality standards. Stormwater runoff from surface construction activities would be controlled using silt fences and collection ponds to store and settle particles from turbid water. No water or material discharges to Lake Powell would occur from the surface construction activities.

Construction of Sand Hollow Hydro Station would be performed in upland conditions where all construction site drainage would be collected, pumped into settling ponds and disposed away from the reservoir. The tailrace construction would be performed in solid sandstone bedrock and would be completed during low annual reservoir water surface elevations. Sediment recruitment and turbidity would be controlled within the construction site through implementation of surface water quality BMPs. There would be no measurable construction effects on water quality in Sand Hollow compared to baseline conditions.

5.3.4.2.2.2 Summary of Construction Effects.

Surface water quality BMPs would be implemented to control temporary water quality effects of pipeline crossings of streams and washes if water is flowing during construction. The use of BMPs and standard construction procedures (SCPs) at pipeline crossings of streams would avoid or minimize temporary water quality effects, primarily consisting of turbidity and sediment recruitment. The BMPs and SCPs would include the following:

- Construction of pipeline crossings of dry washes would be performed when the washes are dry.
- Construction of pipeline crossings of perennial or intermittent flowing streams (e.g., Paria River) would be performed when the streams are either at low flows or are dry.

  Silt fences and/or straw bales would be temporarily installed upstream or up-gradient of riparian areas to filter suspended sediments and bedload sediments to avoid sedimentation effects during construction. If necessary, silt fences and/or straw bales would be installed in series to control sediments generated by construction activities.
- Temporary coffer dams would be installed upstream of pipeline crossing for diversion of Paria River flows around the pipeline crossing work area during construction.

- Equipment usage and operation within temporarily dewatered reaches of stream channels would be minimized to protect stream bed substrates.
- Construction equipment working within the temporarily dewatered reaches of stream channels would be checked and regularly monitored for leaking hydraulic fluid, oil, grease, and fuel. Relevant land management agencies would be notified of any spills or leaks detected.
- All construction equipment refueling would be performed on upland areas to prevent fuel spills from contaminating stream substrates and the dewatered stream reaches.
- Construction trenches within dewatered stream reaches would be pumped as necessary to remove subsurface water. The water would be pumped into settling ponds, and then disposed within the right-of-way away from the stream.
- Silt fences would be installed across the stream channels within the dewatered construction areas downstream of the pipeline crossing excavation to capture sediments that may be mobilized by precipitation events during construction activities. The silt fence toe would be anchored into the stream bed with native material. The silt fence would be removed following completion of the pipeline crossing construction and native material used to anchor the silt fence toe would be returned to pre-construction conditions. The collected silt would be land applied in off-channel areas within the right-of-way, but outside the boundaries of the stream channel or direct stream channel drainage area.

Incorporating these BMPs and SCPs into pipeline construction at crossings of streams and dry washes would protect water quality and result in minimal or unmeasurable water quality effects. There would be no significant effects on water quality at stream crossings from pipeline construction.

Construction activities at the water intake site on Lake Powell and at the Sand Hollow Hydropower Station tailrace would not have measurable effects on reservoir water quality. Construction of the horizontal tunnels intercepting Lake Powell at the water intake site would be through Navajo sandstone, and particles resulting from construction at the bedrock/surface water interface would be sand-sized or larger. Turbidity within Lake Powell would not increase measurably. Construction of the Sand Hollow hydro station tailrace channel would be in Navajo sandstone bedrock extending from the ground surface downward. Sand Hollow Reservoir water surface elevation would be lowered by WCWCD during tailrace construction to below the level of any construction effects on surface water quality. The tailrace construction would involve excavating sandstone bedrock, which would generate sand-sized particles or larger. Construction-generated particles would occur temporarily in dry portions of the excavated tailrace channel, and these particles would be cleaned from the channel prior to contact with water stored in Sand Hollow Reservoir. There would be no measurable and no significant water quality effects from construction activities at either reservoir.

5.3.4.2.2.3 Operations and Maintenance Effects.

Operation and maintenance of booster pump stations, hydro generating stations, and the transmission lines would not result in routine water discharges or cause other effects on water quality. Where applicable, booster pump stations would have surface emergency overflow detention basins. However, operation and maintenance of the proposed pipelines would include occasional annual water discharges with the potential to affect natural surface water features in the project area. LPP Project operation would alter the inflow water source to Sand Hollow Reservoir. Changes in Lake Powell water quality resulting from LPP Project operations would not be measurable (see Final Surface Water Quality Study Report, Appendix B, Reclamation Water Quality Modeling Documentation).

Pipeline Flushing

Based on preliminary design information, it is anticipated that water from Lake Powell would enter the intake structure at depths ranging from the reservoir surface to approximately 350 feet below the water surface. It is anticipated that the untreated water pumped into the LPP Project would have low concentrations of suspended solids and turbidity because a high percentage of suspended solids in inflows to Lake Powell settle out below this level. However, some pipeline flushing may be required to remove the smaller particles which enter the LPP and manage to settle in the pipeline. Flushing would only be required when pipeline flows are low enough for long periods of time to allow particles to settle. Flushing would be accomplished by increasing the pipeline flow to near-maximum rates to re-suspend particles that may have settled in the pipeline at lower flows. The flushed water would be discharged into the Proposed Action forebay reservoir above the Hurricane Cliffs.

It is anticipated that standard operating procedures for the Proposed Action would include measures to divert flows generated from flushing operations away from surface water bodies, to settling basins and/or retention/percolation basins.

Drain Valves

Drain valves for draining the Proposed Action pipeline and penstock segments for maintenance and repairs would be installed at low points in the pipeline and penstock profiles. Pipeline and penstock segment draining would occur in January for up to 15 days. The Water Conveyance System would be drained back to the booster pump stations, and low points in the pipeline would be drained to dry washes. Pipeline water drained to dry washes would be discharged at low rates to avoid transporting sediments and avoid causing local turbidity and sediment recruitment to flowing streams or reservoirs. Water in the Hydro System penstocks during the annual maintenance period would be discharged into the forebay reservoir. Low points in the Hydro System penstocks would be drained to the adjacent drainage channels at low discharge rates.

The standard operating procedures for the LPP Project include measures to divert flows generated from opening the drain valves away from surface water bodies, to settling ponds and/or retention/percolation basins, if warranted, or to control the release velocity to avoid uncontrolled erosion.

Pigging

The proposed pipelines would include provisions for “pigging.” Pigging refers to the practice of using pipeline inspection gauges or 'pigs' to perform maintenance operations such as cleaning and inspection on a pipeline without stopping the flow of water through the pipeline and penstock. This is accomplished by inserting the pig into a launching station. Water pressure in the pipeline or penstock would push the pig along the pipeline or penstock segment until it reaches the retrieval station from where it would be removed.

Slime buildup in the pipeline would decrease conveyance capacity and the proposed pipelines and penstocks may have to be cleaned/pigged once or twice a year. Standard operating procedures for the Proposed Action would include measures to divert organic wastes such as biofilms detached from the pipeline during pigging operations away from surface water bodies to retention basins.

Pipeline Rupture

Although highly unlikely, a pipeline rupture from exceedances of pipeline or penstock capacity, seismic activity, or other catastrophic event could result in discharge of large amounts of untreated water which could mix with local surface waters. Potential adverse water quality effects would be limited to increased velocity in the receiving water and potentially increased turbidity and sedimentation from water released to the ground surface, even though the quality of Lake Powell water is generally superior to local surface waters. Valves at booster pump stations and hydro generating stations would be closed in the event of a rupture to isolate the affected segment and prevent further uncontrolled LPP water discharges.

Sand Hollow Reservoir Water Quality Effects

Lake Powell water quality is similar to or superior to the quality of local surface waters, including the Virgin River, which is the primary inflow source to Sand Hollow Reservoir. Water temperatures are projected to be unaffected by the gradually increasing deliveries of LPP Project water, primarily because Sand Hollow Reservoir is relatively shallow with a proportionately large surface area and experiences thermal stratification during the summer months, regardless of the inflow temperatures. As the LPP Project water deliveries increase, Sand Hollow Reservoir water temperatures during summer months could be slightly colder because of the influence of slightly colder Lake Powell water. Dissolved oxygen concentrations are projected to remain unaffected by the gradually increasing deliveries of LPP Project water because the top 50 feet of the reservoir is near or above dissolved oxygen saturation that occurs from atmospheric pressure at the air/water interface. The upper portions of the reservoir are well mixed throughout the year and maintain dissolved oxygen concentrations near or above saturation.

Groundwater quality would not be measurably affected by recharge associated with LPP Project operation. As LPP Project inflows to Sand Hollow Reservoir increase gradually at an overall lower TDS concentration than water delivered from the Virgin River, TDS concentrations in groundwater may decrease slightly, eventually approaching approximately 570 mg/L. There would be no measurable effects on groundwater quality from the LPP Project that would affect surface water quality.

The primary effect of LPP Project deliveries on Sand Hollow Reservoir water quality is focused on potential changes in TDS concentrations. A TDS mass balance model was completed for the LPP Project deliveries to Sand Hollow Reservoir. The model is based on an annual time step for a planning period ranging from year 2025 to year 2060. A salt balance is performed for each time step which tracks the inflows, the outflows, and the corresponding change in storage in the reservoir. It is assumed that complete mixing would occur within Sand Hollow Reservoir. Inflows to the reservoir include raw water deliveries from Lake Powell, direct precipitation, and diversions from the Virgin River. Outflows from the reservoir include water lost to evaporation, groundwater seepage, and planned releases from the reservoir to meet raw water demands. It is assumed that the initial (year 2025) storage volume in the reservoir is 50,000 acre-fee and the corresponding TDS concentration in the reservoir is 600 milligrams per liter (mg/L). The inflow and outflow components considered for this evaluation are described below.

Inflows

- Phased delivery of raw water from Lake Powell via the LPP Project – Table 5-67 lists the planned phased deliveries of raw water from Lake Powell to Sand Hollow Reservoir. Annual deliveries increase from approximately 4,153 ac-ft per year in 2024 to approximately 69,000 ac-ft per year in 2046. Annual deliveries remain constant at 69,000 ac-ft per year from 2046 through 2060. The TDS concentration in the Lake Powell raw water is assumed to be 540 mg/L.
- Direct precipitation on Sand Hollow Reservoir – It is assumed that most of the precipitation in the area either evaporates or is absorbed into the soil because of the minimal precipitation in the area and the arid landscape. Therefore, runoff resulting from precipitation is not included as an inflow component. However, direct precipitation on the reservoir is considered as an inflow component. It is assumed that direct precipitation does not add any TDS load on the reservoir. Historical average annual precipitation for the St. George area is assumed to be 0.7 feet based on information available from the Western Regional Climate Center of the Desert Research Institute (WRCC 2010). An elevation-area-capacity relationship for the reservoir is presented in Table 5-68. This relationship is used to estimate the total

surface area at the beginning of each time step. The product of the total reservoir surface area (in acres) and the average annual precipitation (in feet) yields the total volume contributed by direct precipitation.

Table 5-67
Phased Delivery of Raw Water from Lake Powell to Sand Hollow Reservoir

Year	Planned Deliveries (acre-feet/year) 69,000 acre-feet/year maximum
2024	4,153
2025	6,175
2026	8,911
2027	11,647
2028	14,383
2029	17,120
2030	19,858
2031	22,837
2032	25,816
2033	28,795
2034	31,774
2035	34,753
2036	37,732
2037	40,711
2038	43,690
2039	46,669
2040	49,648
2041	52,941
2042	56,234
2043	59,527
2044	62,820
2045	66,113
2046	69,000
2047	69,000
2048	69,000
2049	69,000
2050	69,000
2051	69,000
2052	69,000
2053	69,000
2054	69,000
2055	69,000
2056	69,000
2057	69,000
2058	69,000
2059	69,000
2060	69,000

Table 5-68 Elevation-Area-Capacity Relationship for Sand Hollow Reservoir		
Elevation (feet)	**Area (acres)**	**Capacity (acre-feet)**
2,972	0	0
2,980	34	64
2,990	138	931
3,000	246	2,835
3,010	385	5,939
3,020	658	11,317
3,030	834	18,858
3,040	1,011	28,128
3,050	1,159	38,970
3,060	1,322	51,360

- Inflows from the Virgin River – It is assumed that water from the Virgin River would be delivered into the reservoir when the volume of water lost by the reservoir via evaporation and seepage exceeds the inflows into the reservoir from precipitation and LPP deliveries. If the volume of the inflow water (LPP deliveries and precipitation) is greater than the volume of water lost to evaporation and seepage, it is assumed that there would be no deliveries from the Virgin River to Sand Hollow Reservoir. It is assumed that inflows from the Virgin River have an average TDS concentration of 550 mg/l.

Outflows

- Evaporation – Based upon a review of historical data at the Sand Hollow Reservoir site (USGS 2009), average annual evaporation of 5 feet (or 60 inches) is assumed. The elevation-area-capacity show on Table 5-68 is used to estimate the total surface area at the beginning of each time step. The product of the total reservoir surface area (in acres) and the average annual evaporation (in feet) yields the total volume lost by evaporation. It is assumed that no TDS load is lost to evaporation.
- Groundwater seepage – Based upon a review of historical data at the Sand Hollow Reservoir site (USGS 2009), average groundwater seepage of 11,856 acre-ft/year is assumed. The TDS concentration associated with groundwater seepage at any time-step is assumed to be same as the TDS concentration of the reservoir at the beginning of that time-step.
- Outflows from the Sand Hollow Reservoir to meet water demands – It is assumed that all raw water deliveries from Lake Powell would be used to meet demands after offsetting reservoir losses to seepage and evaporation. It is assumed that there would be no releases from the reservoir if the volume of water lost to evaporation and seepage is higher than the inflows into the reservoir.

Model Results

The model indicates that the TDS concentration in the reservoir would increase initially as the salt load inflows into the reservoir exceed the outflows. As planned deliveries from Lake Powell increase over time and Virgin River water inflows decrease, the TDS concentration in the reservoir would gradually decrease and eventually stabilize at a concentration of 576 mg/l at the end of year 2055 under full deliveries of LPP water. The variation in the TDS concentration in Sand Hollow Reservoir is depicted in Figure 5-94. In summary, a minor reduction in TDS concentration would be anticipated at Sand Hollow Reservoir from the delivery of raw water from Lake Powell.

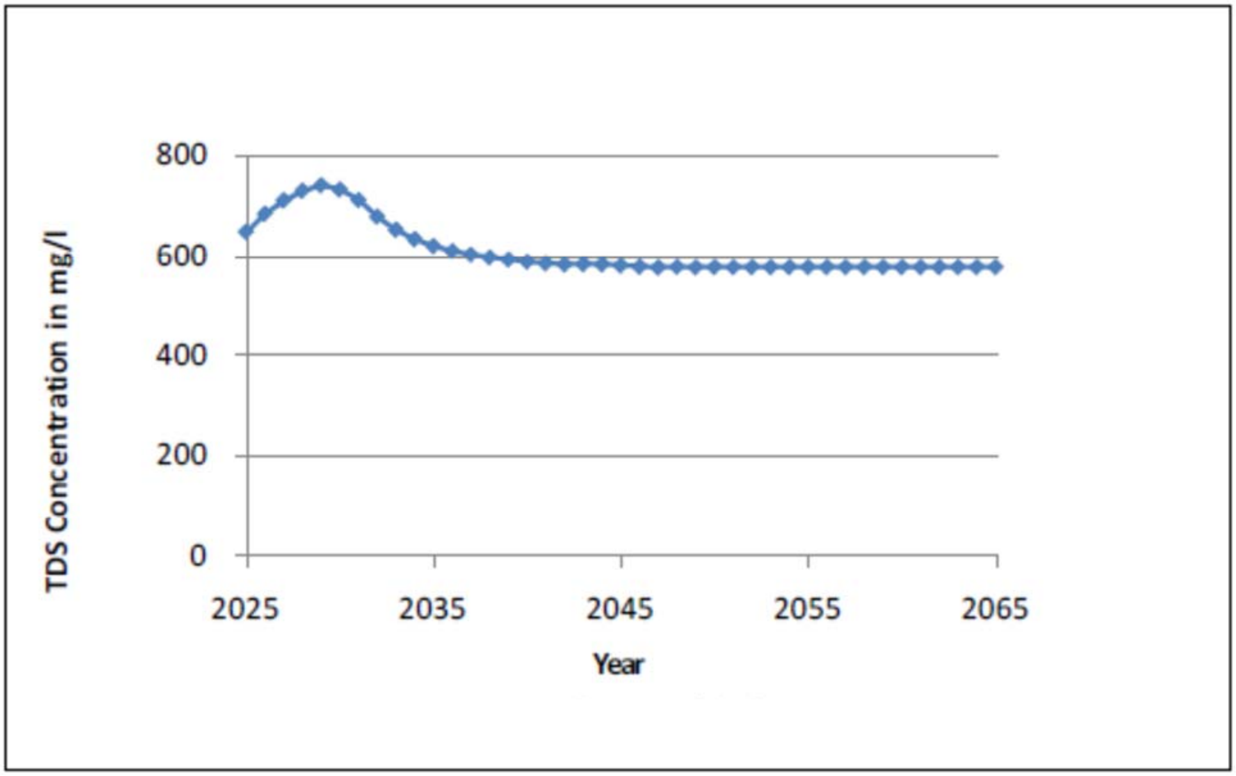

Figure 5-94
TDS Concentration versus Time (Sand Hollow Reservoir)

Lake Powell and Lower Colorado River Water Quality Effects

Computer modeling was performed by the US Bureau of Reclamation – Upper Colorado Region (Reclamation) to evaluate potential effects of the Proposed Action on temperature, TDS, and other water quality parameters for the following water bodies: Lake Powell, below Glen Canyon Dam, and the lower Colorado River. The CRSS and Lake Powell CE-QUAL-W2 models were used to simulate water quality parameters in and below Lake Powell for the No Action and Proposed Action scenarios (Reclamation, 2016).

Water quality results from the Proposed Action scenario were compared to the No Action alternative scenario to determine effects, if any, on water quality. Water quality modeling results included temperature and dissolved oxygen in Lake Powell, temperature, TDS, and dissolved oxygen below Glen Canyon Dam from the CE-QUAL-W2 modeling, and TDS along the lower Colorado River from the CRSS modeling. Other water quality parameters were simulated by the CE-QUAL-W2 model including nutrients and phytoplankton but quantitative results are not presented for these parameters. Additionally, CE-QUAL-W2 modeling of Glen Canyon Dam release temperatures at varying elevations was performed as part of the "Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead, Final Environmental Effect Statement" or Shortage Criteria EIS (Reclamation 2007) results from that modeling are interpreted based on the projected changes in Lake Powell water surface elevations as a result of the proposed LPP Project (Reclamation 2016).

Lake Powell

Lake Powell temperature and dissolved oxygen concentrations were evaluated at five day intervals for three reservoir locations and five depths. The three locations were above the dam, below the confluence of the San Juan River, and the upstream reservoir. The five depths were 5, 10, 25, 50, and 100 meters. Simulated reservoir temperatures for the 86,249 ac-ft pipeline simulation were compared with the No Action alternative simulation. Average temperatures at each depth modeled are between 0.04 (0-meter depth) and 0.19°C (25-meter depth) colder. Simulated reservoir dissolved oxygen (DO) concentrations for the 86,249 acre-feet per year pipeline diversion simulations were compared with the No Action alternative simulation and were 0.1 mg/L lower at 25 meters, 0.2 mg/L lower at 50 meters and 0.1 mg/L higher at 100 meters (Reclamation 2016). The DO concentrations for the 0 meter and 10 meter depths modeled for the pipeline simulation were the same as the No Action alternative.

Glen Canyon Dam Releases

Modeled release results from Glen Canyon Dam for the No Action alternative and Proposed Action pipeline simulations were evaluated for effects on temperature, TDS, and dissolved oxygen concentrations. Simulated mean dam release temperatures for the period 2045 to 2060 indicate that generally in the Proposed Action pipeline scenario, dam release temperatures are slightly colder in winter and spring months (colder by approximately 0.1°C) and slightly warmer (warmer by approximately 0.1°C) in summer and fall months compared with the No Action alternative scenario (Reclamation 2016).

Glen Canyon Dam release temperatures often peak in October and simulated results show that when the reservoir is at or near full pool elevations, as was the case from 2050 to 2056, water temperatures of releases from the dam for the Proposed Action scenario were colder than in the No Action alternative scenario. The release temperatures from the dam in the pipeline scenarios are colder when the reservoir is near full capacity because of the removal of warm water from the upper, warm layer of the reservoir by the pipeline. Simulated release temperatures for the Proposed Action scenario were warmer than the No Action alternative scenario during summer and fall months when reservoir pool elevations were below full pool. The largest differences between the Proposed Action scenario and the No Action alternative scenario coincided with the lowest reservoir pool elevations (Reclamation 2016). On average, the modeled results for the Proposed Action compared with the No Action alternative are within 0.1°C for the 2045-2060 period. For individual years, differences of up to 0.71°C were predicted (Reclamation 2016).

TDS results from the No Action alternative and Proposed Action models indicate that the average release TDS concentrations from 2045-2060 for the results of the three models would all be within 0.7 mg/L of each other. The Proposed Action average TDS values would be slightly higher than the No Action alternative (Reclamation 2016).

Dissolved oxygen results from the No Action alternative and Proposed Action models indicate that the average release dissolved oxygen concentrations from 2045-2060 for the two models would not vary (Reclamation 2016).

Lower Colorado River Salinity

Numeric criteria have been established for salinity at three sites on the Lower Colorado River: below Hoover Dam, below Parker Dam, and above Imperial Dam. The salinity criteria at each of these sites are 723 mg/L, 749 mg/L, and 879 mg/L, respectively. The CRSS model simulated the period 2015 to 2060 using the DNF inflow hydrology scenario to estimate changes in lower Colorado River salinity. Under the DNF scenario, the historic record 1906-2006 was used to generate 101 simulations of the period 2009 to 2060.

The results of salinity modeling from the CRSS DNF hydrology and operations model comparing the No Action alternative with the Proposed Action at these three sites indicate that no appreciable differences are found at the 90th, 50th, or 10th percentile levels (Reclamation 2016).

Detailed results of the water quality modeling are published in *Lake Powell Pipeline Water Quality Modeling Documentation* (Reclamation 2016).

5.3.4.2.2.4 Summary of Operations and Maintenance Effects.

A comparison of the raw water quality from Lake Powell and the water quality objectives for the major surface waters in the vicinity of the LPP is presented in Table 5-69. Based on the water quality simulation results, Lake Powell water quality would meet or be well within established water quality criteria and standards for the major surface water bodies in the area of potential effect.

Table 5-69
Summary Comparison of Lake Powell Water Quality and Water Quality Criteria for Surface Waters in the Project Area

Parameter	Untreated Lake Powell Water	Numeric Criteria for Kanab Creek (Utah)	Numeric Criteria for Paria River (Utah)	Numeric Criteria for Virgin River (Below Quail Creek Diversion)	Numeric Criteria for Kanab Creek (Arizona)	Numeric Criteria for Paria River (Arizona)
Dissolved Oxygen (mg/L)	saturated	-	-	-	6	6
pH-Standard Units	7.8 to 8.2	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0
TDS (mg/L)	540 to 680	1,200	1,200	1,200	-	-
Temperature (C)	7 to 16	27	27	20	-	-
Nitrate (mg/L as N)	< 0.6	4	4	4	-	-

Therefore, potential effects on water quality considered for Proposed Action operation include:

- Sediment transport and introduction of pollutants from pipeline discharges during operation
- Changes in total dissolved solids from the addition of large volumes of Lake Powell water to Sand Hollow Reservoir
- Changes in water quality from volume changes (Lake Powell and downstream in the Lower Colorado River)

Uncontrolled discharge of sediment or organics-laden water from the pipeline during maintenance operations could result in exceedance of water quality objectives in receiving waters. However, it is assumed that standard operating procedures for the Proposed Action would include measures to divert pipeline discharges away from surface water bodies to retention/detention basins and that any subsequent releases would be controlled to avoid adverse effects. Discharges to surface waters during project operation, such as from a settling tank to a natural drainage, may be subject to UPDES or APDES permit requirements.

A TDS mass balance model for the LPP water delivery to Sand Hollow Reservoir indicates that TDS levels in Sand Hollow Reservoir would increase initially as the salt load of inflows exceeded outflows. Over time, however, TDS concentrations are predicted to stabilize at a level slightly below existing concentrations as Lake Powell water replaces Virgin River water in the reservoir.

Modeling performed by Reclamation for water temperature, TDS and dissolved oxygen did not predict measurable or significant changes in Lake Powell, Glen Canyon Dam release, or in the lower Colorado River for the Proposed Action compared with the No Action alternative.

Therefore, with implementation of standard operating procedures to control pipeline discharges, the Proposed Action operation would not be anticipated to result in the violation of applicable surface water quality standards or cause substantial degradation of surface water quality or cause substantial alteration of the existing drainage pattern of the site or area.

All identified mitigation measures would be implemented. BMPs employed during operation would prevent sediment recruitment and resultant increases in salinity in the Colorado River Basin. The Colorado River Basin Salinity Control Program emphasizes agricultural flows and reduces soil erosion resulting from agricultural activity; the program goals would be satisfied by BMPs to control sediment and salinity releases. Because open-cut pipeline crossings would be constructed during dry conditions or with use of active temporary water diversion, sediment recruitment would not be measurable or significant. Any negligible effects on overall Colorado River salinity would not be measureable.

5.3.4.2.3 Existing Highway Alternative.

The Existing Highway Alternative would have the same effects on surface water quality as described for the Proposed Action in Section 5.3.4.2.2.

5.3.4.2.4 Southeast Corner Alternative.

The Southeast Corner Alternative would have the same effects on surface water quality as described for the Proposed Action in Section 5.3.4.2.2.

5.3.4.2.5 No Lake Powell Water Alternative.

The No Lake Powell Water Alternative would involve a combination of developing remaining available surface water and groundwater supplies, developing reverse osmosis treatment of existing low quality water supplies, and restricting residential outdoor watering in the WCWCD service area. This alternative could provide a total of 86,249 ac-ft of water annually to WCWCD and KCWCD for M&I use without diverting Utah’s unallocated water from Lake Powell.

Construction of the facilities necessary for the No Lake Powell Water Alternative would result in water quality effects related to soil disturbance and use of heavy equipment during construction. Construction effects on water quality would be potentially significant and require the implementation of mitigation measures to reduce adverse effects.

Sand Hollow Reservoir would continue to receive Virgin River water as at present and water quality of the reservoir would be the same as existing conditions. The minor changes in temperature, TDS, and dissolved oxygen predicted for Lake Powell, Glen Canyon Dam release, and the lower Colorado River would not occur with no diversion of water from Lake Powell.

Indirect effects under the No Lake Powell Water Alternative would be significant and include increased water temperatures in the Virgin River and tributary streams under the influence of groundwater recharge from outdoor watering in the St. George metropolitan area. The cessation of residential outdoor watering with potable water would significantly reduce recharge and is expected to result in changing the Virgin River from a gaining stream during the summer and fall months to a losing stream year round. This indirect effect would cause the stream water temperatures to increase because the cooler groundwater discharging to the stream under baseline conditions helps control the water temperature during the summer and fall months.

Therefore, the No Lake Powell Water Alternative may indirectly result in violation of applicable surface water quality standards for temperature and cause substantial degradation of surface water quality. This would be a significant effect on water quality in the Virgin River.

5.3.4.2.6 No Action Alternative.

The No Action Alternative would have no effects on surface water quality in Lake Powell and the Colorado River downstream from Glen Canyon Dam, no effects in streams and ephemeral drainages crossed by the LPP action alternatives, and no effects in Sand Hollow Reservoir.

5.3.4.3 Protection, Mitigation and Enhancement Measures

Construction of LPP Project facilities would result in extensive areas of construction disturbance and potentially significant, although short-term, water quality effects. Erosion generating turbidity and sediment is the primary water quality concern during construction. In addition to sediment recruitment, stormwater runoff from construction areas can carry potential hazardous substances used in construction such as fuels, oils, antifreeze, coolants, paints and other coatings, solvents, and other substances.

This section presents the types of protection and mitigation measures that would be implemented during project construction by UDWRe to mitigate the potential adverse effects on surface water quality. These protection and mitigation measures would apply to the effects associated with constructing all proposed pipeline, penstock and power transmission line alignments.

5.3.4.3.1 Compliance with NPDES Permitting.

The proposed pipeline and penstock facilities for the conveyance of raw water from Lake Powell would pass through the states of Utah and Arizona. Both states have administrative programs for stormwater permitting in compliance with the National Pollution Discharge Elimination System (NPDES) permitting system. In Arizona, this program is called the Arizona Pollutant Discharge Elimination System (APDES). Arizona has a general permit (Arizona G2008-001) that covers stormwater discharges from construction activities, except for those construction discharges in tribal lands. However, an individual permit is required when the general permit requirements do not accurately represent the activity at a facility and a permit is customized to the site. In Utah, this program is called the Utah Pollutant Discharge Elimination System (UPDES). Utah has a general permit (Utah R300000) that covers stormwater discharges from construction activities. Alternately, an individual permit is issued for some construction projects.

In compliance with the NPDES permits for stormwater discharge associated with construction activity, a storm water pollution prevention plan (SWPPP) would be developed prior to the construction phase during final project design. The SWPPP would identify BMPs that would be incorporated during construction to prevent or to minimize the entry of contaminants in the local surface water bodies. Implementation of the SWPPP would typically begin during initial clearing, grubbing, and grading operations, since these activities have the potential to increase erosion at the project sites. The SWPPP would be frequently referred to during the construction phase and amended as changes occur in construction operations, which could further reduce the potential for discharge of pollutants into the local surface water bodies.

The SWPPP would include the types of measures described in the following sections to mitigate the effects on surface water quality during the construction of the proposed project facilities. The final SWPPP would be developed in collaboration with the contractor(s) and would be site-specific for each phase of the construction, and for all project facilities (pipelines, penstocks, booster stations, power transmission lines, hydro generating stations, etc.).

5.3.4.3.1.1 Erosion Control.

BMPs for erosion control would be implemented to prevent the detachment of soil particles from the ground surface caused by rainfall, wind, or flowing water. In general, steep slopes and large exposed areas in the vicinity of construction sites would require erosion control mechanisms. Erosion control BMPs would be implemented at slopes and areas where soil has been disturbed during construction. These areas would be protected from concentrated flows by intercepting, diverting, conveying, and discharging concentrated flows such that sediment removal and transport is prevented. Soil disturbed and stockpiled during construction would be moved to areas where there is minimum potential for accelerated erosion and sediment recruitment to streams and reservoirs. Selected BMPs to control erosion are described in the following sections.

Preservation of Existing Vegetation

Developed root systems of existing vegetation in the vicinity of the construction site hold the soil in place and prevent rapid drying of the soil thereby providing natural protection against erosion. Prior to clearing and grubbing activities, a plan would be developed to preserve existing vegetation to minimize erosion. All vegetation identified for ultimate removal would be temporarily preserved and utilized for erosion control. Vegetated areas would be clearly marked and a buffer area would be provided to help to preserve these areas and take advantage of natural erosion prevention.

Soil Binders

Soil binders would be used disturbed areas that require temporary stabilization of the soil surface to prevent erosion caused by rainfall or wind. The binder would be selected based upon the type of the soil at the site. The selected soil binder would not be toxic to existing plant and animal life and would not pollute stormwater. Soil binders would be used only for flat, exposed areas and not for steep slopes. Soil binders would require a curing period of 24-hours upon application. Re-application may be required after storm events because soil binders offer only temporary protection. The soil binders can be plant-material based (guar, psyllium, starch, pitch and rosin emulsion etc.), polymeric emulsion based (acrylic copolymers and polymers, hydro-colloid polymers etc.), or cementitious based (gypsum, etc.).

Matting

For surfaces with slopes steeper than 3H:1V, UDWRe could install mats of natural materials to cover the soil surface to minimize erosion caused by the effect of rainfall. Such mats are generally installed in areas where the flow velocities are between 3 feet per second (fps) and 6 fps. The selected material would not be toxic to existing plant and animal life and would not pollute stormwater. The choice of the matting material is usually governed by the size of area, side slopes, surface conditions such as hardness, moisture, weed growth, and availability of materials. Geotextiles, plastic covers, and erosion control blankets are some of the natural and synthetic mattings commonly used. Organic matting materials have been found to be effective where re-vegetation would be provided by re-seeding. Jute, straw blanket, wood fiber or excelsior blanket, coconut fiber blanket, coconut fiber mesh, etc. are some examples of organic matting materials.

Runoff Interception and Diversion

In order to prevent runoff from washing away disturbed soil, temporary structures would be planned and designed to divert runoff to a designated location such as a sediment basin or trap. Design of the structures would be developed in collaboration with, and approved by, federal land management agencies. This would be performed by constructing drainage swales and earth dikes in areas where runoff is expected to affect an erodible area. An earth dike is a ridge constructed from compacted soil while a drainage swale is a sloped depression in the soil. Depending on the intensity of the storm and the expected flow rate, permanent structures may also be constructed to intercept and divert runoff. Diversion structures concentrate surface runoff and increase the flow velocity. All flows from the diversion structure would be directed to a flow stabilization structure such as a sediment basin which would allow for the settling of suspended solids. Check dams may be installed along the drainage swales to reduce the effective slope of the channel, thereby reducing the velocity of flowing water, allowing sediment to settle and reduce erosion and sediment recruitment.

Dust Control

Dust control measures would be implemented to prevent sediment erosion and transport through wind. The direction of the prevailing winds would be monitored and measures would be planned accordingly for dust control. Disturbed soil would either be covered in small stockpiles or water or soil binders would be applied to keep them moist. Dust control by watering would have to be carried out at pre-determined intervals to avoid drying and erosion of the disturbed soil. Dust control watering would be monitored to make sure over-watering does not occur. All trucks that haul soil would be equipped with covers for adequate dust control. Track in/track out devices would be implemented to reduce the transport of sediments by vehicles at specific locations.

5.3.4.3.1.2 Sediment Control.

BMPs for sediment control would be implemented to prevent the transport of sediment particles by rain, wind, or flowing water. These BMPs would intercept and detain the runoff to allow sediment to settle and be trapped. Sediment control BMPs would be used in conjunction with erosion control BMPs to increase their effectiveness. Selected BMPs for sediment control are described in the following sections.

Silt Fence and Sandbag or Straw Bale Barriers

Silt fences would be installed in areas where sediment transport occurs because of runoff in the form of sheet flows on level ground. A silt fence is made of a filter fabric attached to supporting poles and supported by wire mesh. The silt fence detains the flow, leading to sediment deposition behind the fence. In most cases, the detained water would be allowed to evaporate. Silt fences are temporary sediment control structures and would not be used in areas where the runoff is concentrated. Sandbags would be installed to intercept and detain sheet flows. Unlike silt fences that can only be used on level ground, sand bags and straw bales can be used on slopes to impound runoff and facilitate sedimentation. Sediment laden flows impounded and/or diverted by these structures may be directed to a sediment basin for settling and evaporation.

Sediment Basins

Prior to clearing and grubbing activities, a plan would be developed for identifying and constructing sediment basins at the construction sites. Design of the structures would be developed in collaboration with, and approved by, federal land management agencies. The sediment basins would be designed based on factors such as rainfall intensity, the expected precipitation volume, and the runoff flow rate. The sediment basins would be located such that they intercept maximum runoff from the disturbed areas. Sediment basins would be installed to allow settling of the suspended particles prior to discharging the runoff into a receiving water body. A sediment basin is a temporary structure formed by excavation or by the construction of an embankment. The sediment basin would be maintained until the site area is permanently protected against erosion. During construction, provisions would be made for removal of accumulated sediments from the basin. Sediments would be land applied within the right-of-way in uplands away from the receiving water or direct drainage area.

5.3.4.3.1.3 Hazardous Material Control.

In order to minimize the potential for spills of potential contaminants into the surface water bodies, BMPs would be developed to identify specific fueling areas for construction vehicles and equipment. Procedures for handling hazardous material would be developed. Containment basins and absorbent pads to intercept fuel and other discharges from sedentary equipment would be developed. It is anticipated that the implementation of these BMPs would mitigate the potential effects of contaminants entering receiving waters.

5.3.4.3.1.4 Final Site Stabilization.

Implementation of construction BMPs is completed when final site stabilization can be documented and approved by the federal land management agency authorized officers. All disturbed areas must be either built on, paved, re-vegetated or have equivalent permanent, physical post-construction erosion controls in place. For stream crossings, bank re-contouring to close to pre-project conditions and revegetation would be completed. Where implemented, specific standards for revegetation would apply (e.g., 70 percent of pre-disturbance plant density is considered to be "finally stabilized" per the Utah NPDES stormwater general permit).

5.3.4.4 Cumulative Effects

5.3.4.4.1 Proposed Action.

The Proposed Action would have minimal short-term effects on surface water quality during construction. Therefore, there would be no measurable cumulative effects of the LPP alternatives on surface water quality when combined with other past, present, and reasonably foreseeable future actions. The unmeasurable short-term cumulative effects would not be significant.

The Proposed Action could have minimal long-term cumulative effects on surface water quality in Lake Powell and Glen Canyon Dam releases when combined with the following past, present, and reasonably foreseeable future actions during operations:

- Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead EIS and ROD
- Operation of Glen Canyon Dam EIS and ROD
- Interim Surplus Criteria EIS and ROD
- Bureau of Reclamation and National Park Service LTEMP EIS

These interrelated actions determine the elevation, storage, release, operational timing, and volume of water in Lake Powell and release rates, release volumes, and operational timing of Glen Canyon Dam releases to the Colorado River. The Proposed Action would have minimal effects on surface water quality in Lake Powell, and when combined with these interrelated actions, there would be long-term minimal cumulative effects on surface water quality. Similarly, the Proposed Action would have minimal effects on Glen Canyon Dam release water quality and when combined with these interrelated actions, there would be long-term minimal cumulative effects on surface water quality. These long-term cumulative effects would not be physically measurable in Lake Powell and Glen Canyon Dam releases. However, these unmeasurable long-term cumulative effects would result from depletions up to 86,249 ac-ft per year from Lake Powell, and there would be minimal cumulative effects on Bureau of Reclamation operations and other actions implemented by the U.S. Department of the Interior. These cumulative effects on surface water quality would not be significant.

5.3.4.4.2 Existing Highway Alternative.

The cumulative effects of the Existing Highway Alternative would be the same as described for the Proposed Action in Section 5.3.4.4.1.

5.3.4.4.3 Southeast Corner Alternative.

The cumulative effects of the Southeast Corner Alternative would be the same as described for the Proposed Action in Section 5.3.4.4.1.

5.3.4.4.4 No Lake Powell Water Alternative.

The No Lake Powell Water Alternative would have a long-term cumulative effect on surface water quality when combined with the operation of the St. George Wastewater Reuse Project. All of the available reclaimed wastewater effluent from the St. George Regional Wastewater Reclamation Facility would be conveyed to a future Warner Valley Reservoir for mixing with Virgin River water pumped from the Washington Fields Diversion, comprising the raw water supply for RO treatment processes. No reclaimed water would be available for reuse in city parks, golf courses and cemeteries. This cumulative effect on surface water quality could be moderate and could be a significant cumulative effect, resulting from cessation of irrigating city parks, golf courses, and cemeteries with reuse water. The replacement water supply would be water stored in the future Warner Valley Reservoir, which would have lower TDS concentration than the St. George Regional Water Reclamation Facility effluent.

5.3.4.4.5 No Action Alternative.

The No Action Alternative would have no cumulative effects on surface water quality in Lake Powell and the Colorado River downstream from Glen Canyon Dam, in streams and ephemeral drainages crossed by the LPP Project action alternatives, and in Sand Hollow Reservoir.

5.3.4.5 Unavoidable Adverse Effects

5.3.4.5.1 Proposed Action.

The Proposed Action would have minor short-term unavoidable adverse effects on surface water quality, including temporary diversions at actively flowing stream crossings. Potential unavoidable adverse effects include unmeasurable or minor increases in turbidity and sediment recruitment at perennial stream crossing sites.

The Proposed Action would have unmeasurable, minor long-term unavoidable adverse effects on surface water quality, including TDS and dissolved oxygen (DO) concentrations and temperatures in Lake Powell and Glen Canyon Dam releases to the Colorado River, Virgin River water quality through the St. George metropolitan area, and unmeasurable cumulative effects in combination with Bureau of Reclamation operating decisions on Lake Powell elevations and Glen Canyon Dam releases. Operation and maintenance activities would have a minor unavoidable adverse effect on surface water quality in Sand Hollow Reservoir. TDS concentrations would initially increase over baseline conditions as the salt load in the LPP inflow water exceeds the outflow from Sand Hollow Reservoir. Water quality modeling indicates the TDS concentration would decrease after the first several years of LPP operation as the LPP water with lower TDS concentration becomes the primary inflow source to Sand Hollow Reservoir. The TDS concentration would be lower than baseline conditions after 2028 and would stabilize at a lower concentration through 2060. There would be no other unavoidable adverse effects on surface water quality under the Proposed Action.

5.3.4.5.2 Existing Highway Alternative.

The unavoidable adverse effects of the Existing Highway Alternative on surface water quality would be the same as described for the Proposed Action in Section 5.3.4.5.1.

5.3.4.5.3 Southeast Corner Alternative.

The unavoidable adverse effects of the Southeast Corner Alternative on surface water quality would be the same as described for the Proposed Action in Section 5.3.4.5.1.

5.3.4.5.4 No Lake Powell Water Alternative.

The No Lake Powell Water Alternative would have no short-term unavoidable adverse effects on surface water quality. The No Lake Powell Water Alternative would have major long-term unavoidable adverse effects on water quality in the Virgin River and its local tributary streams under the influence of groundwater resulting from reduced return flows in response to cessation of outdoor watering with potable water. The decrease in subsurface return flows could adversely affect stream flows, increase water temperatures, and decrease DO concentrations with exceedance of temperature and DO criteria during the summer months. These unavoidable adverse effects on water quality would be significant.

5.3.4.5.5 No Action Alternative.

The No Action Alternative would have no short-term or long-term unavoidable adverse effects on surface water quality in Lake Powell and the Colorado River downstream from Glen Canyon Dam, in streams and ephemeral drainages cross by the LPP Project action alternatives, and in Sand Hollow Reservoir.

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