JORDAN RIVER TMDL:

WORK ELEMENT 1 – EVALUATION OF EXISTING INFORMATION

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1.0 INTRODUCTION

The purpose of this report is to document the process of acquiring, compiling, reviewing, evaluating, and summarizing the existing information necessary to support a defensible Total Maximum Daily Load (TMDL) Water Quality Study addressing impaired segments of the Jordan River. Work Element 1 is the first step in the TMDL process and provides a detailed assessment of water quality, flow, and biological parameters that indicate the current health of the Jordan River. GIS data has also been collected to provide a tool for assessing watershed-scale processes that influence the health of the river. This report provides the detailed data needed for the load calculations, assessment of beneficial use impairment, load allocations, and reductions necessary to complete the subsequent TMDL work elements.

This TMDL process was initiated because routine water quality monitoring data collected at stations on the Jordan River indicated that levels of Dissolved Oxygen (DO), Total Dissolved Solids (TDS), *Escherichia coliform* (E. coli), and Water Temperature (Temperature) were in violation of the designated beneficial use standards assigned to several Jordan River segments. This necessitated an in-depth study to clearly define the nature and extent of water quality impairment and to devise a viable plan to correct that impairment. In general, this assessment focuses on the mainstem Jordan River and will not evaluate conditions in tributary watersheds.

The quality of Utah water bodies is supported by water quality standards and goals adopted by the State to safeguard public health, enhance water quality, and protect assigned beneficial uses (e.g. aquatic life, recreation, or agricultural use). The Utah 2006 303(d) list identifies seven segments of the Jordan River as water quality impaired. The impaired beneficial uses and parameters of concern associated with this listing are identified below in Table 1. This TMDL assessment will examine both 303(d) listed parameters and other water quality constituents that may influence listed parameters.

Table 1. Jordan River segments included on the Utah 2006 303(d) list.

Name	Impaired beneficial use	Existing support status	Pollutant of concern	Standard
Jordan River 1 – from Farmington Bay upstream to Davis County line.	3B – Warm water game fish/aquatic life.	Non-Support	Dissolved Oxygen	Aug-Apr = 4 mg/L May-Jul = 4.5 mg/L
	4 – Agriculture/ irrigation.	Non-Support	Total Dissolved Solids	1,200 mg/L
Jordan River 2 – from Davis County line upstream to North Temple Street.	2B – Secondary Contact Recreation	Non-Support	E. Coli	Criterion 1 > 940 col/100 ml, Criterion 2 geometric mean > 206 col/100 ml
	3B – Warm water game fish/aquatic life.	Partial-Support	Dissolved Oxygen	Aug-Apr = 4 mg/L May-Jul = 4.5 mg/L
Jordan River 3 – from North Temple Street to 2100 S.	2B – Secondary Contact Recreation	Non-Support	E. Coli	Criterion 1 > 940 col/100 ml, Criterion 2 geometric mean > 206 col/100 ml

Table 1. (cont'd) Jordan River segments included on the Utah 2006 303(d) list.

Name	Impaired beneficial use	Existing support status	Pollutant of concern	Standard
Jordan River 5 – from 6400 S to 7800 S.	2B – Secondary Contact Recreation	Partial-Support	E. Coli	Criterion 1 > 940 col/100 ml, Criterion 2 geometric mean > 206 col/100 ml
	3A – Cold water game fish/aquatic life	Partial-Support	Temperature	20 degrees C
	4 – Agricultural use	Non-Support	Total Dissolved Solids	1,200 mg/L
Jordan River 6 – from 7800 S to Bluffdale.	3A – Cold water game fish/aquatic life	Partial-Support	Temperature	20 degrees C
	4 – Agricultural use	Non-Support	Total Dissolved Solids	1,200 mg/L
Jordan River 7 – from Bluffdale to Narrows.	3A – Cold water game fish/aquatic life	Partial-Support	Temperature	20 degrees C
	4 – Agricultural use	Non-Support	Total Dissolved Solids	1,200 mg/L
Jordan River 8 – from Narrows to Utah Lake.	4 – Agricultural use	Non-Support	Total Dissolved Solids	1,200 mg/L

Various federal, state, and local agencies including the Environmental Protection Agency (EPA), U.S. Forest Service (USFS), U.S. Geological Survey (USGS), DWQ, Utah Division of Water Rights (DWR), Utah Division of Wildlife Resources, Salt Lake County, and Salt Lake City have assessed water quality and flow as well as stream habitat and health of aquatic resources in the Jordan TMDL analysis area between Utah Lake and Farmington Bay (Figure 1). Measurements of water quality and flow that were acquired and reviewed for this assessment generally begin in the early 1970s and continue through mid-2005. Some irrigation flow measurements extend back to the early 1950s, while some assessments of surface and groundwater conditions extend back to the early 1900s. The number of measurements collected at each monitoring site varies, with only a limited number of stations maintaining a consistent sample record. Biological data collection has been spotty, dating back to the 1970s.

The data sources investigated as part of the Work Element 1 assessment are summarized in Table 2 and discussed in detail in Section 2 of this report. Members of the Cirrus team obtained the majority of water quality, flow, and macroinvertebrate measurements from the publicly accessible EPA-STORET database and the USGS-NWIS data archives. Other biological data was retrieved from the USGS-NAWQA and Utah Division of Wildlife Resources databases. These records are generally believed to be the most comprehensive data sets available in the state of Utah.

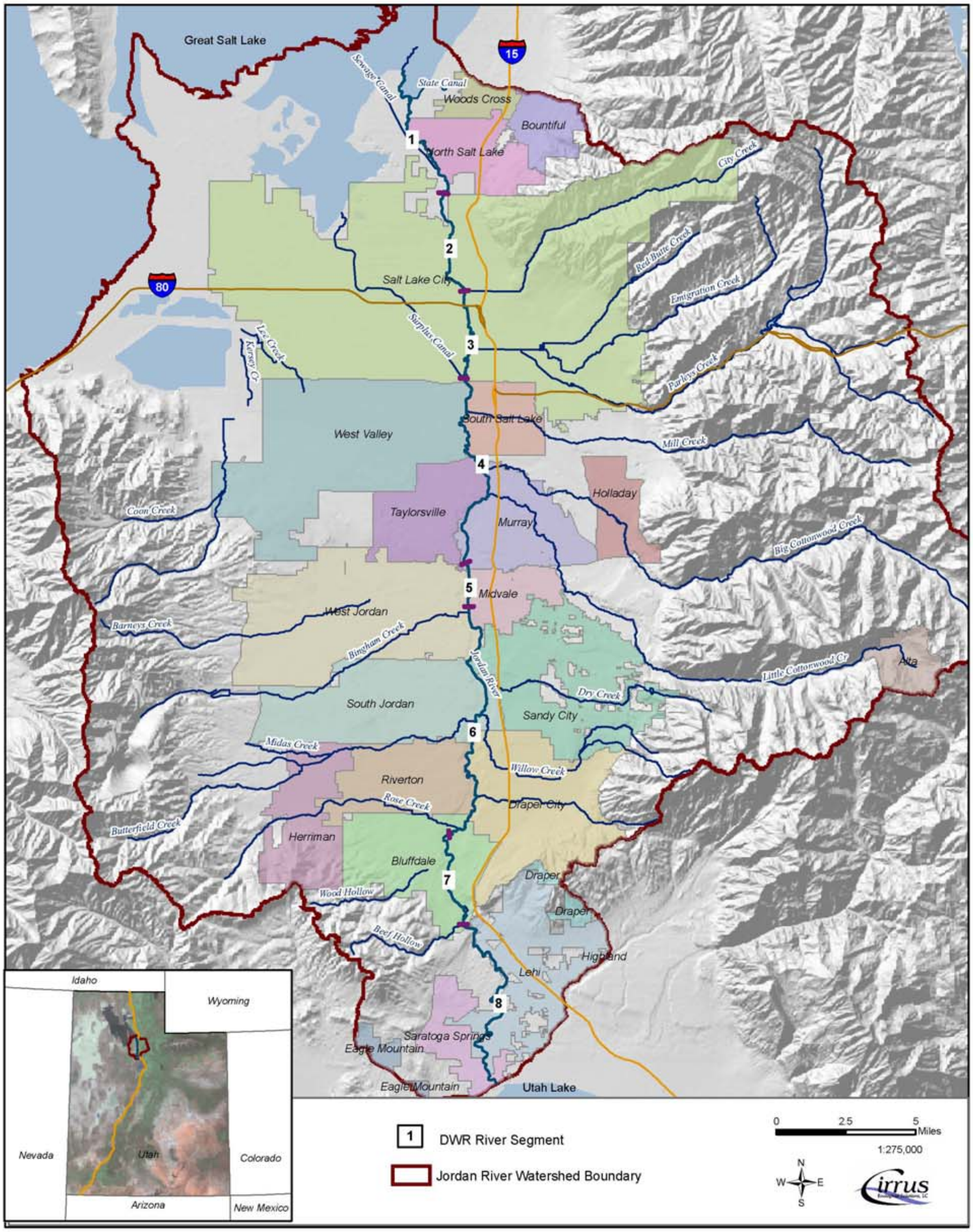

Figure 1. Jordan River TMDL study area.

Table 2. Data sources that were investigated as part of the Jordan River TMDL Work Element 1 deliverable.[1]

Data source	Data Type
EPA-STORET database	Water quality of surface and groundwater resources and flow monitoring of surface water bodies, including field measurements, instantaneous flow measurements, and wet samples of water quality submitted for laboratory assessment.
EPA-CERCLIS database	Locations of listed and potentially listed Superfund cleanup sites and contact information on where to obtain additional monitoring data.
USGS-NWIS database	Water quality surface and groundwater resources, continuous flow measurements of streams/rivers, and water level measurements of groundwater.
USGS Water-Resources Investigation Reports	Surface water and groundwater quality assessments, and groundwater flow assessments.
National Water-Quality Assessment Program – Utah	Surface water and groundwater quality assessments.
Utah Department of Environmental Quality, Division of Water Quality	Water quality and flow monitoring data archived on the UDAIT – DWQ database, watershed management unit stream assessments, diurnal field monitoring, synoptic survey monitoring on the Jordan River and tributaries, and macroinvertebrate monitoring data
Utah Department of Environmental Quality, Division of Environmental Response and Remediation	Stream monitoring above and below Superfund cleanup sites.
Utah Department of Natural Resources Technical Publication Series	Aquatic population surveys including native and non-native species, and surface water and groundwater quality assessments.
Utah Division of Water Rights-Water Use Report Series	Flow monitoring data collected from irritation diversions, mainstem Jordan River, and tributaries.
State Engineers Office	Surface and groundwater flow assessments of Salt Lake County.
Salt Lake County Engineering Division	Flow monitoring data collected on the mainstem Jordan River, and stormwater and precipitation monitoring data.
Salt Lake City Department of Public Utilities	Water quality and flow monitoring data collected primarily in the headwater areas of municipal watersheds.
Kennecott Utah Copper Corp.	Groundwater quality monitoring data collected in the Kennecott South Zone Operable Unit 2, and surface water monitoring collected on the Jordan River and the Riter Canal.
Jordan Valley Water Conservancy District	Surface water monitoring data collected from the Jordan River at the Narrows pumping station.
UPDES permittees (South Davis WWTP, Central Valley WRF, South Valley WRF)	Jordan River monitoring data above and below point of discharge and influent/effluent data.

[1]Data collection was limited to the Jordan River watershed (HUC 16020204) and selected areas of the Utah Lake watershed (HUC 16020201) immediately downstream of the Utah Lake outlet.

In regard to water quality, the TMDL assessment relies primarily on data collected by the DWQ during intensive monitoring cycles and other time periods from 1995 through 2005. The main source of flow data is USGS continuous monitoring at various gauging stations in the analysis area since 1980. Biological data is drawn primarily from various sources dating back to 1995.

Screening criteria for each of these three types of input were used to insure that the highest quality (e.g., collected on a consistent basis using uniform protocols) and most timely (e.g., representative of current conditions) was carried forward into the TMDL analysis.

As noted above, Section 2 of this report describes to the process of acquiring, compiling, and evaluating data. Sections 3, 4, and 5, respectively, summarize the water quality, flow, and biological data identified through this process to be carried into the TMDL analysis. In addition to summarizing the best available data on these parameters, Sections 3 – 5 identify and review previous, published studies to validate and/or amplify the analytical findings and to put them in context.

All data retrieved as part of Work Element 1, including measurements of water quality, flow, and biological parameters, digital versions of reports, and GIS data, are included on CDs that accompany this report.

Impairment of surface water bodies is initially determined by the DWQ through a comparison of monitoring data to numeric criteria and indicator values. Table 3 lists the numeric criteria and indicator values used in the water quality assessment of the Jordan River TMDL. At present, there are no recommended numeric criteria or indicator levels associated with biological parameters in the state of Utah. However, this information was still collected, reviewed, and will ultimately be used to determine the full extent of impairment to listed segments of the Jordan River.

Several different DO criteria were used to evaluate monitoring data, including those associated with assigned beneficial uses and site-specific criteria assigned to lower segments of the river. Assigned beneficial uses generally have acute and chronic standards that are designed to protect different life stages of aquatic species. The acute criterion represents the minimum acceptable value for instantaneous DO measurements collected during field sampling efforts. The chronic criterion can be used to evaluate the potential risk of longer-term impacts on aquatic species. The DWQ typically utilizes an appropriate 30-day average DO concentration as a chronic standard to determine impairment of water bodies and placement on the most recent 303(d) list. In general, the 30-day average criterion is believed to provide better protection against the diurnal DO fluctuations observed in many Utah streams.

For most water quality parameters, if 10 – 25 percent of all samples are in violation of numeric criteria or indicator values, DWQ assigns a partial support status to the surface water body. A non-support status is allocated if more than 25 percent of all samples violate standards or criteria. For some parameters such as E. coli, the geometric mean of at least five samples collected within a 30-day period is used to determine support of beneficial uses.

Table 3 summarizes all water quality constituents examined in this assessment, including several parameters that are not included on the 2006 303(d) list but have either the potential to influence pollutants of concern or can provide information regarding impairment of beneficial uses. Where available, Table 3 provides the numeric criteria and indicator values recommended by the State for the Jordan River. Note that several criteria and indicator values included in Table 3 are not currently used by the State for determining impairment. Although these metrics are not used for regulatory purposes, they still provide meaningful information for assessing water quality conditions and are reflective of stream health. Also note that pollution indicators (including phosphorus) are not considered to indicate impairment until a linkage analysis has been finished that defines the cause-and-effect relationship between water quality targets and pollutant sources.

Table 3. State of Utah water quality criteria and pollution indicators used to assess water quality on the Jordan River.

Parameter	Numeric Criterion or Indicator Value
Bacteriological	
Total Coliform[1] – Max	5,000 colonies/100 ml
Fecal Coliform[1] – Max [2]	400 colonies/100 ml
Fecal Coliform [1] – 30 Day Geometric Mean[3]	200 colonies/100 ml
E. Coli – Max[2]	940 colonies/100ml
E. Coli – 30-Day Geometric Mean[3]	206 colonies/100 ml
Physical	
Dissolved Oxygen - Min	• 4 mg/L (acute) August – April, 4.5 mg/L (acute) May – July: site- specific criteria for Jordan River from Farmington Bay to confluence with Little Cottonwood Creek. • 5.5 mg/L (chronic) : 30-day mean for Class 3B beneficial use • 6.5 mg/L (chronic) : 30-day mean for Class 3A beneficial use.
Temperature – Max	• 27 ºC : Class 3B beneficial use • 20 ºC : Class 3A beneficial use
pH – Range	6.5 – 9.0
Inorganics	
Total Ammonia as N	pH dependent (see R317-2 Table 2.14.2)
Total Dissolved Solids	1,200 mg/L
Pollution Indicators[4]	
Biochemical Oxygen Demand	5 mg/L
Total Phosphorus and Dissolved Phosphorus as P	0.05 mg/L
Other	
Dissolved Phosphorus	0.05 mg/L
Specific Conductivity	None
Salinity	None

[1] Total and fecal coliform are no longer included in Utah water quality standards.
[2] All sample values within a 30 day sample period compared to a threshold value. Minimum of five samples collected within 30-days, if <10 samples collected in 30 days, at least two samples must exceed criteria for impairment.
[3] Geometric mean calculated from a minimum of five samples collected within 30 days.
[4] Pollution indicators (including phosphorus) are not considered to indicate impairment until a linkage analysis has been finished that defines the cause-and-effect relationship between water quality targets and pollutant sources.

2.0 DATA SOURCES

This section of the document identifies sources of the water quality, flow, and biological data compiled and reviewed for this TMDL. The primary purpose of this review was to determine which data would contribute to an accurate and defendable characterization of these parameters, setting the stage for load calculations, assessment of beneficial use impairment, load allocations, and reductions necessary to meet the TMDL. Data that passed this review is summarized and interpreted in Sections 3, 4, and 5 (water quality, flow, and biological parameters, respectively).

Not all of the data reviewed met the standard of contributing to an accurate and defendable characterization. Where specific screening criteria were established, they are outlined in this section. All data compiled for this TMDL, whether carried into the detailed analysis or not, is available in the appendices or in the project files. Data sources were generally stations located on the mainstem Jordan River as well as the outlet of tributaries to the Jordan River, including streams, permitted discharges, and stormwater.

2.1 SURFACE WATER QUALITY MONITORING

Over 1,300 water quality monitoring stations in the Jordan River Basin have been identified to date. In general, water quality samples from streams have been collected from early spring to early fall, although a limited number of stations have been visited on a monthly basis during some years. Figure 2 indicates the geographic distribution of all water quality monitoring stations identified in the TMDL analysis area. A more detailed view of water quality monitoring stations associated with each river segment is displayed in Figures A-1 through A-8 in Appendix A.

Several of the stations shown in Figure 2 are associated with DWQ monitoring of the mainstem Jordan River or tributary flows to the river, including creeks and permitted discharges. Table 4 summarizes all DWQ monitoring sites on the mainstem Jordan River, tributaries/diversions, and points of discharge to the Jordan River (i.e. stormwater and treated wastewater) and indicates when these stations were visited.

Although the TMDL assessment of surface water quality relies heavily on this DWQ monitoring, water quality data collected by other agencies has been reviewed and is utilized where appropriate throughout this assessment. The DWQ has collected the majority of surface water quality samples in the analysis area, extending back to the early 1970s. More than 400 different stations in the analysis area have been archived by DWQ on the EPA-STORET database, including data collected by DWQ and entities supervised by DWQ. Other entities have collected water quality and flow monitoring data under the direction and guidance of the DWQ, including various state, county, and city agencies as well as several private entities operating in the Jordan River Basin. Water quality data from each non DWQ source was also reviewed for use in this TMDL assessment. Table 5 identifies all non DWQ surface monitoring stations located on the mainstem Jordan River as well as tributaries to the river including streams, permitted discharges and stormwater.

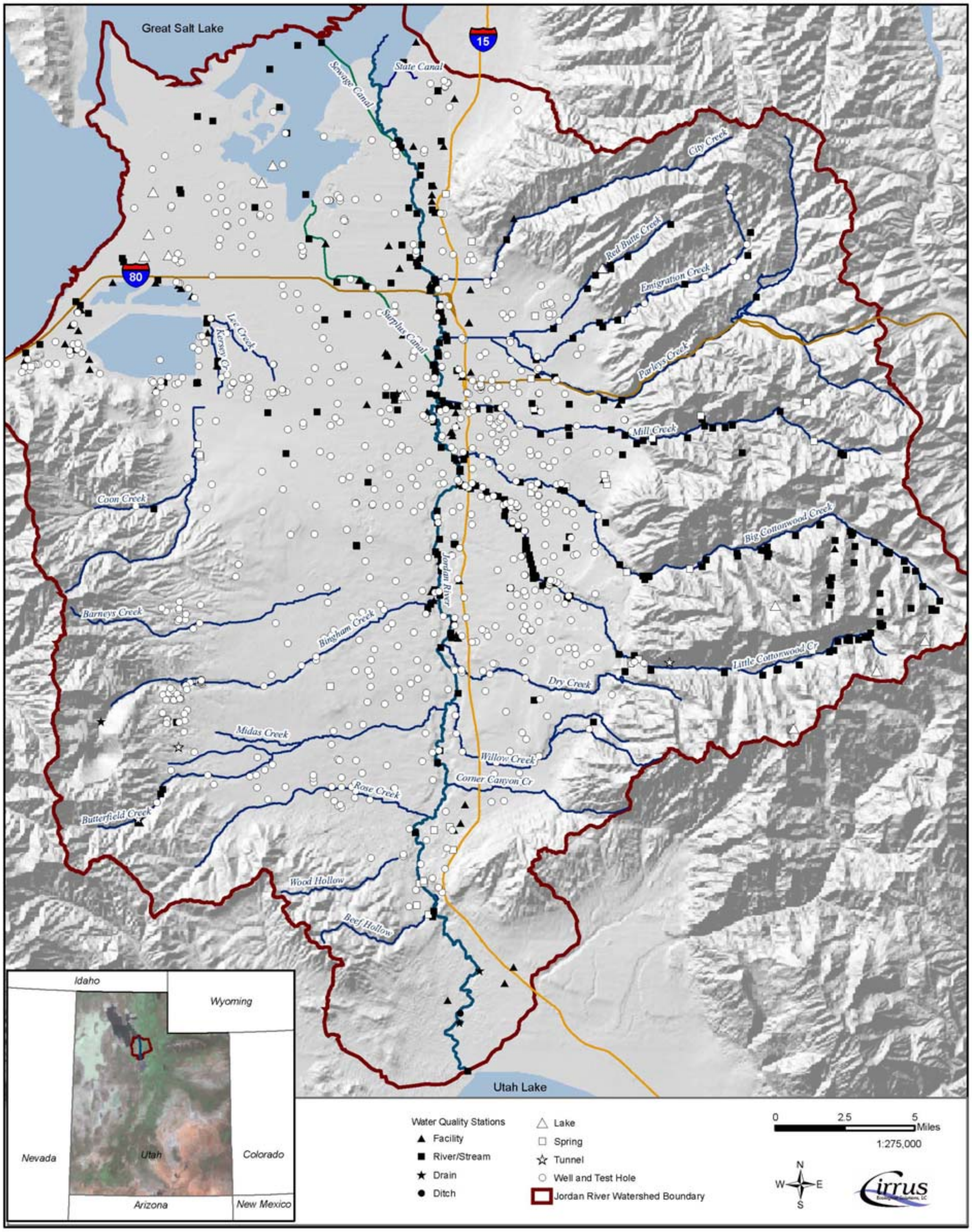

Figure 2. Surface and groundwater quality monitoring stations in the Jordan River TMDL study area.

Table 4. Measurement frequency of all DWQ monitoring stations located on the Jordan River as well as diversions, discharges, and tributaries associated with the Jordan River. Shaded cells indicate years during which monitoring occurred and numbers within shaded cells indicate the number of visits to each site that occurred during a given year. The Jordan River segment that each station is associated with is displayed in the third row of the table.

Mainstem Jordan River

	4991800	4991820	4991860	4991880	4991890	4991910	4991940	4992010	4992030	4992050	4992270	4992290	4992320	4992860	4992880
Segment	1	1	2	2	2	3	3	3	3	3	3	3	4	4	4
1974															
1975		3													
1976	4	5	5			3					5				
1977	1	1	3		2			2			3		3		
1978	6	6	2		1	1		1			2		2	3	3
1979	2	3	4		3	1		3			4		4		5
1980		8	2			1					2		2		
1981		23	10		1			1			10		8		
1982		18	6			3					6		9		3
1983		9	7			5					6	5	6		5
1984		11	2		1	2					2	2	2		2
1985		9	13	7	7	13				7	13	13	13		6
1986		8	5		1	5					5	5	6		5
1987		9	5			6					6	5	6		6
1988		5	6			6					2	5	6		6
1989		10	5			7						6	7		6
1990		9	7			7						7	7		7
1991		6	7			7						7	7		7
1992		6	1			2						1	1		1
1993		8				1							1		
1994		18											12		
1995		14											11		
1996		7											4		4
1997		9											5		5
1998		14											4		4
1999		12											6		4
2000		12											11		5
2001		5		4		4							8		8
2002		6											4		4
2003		7											4		4
2004		26	16			20	16		19		15		23		4
2005		2				2							2		1
2006		4										3	1		1
TOTAL	13	293	106	11	16	96	16	7	19	7	81	59	185	3	106
	Below S. Davis WWTP	**Cudahy Lane**	**Redwood Road**	**900 North**	**500 North**	**North Temple**	**400 South**	**300 South**	**700 South**	**800 South**	**1300 South**	**1700 South**	**2100 South**	**Below 3000 South**	**3300 South**

	4992890	4993470	4993490	4993560	4994090	4994100	4994120	4994140	4994170	4994270	4994490	4994600	4994720	4994790
Segment	4	4	4	4	4	5	5	5	5	6	6	7	8	8
1974														1
1975			2						2	2		2		4
1976	4	4	6						5	6		14		12
1977	2	3	3			3			3	3		9		6
1978	2	3	3			4	3		4	3		8		6
1979	4	4	4			4		1	4	4		7		2
1980	2	2	3			3			2	2		7		5
1981	11	11	11			12		1	7	11		15		6
1982	8	9	7			10			6	7		13		7
1983	6	6	6			6			9	6		14		9
1984	2	2	2			2		1	2	2		14		12
1985	13	6	13			6		2	7	12		14	7	8
1986	5	5	5	1		5		2	6	5		11		7
1987	6	6	6			6			6	6		15		8
1988	6	6	2			5			6	6	1	15		7
1989	6	6				6			7	6	6	14	3	9
1990	7	7			5	7			7	7	8	10	12	12
1991	8	8			7	7			7	7	8	14	12	12
1992	1	1			1	1			1	4		5	11	12
1993												4	12	12
1994					13				13			15	16	16
1995					10				10			14	10	10
1996					3				2			8		
1997					4				4			8		
1998					4				4			6		
1999					6				6			7	4	4
2000					9				9			10	6	11
2001					4				4			5		5
2002					4				4			7		6
2003					4				4			10		7
2004					23				7			29	11	9
2005					2				2			2	2	11
2006					1				1					4
TOTAL	93	89	73	1	100	87	3	7	161	99	23	326	106	240
	3900 South	**4500 South**	**Near 4700 South**	**4800 South**	**5400 South**	**6400 South**	**Below 7000 South**	**Above 7000 South**	**7800 South**	**9000 South**	**Above 12600 South**	**Bluffdale Road**	**Narrows**	**Utah Lake Outlet**

Diversions and **Discharges**

	Diversions: 4990880	4991810	4992040	4992020	4992330	4992390	4992500	4994160	4994590	4994740	4994760	4994770
Segment	1	1	3	3	4	4	4	5	6	8	8	8
1974												
1975		5	3	2	3							
1976	12	11	1	1	1							
1977	11	10	2	2	2							
1978	6	11	1		1							
1979	3	3	2	2	2	3						
1980	6	8				2						
1981	23	12	1	1	1	10						
1982	19	11				5						
1983	9	9				6						
1984	10	11				2			2			
1985	4	8				6		3	2			
1986	2	7				5		11	5			
1987		9				5		13	5			
1988	6	5				6	11	18	4			
1989	9	10				6	21	18	12	2	2	2
1990	11	8				7	12	12	16	12	12	12
1991	8	6				7	12	12	8	12	12	12
1992	8	6				1	3	2	4	11	11	9
1993	7	8							5	12	12	14
1994	5	8					1	1	8	3	3	3
1995	7	7					7	5	6			
1996	6	8					8	8	6			
1997	8	8					8	8	1			
1998	6	6					6	6				
1999	7	7					7	7				
2000	12	12					11	10				
2001	5	5					5	6	1			
2002	6	6					6	6	1			
2003	10	6					6	6	1			
2004	9	7					8	8				
2005	7	1					1	1				
2006	1	1					1	1				
TOTAL	243	240	10	8	10	71	134	162	87	52	52	52
	State Canal	**S. Davis South WWTP**	**800 S. Storm Drain**	**600 S. Storm Drain**	**2100 S. Storm Drain**	**Decker Pond Outflow**	**Central Valley WRF**	**South Valley WRF**	**Utah State Prison**	**Refractory Drain - Lehi**	**Lehi Waste Ditch**	**Drain - Saratoga Spr. Rd.**

Tributaries

	4991920	4992070	4992540	4992970	4993580	4994190
Segment	3	3	4	4	4	6
1974						
1975	3	2		2		
1976	4	1		6		
1977	2	1		4		
1978	1	1		3		
1979	3	2		4		
1980				2		
1981	1	1		11	1	
1982			1	5		
1983			4	6		
1984				2		
1985				6		
1986				5		
1987				6		
1988				6		
1989				5		
1990				8		
1991				7		
1992				1		
1993						
1994			12	13	13	
1995	7		10	10	10	
1996						
1997						
1998						
1999			4	4	4	1
2000			7	7	7	4
2001						
2002						
2003						
2004			5	5	5	
2005			2	2	2	
2006				3	3	
TOTAL	21	8	45	133	45	5
	City Creek	**Red Butte, Emigration, Parleys - Creek**	**Mill Creek**	**Big Cottonwood Creek**	**Little Cotonwood Ceek**	**Bingham Creek**

Table 5. Measurement frequency of all non DWQ monitoring stations located on the Jordan River as well as diversions, discharges, and tributaries associated with the Jordan River. Shaded cells indicate years during which monitoring occurred and numbers within shaded cells indicate the number of visits to each site that occurred during a given year. The Jordan River segment that each station is associated with is displayed in the fourth row of the table.

	Mainstem Jordan River															
Station ID	Station 1 SDS WWTP	Station 3 SDS WWTP	10172600	10172623	404833112022201	Station 2 SDS WWTP	404659112005601	10172550	404619112043801	Station 1 CVWRF	404515111570501	404432112040101	404356111562400	10171000	10170490	Station 2 CVWRF
Monitoring Entity	S. Davis Sewer District	S. Davis Sewer District	USGS	USGS	USGS	S. Davis Sewer District	USGS	USGS	USGS	Central Valley WRF	USGS	USGS	USGS	USGS	USGS	Central Valley WRF
Segment	1	1	1	1	2	2	2	2	3	3	3	3	3	3	4	4
1931							1									
1940																
1941							4									
1942							2									
1955																
1956																
1957							1									
1958							1				1	1				
1959														20		
1960							3							81		
1961							1							53		
1962																
1963			1											2		
1964							5		1					10		
1965					2		3		2					11		
1966					1									7		
1967												1				
1968																
1969							1							1		
1970				1				1						1		
1971														9		
1972							1							23		
1973			1				1							18		
1974			20											12		
1975			27					1						14		
1976			25				1							15		
1977			28				1							13		
1978			24				1							12		
1979			15				1							11		
1980							1	7					5	18		
1981							1	22					21	33	1	
1982							1	11						13		
1983							1	12						6		
1984					1		1	7						6		
1985							1							6		
1986														6		
1987							1							8		
1988							1							12		
1989							2							9		
1990							2							12		
1991							1							7		
1992							1							6		
1993							1							5		
1994							1							4		
1995							1									
1996										5						13
1997																1
1998														3		
1999														24		
2000	11	10				10								12		
2001	2	2				2								12		
2002														10		
2003														10		
2004														7		
2005																
2006																
TOTAL	13	12	141	1	4	12	45	61	3	5	1	2	26	542	1	14
	JR downstream of S Davis S WWTP	Center Street - NSL	Cudahy Lane	Cudahy Lane	1850 N	1000 N	500 N	500 N	North Temple	North Temple	700 S	JR below 1300 S Conduit	1330 S	1700 S	JR above Surplus Canal	JR below Mill Creek

	Mainstem Jordan River (cont.)														
Station ID	Station 4 CVWRF	403955111551501	10167300	403755111514201	Station 1 SV WRF	403640111594801	Station 2 SV WRF	Station 2 Sharon Steel	Station 1 Sharon Steel	10167230	Station VWS1	10167200	403138111550901	Station 1 JVWCD	10167001
Monitoring Entity	Central Valley WRF	USGS	USGS	USGS	South Valley WRF	USGS	South Valley WRF	Utah DEQ - DERR	Utah DEQ - DERR	USGS	Kennecott	USGS	USGS	Jordan Valley WCD	USGS
Segment	4	4	4	5	5	5	5	6	6	6	6	6	6	8	8
1931													1		
1940						1									
1941															
1942															
1955		1													
1956															
1957															
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1997	1							2	2					41	
1998								4	4					22	
1999								2	2		1			18	
2000				3	9		9	1	1		1			17	
2001					11		11	1	1		1			9	
2002					10		10	1	1		1			21	
2003					10		10	1	1		1			20	
2004					10		10	1	1					19	
2005					11		11	1	1					21	
2006					8		8								
TOTAL	14	3	244	3	69	1	69	14	14	60	5	26	1	479	39
	JR above Mill Creek	4800 S	5800 S	6400 S	7200 S	7800 S	7800 S	JR downstream of Sharon Steel	JR upstream of Sharon Steel	9000 S	9000 S	9400 S	12300 S	Narrows	Narrows

	Discharges						Tributaries									
Station ID	10172520	10172370	10172350	10170900	10167244	10167240	10172400	404351111562301	404432111550201	404505111552501	10172300	10170250	10170350	Station 5 CVWRF	10169500	10168000
Monitoring Entity	USGS	USGS	USGS	USGS	USGS	USGS	USGS	USGS	USGS	USGS	USGS	USGS	USGS	Central Valley WRF	USGS	USGS
Segment	3	3	3	4	6	6	3	3	3	3	3	4	4	4	4	4
1931																
1940																
1941																
1942																
1955																
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1980	6	1	1	6		6						6			7	6
1981	8	2	4	5	4	9			1			5	6		5	7
1982					5	4			1	1		1			1	1
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2004																8
2005																
2006																
TOTAL	14	3	5	11	9	19	56	2	2	2	6	14	6	6	13	101
	N Temple Conduit	8th S Conduit	1300 S Conduit	2100 S Conduit	Overland Flow Outfall	90th S Conduit	City Creek	Emigration Creek at 1200 E	Emigration Creek at 1300 S	Emigration Creek up of mouth	Red Butte Creek	Mill Creek	Mill Creek	Mill Creek above CVWRF	Big Cottonwood Creek	Little Cottonwood Creek

The USGS has collected water quality data at more than 800 different stations in the analysis area in order to meet research interests and address water quality issues. Most of the USGS sites have been monitored intensively for a few years or less intensively over a longer period of time. Four long-term monitoring sites were identified in the analysis area associated with the USGS National Water Quality Assessment (NAWQA). One of these sites is located on the Jordan River at 1700 South and a second site is located on Little Cottonwood Creek near the outlet to the Jordan River. These two sites provided the USGS data most relevant to this assessment.

Surface water monitoring has been conducted by Utah Department of Environmental Quality, Division of Environmental Response and Remediation (DERR) and Kennecott Utah Copper Corporation (KUCC) to meet federal requirements associated with hazardous waste monitoring. Site information for hazardous or potentially hazardous waste sites is contained in the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS database). The CERCLIS database contains sites on EPAs National Priorities List (NPL) or currently being considered for the NPL.

A review of information from this database indicated that 11 hazardous waste sites were located in the analysis area. Three of these sites have potential to influence surface as well as ground water quality in some segments of the Jordan River including Sharon Steel, Midvale Slag, and the Kennecott South Zone. (Table 6). None of the water quality parameters monitored in the Jordan River at these sites are pollutants of concern with the exception of sulfate and TDS which occurs as part of remedial activities associated with the Kennecott South Zone. Groundwater monitoring results from this effort were reviewed and are discussed below under groundwater quality. Surface water monitoring at hazardous waste sites occurs at three locations on the Jordan River including above and below Sharon Steel and Midvale Slag and at 9000 South below KUCC South Zone. Monitoring at these sites has occurred since 1995 with approximately one measurement collected at each site per year.

Table 6. Hazardous waste sites included on the National Priorities List with potential to influence Jordan River water quality.

Site Name	Cerclis ID	Pollutants of concern	Partial Listing	Final Listing	Partial Deletion	Deletion
Kennecott (South Zone)	UTD000826404	Lead, arsenic, sulfates	1/18/94	NA	NA	NA
Midvale Slag	UTD081834277	Lead, arsenic, chromium, cadmium	6/10/86	2/11/91	NA	NA
Sharon Steel Corp. (Midvale Tailings)	UTD980951388	Lead, arsenic, heavy metals such as iron, manganese, and zinc	10/15/84	8/30/90	NA	9/24/04

Salt Lake City monitors water quality in the headwater areas of seven canyons along the Wasatch Front in the Jordan River Basin. Monitoring activities are conducted to help protect municipal water resources supplied by these upper watershed areas. Several water quality parameters have been measured in these areas including Total and Fecal Coliform, nutrients (Phosphorus and Nitrogen), turbidity, and metals since 1987 (Salt Lake City Department of Public Utilities 1999). Although this data has been reviewed it will not be discussed further due to the distance of these sites from the Jordan River.

Three wastewater treatment facilities have monitored surface water quality at nine locations including South Davis South WWTP (three sites), Central Valley WRF (four sites) and South Valley WRF (two sites). These sites are all located on the Jordan River with the exception of one site on Mill Creek above Central Valley WRF. Monitoring at these sites has taken place since 1996 with most of the sites visited after 2000. In addition, Central Valley WRF has collected Jordan River water quality data that was ultimately submitted to DWQ and the EPA. This data was included in the review and assessment of DWQ monitoring sites.

The Jordan River at the Narrows has been routinely monitored by JVWCD from 1991 to the present time. This data record includes multiple samples collected each year from this site.

Following an extensive review of surface water quality data collected by all agencies, several water quality monitoring stations were identified for a detailed assessment based on the period of record and the total number of samples collected. DWQ monitoring sites with a minimum of 10 samples collected 1995 – 2005 were included in this assessment. A list of DWQ stations selected for detailed assessment is provided below in Table 7. Non DWQ monitoring sites with a minimum of 15 samples were selected for detailed assessment including four mainstem sites and one tributary site.

Table 7. Monitoring stations selected for detailed assessment of surface water quality conditions in the Jordan TMDL analysis area.

Station ID	Name	River Mile	DWQ River Segment	Year[1]	
				1999-2000	2004-2005
4990880	Jordan River at State Canal road crossing	1.3	NA	19	8
4991810	South Davis S. WWTP	6.2	1	19	8
4991820	Jordan River at Cudahy Lane above South Davis South WWTP	6.3	1	24	28
4991860	Jordan River 1800 North crossing Redwood Road Bridge	8.11	2	0	16
4991910	Jordan River below Gadsby Plant 001 Outfall at North Temple	12.5	3	0	22
4991940	Jordan R at 400 South	13.4	3	0	16
4992030	Jordan R at 700 South	13.9	3	0	19
4992270	Jordan River at California Ave. (1300 S.) crossing	15.49	3	0	15
4992320	Jordan River 100 West 2100 South	17.1	4	17	25
4992500	Central Valley WWTP	18.5	4	18	9
4992540	Mill Creek above Central Valley WWTP at 300 West	18.9	4	9	7
4992880	Jordan River 3300 South	19.5	4	9	5
4992970	Big Cottonwood Creek above Jordan River at 500 West 4200 South	21.7	4	11	7
4993580	Little Cottonwood Creek 4900 South 600 West, Salt Lake City	22.7	4	11	7
4994090	Jordan River above 5400 South at Pedestrian Bridge	25.3	4	15	25
4994160	South Valley WWTP	27.3	5	17	9

Table 7. (cont'd) Monitoring stations selected for detailed assessment of surface water quality conditions in the Jordan TMDL analysis area.

Station ID	Name	River Mile	DWQ River Segment	Year[1]	
				1999-2000	2004-2005
4994170	Jordan River at 7800 South crossing above South Valley WWTP.	27.4	5	15	9
4994600	Jordan River at Bluffdale Road crossing	39.2	7	17	31
4994720	Jordan River at Narrows - pump station	42.9	8	8	13
4994790	Jordan River at Utah Lake outlet	52.1	8	15	20

[1]Numbers shown under year column indicate the number of visits completed by DWQ to each site during recent periods of intensive water quality monitoring in the Jordan River Basin.

Most of the DWQ stations were visited during periods of intensive monitoring completed in 1999 – 2000 and 2004 – 2005. Visits to each DWQ site occurred at approximately 2-to-4-week intervals throughout a 12-month period. The similarity of sample size and measurement frequency among stations provided a comprehensive view of water quality conditions for the entire Jordan River corridor between Utah Lake and Farmington Bay. In addition, the location of these stations with respect to impaired segments of the Jordan River provides a level of spatial resolution that can be used to support TMDL analysis for individual river segments. Water quality measurements collected during these intensive monitoring periods are the best data sets available for characterizing water quality along the length of the Jordan River. As a result, they will be used to provide support to the TMDL assessment for impaired river segments.

In addition to the assessment of data collected during intensive monitoring periods, a historical review of Jordan River water quality data was conducted for selected DWQ and non DWQ monitoring stations where data was collected during more than two years. This review includes a statistical assessment of both historic (beginning of record – 1994) and recent (1995 – present) water quality measurements. Results of this assessment can be found in Appendix B to this report.

Utah DWQ is completing a synoptic monitoring study during 2006-07 at selected monitoring locations on the Jordan River and its tributaries. This study is being conducted to provide supporting data for QUAL2K water quality model calibration and validation. Information obtained during the synoptic study will further clarify and define DO and processes influencing DO during various seasons and flow scenarios typically experienced on the Jordan River.

2.2 GROUNDWATER QUALITY MONITORING

Groundwater quality has been monitored at numerous sites in the Jordan River basin including springs, test holes, tunnels, and permanent (water supply) and temporary wells. A total of 812 groundwater monitoring sites were identified in the analysis area. The majority of groundwater monitoring stations were associated with USGS efforts (701 stations) with the remaining stations maintained by the DWQ and KUCC. These stations consisted of a mixture of wells (735 stations), test holes (36 stations), springs (35 stations), drains (three stations), and tunnels (three stations).

Water quality monitoring data at these stations has been very limited, with the number of observations generally restricted to 10 measurements or less over the entire period of record; one or two observations per site is common. The geographic location of groundwater monitoring sites is shown in Figure 2 for the analysis area. A more detailed view of the location of groundwater monitoring sites located adjacent to the Jordan River is provided in Figures A-1 through A-8 in Appendix A.

Groundwater quality monitoring data is used by the USGS in their efforts to assess conditions in Salt Lake Valley aquifers. Results from these assessments were reviewed in published technical reports to determine if they contained additional data records that were not available on the USGS-NWIS database. This review indicated that the majority of groundwater monitoring records used in USGS technical reports were archived on the USGS-NWIS database and subsequently incorporated into the database assembled for this TMDL assessment.

Groundwater quality is also being routinely monitored at several locations in Salt Lake County that are included on EPAs Superfund National Priorities List, some of which have the potential to influence water quality in the Jordan River. A general summary of groundwater monitoring results from applicable Superfund cleanup sites was reviewed in reports submitted from each site to the EPA every five years. A limited amount of monitoring data was obtained from two Superfund cleanup sites, including the Sharon Steel/Midvale Tailings Operable Unit One (Sharon Steel) and the KUCC South Facilities Groundwater Remediation Operable Unit Two (Kennecott South). The Sharon Steel site is located on the Jordan River at Midvale and just upstream of 7800 South. A total of 23 monitoring wells are located at this site to measure any contamination that may move from the site into groundwater aquifers and ultimately the Jordan River. Contaminants at the Sharon Steel site include lead, arsenic, and heavy metals such as iron, manganese, and zinc. The Kennecott South site is located immediately downgradient of the old Bingham Reservoir on Bingham Creek and upslope of the Jordan River. Monitoring data was obtained for five groundwater monitoring wells at the Kennecott South site. Contaminants at the Kennecott South site include acidic heavy metals (lead and arsenic) and sulfates.

Groundwater monitoring stations that were selected for detailed review included all shallow wells (less than 101 feet) located within approximately 1.5 miles of either side of the Jordan River. However, KUCC wells were also included in the detailed assessment, which included wells located as far away as 5 miles from the Jordan River, due to their potential to influence TDS levels in upper Jordan River segments.

2.3 FLOW MONITORING

Instantaneous flow measurements are typically collected along with water quality samples at DWQ monitoring stations. Where possible, DWQ field crews rely on USGS gages located nearby to provide flow readings. Instantaneous flow measurements are limited in their ability to characterize flows to only those days and times when each sample was collected. As a result, storm events and peak flows are typically not accounted for in flow averages that are based on instantaneous measurements. A list of DWQ monitoring stations located on the mainstem Jordan River, tributaries, discharges and diversions has been presented above in Section 2.1. All DWQ monitoring stations with more than 10 samples collected since 1980 were selected for a detailed assessment of flow measurements.

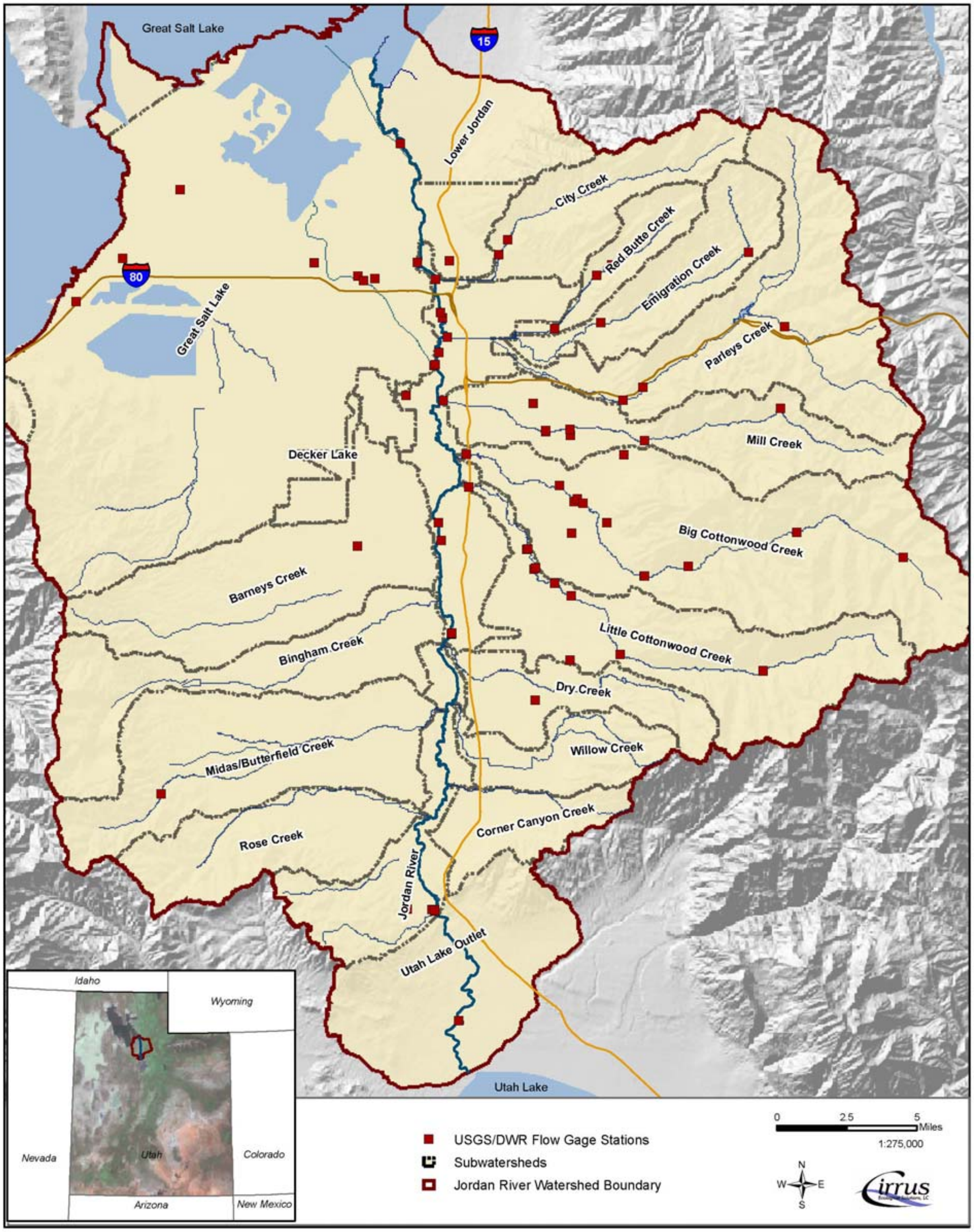

Figure 3. Location of continuous flow gage stations in the Jordan River TMDL study area.

A total of 134 stations were identified in the analysis area where surface flow had been monitored on a continuous basis including 81 stations established by the USGS and 53 stations maintained by the DWR. Flow monitoring stations located in the analysis area are shown in Figure 3. A more detailed view of flow monitoring stations associated with each river segment is displayed in Figures A-1 through A-8 in Appendix A. Many of the flow records maintained by DWR did not have location information and as a result, do not appear in Figure 3. Borup and Haws (1999) and CH2MHill (2005) provide good descriptions of DWR flow monitoring locations that were used to associate DWR flow measurement records with monitoring locations.

Flow measurements from stations located in the Jordan TMDL study area have been archived by the USGS and the DWR in databases that can be accessed through the internet. The majority of continuous flow measurements have been collected by the USGS. Flow data collected by the DWR on canals and irrigation ditches generally includes measurements from May 1 through October 31 of each year. Salt Lake County monitors flow at select locations on the Jordan River as well as some tributaries and outflow locations. Instantaneous flow measurements have been collected by the DWQ during routine water quality monitoring efforts on the Jordan River and tributaries, although some of these stations utilize flow readings from nearby USGS gage stations.

The periods of record for 38 flow monitoring stations located directly on the mainstem Jordan River or at points of inflow or outflow to the river are shown in Table 8, including 37 continuous flow stations and 1 station where instantaneous flow measurements were collected. The USGS has monitored continuous flow at 11 stations located directly on the mainstem Jordan River as well as tributary flow to the Jordan River, including streams and stormwater flow. Additional flow records are maintained by the DWR at irrigation diversions from the mainstem Jordan River and by permitted discharges according to Utah Permitted Discharge Elimination System (UPDES) regulations enforced by DWQ. The longest continuous flow records associated with the Jordan River date from 1942 through 2003, including the Jordan River at 1700 South, Surplus Canal, and Jordan River above the Surplus Canal diversion. A total of 18 flow stations shown in Table 8 have a measurement record of more than 10 years. Twelve stations have a record of 5 years or less, including one station where only instantaneous flow readings were collected. At present, there are 16 locations where flow is measured on a continuous basis, including sites on the mainstem Jordan River and inflow/outflow to the river.

Flow records were assessed based on the period of record collected at each site. In general, continuous flow monitoring records were available at most locations after 1980. In addition, the hydrologic regime at each station may have been influenced by imported water volumes in response to increased municipal and industrial development in the recent past. Based on these factors, a more detailed level of assessment was made for all stations with monitoring records collected after 1980. An assessment of historic conditions (prior to 1995) was also completed for stations with available data. Monthly average flows were also calculated at select Jordan River locations where the period of record was of sufficient length to complete an assessment of this type.

Patterns of groundwater flow in the analysis area have been defined using water level measurements in monitoring wells as well as knowledge of local and regional aquifer systems. Measurements of groundwater flow are more limited in frequency and extent. Published reports on groundwater flow in the analysis area have been provided by federal, state and local entities. This information has been reviewed and is summarized below.

Table 8. Flow Gage Stations located on the mainstem Jordan River and tributary flows to the Jordan River. Station names in bold text are located on the mainstem Jordan River while those in italicized text are located on the mouth of streams flowing to the Jordan River. All other stations measure flow from stormwater or permitted discharge to the Jordan River. Shaded cells indicate years when continuous flow measurements were collected. Cells with diagonal lines represent years when periodic (instantaneous) flow measurements were taken.

Station ID	4990880	UT0021628	**10172600**	**10172550**	*10172520*	10172373	10172372	10172371	10172370	*10172352*	*10172351*	*10172350*	**10171000**	10170900	10170500	**10170490**	*10170250*	UT0024392	*10169500*	*10168000*	**10167300**	10167242	UT0024384	10167244	10167240	**10167230**		**10167200**	10167141		10167101	10167100			**10167001**	**10167000**	**10166605**	
Station Name	State Canal	South Davis South WWTP	**Cudahy Lane**	**500 North**	*North Temple Conduit*	800 South Conduits - North Conduit	800 South Conduits - Middle Conduit	800 South Conduits - South Conduit	800 South Conduit	*1300 South Conduits - North Conduit*	*1300 South Conduits - South Conduit*	*1300 South conduits*	**Jordan River @ 1700 South**	2100 South Conduit	Surplus Canal	**Jordan River @ Surplus Canal**	*Mill Creek*	Central Valley WRF	*Big Cottonwood Creek*	*Little Cottonwood Creek*	**Jordan River @ 5800 South**	I-215 median drain near Murray	South Valley WRF	Overland Flow Outfall near Midvale	9000 South Conduit	**Jordan River @ 9000 South**	North Jordan Canal	**Jordan River @ 9400 South**	Jordan and Salt Lake Canal	South Jordan Canal	East Jordan Canal, UT & SL Canal	East Jordan Canal	Utah and Salt Lake Canal	Utah Lake Distributing Canal	**Jordan River below Turner Dam**	**Jordan River @ Narrows**	**Jordan River @ Lehi Bridge**	**Jordan River @ Utah Lake Outlet**
Agency	DWQ/DWR	DMR/DWQ	**USGS**	**USGS**	USGS	USGS	USGS	USGS	USGS	USGS	USGS	USGS	**USGS**	USGS	USGS	**USGS**	USGS	DMR/DWQ	USGS	USGS	**USGS**	USGS	DMR/DWQ	USGS	USGS	**USGS**	DWR	**USGS**	USGS /DWR	DWR	USGS /DWR	USGS /DWR	DWR	DWR	**USGS**	**USGS**	**USGS**	**DWR**
Segment		1	**1**	**2**	*2*	3	3	3	3	*3*	*3*	*3*	**3**	3	3	**3**	*4*	4	*4*	*4*	**4**	4	5	6	6	**6**	6	**6**	7	7	7	7	7	7	**7**	**7**	**7**	**8**
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Table 8. Flow Gage Stations located on the mainstem Jordan River and tributary flows to the Jordan River. Station names in bold text are located on the mainstem Jordan River while those in italicized text are located on the mouth of streams flowing to the Jordan River. All other stations measure flow from stormwater or permitted discharge to the Jordan River. Shaded cells indicate years when continuous flow measurements were collected. Cells with diagonal lines represent years when periodic (instantaneous) flow measurements were taken.

Station ID	4990880	UT0021628	**10172600**	**10172550**	*10172520*	10172373	10172372	10172371	10172370	*10172352*	*10172351*	*10172350*	**10171000**	10170900	10170500	**10170490**	*10170250*	UT0024392	*10169500*	*10168000*	**10167300**	10167242	UT0024384	10167244	10167240	**10167230**		**10167200**	10167141		10167101	10167100			**10167001**	**10167000**	**10166605**	
Station Name	State Canal	South Davis South WWTP	**Cudahy Lane**	**500 North**	*North Temple Conduit*	800 South Conduits - North Conduit	800 South Conduits - Middle Conduit	800 South Conduits - South Conduit	800 South Conduit	*1300 South Conduits - North Conduit*	*1300 South Conduits - South Conduit*	*1300 South conduits*	**Jordan River @ 1700 South**	2100 South Conduit	Surplus Canal	**Jordan River @ Surplus Canal**	*Mill Creek*	Central Valley WRF	*Big Cottonwood Creek*	*Little Cottonwood Creek*	**Jordan River @ 5800 South**	I-215 median drain near Murray	South Valley WRF	Overland Flow Outfall near Midvale	9000 South Conduit	**Jordan River @ 9000 South**	North Jordan Canal	**Jordan River @ 9400 South**	Jordan and Salt Lake Canal	South Jordan Canal	East Jordan Canal, UT & SL Canal	East Jordan Canal	Utah and Salt Lake Canal	Utah Lake Distributing Canal	**Jordan River below Turner Dam**	**Jordan River @ Narrows**	**Jordan River @ Lehi Bridge**	**Jordan River @ Utah Lake Outlet**
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Total years of record	23	9	6	28	3	2	2	2	3	6	6	6	62	2	62	62	7	18	9	12	6	3	14	2	3	27	56	3	55	55	2	56	56	56	5	57	2	56

2.4 BIOLOGICAL MONITORING

Biological conditions in the Jordan River corridor have changed dramatically over the past century due primarily to development of land and water resources. Changes in the composition of vegetation, wildlife, fish, macroinvertebrate, and phytoplankton communities reflect reduced health and diversity of the Jordan River and adjacent riparian areas.

Biological data was obtained in the form of survey measurements of macroinvertebrate, fish and phytoplankton surveys. The focus of most biological surveys has included macroinvertebrate and fish species, with a lesser effort on aquatic plant and algal communities. Data sources for each category are detailed in Table 9.

Table 9. Biological Data Records identified for the Jordan River and Little Cottonwood Creek at the confluence with the Jordan River.

Data Type	Data Source	Station ID/Name	Jordan River Segment	Period of record	Total sample visits
Macroinvertebrates	Utah DWQ biological monitoring	4990880 – Jordan River at State Canal Road Crossing	-	1985 - 2003	24
		4991820 - Jordan River at Cudahy Lane above Sl Davis S. WWTP	1	1986	1
		4991890 – Jordan River at 500 North Crossing	2	1986	1
		4992320 – Jordan River 100W 2100 S	4	1986	1
		4993560 – Jordan River at 4800 S	4	1986	1
		4994170 – Jordan River at 7800 S Crossing Above S Valley WWTP	5	1986 - 2000	3
		4994500 – Jordan River below 123rd South	6	2003	1
		4994600 – Jordan River at Bluffdale Road Crossing	7	1985 - 2002	28
	USGS NAWQA – Great Basins Study Unit	10171000 – Jordan River at 1700 S at SLC	3	2000	1
		10168000 – Little Cottonwood Creek at Jordan River near SLC	4	1999 - 2001	6
Fish	USGS NAWQA – Great Basins Study Unit	10171000 – Jordan River at 1700 S at SLC	3	2000	1
		10168000 – Little Cottonwood Creek at Jordan River near SLC	4	1999 - 2004	8
	Utah Division of Wildlife Resources	Jordan River segments between Utah Lake outlet and Salt Lake City.	4 - 8	1980 - 2004	118
Phytoplankton	USGS NAWQA – Great Basins Study Unit	10168000 – Little Cottonwood Creek at Jordan River near SLC	4	1999 - 2003	7
		10171000 – Jordan River at 1700 S at SLC	3	2000	1

A query of the EPA-STORET and NAWQA databases identified several locations where actual measurements had been made of macroinvertebrates, fish, and phytoplankton. Macroinvertebrate data was identified at eight locations on the Jordan River, some of which was measured after 1995. Fish population measurements were identified at several locations and included numbers of fish measured with different protocols and classified using different methodologies. As a result, it was difficult to make a direct comparison of fish data between measurement dates or measurement locations. Stocking rates of sport fish were also obtained from the Utah Division of Wildlife Resources and included number and rates of fish placed in the Jordan River from 1980 through 2004. Phytoplankton data was identified at one station on the Jordan River at 1700 South and one station at the outlet of Little Cottonwood Creek.

A statistical assessment was completed for available measurements of macroinvertebrates collected during 1995-2005 at applicable monitoring stations. Due to the limited nature of Jordan River fish data, a statistical assessment of fish populations could not be completed. All available fisheries data was reviewed, regardless of when it was collected. Phytoplankton data collected from the Jordan River and Little Cottonwood Creek were assessed by Rushforth Phycology, LLC.

Additional biological data was obtained from a review of documented studies of macroinvertebrates, fish, and periphyton. Many of these reports are published in the format of conference proceedings, university documents, theses/dissertations, and government reports that are not widely circulated. As a result, some of them have not been reviewed individually but were identified in bibliographies that summarize previous research on the Jordan River. An in-depth discussion of these studies is included below in Section 5.

2.5 DISCHARGE MONITORING

Monitoring of UPDES permitted discharges in the Jordan River Basin includes routine measurements of flow and water quality. Nine points of discharge have been identified following discussion with DWQ personnel, including some facilities that discharge directly to the Jordan River while others discharge to stormwater collection systems or tributaries that flow to the Jordan River. A list of these permitted discharges is provided below in Table 10. Water quality measurements from each point of discharge are monitored by the permittee as required by federal and state legislation. The record of measurements is summarized in Discharge Monitoring Reports (DMRs) submitted to DWQ on a regular basis. DWQ did not provide DMR data for all facilities listed in Table 10. In addition to DMR documentation, periodic water quality measurements of effluent are also collected by DWQ during routine monitoring efforts.

Stormwater is monitored at six locations throughout Salt Lake County by the Salt Lake County Engineering Division. Data from this monitoring effort is published in summary reports that compare storm-effort mean concentrations to similar concentrations that are reported for urban areas at the regional and national level. Results from these reports are discussed below.

Table 10. Permitted discharges to Jordan River and tributaries where water quality monitoring occurs.

Permit Name	Owner ship	UPDES ID	Receiving Water	Permit issued date	Permit expired date	DMR period of record
Central Valley Water Reclamation Facility	Public	UT0024392	Mill Creek to Jordan River	18-Feb-05	28-Feb-10	1996 – 2006
Holliday Water Co.	Private	UT0025429	Spring Creek to Jordan River	1-Dec-01	30-Nov-06	NA
Moog Aircraft – Montek Operation	Private	UTG790013	Storm Drain to the Jordan River	16-Mar-05	31-Oct-10	NA
PacifiCorp – Gadsby	Private	UT0000116	S.L. Abatement Canal and/or Jordan River	26-Dec-01	31-Dec-06	NA
Rubber Engineering	Private	UT0024767	Storm Drain to Mill Creek to Jordan River	1-Mar-04	28-Feb-09	2001 – 2006
S. Davis Co Sewer – South	Public	UT0021628	Jordan River	2-Apr-01	30-Apr-06	1998 – 2006
South Valley Water Reclamation Facility	Public	UT0024384	Jordan River	22-Jun-05	28-Feb-10	2000 – 2006
Weir Specialty Pumps	Private	UT0025089	Storm Drain to Jordan River	7-Apr-03	30-Apr-08	NA
Utah State Prison	State	UT0024082	Ditch to Jordan River	28-Sep-00	31-Oct-05	1998 – 2005

3.0 WATER QUALITY CONDITIONS

This section summarizes and interprets the data reviewed in regard to surface and groundwater quality, as identified in Sections 2.1 and 2.2, respectively. The section concludes with a summary of findings suggested by the biological data analyzed and the previous studies reviewed. As discussed above, Dissolved oxygen (DO), Temperature, Total Dissolved Solids (TDS), and coliform bacteria are the water quality criteria of concern in this study. Each is important in itself and in combination with the other criteria.

DO is a component in important chemical and biological reactions that support viable aquatic habitat. The main source of oxygen is the atmosphere. Oxygen is consumed in respiration by plants and animals but is only produced by plants under appropriate light and nutrient conditions. The processes of respiration and decomposition can deplete oxygen in water bodies unless it is continually replenished by the atmosphere. Oxygen depletion causes changes in the solubility of many metals and some nutrients. Organic matter from natural, domestic, and industrial sources can also contribute to the depletion of oxygen concentrations. Under low oxygen or anoxic conditions, most aquatic organisms die and are replaced by few specialized organisms that can tolerate these circumstances.

DO can be significantly influenced by temperature, but photosynthesis, respiration, and aeration of the water can also affect DO concentrations. In general, the concentration of DO is inversely proportional to the water temperature.

Although certain amounts of TDS are required by aquatic species to maintain an osmotic balance that provides for flow of water into and out of cells (osmosis), abnormally high or low TDS levels disrupt this balance and may eventually lead to death of aquatic life forms. High TDS levels can also reduce water clarity, resulting in decreased photosynthesis and increased water temperature. Dissolved ions contained in TDS pollutant loads can influence pH, leading to additional negative impacts on aquatic life. TDS pollutants are known to impact poultry and livestock productivity at levels exceeding 1,000 mg/L. However, some differences have been identified in the level of impacts according to the dominant ion species present in TDS-laden waters, with carbonate-dominated waters being more acceptable than sulfur-dominated waters. In general, high TDS concentrations are known to produce laxative effects on animals and humans and may create an unpleasant mineral taste in drinking water.

Coliform bacteria have been used in the past to indicate the presence of fecal contamination and more specifically pathogens, which can result in severe sickness and death in humans. The type of coliform associated with DWQ numeric criteria has been modified over time, moving from measurements of Total Coliform and Fecal Coliform to measurements of E. coli. Measurements of E. coli are presently used due to its close association with warm blooded species including animals and humans. Use of E. coli alone as an indicator of human fecal matter can sometimes be misleading due to environmental conditions which promote coliform growth, such as high (Biochemical Oxygen Demand) BOD levels.

Water quality data collected at monitoring stations on the Jordan River have indicated that existing levels of DO, Temperature, TDS, and E. coli may impair the assigned beneficial use classes of river segments. Although the pollutants of concern are the focus of this TMDL study, other parameters were assessed as well due to their ability to characterize impairment. These include Phophurus, Ammonia, BOD, pH, and Specific Conductivity.

The importance of each parameter is discussed below, followed by a summary of monitoring results. The discussion focuses on water quality measurements collected by DWQ during the 1999 – 2000, and 2004 – 2005 intensive monitoring cycles as well as long-term characteristics (1995 – 2005) of each parameter. Plots are used to display mean concentrations of selected water quality parameters for stations included in Table 7. Exceedance of numeric criteria and indicator values were also reviewed, followed by a discussion of seasonal variation in concentration levels. Where applicable, diurnal monitoring data was assessed. For the sake of brevity, abbreviated location names are used in the discussion instead of station IDs. For instance, Station 4991820, Jordan River at Cudahy Lane above South Davis South WWTP, is referred to as Cudahy Lane. The complete station ID and name of selected monitoring locations is provided in Table 7.

Statistical parameters (including percent exceedances) for monitoring stations located on the mainstem Jordan River and tributary outlets are included in Appendix B. Tables in Appendix B are arranged by river mile, moving upstream (from north to south). Time-series plots and monthly distributions of mean concentrations for selected parameters are also shown for selected monitoring station in Appendix C. Censored data (below detection limit values) are not shown in these plots. The seasonal distribution of monthly mean concentrations is displayed using box and whisker plots. These plots illustrate the distribution of all data points for a particular time period or season rather than plotting or examining individual data points. Note that for all box plots contained in this report, the shape of each box represents the distribution of the data as shown in Figure 4 below.

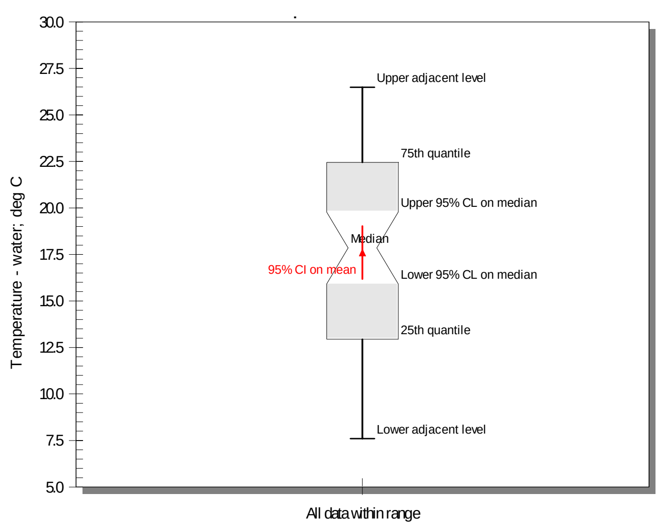


Figure 4. Description of box plots used in this report. Note that CL = “Confidence Limit” and CI = “Confidence Interval” in this diagram.

3.1 SURFACE WATER QUALITY

3.1.1 PREVIOUS STUDIES

Numerous studies have been completed examining water quality in the mainstem Jordan River and, to a lesser degree, its tributaries. Table 11 below provides a list of the more recent studies.

Table 11. Previous studies addressing water quality conditions at select locations in the Great Salt Lake Basin including the Jordan River and tributaries.

Reference	Extent of study	Description
EPA 1972	Jordan River, Emigration Creek, Corner Canyon Creek.	First water quality studies completed by Region 8 EPA in an effort to meet Clean Water Act requirements.
Salt Lake County 1978	Jordan River and tributaries in Salt Lake County.	208 Water Quality Management Plan with description of existing and projected future water quality conditions in Salt Lake County. Includes recommendations for controlling point and non-point sources of pollution.
McCormack et al. 1983	Jordan River and tributaries.	Concentrated assessment of stormwater runoff quality and resulting water quality impacts to the Jordan River and tributaries. Completed by the USGS. Provides support to existing Salt Lake County Stormwater Management Plans.
Thompson 1984	Jordan River.	Investigation of coliform in the Jordan River including total, fecal, and fecal strep to determine the extent of sanitary contamination, trends of sanitary quality, and effects of storm runoff from urban areas.
Stephens 1984a	Jordan River.	Assessment of DO, BOD, COD and organic carbon levels in the Jordan River 1981-1982.
Stephens 1984b	Jordan River and tributaries	Report of USGS water quality investigations of Jordan River 1980-1982.
Jensen 1994	Jordan River.	Comprehensive seasonal assessment of water quality 1992-1993 using Equal-Width integrated sampling techniques.
Borup and Smith 1999	Jordan River and tributaries.	Assessment of water quality monitoring data collected by DWQ from the mainstem Jordan River sites (10 sites), point sources (four sites) and tributaries to the Jordan River (four sites) 1990-1997.
Salt Lake County 2000	Jordan River and tributaries.	Assessment of 4 years of stormwater monitoring data collected at nine stormwater outfall locations including three sites in Salt Lake City and six sites in Salt Lake County.
Hadley 2001	Great Salt Lake Basins study unit, including the Jordan River.	Compilation of USGS and DEQ/DWQ measurements of nutrients, suspended sediment, and total suspended solids collected in the Great Salt Lake Basin 1980-1995.
Toole 2002	Utah Lake and tributaries, Jordan River and tributaries.	Summary assessment of water quality monitoring data collected by DWQ 1995-2000 including the 1999-2000 intensive monitoring cycle.

Table 11. (cont'd) Previous studies addressing water quality conditions at select locations in the Great Salt Lake Basin including the Jordan River and tributaries.		
Reference	**Extent of study**	**Description**
Baskin et al. 2002	Great Salt Lake Basins study unit, including the Jordan River.	Description of the NAWQA environmental study setting and design used to identify natural and human factors that may have a regional influence on surface and groundwater quality.
Gerner 2003	Great Salt Lake Basins study unit, including the Jordan River.	Assessment of NAWQA data collected at 10 long-term monitoring sites in the Great Salt Lake Basin 1999-200.
Gerner and Waddell 2003	Little Cottonwood Creek from headwaters to confluence with Jordan River.	Examination of hydrology and water quality in an urbanized reach of Little Cottonwood Creek from October 1998 through September 2000.
Waddell et al. 2004	Great Salt Lake Basins study unit, including the Jordan River.	Report of the major findings of a 1998-2001 assessment of NAWQA monitoring data.

Early studies of water quality were developed in response to federal regulations included in Section 208 of the Clean Water Act (EPA 1972, Salt Lake County 1978). These early studies identified several impacts on water quality including extensive development in the riparian corridor, stormwater runoff from urban areas, solid waste operations (landfills) in areas of high groundwater, and discharge from industrial and municipal facilities. Measured DO concentrations were noted to range from 5.5 mg/l to 7.5 mg/l. Fecal coliform concentrations in the Jordan River were reported at 43 cfu/100 ml at the Narrows up to a maximum of 3,150 cfu/100 ml at 2100 South.

Stormwater discharge in Salt Lake County was assessed by the USGS as part of the Nationwide Urban Runoff Program (NURP) 1979 – 1981. Stormwater discharge has been monitored by Salt Lake County and the Utah Department of Transportation Region 2 since 1992. Results of this monitoring are submitted to the DWQ and Region 8 EPA on an annual basis. A summary report of stormwater monitoring data collected 1992 – 2000 calculated Event Mean Concentration (EMC) levels for representative storm events (Salt Lake County 2000). A comparison to other municipalities involved in the NURP program indicated that Salt Lake County EMCs were within the range of all measured parameters. Salt Lake County average EMC values for Total Suspended Solids (TSS), Total Phosphorus (Total P), and Total Zinc were below the average values for other municipalities.

The National Water Quality Assessment (NAWQA) program was implemented by the USGS to define status and trends in surface and groundwater quality and to characterize natural and human factors that affect these resources. The Great Salt Lake Basin (GRSL) study unit is one of 51 NAWQA study units located across the nation. Full implementation of the NAWQA monitoring program in the GRSL study unit began in 1997. A comparison of 10 fixed sites (i.e., stream locations monitored at regular intervals) in the GRSL study unit indicated that the Jordan River near Salt Lake City had the highest median concentration of TDS during any season measured, ranging from 800 mg/l to nearly 1,000 mg/l (Gerner 2003). In general, TDS concentrations were lowest during the spring snowmelt period and highest during the late summer/early fall season when upstream diversions and irrigation return flows made significant contributions to streamflow. Gerner (2003) indicated that median DO concentrations in the Jordan River were 8 – 9 mg/l and generally below all other monitoring locations in the GRSL, likely because of high BOD concentrations and low natural aeration from minimal channel slope and stream turbulence.

Median concentrations of Total Nitrogen at the Jordan River NAWQA monitoring site were approximately 3 mg/l while median Total P concentrations were nearly 0.5 mg/l.

Borup and Smith (1999) completed an assessment of water quality conditions based on measurements collected from the Jordan River from 1990 through 1997 in an effort to begin analyzing how water can be best protected from pollution. Their assessment, which included DWQ monitoring stations from the outlet of Utah Lake to the State Canal crossing (below Cudahy Lane), indicated that some of the State's water quality standards were being violated. Parameters exceeding the established criteria included Fecal Coliform, TDS, BOD, Total P, and TSS.

The Total and Fecal Coliform standards were exceeded by 21 percent (n=290) and 25.6 percent (n=312), respectively. The TDS criteria were exceeded at stations located between the Utah Lake Outlet and 6400 south. BOD concentrations exceeded the criterion at almost every monitoring station included in the assessment, with the highest exceedances observed at 2100 south (40 percent) and Cudahy Lane (50 percent). High concentrations of Total P were observed across all stations but were particularly high below 7800 south; the Total P indicator was exceeded in 64 percent of all samples. TSS indicators were exceeded by 22 percent of the samples collected. TSS concentrations were very high at the Utah Lake outlet (approximately 140 mg/L) but decreased dramatically below Bluffdale Road (below 50 mg/L). Of the samples tested for DO (n=695), only 4 percent exceeded the applicable standard.

In conclusion, Borup and Smith (1999) found that while some of the water quality problems in the Jordan River can be attributed to discharges from Publicly Owned Treatment Works (POTWs), problems exist along this entire section of river that are not directly associated with such discharges.

Toole (2002) used water quality samples collected from 1995 to 2000 at eight stations within the Utah Lake-Jordan River watershed to determine if designated stream beneficial uses were being met. Nearly 83 percent of all stream miles assessed were fully supporting the designated beneficial use while 10.6 percent were assessed as partially supporting, and 6.7 percent were determined to not be supporting at least one beneficial use. Major causes of impairment of streams included high metals concentration, habitat and flow alterations, mining development, and agricultural activities. Low oxygen concentrations were attributed to oxygen demands resulting from organic matter loading. Jordan River Segments 1 and 2 (from Farmington Bay upstream to North Temple) were determined to be impaired due to low DO concentrations.

3.1.2 STREAM WATER QUALITY MONITORING - DWQ

Existing water quality conditions in the Jordan River are characterized below primarily with DWQ monitoring data, as identified in Section 2.1. A brief review of water quality measurements for impaired segments is provided below for each pollutant of concern, including DO, Temperature, TDS, and Coliform followed by a review of other parameters that can influence the pollutants of concern.

3.1.2.1 Dissolved Oxygen

The Utah DWQ has identified Jordan River Segments 1 and 2 as impaired for low DO concentrations (Table 1). Long-term mean DO concentrations (1995 – 2005) measured on impaired segments of the Jordan River ranged from 5.7 mg/L at Redwood Road (Segment 2) to 6.92 mg/L at Cudahy Lane (Segment 1) (Figure 5). Note that mainstem Jordan River stations displayed in Figure 5 are represented as line features while tributary inputs, permitted discharges, and diversions are displayed as individual points. The background of each plot is shaded according to DWQ segments associated with the Jordan River. The locations of monitoring sites are displayed on the X-axis by river mile and by name, with river mile 0 equal to the downstream end of the Jordan River at Burton Dam. These same features are used on plots in the discussion of other water quality parameters below.

In general, DO concentrations in the Jordan River increased with distance downstream from the Utah Lake outlet to just below river mile 30 where concentrations began to decline through Segment 3. Increasing DO concentrations below 5400 South are likely a response to tributary inflow from Mill Creek, Big Cottonwood Creek, and Little Cottonwood Creek. Mean DO concentrations in the Jordan River 2004 – 2005 were below the Class 3B 30-day average standard of 5.5 mg/l in Segments 2 and 3. Mean DO concentrations 2004 – 2005 were generally less than those observed 1999 – 2000 as well as the long-term period. No DO measurements associated with routine monitoring were obtained for the Jordan River below Cudahy Lane. Diurnal DO data is being collected below Cudahy Lane during 2006-07 as part of a DWQ synoptic monitoring effort on the Jordan River. A limited portion of this data has been reviewed is discussed later in this section.

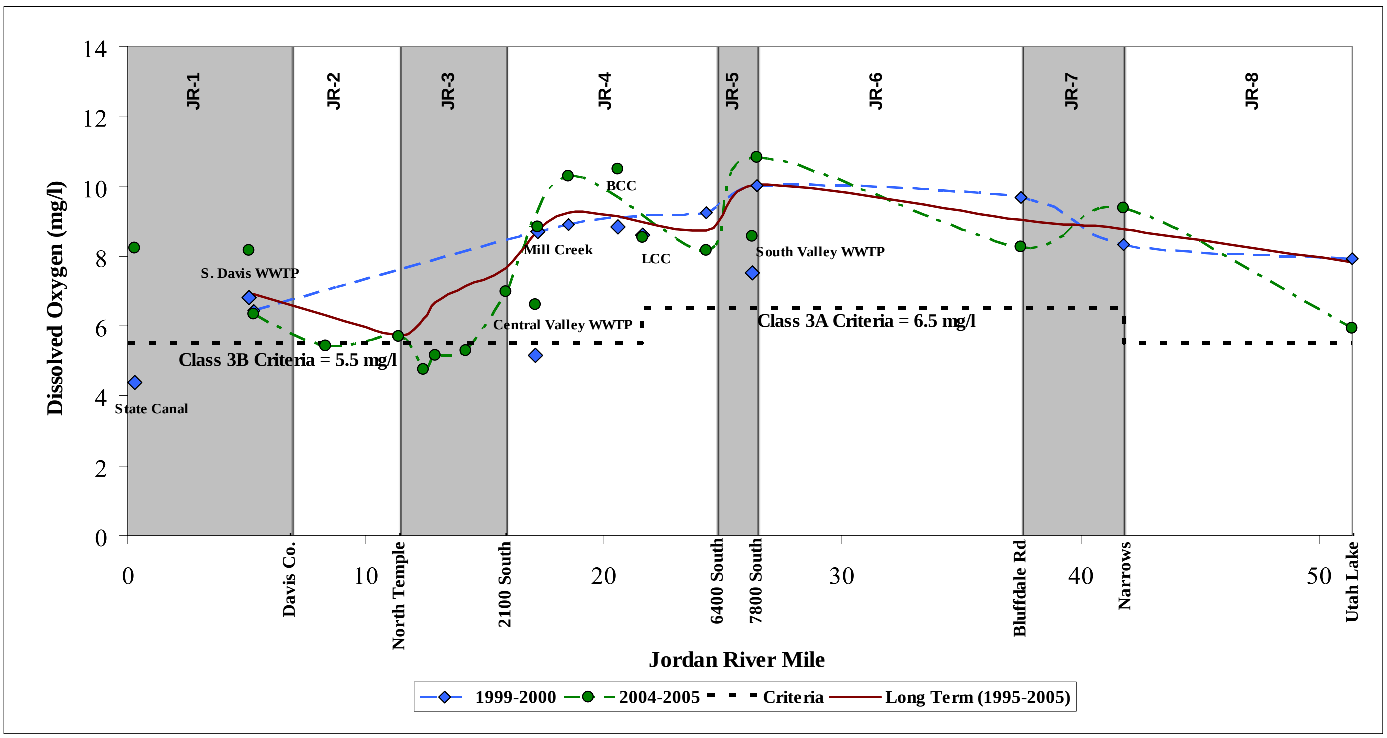


Figure 5. DO concentration measured at intensive monitoring locations in the Jordan River. The plot background indicates relative positions of Jordan River segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

The percent of DO measurements that violate criteria applicable to Jordan River monitoring sites below 2100 South are presented in Table 12. Note that several stations in Table 12 were only visited during the 2004 – 2005 monitoring period. Three stations are available to evaluate DO conditions at 303(d) listed Jordan River segments including Cudahy Lane (Segment 1), Redwood Road (Segment 2), and North Temple (upstream boundary of Segment 2). Table 12 indicates that DO measurements from impaired Segments 1 and 2 consistently violated the 5.5 mg/l criteria during the 2004 – 2005 monitoring period as did sites upstream of Segment 2. Violation of DO criteria is much greater for the 4.0 mg/l criteria enforced August through April on Jordan River Segments 1 – 4 than for the 4.5 mg/l criteria used May through July. This condition could be a response to low flow conditions that existed in the Jordan River during August and September.

Table 12. Percent exceedance of DO criteria from Jordan River Segments 1 and 2 that are considered to be impaired due to low DO levels.

		Cudahy Lane - Segment 1		Redwood Road - Segment 2		North Temple - Segment 3		400 South - Segment 3		700 South - Segment 3		1300 South - Segment 3		2100 S - Segment 4	
Year	DO Criteria (mg/l)[1]	% exceedance	Sample size	% exceedance	Sample size	% exceedance	Sample size	% exceedance	Sample size	% exceedance	Sample size	% exceedance	Sample size	% exceedance	Sample size
1999-2000	4	0.0	12	na	0	na	0	na	0	na	0	na	0	0.0	10
	4.5	33.3	6	na	0	na	0	na	0	na	0	na	0	0.0	5
	5.5	27.8	18	na	0	na	0	na	0	na	0	na	0	0.0	15
2004-2005	4	6.3	16	25.0	4	10.0	10	25.0	4	14.3	7	33.3	3	8.3	12
	4.5	0.0	12	9.1	11	9.0	11	9.1	11	18.2	11	18.2	11	0.0	12
	5.5	39.3	28	33.3	15	61.9	21	86.7	15	66.7	18	50.0	14	33.3	24
1995-2005	4	2.9	68	na	na	7.7	13	na	na	na	na	na	na	2.1	47
	4.5	12.9	31	na	na	9.1	11	na	na	na	na	na	na	0.0	29
	5.5	19.2	99	na	na	54.2	24	na	na	na	na	na	na	14.5	76

[1] DO criteria used to assess Jordan River Segments 1-4 include: 4.0 mg/l = August–April, 4.5 mg/l = May-July, 5.5 mg/l = 30-day average.
Note: some sites are located at segment boundaries including North Temple and 2100 South. An assessment of long-term (1995-2005) conditions was not completed for sites with insufficient data.

A review of flow data collected from the USGS gage at 1700 South (Segment 3) indicated that mean monthly flows from July 2004 through September 2004 were slightly below the 10th percentile. In other words, 90 percent of flow measurements recorded July through September for the entire period of record at this station (1942 – 2005) were greater than mean monthly flows measured July 2004 through September 2004. Low flows that occur in the Jordan River below 2100 South could be influenced by management of the Surplus Canal.

Seasonal fluctuation of DO concentrations 1995 – 2005 at the Cudahy Lane site (Segment 1) are shown in Figure 6. Measurements collected at Redwood Road (Segment 2) were insufficient during 1995 – 2005 to provide an accurate seasonal assessment of DO and are not presented here.

Seasonal DO patterns for selected Jordan River monitoring stations upstream of Segment 2 are shown in Appendix C. DO concentrations for all Jordan River monitoring stations generally follow the same pattern shown in Figure 6 for Cudahy Lane (including the State Canal monitoring site) with minimum monthly concentrations occurring June through September. Seasonal fluctuations in DO could be influenced by warmer temperatures as well as decreased flows due to irrigation diversions from upstream Jordan River segments. Mean monthly DO concentrations at Cudahy Lane were slightly below the 5.5 mg/l criteria during July (5.49 mg/l) and August (5.27 mg/l).

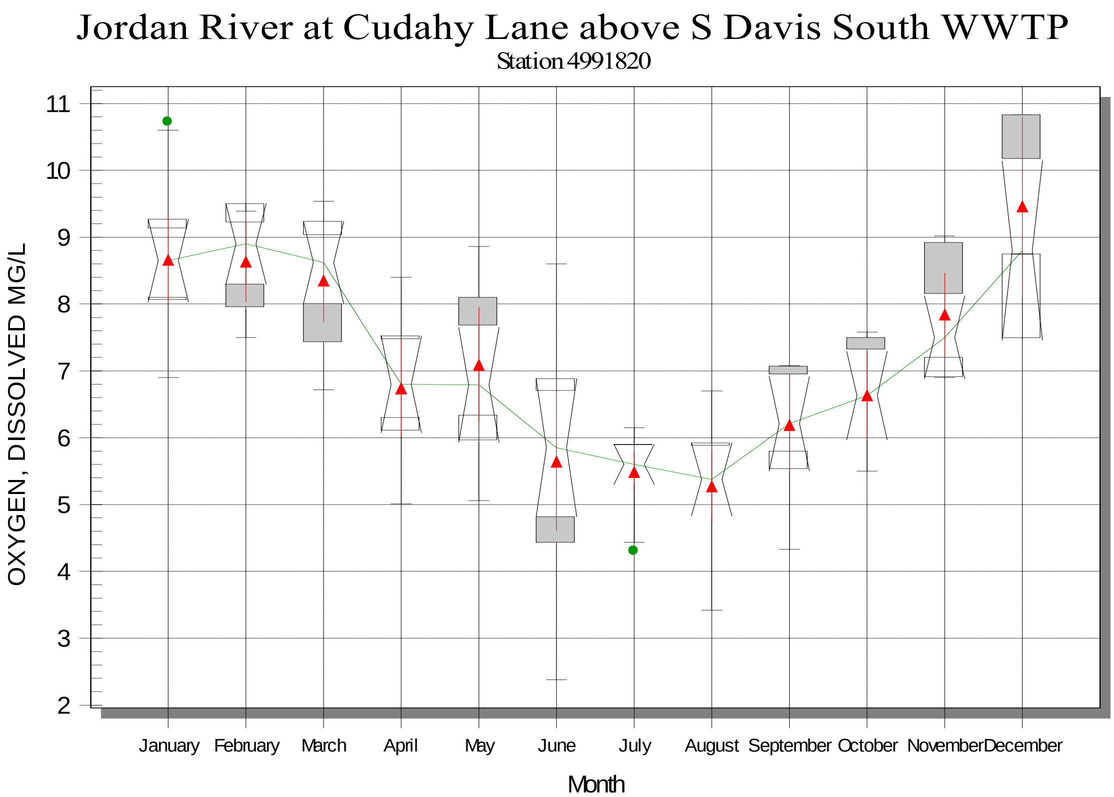


Figure 6. Monthly concentrations of DO on impaired Jordan River Segment 1. Data shown considers all field measurements of DO collected 1995 – 2005 including 99 measurements at Cudahy Lane

DO concentrations experience a natural fluctuation through a 24-hour period. These diurnal fluctuations are generally characterized by minimum levels in the early morning hours prior to sunrise and maximum levels in the afternoon hours. This cycle is a response to photosynthetic activity by algae and zooplankton which in turn is a function of available light. As a result, DO concentrations are generally lowest during the nighttime hours when photosynthetic activity ceases. If the shift in diurnal DO concentrations is large, aquatic species can be impacted during certain time periods each day as a result of low DO levels. DO concentrations are measured as a part of routine water quality monitoring efforts and typically include a single measurement collected during each visit. A review of measurement times associated with field efforts indicated that nearly all stream samples collected by DWQ were taken during daylight hours. As a result, DO measurements may be slightly biased towards higher concentrations when compared to other hours in a full diurnal cycle.

Diurnal measurements of DO were recently collected by DWQ during August 2005, July 2006, and August 2006 at several monitoring stations on the Jordan River. Data collected at some stations during the August 2005 visit were not usable as a result of sediment deposits which accumulated on the measurement face of each probe. This assessment focuses on measurements collected during 2006 field efforts that were part of a synoptic monitoring effort being completed by DWQ for the Jordan River.

A typical method of assessing diurnal DO cycles is to calculate the difference between maximum and minimum DO concentrations within a 24-hour period. This difference indicates the change in DO concentrations that aquatic species experience each day at a particular site. The magnitude of DO shift can be influenced by the presence and extent of periphyton as well as daylight length. The diurnal shift in DO concentration measured during 2006 at 10 sites on the Jordan River is shown in Figure 7. Measured diurnal DO shift during July 2006 was fairly consistent during July across the length of the Jordan River. In contrast, diurnal DO shift in August varied greatly between Burnham Dam and Utah Lake.

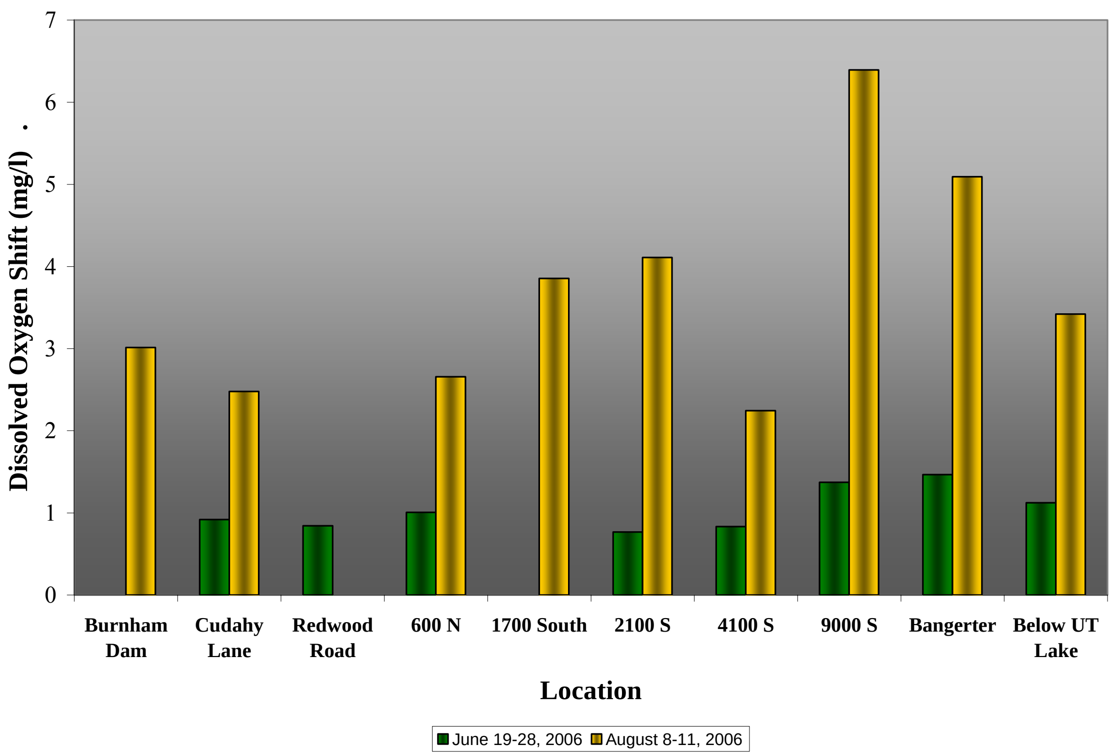


Figure 7. Jordan River DO shift measured during 2006 including June 19-28 and August 8-11. Bars indicate the mean of measured differences between diurnal minimum and maximum DO concentrations for each time period.

Table 13 provides an indication of the average characteristics of diurnal cycles measured during these two time periods for impaired segments of the Jordan River. An important diurnal characteristic is the amount of time that DO concentrations remain below threshold levels which influence the presence, composition, and extent of aquatic communities. (The average number of hours spent below 5.5 mg/l ranged from 6.8 to 7.5 during August while all diurnal DO measurements were above 5.5 mg/l in June.) In general, minimum DO concentrations were lower in August than during June. Note that DO conditions in August appear to degrade slightly below Cudahy Lane as shown by minimum DO concentrations and hours where DO concentrations are less than 5.5 mg/l.

Table 13. Average characteristics of diurnal DO measured during June 20-28, 2006 and August 8-11, 2006 on Jordan River Segments 1 and 2 that are considered to be impaired due to low levels of DO.

DO Concentration (mg/l)						
	June 20-28, 2006			**August 8-11,2006**		
Segment	**1**	**2**	**2**	**1**	**1**	**2**
Station	**Cudahy Lane**	**Redwood Road**	**600 N**	**Burnham Dam**	**Cudahy Lane**	**500 N**
Min. Concentration (mg/l)	6.22	7.16	6.85	4.82	4.87	4.80
Max. Concentration (mg/l)	7.13	8.00	7.86	7.83	7.35	7.46
Diurnal Shift (mg/l)	0.92	0.84	1.01	3.01	2.48	2.66
Time of Min.	7:46 AM	5:46 AM	6:53 AM	7:00 AM	6:30 AM	8:15 AM
Time of Max.	6:13 PM	3:20 PM	4:26 PM	5:30 PM	5:30 PM	4:45 PM
Hours < 5.5 mg/l	0	0	0	7.5	6.8	7.0
DO Saturation (%)						
	June 20-28, 2006			**August 8-11,2006**		
Segment	**1**	**2**	**2**	**1**	**1**	**2**
Min. Saturation (%)	77.9	93.3	90.2	64.1	64.7	64.1
Max. Saturation (%)	94.8	106.6	107.0	109.7	101.2	100.9
Saturation Shift (%)	16.9	13.3	16.8	45.6	36.5	36.8
Time of Min.	7:33 AM	6:13 AM	7:06 AM	7:15 AM	6:45 AM	8:30 AM
Time of Max.	6:00 PM	3:53 PM	4:46 PM	5:30 PM	6:00 PM	4:45 PM
Hours > 100%	0	11	9	6.5	3	2

Percent of DO saturation was measured at the same time as DO concentration. Measurements of percent saturation provide an indication of time periods when oxygen is introduced into the water column faster than it can be fully dissolved. As a result, the water column is supersaturated with DO. This condition could indicate the influence of photosynthesis by algae or periphyton communities. Table 13 indicates that diurnal cycles of percent DO saturation measured during field monitoring were similar to those observed for DO concentration. Measurements indicated supersaturated conditions at two sites in June and at all three sites in August. However, the amount of time spent in a supersaturated condition was comparatively less in August than in June.

3.1.2.2 TDS

TDS was identified as a pollutant of concern on the 2006 303(d) list for Jordan River Segments 1, and Segments 5 through 8. An assessment of mean TDS concentrations indicated slight increases from Utah Lake through Segment 5, followed by a decrease in mean concentrations downstream of this site (Figure 8). Tributaries had mean TDS concentrations that were typically lower than mainstem Jordan River sites during intensive monitoring periods. In general, TDS concentrations showed substantial decreases below the confluence of tributaries to the Jordan River. Lower TDS concentrations in tributaries served to dilute Jordan River TDS levels. No TDS measurements were identified for wastewater treatment facilities. Mean TDS concentrations were highest during 2004 – 2005 in comparison to other time periods, and exceeded the 1,200 mg/l criteria from the Narrows through Segment 5.

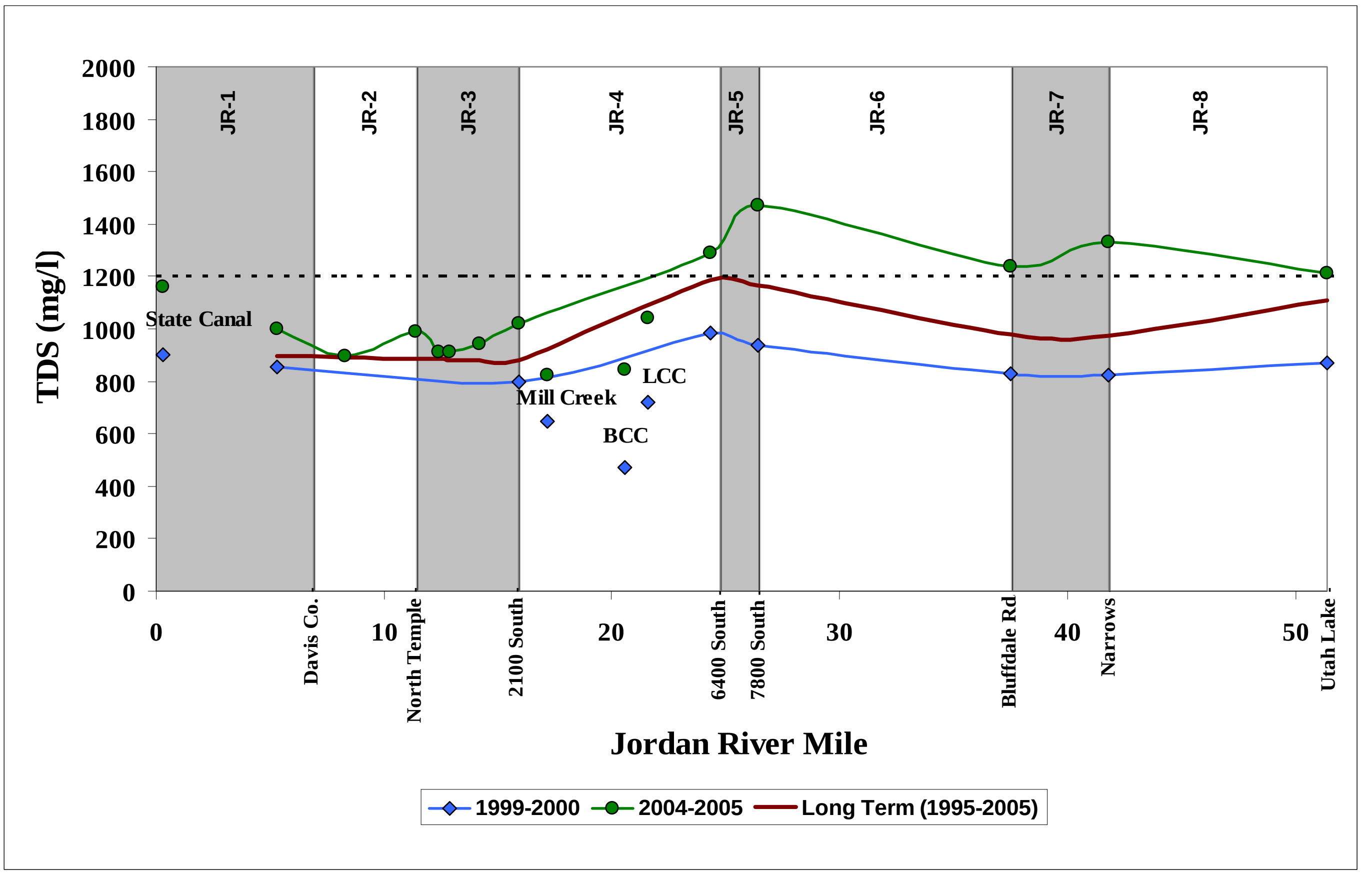


Figure 8. Mean concentration of TDS measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River segments one (JR-1) through eight (JR-8) with respect to monitoring locations.

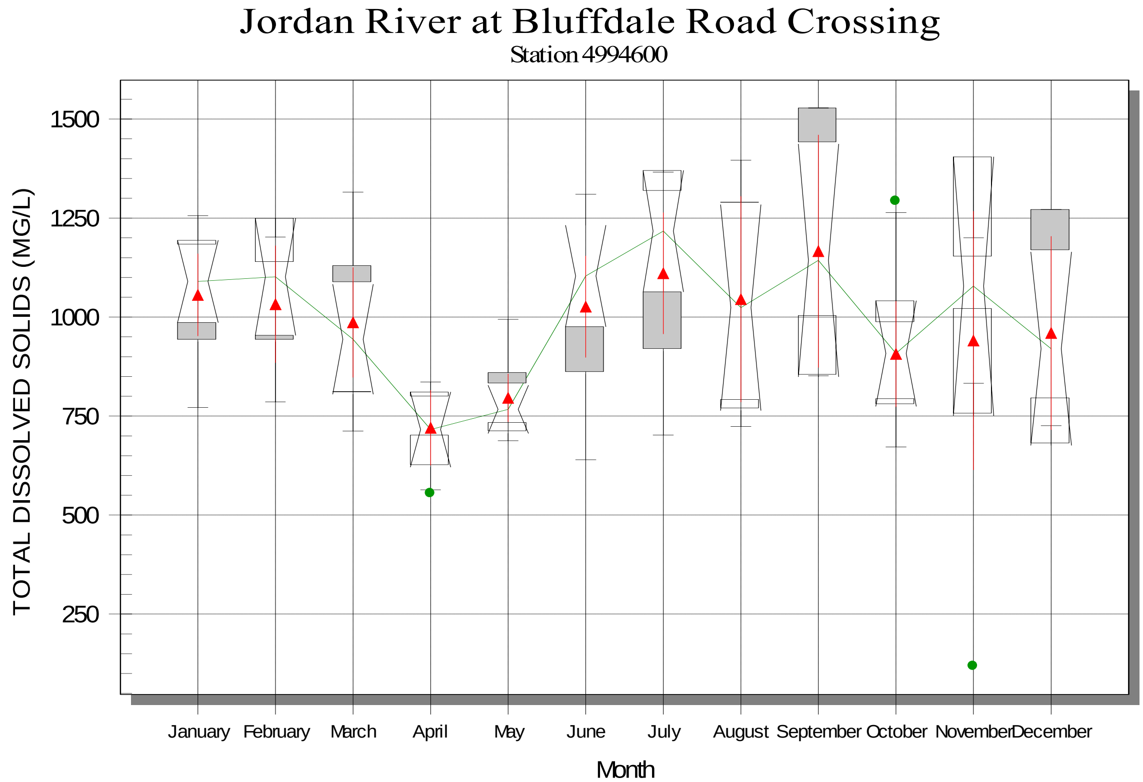
The TDS criterion for listed Jordan River segments is 1,200 mg/l and is associated with the Class 4 – Agriculture beneficial use class. Table 14 provides an assessment of TDS samples collected from mainstem monitoring stations located on Jordan River segments listed for TDS impairment, including Segments 1 and Segments 5 through 8. Note that although no stations were identified on Jordan River Segment 6, the Bluffdale Road and 7800 South monitoring sites are located at the upstream and downstream boundaries of this segment, respectively. The percent of samples exceeding State criterion was greatest during the 2004 – 2005 intensive monitoring period. Percent exceedance was significant during the long-term assessment period for all listed segments with the exception of Cudahy Lane where only 6.8 percent of samples violated the 1,200 mg/l standard.

Table 14. Mean TDS concentrations and percent of samples in violation of numeric criteria for segments of the Jordan River considered impaired due to high concentrations of TDS including Segment 1 and Segments 5 - 8.

			1999-2000			2004-2005			Long Term (1995-2005)		
Station	**Segment**	**Criteria**	**Mean**	**n**	**% Exceed**	**Mean**	**n**	**% Exceed**	**Mean**	**n**	**% Exceed**
Cudahy Lane	1	1,200	857	17	5.9	998	18	11.1	897	88	6.8
7800 S	5	1,200	939	11	9.1	1,473	6	100	1,167	27	48.1
Bluffdale Road	7	1,200	830	16	0	1,236	18	72.2	979	87	21.8
Narrows	8	1,200	822	10	0	1,334	6	66.7	976	26	19.2
Utah Lake	8	1,200	872	14	14.3	1,214	11	54.5	1,108	50	38.0

Note: 7800 South and Bluffdale Road are located on the downstream and upstream boundary of Segment 6, respectively.

Seasonal variation of TDS is shown in Figure 9 for Bluffdale Road (Segment 7) and Cudahy Lane (Segment 1). The pattern of monthly TDS concentrations was slightly offset between these two stations, and was typical of seasonal TDS patterns that occur at upstream and downstream Jordan River segments. Maximum and minimum monthly values were observed at the Bluffdale Road site approximately 1 – 2 months before similar events occur at Cudahy Lane. No monthly means exceeded the 1,200 mg/l criterion during any time of the year, although monthly values during the fall season approached this level at each location.



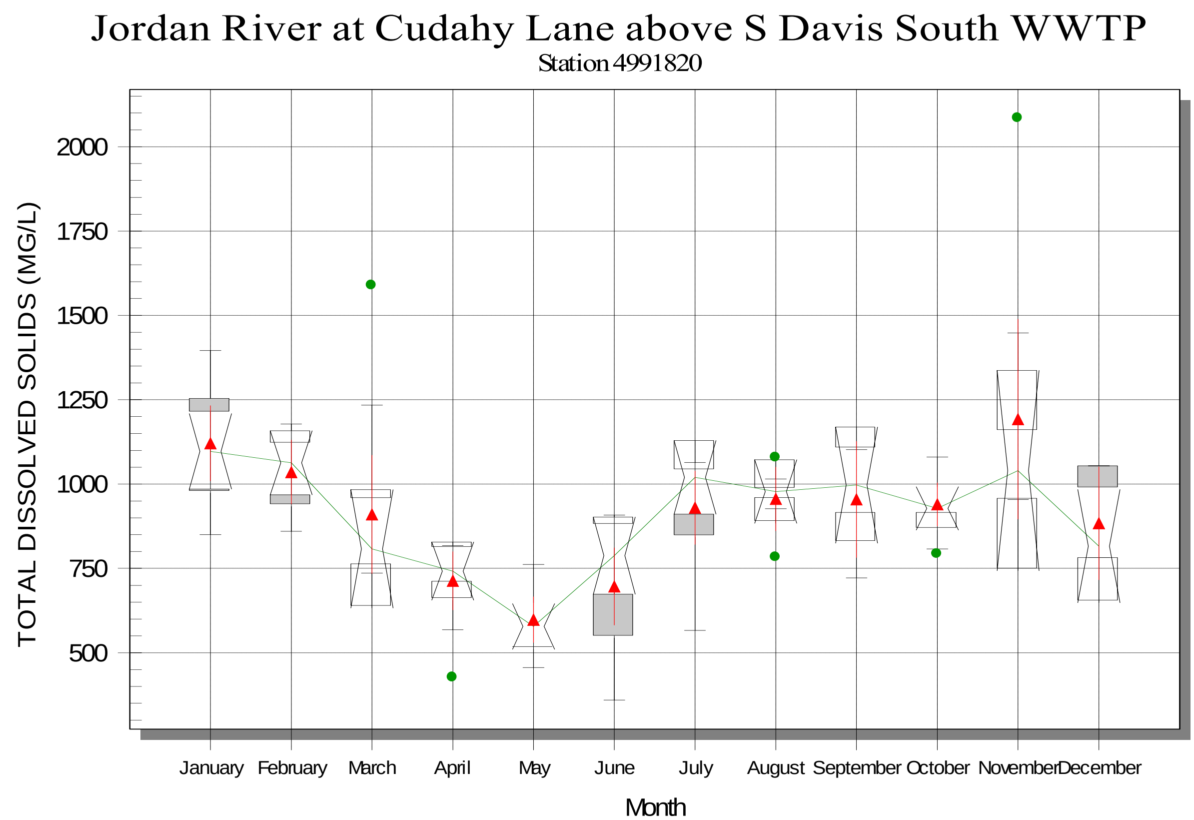


Figure 9. Monthly concentrations of TDS on impaired Jordan River segments including Bluffdale Road (Segment 7, upper plot) and Cudahy Lane (Segment 1, lower plot). Data shown considers all samples of TDS collected during 1995-2005 including 87 samples at Bluffdale Road and 88 samples at Cudahy Lane.

3.1.2.3 Coliform (E. coli)

Coliform measurements have been used by DWQ to indicate health hazards in waters designated for primary and secondary contact recreation. The 2006 303(d) list includes three segments as impaired for E. coli including Segments 2, 3, and 5. As recently as 2004, measurements of Total and Fecal Coliform were used to determine if impairment existed in waters of the State. Neither of these parameters are currently used by DWQ to indicate impairment. Two criteria that were associated with Fecal Coliform including a sample maximum of 400 col/100 ml and a geometric mean of 200 col/100 ml for a minimum of five samples collected within any 30-day period. Although Fecal Coliform is not currently used by DWQ to indicate impairment, it is discussed here due to the supporting information it could provide in an assessment of E. coli. Criteria used by DWQ for E. coli include a sample maximum of 940 col/100 ml and a geometric mean of 206 col/100 ml for a minimum of five samples collected within any 30-day period.

All coliform monitoring data was reviewed as part of this assessment. As with other water quality parameters, this discussion will focus on monitoring data collected from 1995 to the present including periods of intensive monitoring. A limited number of E. coli and Fecal Coliform measurements were identified for Jordan River sites that met the minimum sample size and 30-day collection period. All coliform monitoring data that met the minimum requirements was collected entirely within a 6-week period during June and July of 2004. No coliform monitoring data was identified for mainstem Jordan River Segment 5, tributaries to the Jordan River, or from wastewater treatment facilities during this time period. In addition, this time period includes the only E. coli data that was identified for any Jordan River monitoring station maintained by the DWQ.

Figure 10 shows the average 30-day geometric mean concentrations of E. coli and Fecal Coliform collected from Jordan River monitoring sites during this time period. The geometric mean shown in Figure 10 is for all samples collected within the 6-week period, while individual data points indicate sample concentrations. E. coli samples that measured below the detection limit were replaced with a value of 1 in order to calculate the geometric mean. Coliform levels increased with distance downstream for both E. coli and Fecal Coliform. Maximum levels of E. coli were observed in Segments 2 and 3. The geometric mean for E. coli exceeded the criterion in Segments 1 through 3. Note that several E. coli samples measured below the detection limit as indicated by a value of 1 in Figure 10. Maximum levels of Fecal Coliform data were also observed in Segments 2 and 3 while the geometric mean for Fecal Coliform exceeded the criterion in Segments 1 through 5.

The percent of E. coli and Fecal Coliform monitoring data that exceeded DWQ criteria are shown in Table 15 and Table 16, respectively. The results of a statistical assessment of coliform monitoring data collected from stations visited during periods of intensive monitoring is included in Appendix B. Percent exceedance of coliform criteria was based on the minimum requirement of at least five samples collected within a 30-day period. The data set assessed in Table 15 and Table 16 was collected over a period of approximately 6 weeks. As a result, more than one 30-day time period was assessed.

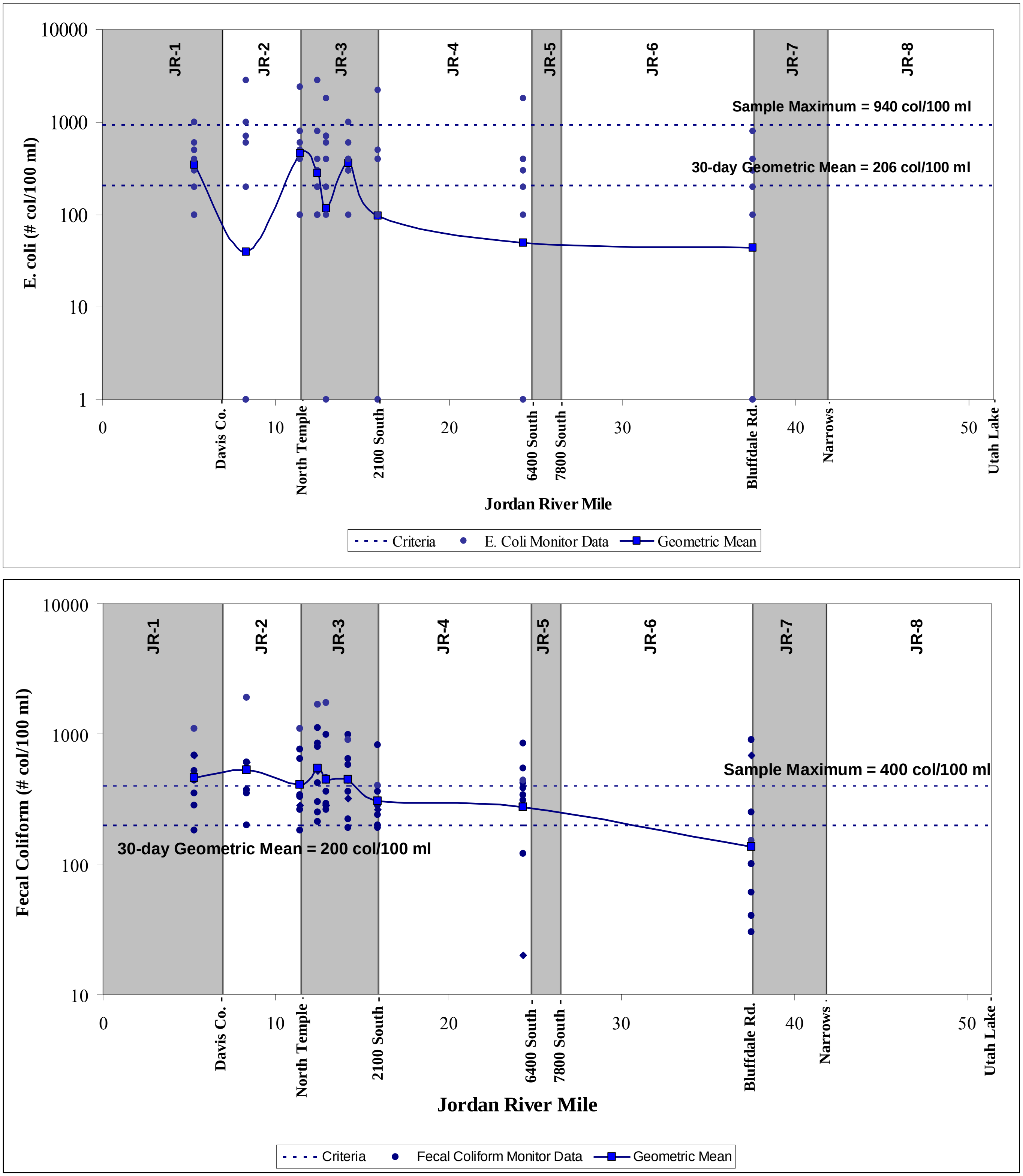


Figure 10. Coliform monitoring data collected during June – July 2004 at intensive monitoring locations in the Jordan River including E. coli (upper plot) and fecal coliform (lower plot). The plot background indicates relative positions of Jordan River Segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Table 15. Assessment of E. coli samples collected during 2004 including percent of samples in violation of numeric criterion.

Station	Segment no.	30-day Sample Maximum Criteria	30-day Geometric Mean Criteria	n	Range of 30-day Geometric Means	% Exceed Sample Max Criteria	% Exceed Geo. Mean Criteria
Cudahy Lane	1	940	206	9	290 – 359	22	100
Redwood Road	2	940	206	9	10 – 113	22	0
North Temple	3	940	206	9	290 – 464	11	100
400 South	3	940	206	9	170 – 280	11	60
700 South	3	940	206	9	86 – 458	11	60
1300 South	3	940	206	9	270 – 365	11	100
2100 South	4	940	206	9	64 – 355	11	60
5400 South	4	940	206	9	71 – 150	11	0
Bluffdale Road	7	940	206	9	25 – 128	0	0

Results shown in this table are based on minimum requirements for sample size within a 30 day period.

Table 16. Assessment of Fecal Coliform samples collected during 2004 including percent of samples in violation of numeric criterion.

	Segment no.	30-day Sample Maximum Criteria	30-day Geometric Mean Criteria	Arithmetic Mean	Range of 30-day Geometric Means	n	% Exceed Sample Max Criteria	% Exceed Geo. Mean Criteria
S. Davis WWTP	1	400	200	6	na	8	na	na
Cudahy Lane	1	400	200	521	362 - 566	9	86	100
Redwood Road	2	400	200	631	374 - 637	9	86	100
North Temple	3	400	200	477	331 - 473	9	43	100
400 South	3	400	200	682	431 - 683	9	86	100
700 South	3	400	200	564	375 - 518	9	57	100
1300 South	3	400	200	514	402 - 557	9	71	100
2100 S	4	400	200	337	312 - 345	9	20	100
Central Valley WRF	4	400	200	8	na	9	na	na
5400 South	4	400	200	379	291 - 382	9	67	100
South Valley WRF	5	400	200	26	na	9	na	na
Bluffdale Road	7	400	200	257	122 - 202	9	29	20

Results shown in this table are based on minimum requirements for sample size within a 30 day period. Note that fecal coliform is no longer included in Utah water quality standards.

The percent of samples that exceeded the sample maximum and geometric mean criteria generally increased with distance downstream from Utah Lake for both types of coliform with the exception of Redwood Road which exhibited low values for E. coli. Exceedance of the E. coli geometric mean criterion ranged from 60 – 100 percent at all sites with the exception of Redwood Road, 5400 South and Bluffdale Road which had all samples in compliance. Most stations had all geometric means exceed the Fecal Coliform criterion with the exception of the most upstream monitoring site at Bluffdale Road. The percent of E. coli samples that exceeded the sample maximum criteria ranged from 0 – 22 percent with the lowest values observed at the Bluffdale Road site. Nearly all Fecal Coliform samples exceeded the sample maximum criterion at Cudahy Lane, Redwood Road, and 400 South. Twenty percent of Fecal Coliform samples exceeded the sample maximum criteria at the 2100 South site while Bluffdale Road maintained a 29 percent exceedance level.

Insufficient data exists to assess seasonal variations in E. coli levels. Recommendations to fill data gaps are provided below in Section 7. Figure 11 indicates monthly variations in Fecal Coliform concentrations at the 2100 South and 7800 South monitoring sites. Due to the limited data available, all Fecal Coliform samples were included in the monthly assessment shown in Figure 11. Seasonal peaks in Fecal Coliform concentration appeared to exist during the spring and fall seasons at both monitoring locations.

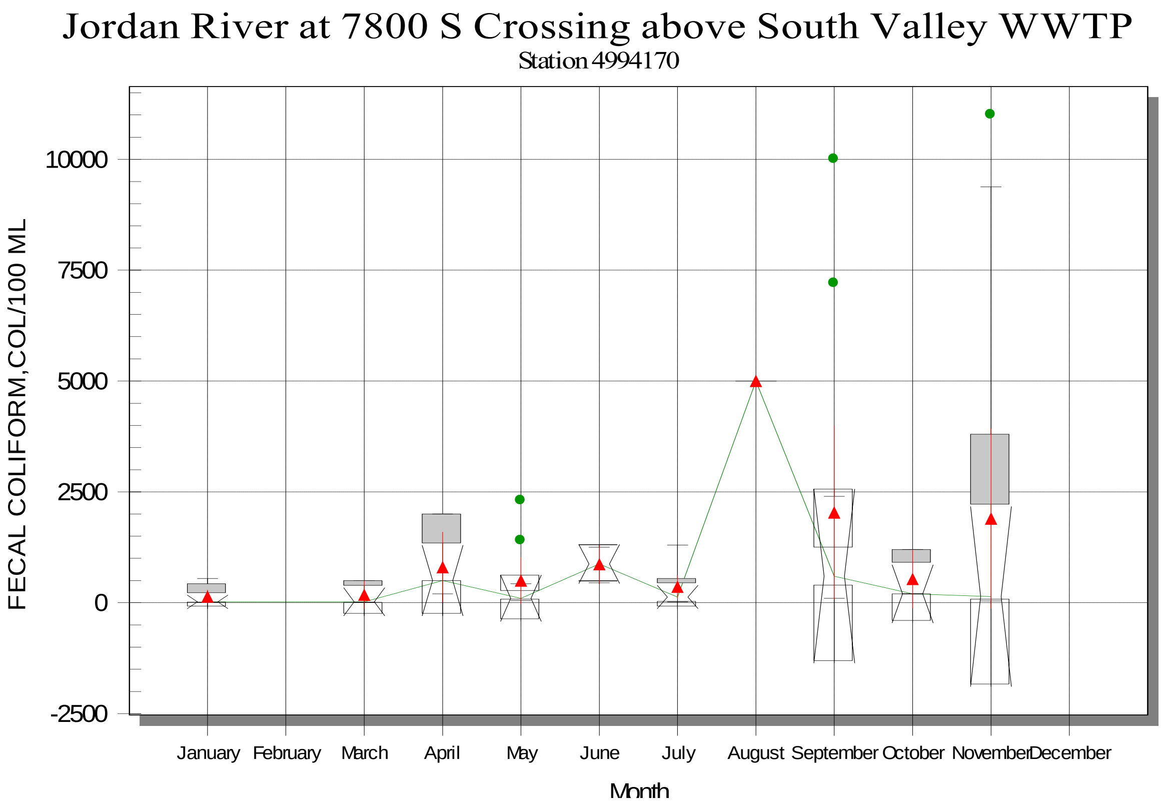
3.1.2.4 Water Temperature

The Utah 2006 303(d) list includes Jordan River Segments 5, 6, and 7 as impaired for high water temperatures. Long term (1995 – 2005) mean water temperatures on impaired Jordan River segments included 13.6 °C on Segment 5 (Station 4994170 – 7800 South) and 13.7 °C on Segment 7 (Station 4994600 – Bluffdale Road)(Figure 12). Although no monitoring stations were identified on impaired Segment 6, stations were identified at the upstream and downstream boundaries of this segment. In general, water temperatures between Utah Lake and Cudahy Lane increased slightly with minor variations that could be associated with warm discharge from wastewater treatment facilities and cool tributary inflow from perennial streams. In general, mean water temperatures were greater during 2004 – 2005 at most sites than during the long-term assessment period (1995 – 2005) or the 1999 – 2000 intensive monitoring period.

The established standards for water temperature are 20 °C and 27 °C for class 3A and 3B streams, respectively. Table 17 includes an assessment of water temperature measurements at stations located upstream of Segment 4. Note that the temperature criteria is 20 °C for Segments 5 – 7 and 27 °C for Segment 8. No exceedance of temperature criteria occurred in Jordan River stream Segments 5 – 8 during 1999 – 2000 or 2004 – 2005 intensive monitoring periods. Exceedance of temperature criteria 1995 – 2005 ranged from 10.9 percent at 7800 South (Segment 5) to 18.5 percent at the Narrows (downstream end of Segment 8).

Seasonal variation in water temperature is shown in Figure 13 for monitoring sites located on impaired segments including 7800 South (Segment 5) and Bluffdale Road (Segment 7). Mean monthly temperatures reached a maximum level in July at each station of approximately 22 °C. Mean monthly temperatures in August were approximately 20 °C at 7800 South and 19 °C at Bluffdale Road. Monthly temperatures declined rapidly September – December, eventually reaching a minimum of about 7 °C in January at 7800 South and approximately 4.5 °C at Bluffdale Road.

Water temperatures can influence the amount of oxygen held within the water column in a dissolved form. Warm water has a lower capacity for absorbing DO than cold water. Seasonal climate patterns in the analysis area influence water temperature and therefore have the potential to influence water temperatures. Mean monthly water temperatures in Jordan River Segments 1 and 2 are shown in Appendix C and follow a similar pattern to those observed in Figure 13. Average water temperatures at Cudahy Lane increased steadily from January to August, reaching their maximum during the summer months (July and August). After reaching this peak, temperatures decrease steadily from September though January.



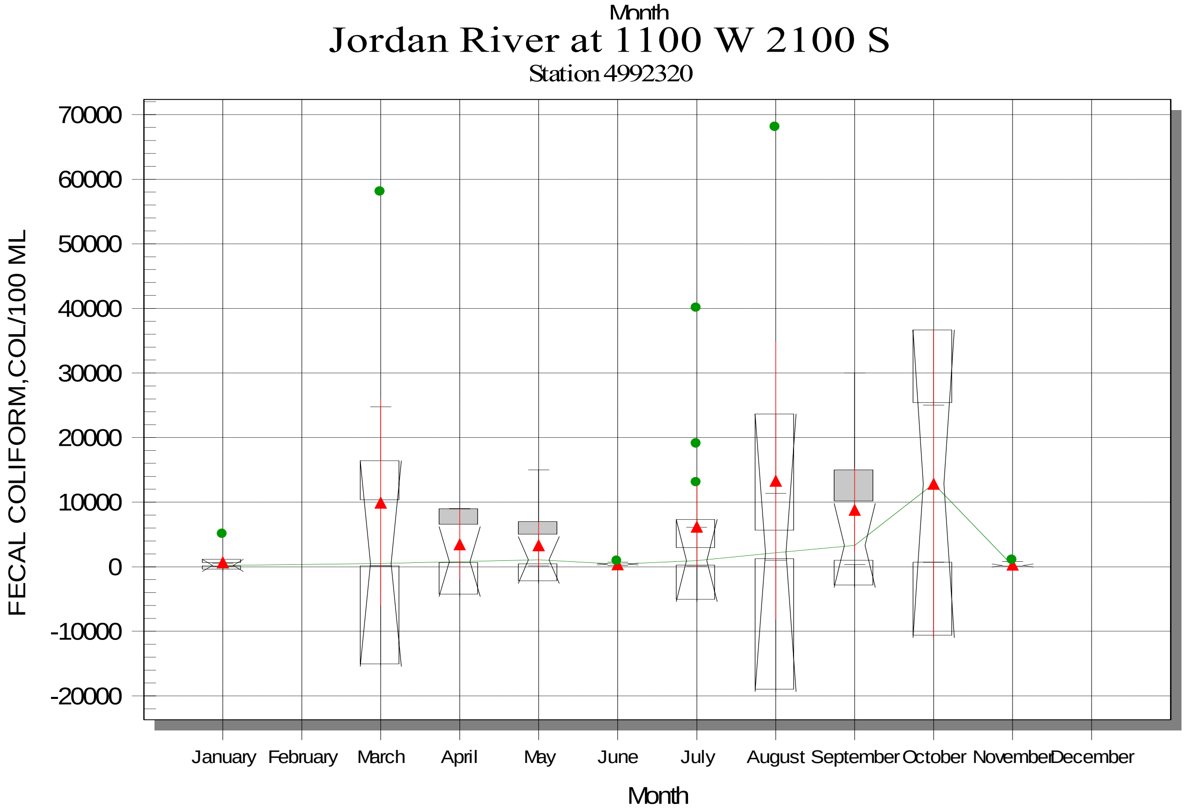


Figure 11. Monthly concentrations of Fecal Coliform on impaired Jordan River segments including 7800 South (Segment 5, upper plot) and 2100 South (upstream boundary of Segment 3, lower plot). Due to the limited data available for some months, all samples of Fecal Coliform collected during the period of record (1975-2005) were considered, including 76 samples at 7800 South and 81 samples at 2100 South.

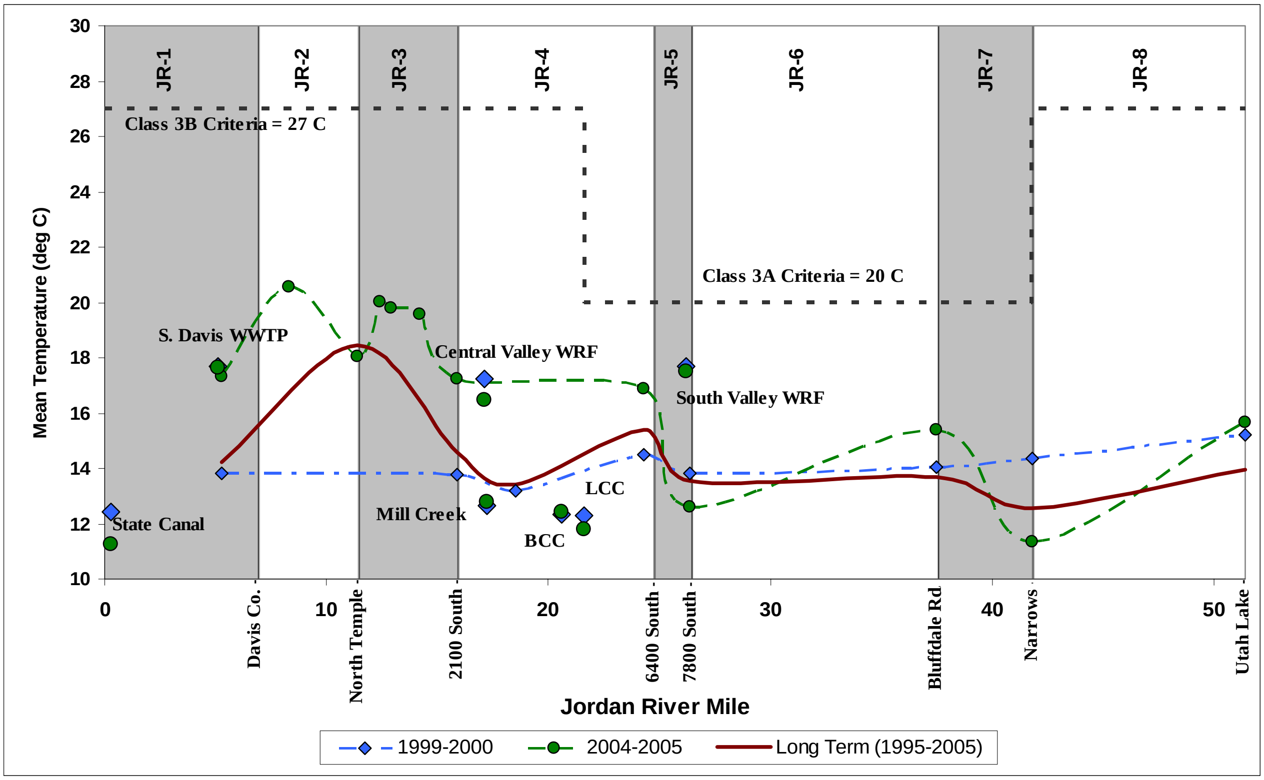
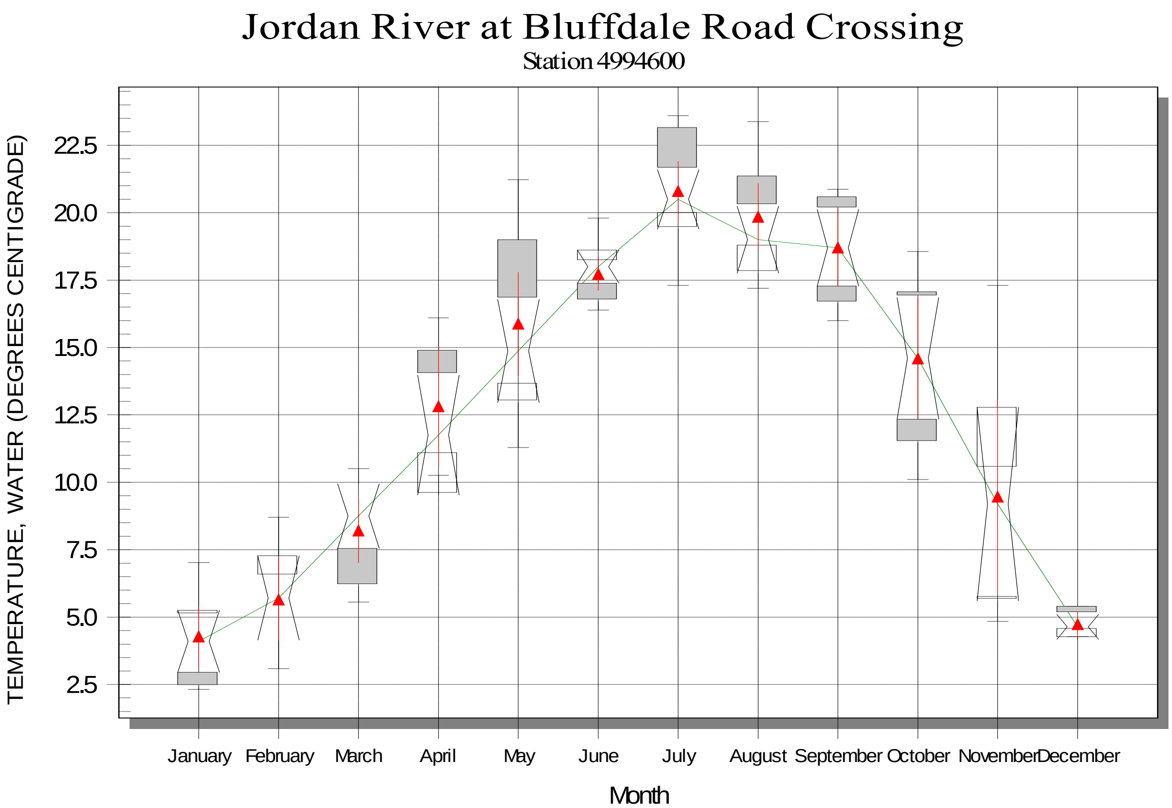


Figure 12. Mean water temperature levels measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River Segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Table 17. Percent of temperature measurements exceeding criteria in Jordan River Segments 5 through 7 that are considered to be impaired due to high temperature levels.

	7800 S (Segment 5)	Bluffdale Road (Segment 7)	Narrows (Segment 8)	Utah Lake (Segment 8)
Temperature Criteria	20 °C	20 °C	27 °C	27 °C
1999-2000				
Mean (°C)	13.84	14.03	14.37	15.23
n	15	17	10	15
Exceedance (%)	0	0	0	0
2004-2005				
Mean (°C)	12.60	15.40	11.35	15.68
n	9	26	7	11
Exceedance (%)	0	0	0	0
1995-2005				
Mean (°C)	13.57	13.67	12.55	13.97
n	55	97	27	50
Exceedance (%)	10.9	16.5	18.5	0

Note: 7800 South and Bluffdale Road are located on the downstream and upstream boundary of Segment 6, respectively.



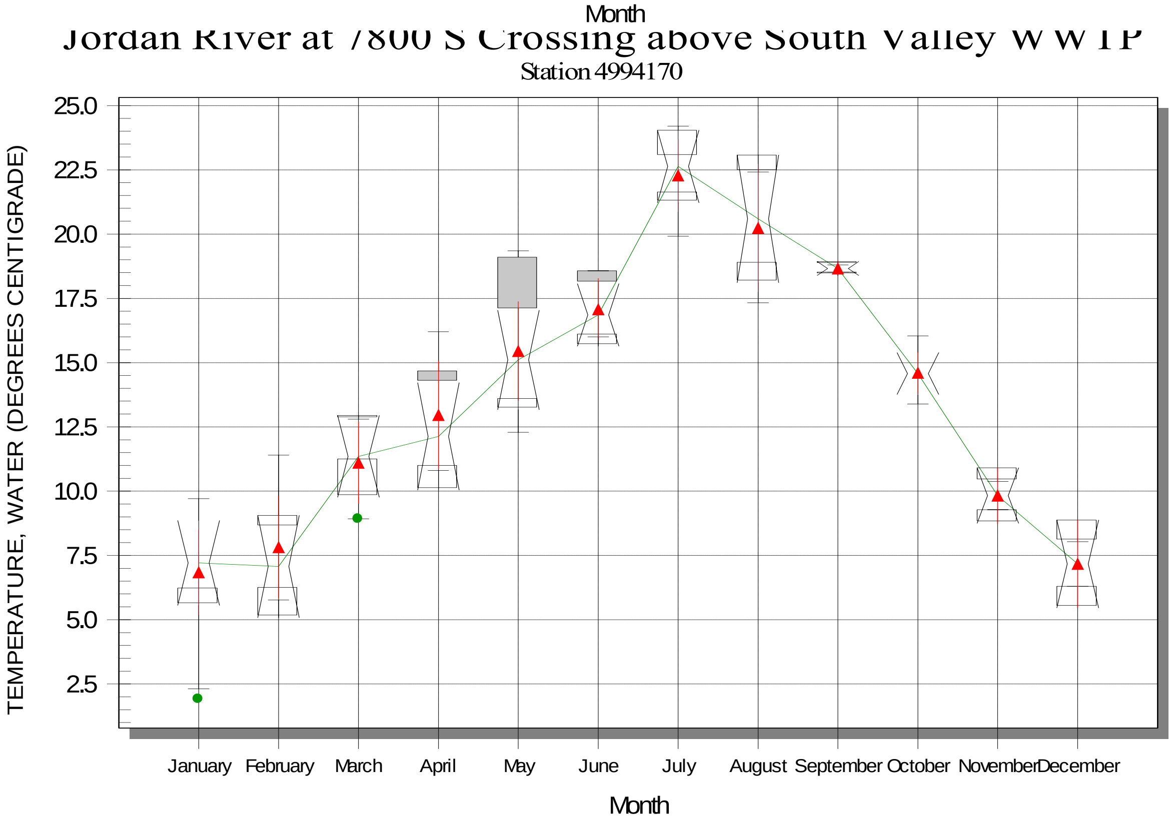


Figure 13. Mean monthly water temperature (°C) levels on impaired Jordan River segments including Bluffdale Road (upper plot) and 7800 South (lower plot). Data shown considers all field measurements of water temperature collected 1995 – 2005 including 97 measurements at Bluffdale Road and 55 measurements at 7800 South.

Diurnal water temperature was measured during the 2006 field DO monitoring efforts. Table 18 includes the mean characteristics of diurnal temperature cycles for impaired Segment 6. Information for the Utah Lake outlet (Segment 8) is included in Table 18 for comparison purposes. No diurnal temperature information was available for Segments 5 and 7. Temperature criteria associated with Segment 6 is 20 ºC while the Utah Lake outlet criteria is 27 ºC. Similar to DO, diurnal temperature shifts were greater in August than in June at all stations. Maximum diurnal temperatures were greater for Segment 6 in comparison to Segment 8. In general, minimum diurnal temperatures decreased below the Utah Lake outlet.

Time of minimum diurnal temperatures ranged from approximately 7:00 – 9:00 AM while maximum temperatures were recorded between 4:00 – 6:00 PM The amount of time diurnal water temperatures exceeded State criterion at each monitoring site was greater in June than during August and greatest at the Bangerter Road site. Diurnal water temperatures measured during either month did not exceed the 27 ºC temperature criteria at the Utah Lake outlet.

Table 18. Mean characteristics of diurnal water temperature measured during June 20-28, 2006 and August 8-11, 2006 on Jordan River Segment 6 that is considered impaired due to high temperature levels.

Water Temperature (°C)						
	June 20-28, 2006			August 8-11,2006		
Segment	**6**	**6**	**8**	**6**	**6**	**8**
Station	**9000 South**	**Bangerter Road**	**Utah Lake outlet**	**9000 South**	**Bangerter Road**	**Utah Lake outlet**
Min. Temperature (°C)	19.8	20.6	20.4	18.1	18.3	20.4
Max Temperature (°C)	23.4	22.8	22.5	23.9	25.8	24.7
Diurnal Shift (°C)	3.6	2.2	2.1	5.8	7.5	4.3
Time of Min.	7:07 AM	8:22 AM	7:45 AM	9:15 AM	8:45 AM	9:00 AM
Time of Max.	5:45 PM	4:37 PM	4:22 PM	4:45 PM	5:00 PM	4:15 PM
Temperature Criteria (°C)	20	20	27	20	20	27
Diurnal Hours > Criteria	19.1	22.7	0.0	13.7	14.0	0.0

Diurnal characteristics are also shown for the Jordan River at Utah Lake outlet (Segment 8) for comparison purposes.

The remainder of section 3.1.2 focuses on water quality parameters that can influence the pollutants of concern associated with Jordan River segments on the 2006 303(d) list.

3.1.2.5 Phosphorus

Phosphorus (P) is considered a pollution indicator by DWQ and is assessed using an indicator value for Total P of 0.05 mg/l. Concentrations above this level have been shown to result in a nutrient rich environment that is conducive to algal growth. Abundant algal growth can impact fishery habitat by creating an oxygen demand during decomposition of plant species at the end of their life cycle. Two forms of phosphorus have been typically measured during monitoring efforts, Dissolved Phosphorus (Dissolved P) and Total Phosphorus (Total P). Dissolved P represents a form of phosphorus that is readily available for plant uptake and use. Total P includes both particulate and dissolved forms of phosphorus and is the most common form of phosphorus measured in the analysis area.

Long term Dissolved P concentrations in the Jordan River ranged from 0.77 mg/L at 2100 S. to 0.02 mg/l at the Narrows (Table 19 and Figure 14). Dissolved P remained below the 0.05 mg/l indicator value until the upstream boundary of Segment 5 where it climbed rapidly and remained well above 0.05 mg/l through the remaining length of the Jordan River. Dissolved P concentrations in tributary streams were below the 0.05 mg/l indicator level during both intensive monitoring periods. Dissolved P concentrations in discharge from wastewater facilities was only measured during the 1999 – 2000 intensive monitoring period and included the highest concentrations in comparison to all monitoring sites, ranging from approximately 1.8 mg/l to 3.1 mg/l.

Table 19. Mean Dissolved Phosphorus concentrations and percent of samples in violation of pollution indicator levels.

			1999-2000			2004-2005			Long Term (1995-2005)		
Station	**Segment**	**Pollution Indicator Level (mg/l)**	**Mean (mg/l)**	**n**	**% Exceed**	**Mean (mg/l)**	**n**	**% Exceed**	**Mean (mg/l)**	**n**	**% Exceed**
State Canal	-	-	0.41	14	na	1.16	2	na	0.48	26	96.2
S. Davis WWTP	1	-	1.78	10	na	na	0	na	1.78	10	na
Cudahy Lane	1	0.05	0.43	14	100	1.00	6	100	0.52	35	100
North Temple	3	0.05	na	0	na	1.00	6	100	na	na	na
2100 S	4	0.05	0.61	11	100	1.30	6	100	0.77	28	96.4
Central Valley WRF	4	-	3.16	9	na	na	0	na	3.16	9	na
Mill Creek	4	0.05	0.03	11	9.1	0.02	6	0	0.03	27	3.7
BCC	4	0.05	0.01	11	0	0.01	6	0	0.02	27	0
LCC	4	0.05	0.04	10	20	0.03	6	0	0.03	26	11.5
5400 South	4	0.05	0.52	11	100	1.08	6	100	0.67	27	100
South Valley WRF	5	-	2.87	8	na	na	0	na	2.87	8	na
7800 S	5	0.05	0.07	11	54.5	0.02	6	0	0.05	27	25.9
Bluffdale Road	7	0.05	0.03	13	15.4	0.02	6	0	0.03	34	8.8
Narrows	8	0.05	0.03	10	20	0.01	6	0	0.02	26	11.5
Utah Lake	8	0.05	0.03	11	18.2	0.02	6	0	0.02	26	7.7

Information is based on data collected from the mainstem Jordan River, and select locations on diversions, tributaries and discharges to the Jordan River. Shaded rows indicate mainstem Jordan River stations. An assessment of long-term (1995-2005) conditions was not completed for sites with insufficient data.

The percent of Dissolved P samples exceeding the 0.05 mg/l indicator level was lowest in tributary streams to the Jordan River including some monitoring periods when all samples were below the indicator level (Table 19). Nearly all samples of Dissolved P measured on Jordan River segments below 7800 South violated the 0.05 mg/l indicator level. In contrast, fewer Dissolved P samples measured from Jordan River segments above 7800 South exceeded the 0.05 mg/l level, particularly during the 2004 – 2005 monitoring period when all samples measured below this level.

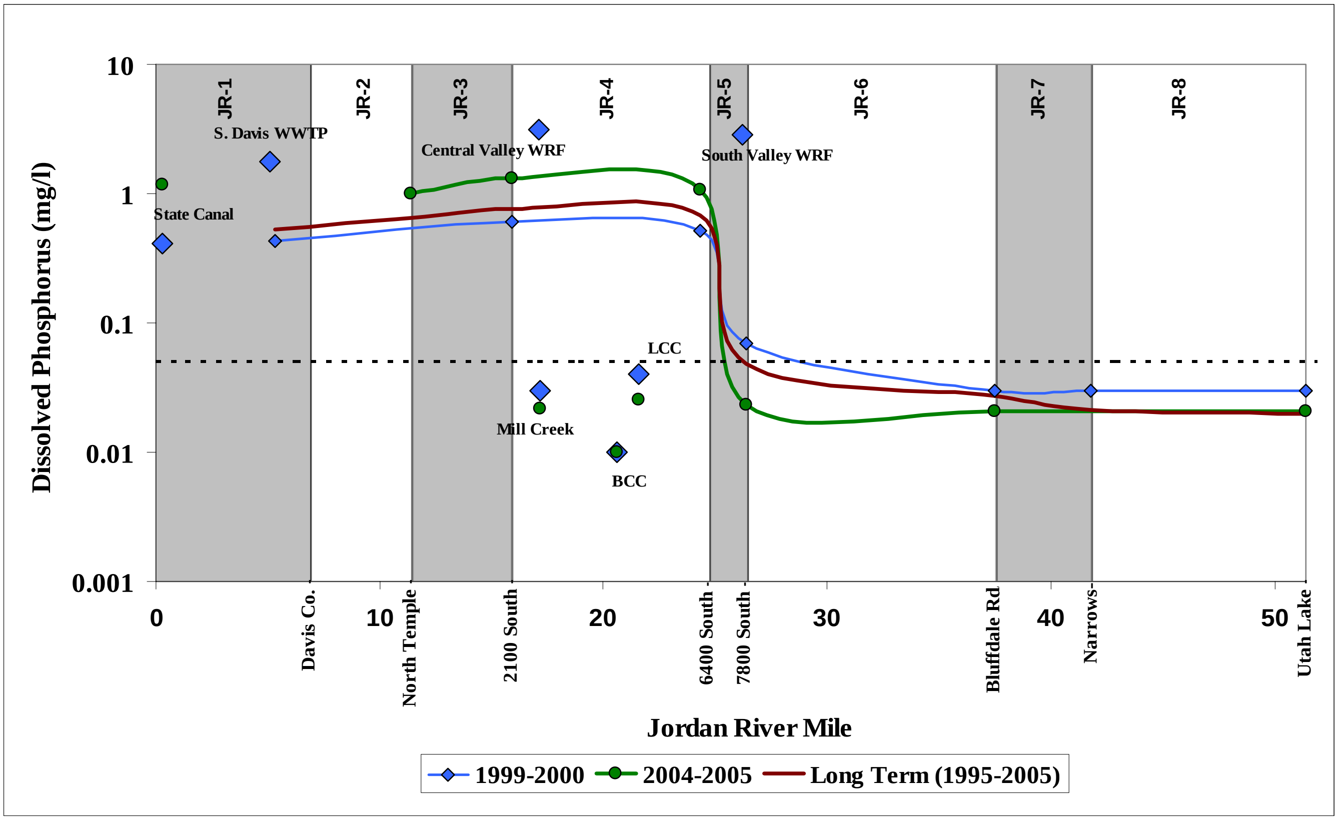
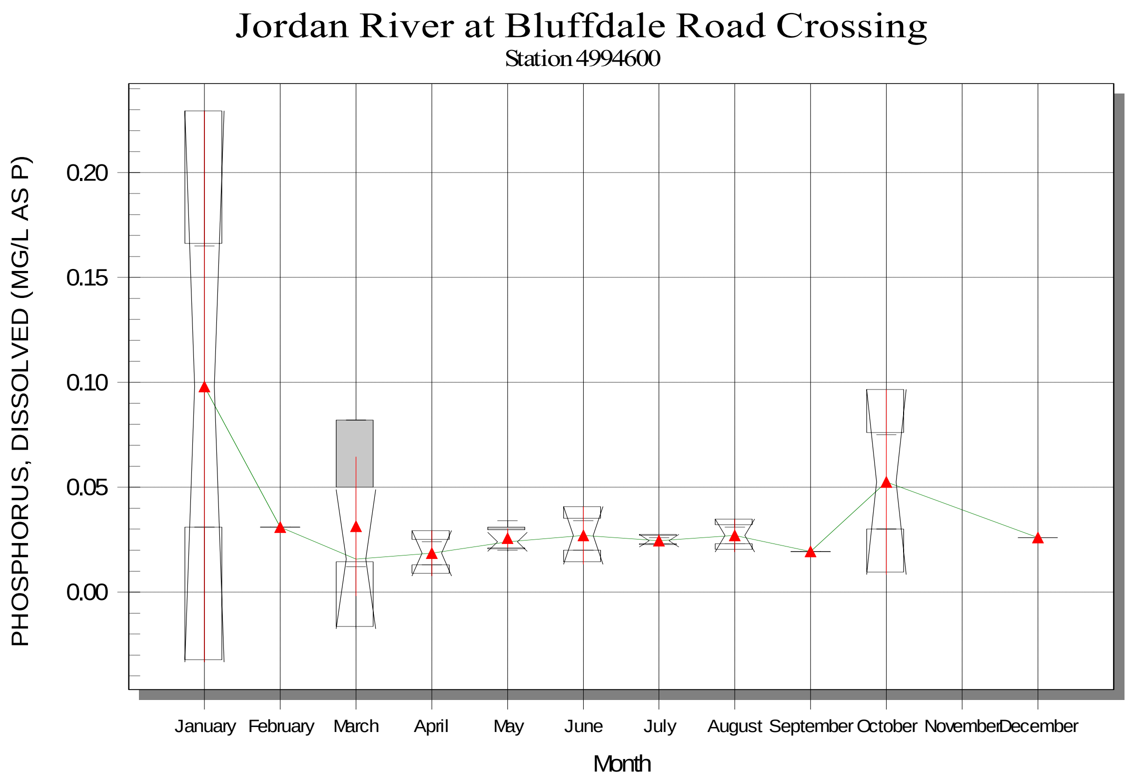


Figure 14. Mean Dissolved P concentration measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River Segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Seasonal variation of Dissolved P is shown in Figure 15 including the Jordan River at Bluffdale Road (upstream of 7800 South) and 2100 South. Monthly Dissolved P concentrations at Bluffdale Road showed little seasonal variation and were consistently below 0.05 mg/l with the exception of January and October. Seasonal trends were evident at 2100 South where Dissolved P concentrations were less than 0.05 mg/l only during May and June after which they steadily climbed to a maximum level in September.

Long-term Total P concentrations showed a pattern similar to Dissolved P at mainstem Jordan River sites and showed dramatic increases in Segment 5 just below the 7800 South monitoring site (Figure 16). Total P concentrations above 7800 South were slightly lower at most sites 2004 – 2005 than 1999 – 2000. However, below 7800 South all sites measured 2004 – 2005 had the highest mean concentrations in comparison to 1999 – 2000 or the long-term assessment period (1995 – 2005).



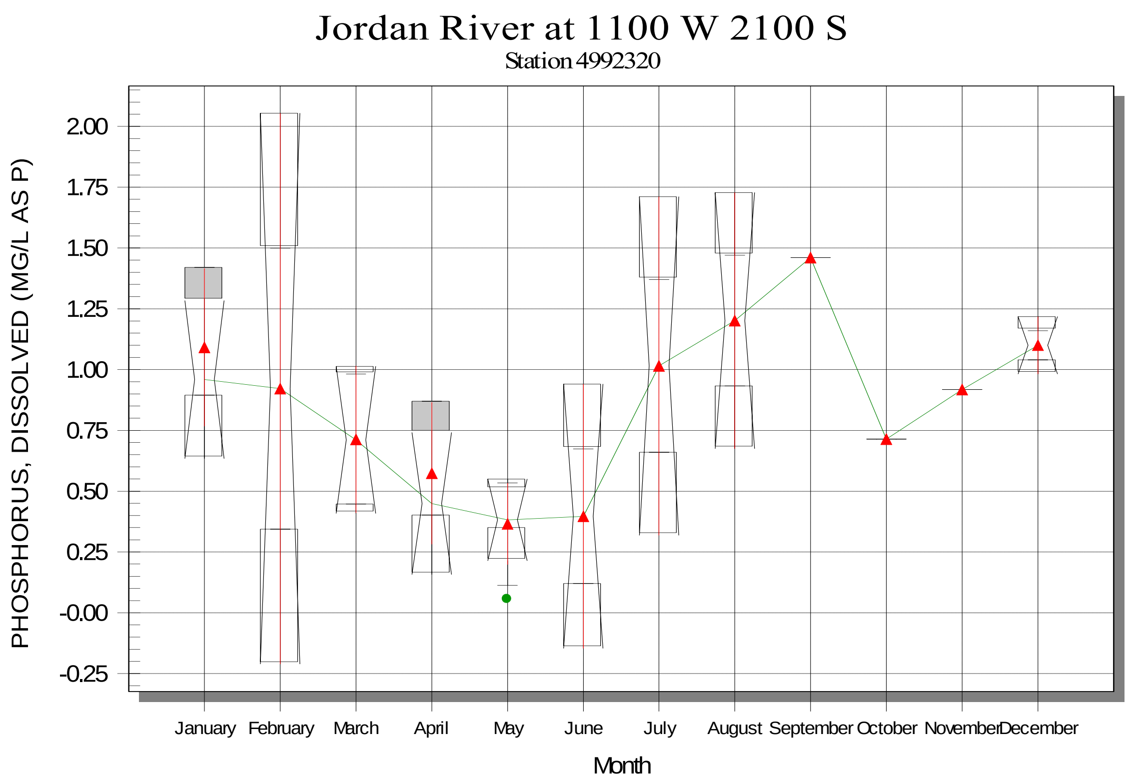


Figure 15. Monthly concentrations of Dissolved Phosphorus at select Jordan River monitoring stations including Bluffdale Road (segment 7, upper plot) and 2100 South (segment 4, lower plot). Data shown considers all samples of Dissolved P collected during 1995-2005 including 34 samples at Bluffdale Road and 28 samples at 2100 South.

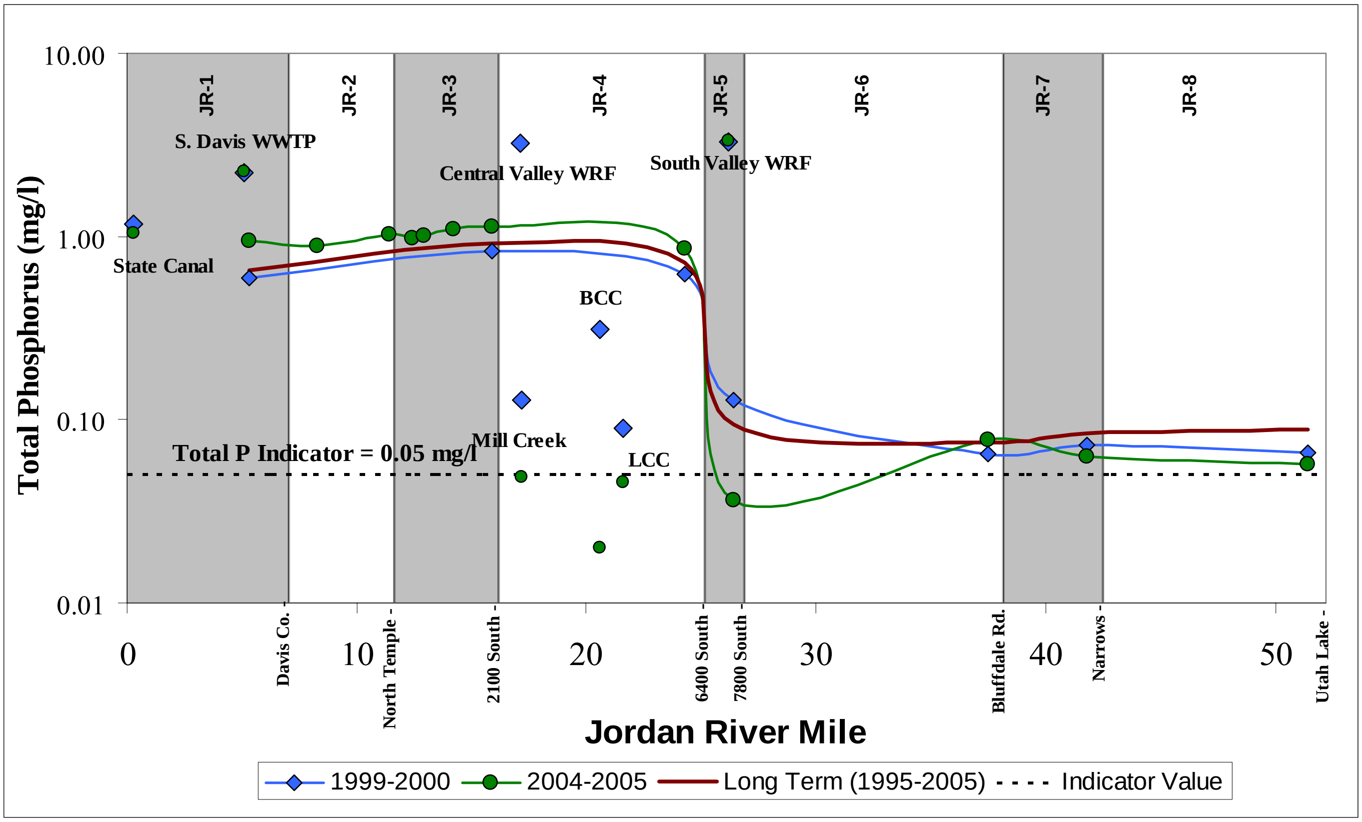


Figure 16. Mean concentrations of Total P measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

All Total P samples collected below 7800 South during intensive monitoring periods exceeded the 0.05 mg/l indicator level (Table 20). The assessment of all Total P samples collected 1995 – 2005 indicated that the indicator level was exceeded from approximately 65 percent to 100 percent of the time. Similar to the intensive monitoring periods, percent exceedance was generally lower at monitoring sites upstream of 7800 South compared to downstream sites.

Seasonal variation of Total P samples ranged between approximately 0.03 and 0.10 mg/l at Bludffdale Road (upstream of 7800 South) and from 0.70 to 1.50 mg/l at 2100 South (Figure 17). The timing of peak monthly concentrations was slightly different at each site. Total P concentrations were greatest during June at Bluffdale Road and during September at the 2100 South monitoring site. Minimum Total P concentrations were observed during November at Bluffdale Road and April-May at 2100 South.

Table 20. Mean Total P concentrations and percent of samples in violation of pollution indicator levels. Information is based on data collected from the mainstem Jordan River, and select locations on diversions, tributaries and discharges to the Jordan River. Shaded rows indicate mainstem Jordan River stations.

			1999-2000			2004-2005			Long Term (1995-2005)		
Station	**Segment**	**Pollution Indicator Level (mg/l)**	**Mean (mg/l)**	**n**	**% Exceed**	**Mean (mg/l)**	**n**	**% Exceed**	**Mean (mg/l)**	**n**	**% Exceed**
State Canal	-	-	1.18	15	na	1.04	10	na	0.83	67	na
S. Davis WWTP	1	-	2.22	10	na	2.25	5	na	2.23	15	na
Cudahy Lane	1	0.05	0.59	20	100	0.95	18	100	0.65	93	97.8
Redwood Road	2	0.05	na	0	na	0.89	9	100	na	na	na
North Temple	3	0.05	na	0	na	1.02	15	100	na	na	na
400 South	3	0.05	na	0	na	0.98	9	100	na	na	na
700 South	3	0.05	na	0	na	1.01	9	100	na	na	na
1300 South	3	0.05	na	0	na	1.09	9	100	na	na	na
2100 S	4	0.05	0.84	11	100	1.14	15	100	0.91	37	94.6
Central Valley WRF	4	-	3.22	9	na			na	3.13	13	na
Mill Creek	4	0.05	0.13	11	45.5	0.05	6	50	0.10	27	48.1
BCC	4	0.05	0.31	11	36.4	0.02	6	0	0.16	27	33.3
LCC	4	0.05	0.09	10	70	0.05	6	33.3	0.07	26	61.5
5400 South	4	0.05	0.63	11	100	0.86	15	100	0.72	37	100
South Valley WRF	5	-	3.27	8	na	3.33	5	na	3.29	13	na
7800 S	5	0.05	0.13	11	72.7	0.04	6	16.7	0.09	27	66.7
Bluffdale Road	7	0.05	0.06	15	73.3	0.08	18	61.1	0.08	82	68.3
Narrows	8	0.05	0.07	10	70	0.06	6	66.7	0.08	26	76.9
Utah Lake	8	0.05	0.07	13	61.5	0.06	11	45.5	0.09	49	67.3

An assessment of long-term (1995-2005) conditions was not completed for sites with insufficient data.

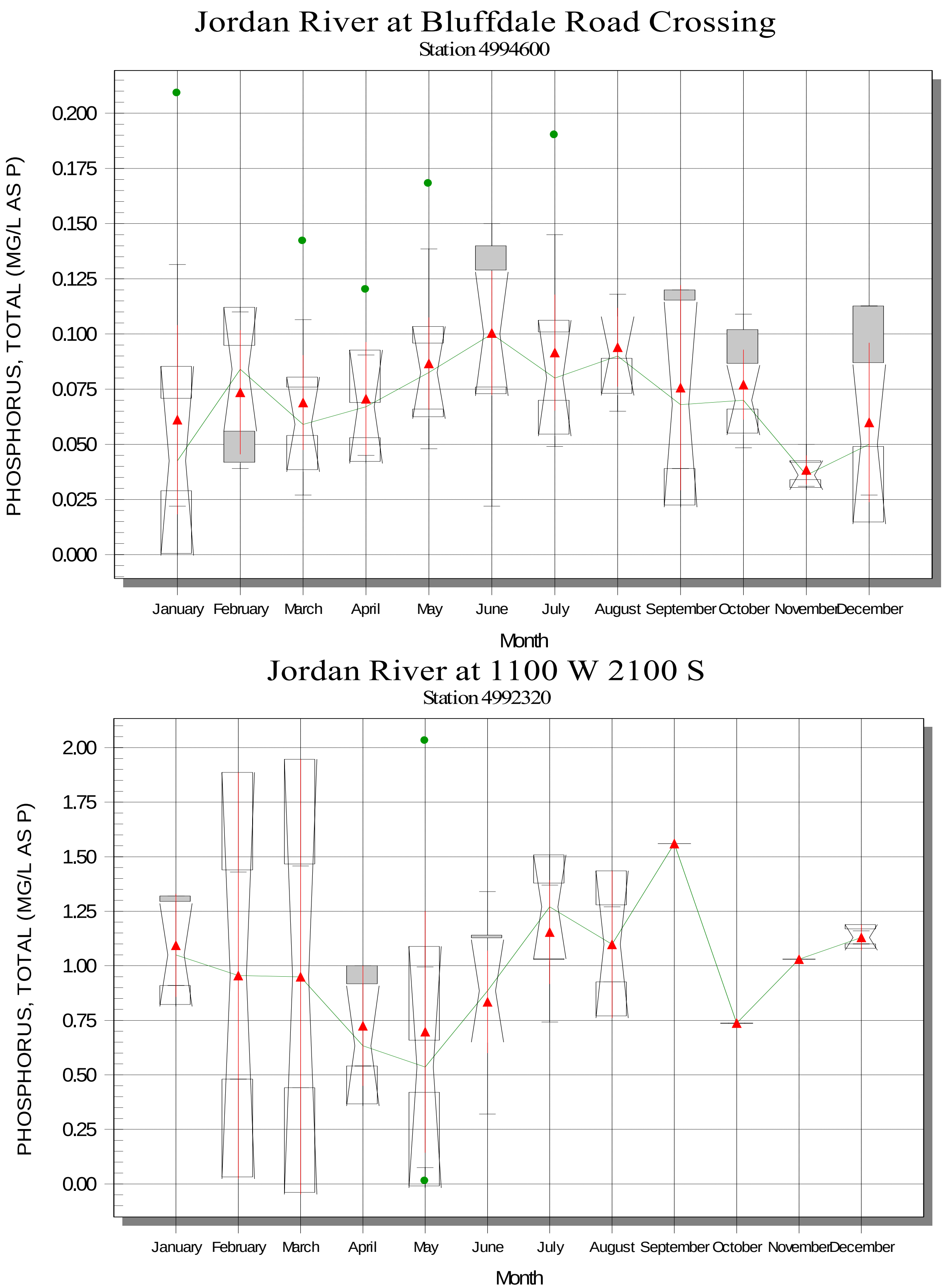


Figure 17. Monthly concentrations of Total P at select Jordan River monitoring stations including Bluffdale Road (segment 7, upper plot) and 2100 South (segment 4, lower plot). Data shown considers all samples of Total P samples collected during 1995-2005 including 82 samples at Bluffdale Road and 37 samples at 2100 South.

3.1.2.6 Ammonia

High Ammonia levels can promote in-river nitrification, which in turn creates oxygen demand and low DO concentrations. The criteria used to assess Ammonia includes both a 30-day and a 1-hour criterion which are based on a function of pH and/or temperature values. This assessment utilizes the 1-hour criterion as defined in Utah Code R317-2 (Table 2.14.2 footnote 9b). This equation requires a simultaneous measurement of pH to define the 1-hour criterion.

Long-term mean Ammonia (Total Amonia) concentrations at Jordan River monitoring stations decreased below the outlet of Utah Lake down through Segment 6 and then increased steadily through Cudahy Lane (Figure 18). Ammonia concentrations during 2004 – 2005 were initially high at the Utah Lake outlet then decreased below the long-term and 1999 – 2000 mean concentrations with the exception of the upstream portion of Segment 4. Ammonia concentrations from wastewater discharge were higher than mean concentrations measured at mainstem monitoring sites.

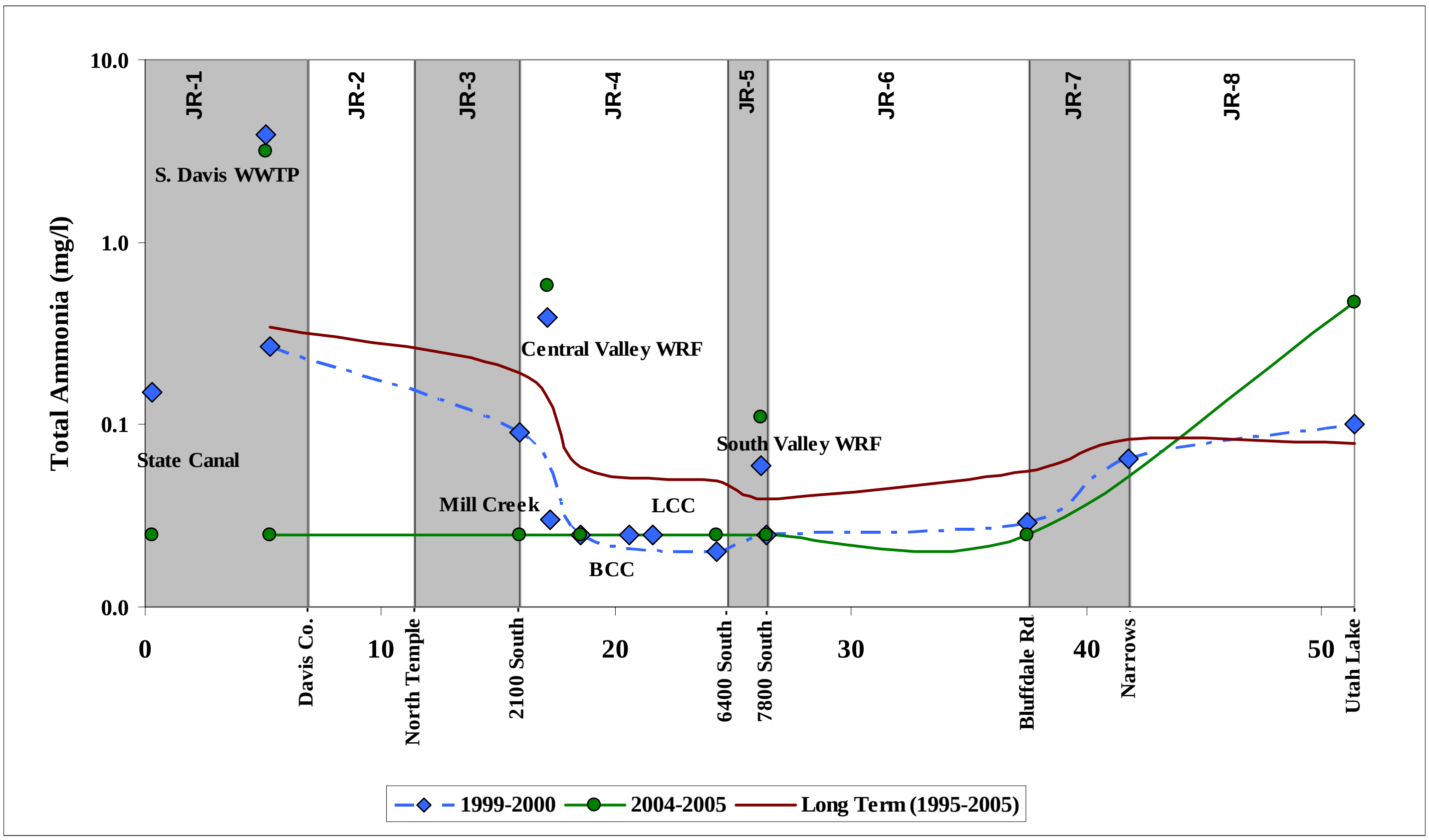


Figure 18. Mean concentrations of Ammonia (NH4 as N) measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Table 21 indicates the percent of Ammonia samples that exceeded criteria. No Ammonia samples exceeded criteria at any monitoring station located on the mainstem Jordan River or tributary monitoring stations. A substantial number of samples were available at most monitoring sites during 1995 – 2005 and provide a good characterization of Ammonia in the analysis area.

Table 21. Concentrations of Ammonia (NH4 as N) and percent of samples in violation of the 1-hour numeric criterion. This criterion is a function of pH measured at the time of sampling (R317-2 Table 2.14.2 footnote 9b).

		1999-2000			2004-2005			Long Term (1995-2005)		
Stations	**Segment**	**Mean (mg/l)**	**n**	**% Exceed**	**Mean (mg/l)**	**n**	**% Exceed**	**Mean (mg/l)**	**n**	**% Exceed**
State Canal	-	0.15	16	na	0.03	3	0	0.25	66	0
S. Davis WWTP	1	3.90	17	na	3.14	2	na	1.70	64	na
Cudahy Lane	1	0.27	15	0	0.03	3	0	0.34	70	0
2100 S	4	0.09	14	0	0.03	2	0	0.19	52	0
Central Valley WRF	4	0.39	17	na	0.58	3	na	1.46	66	na
Mill Creek	4	0.03	11	0	na	0	na	0.03	21	0
3300 S	4	0.03	8	0	0.03	2	0	0.06	35	0
BCC	4	0.03	11	0	na	0	na	0.03	21	0
LCC	4	0.03	10	0	na	0	na	0.04	20	0
5400 South	4	0.02	14	0	0.03	2	0	0.05	49	0
South Valley WRF	5	0.06	15	na	0.11	3	0	0.10	60	na
7800 S	5	0.03	14	0	0.03	2	0	0.04	48	0
Bluffdale Road	7	0.03	15	0	0.03	3	0	0.06	73	0
Narrows	8	0.06	10	0	na	0	na	0.08	20	0
Utah Lake	8	0.10	12	0	0.47	11	0	0.08	47	0

Information shown is based on data collected from the mainstem Jordan River, and select locations on diversions, tributaries and discharges to the Jordan River. Shaded rows indicate mainstem Jordan River stations.

Figure 19 indicates the seasonal distribution of Ammonia for Segment 1. A slight bimodal trend of monthly Ammonia concentrations was observed at Cudahy Lane. At this station, concentrations decreased from February to May. An upward trend was then observed from May though August and September, after which there was again a decline in mean concentrations in October and November.

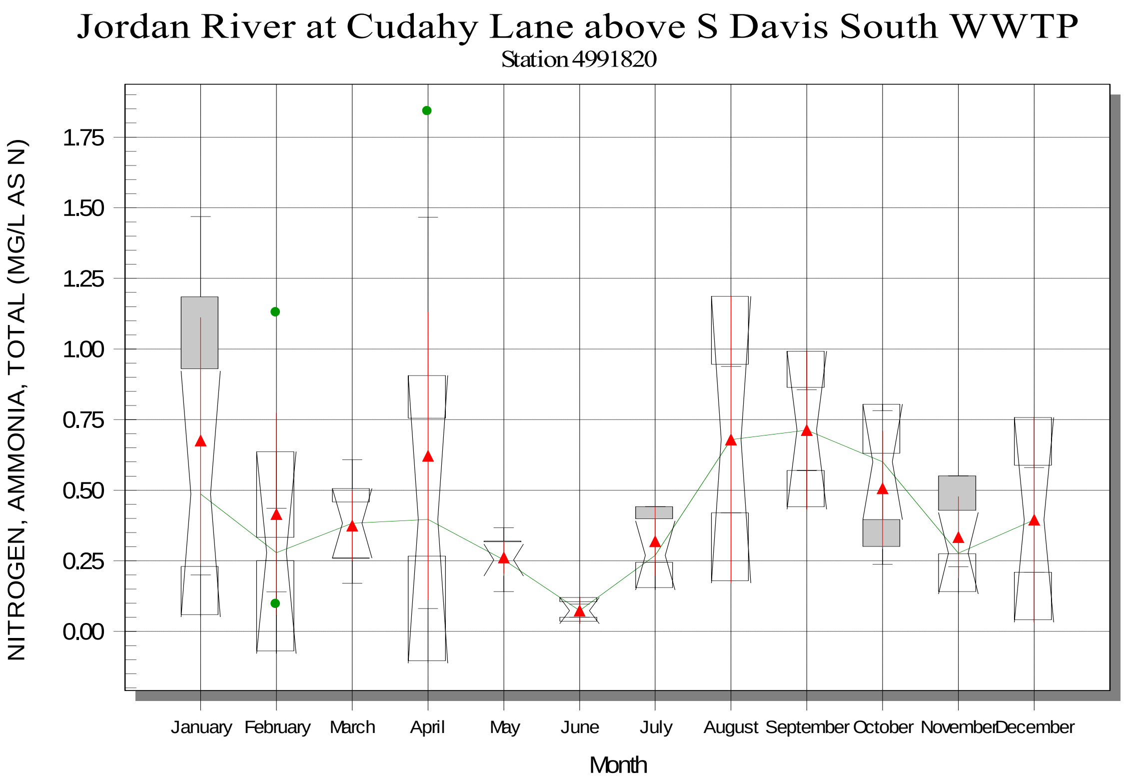


Figure 19. Monthly concentrations of Ammonia at Cudahy Lane located on DO impaired Jordan River Segment 1. Data shown considers all 70 samples of Total Ammonia collected during 1995 – 2005 at Cudahy Lane.

3.1.2.7 BOD

Similar to Total P, the DWQ considers BOD to be a pollution indicator. The indicator value used by DWQ to assess BOD is 5 mg/l. BOD is a measure of the quantity of oxygen consumed by micro-organisms during the decomposition of organic matter. Long-term mean BOD concentrations in the Jordan River were very similar yet showed slight increases with distance downstream from 7800 South (Figure 20). Mean BOD concentrations at mainstem Jordan River monitoring sites were below 5 mg/l during all assessment periods. Mean BOD concentrations from wastewater discharge were higher than mean concentrations measured at mainstem monitoring sites.

Table 22 indicates the percent of BOD samples that exceeded 5 mg/l. BOD measurements were collected at a limited number of sites during the 1999 – 2000 intensive monitoring period and otherwise from 1995 through 2005. Slight exceedances of the indicator value were observed at sites located on Segments 1 through 4 during the 2004 – 2005 intensive monitoring period. The highest percent of BOD samples that exceeded the 5 mg/l indicator value was observed during the long-term assessment period at Cudahy Lane, which is located on Jordan River Segment 1. As mentioned previously, this segment is currently listed as impaired for low DO concentrations.

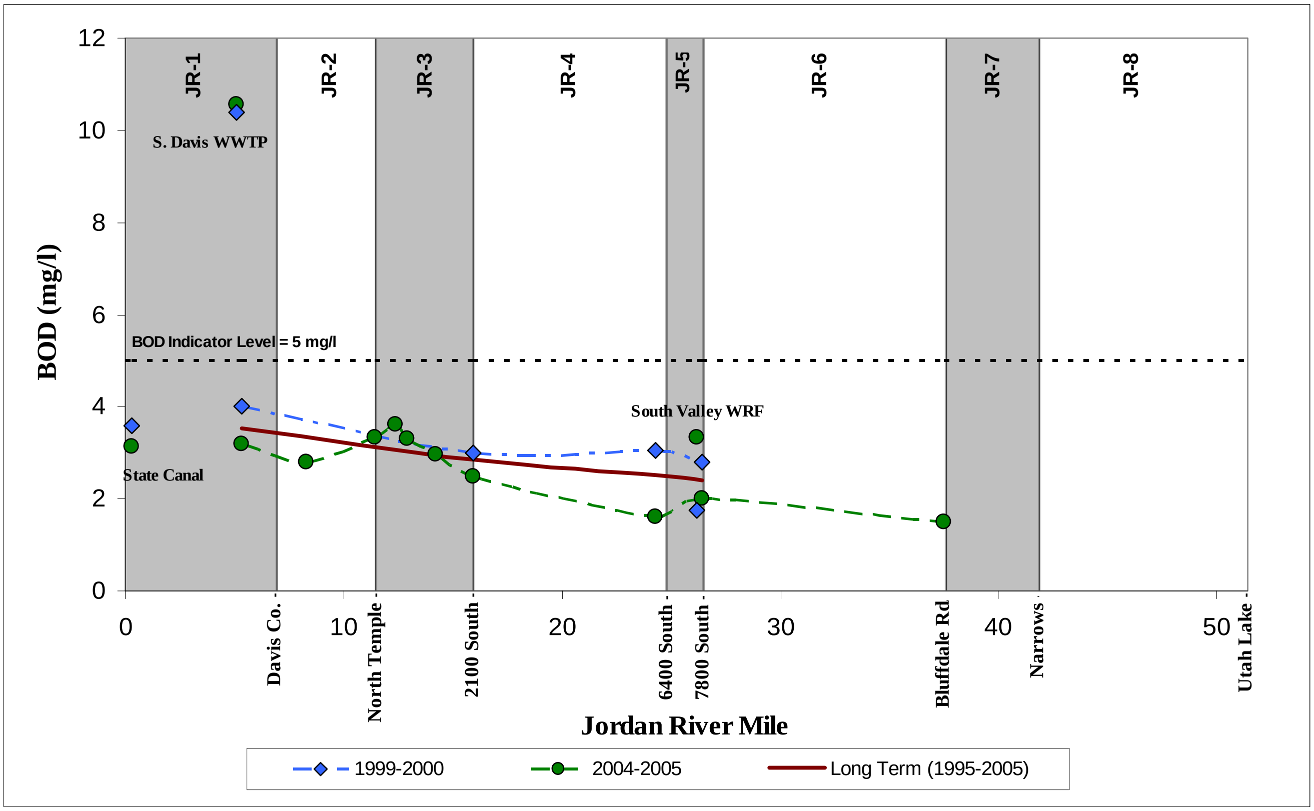


Figure 20. Mean concentrations of BOD measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Table 22. Mean concentrations of BOD and percent of samples in violation of pollution indicator levels.

			1999-2000			2004-2005			Long Term (1995-2005)		
Station	Segment	Pollution Indicator Level (mg/l)	Mean (mg/l)	n	% Exceed	Mean (mg/l)	n	% Exceed	Mean (mg/l)	n	% Exceed
State Canal	-	-	3.14	7	na	3.59	5	na	3.96	41	na
S. Davis WWTP	1	-	10.55	11	na	10.40	8	na	10.59	65	na
Cudahy Lane	1	5	4.02	7	0.0	3.18	14	14.3	3.52	51	17.6
Redwood Road	2	5	na	0	na	2.79	9	0.0	na	na	na
North Temple	3	5	na	0	na	3.32	9	11.1	na	na	na
400 South	3	5	na	0	na	3.63	9	11.1	na	na	na
700 South	3	5	na	0	na	3.30	9	11.1	na	na	na
1300 South	3	5	na	0	na	2.96	9	0.0	na	na	na
2100 S	4	5	2.99	6	0.0	2.47	14	7.1	2.86	44	9.1
5400 South	4	5	3.04	6	0.0	1.60	14	0.0	2.53	42	0.0
South Valley WRF	5	-	3.34	11	9.1	1.76	9	0.0	2.84	53	na
7800 S	5	5	2.79	6	0.0	2.00	3	0.0	2.39	30	0.0
Bluffdale Road	7	5	na	0	na	1.50	9	0.0	na	na	na

Information is based on data collected from the mainstem Jordan River and discharges to the Jordan River. Shaded rows indicate mainstem Jordan River stations. An assessment of long-term (1995-2005) conditions was not completed for sites with insufficient data.

Seasonal variation of BOD is shown in Figure 21 and indicates a slight bimodal trend with monthly peaks occurring in late winter and early fall seasons. Monthly BOD concentrations were lowest during the month of June which corresponded to the only month with a mean BOD concentration below the 5 mg/l indicator value.

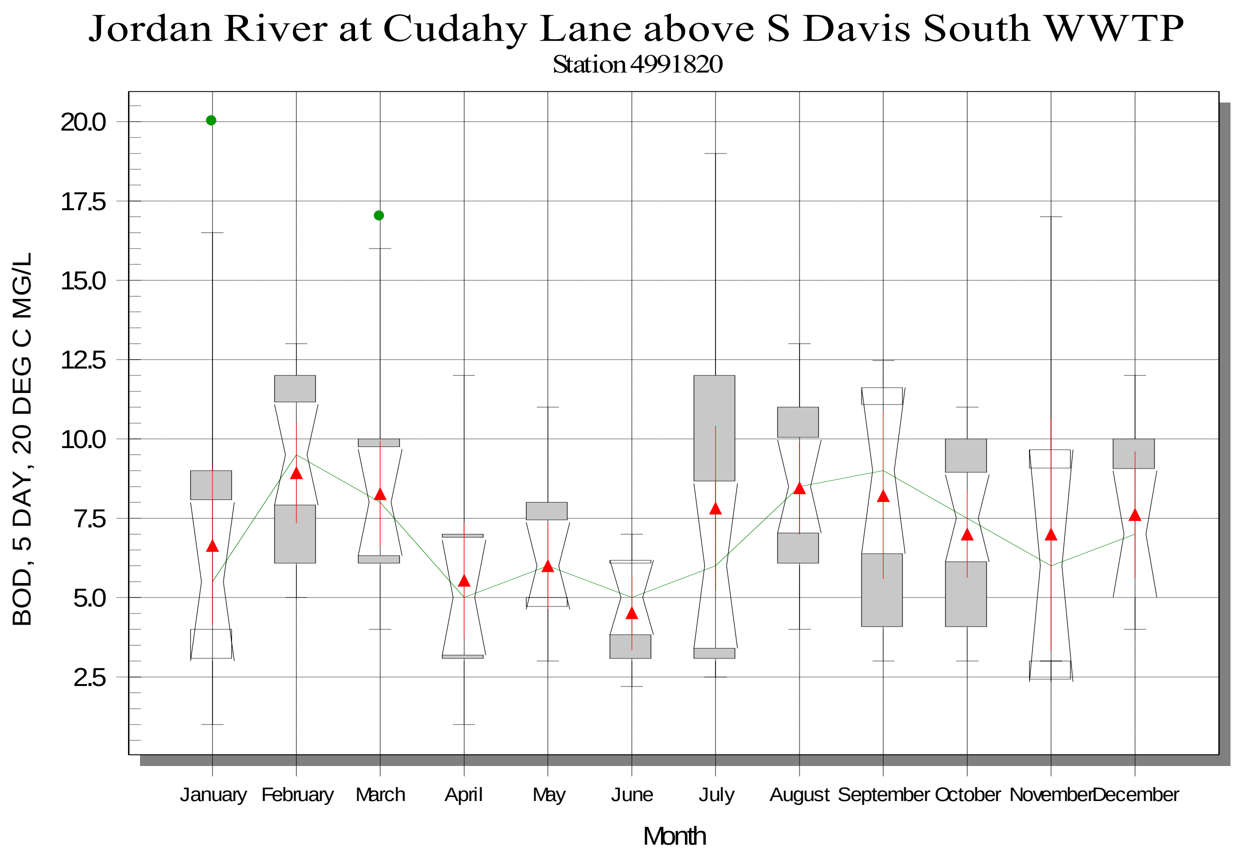


Figure 21. Monthly concentrations of BOD at Cudahy Lane located on DO impaired Jordan River segment 1. Due to the limited amount of data available for some months, all 167 BOD samples collected during the period of record (1975-2005) were considered in this assessment.

<u>3.1.2.8 pH</u>

Mean pH in the Jordan River ranged from approximately 7.7 at North Temple to 8.2 at Bluffdale Road and the Narrows (Figure 22). Measured pH values from tributaries and diversions were in this range while pH values from wastewater discharge was below this range. Central Valley WRF had the lowest long-term mean pH at approximately 7.2. Mean pH across all stations remained within the standard range used by DWQ to determine impairment in these stream sections (i.e., between 6.5 and 9). Mean pH levels during 1999 – 2000 and 2004 – 2005 intensive monitoring closely followed the long-term values. In general, mean pH levels in 1999 – 2000 were slightly above those calculated for 2004 – 2005.

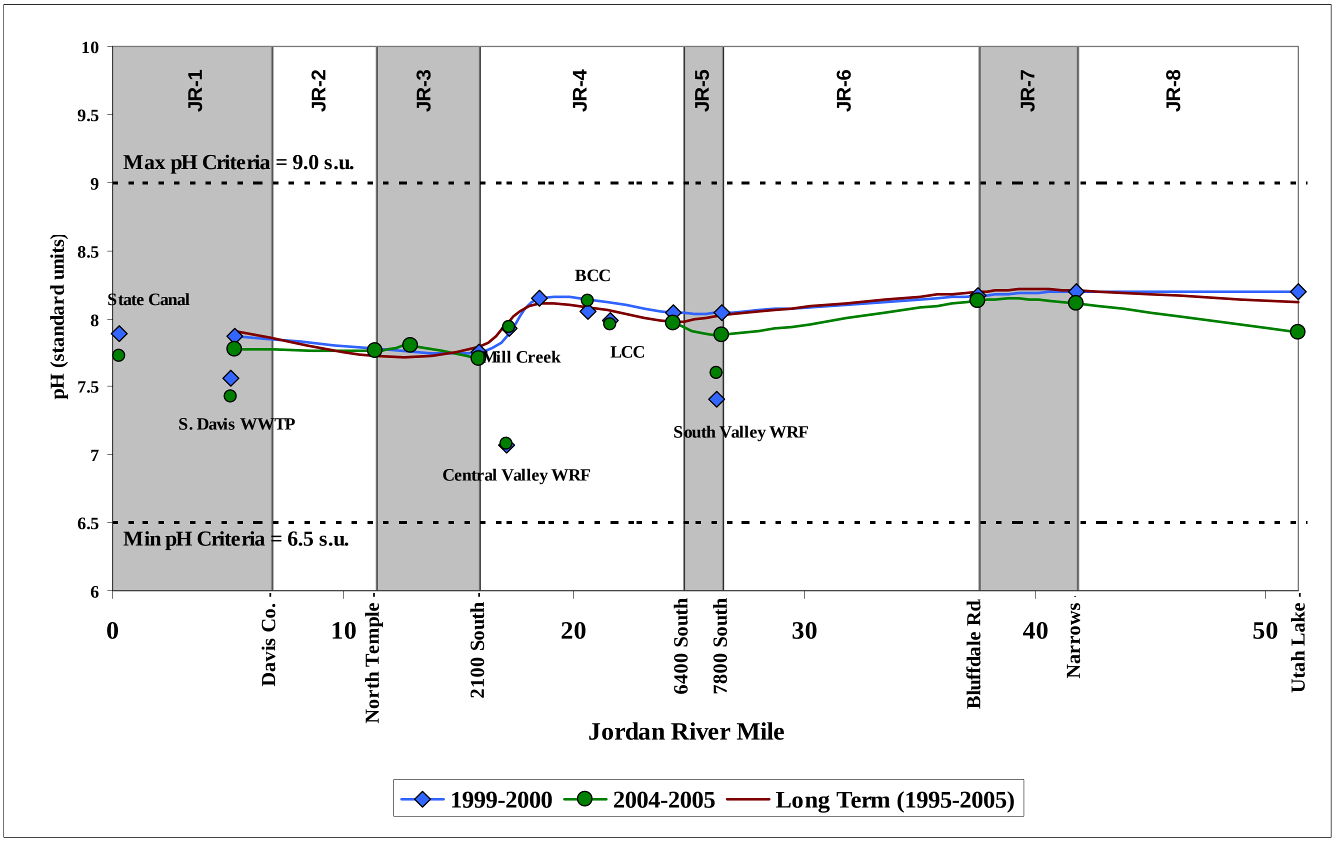


Figure 22. Mean pH levels measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Violation of pH criteria was typically non-existent with one exception at Bluffdale Road where 1.2 percent of the samples exceeded the pH criteria as shown in Table 23. A minor amount of variation in Jordan River pH levels was observed with distance downstream from Utah Lake, with the largest variation occurring below Mill Creek.

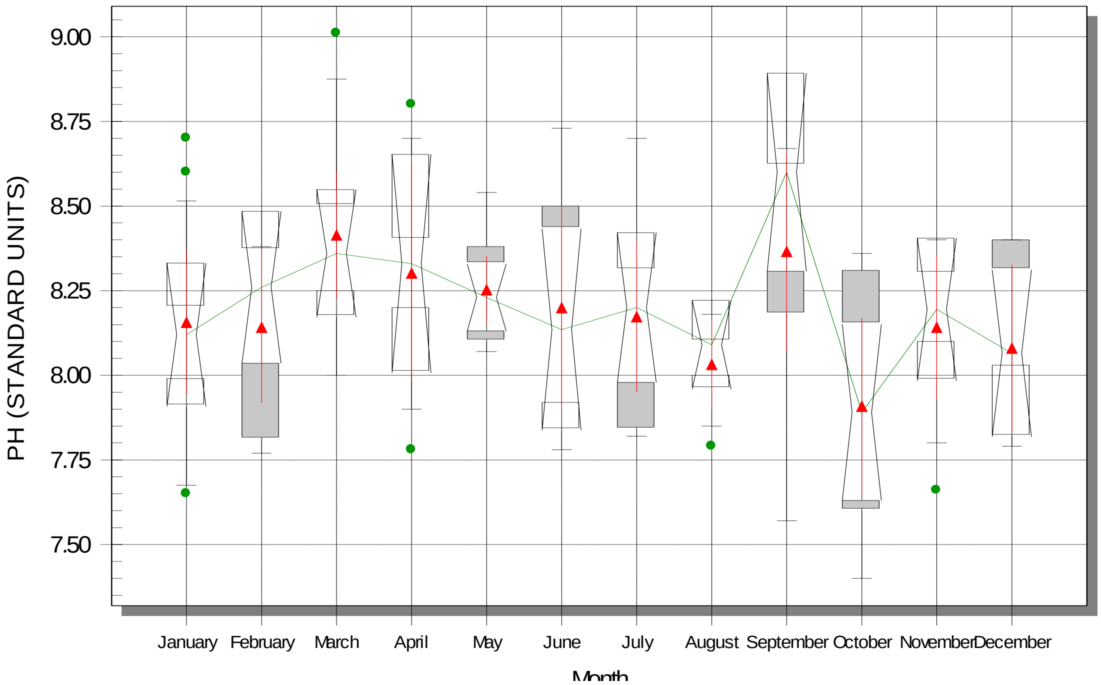
Monthly variation of pH levels is shown in Figure 23 for Bluffdale Road and Cudahy Lane. All monthly mean pH levels at Bluffdale Road were between 8.5 and 8.0 except for October which dropped slightly below 8.0. The maximum pH mean at Bluffdale Road occurred in March followed by a second peak in September. Monthly mean pH levels at Cudahy Lane ranged between 7.5 and 8.0 with the exception of peak values that exceeded 8.0 in October and May and the minimum value which dropped below 7.5 in August. Except for slight variations, pH levels at Bluffdale Road and Cudahy Lane generally increased to maximum pH levels in the spring season then declined to minimum pH levels in the fall.

Table 23. Mean pH values and percent exceedance of monitoring data collected from the mainstem Jordan River, tributaries and discharges to the Jordan River.

		1999-2000			2004-2005			Long Term (1995-2005)		
Station	**Segment**	**Mean**	**n**	**% Exceed**	**Mean**	**n**	**% Exceed**	**Mean**	**n**	**% Exceed**
State Canal	-	7.89	21	na	7.73	10	na	7.91	84	na
S. Davis WWTP	1	7.56	18	na	7.43	8	na	7.54	72	na
Cudahy Lane	1	7.87	18	0	7.77	12	0	7.91	83	0
North Temple	3	na	0	na	7.76	6	0	7.73	9	0
700 South	3	na	0	na	7.80	3	0	na	na	na
2100 S	4	7.75	15	0	7.71	9	0	7.79	61	0
Central Valley WRF	4	7.07	18	na	7.08	9	na	7.17	72	na
Mill Creek	4	7.93	11	0	7.94	7	0	7.94	27	0
3300 S	4	8.15	8	0	na	0	na	8.11	40	0
BCC	4	8.05	11	0	8.13	7	0	8.12	27	0
LCC	4	7.99	11	0	7.96	7	0	8.07	27	0
5400 South	4	8.04	15	0	7.97	9	0	7.98	55	0
South Valley WRF	5	7.41	17	na	7.60	9	na	7.51	69	na
7800 S	5	8.04	15	0	7.88	9	0	8.02	54	0
Bluffdale Road	7	8.17	17	0	8.13	12	0	8.20	82	1.2
Narrows	8	8.20	10	0	8.11	7	0	8.21	26	0
Utah Lake	8	8.20	15	0	7.90	11	0	8.12	49	0

Shaded rows indicate mainstem Jordan River stations. An assessment of long-term (1995-2005) conditions was not completed for sites with insufficient data.

Jordan River at Bluffdale Road Crossing
Station 4994600



Jordan River at Cudahy Lane above S Davis South WWTP
Station 4991820

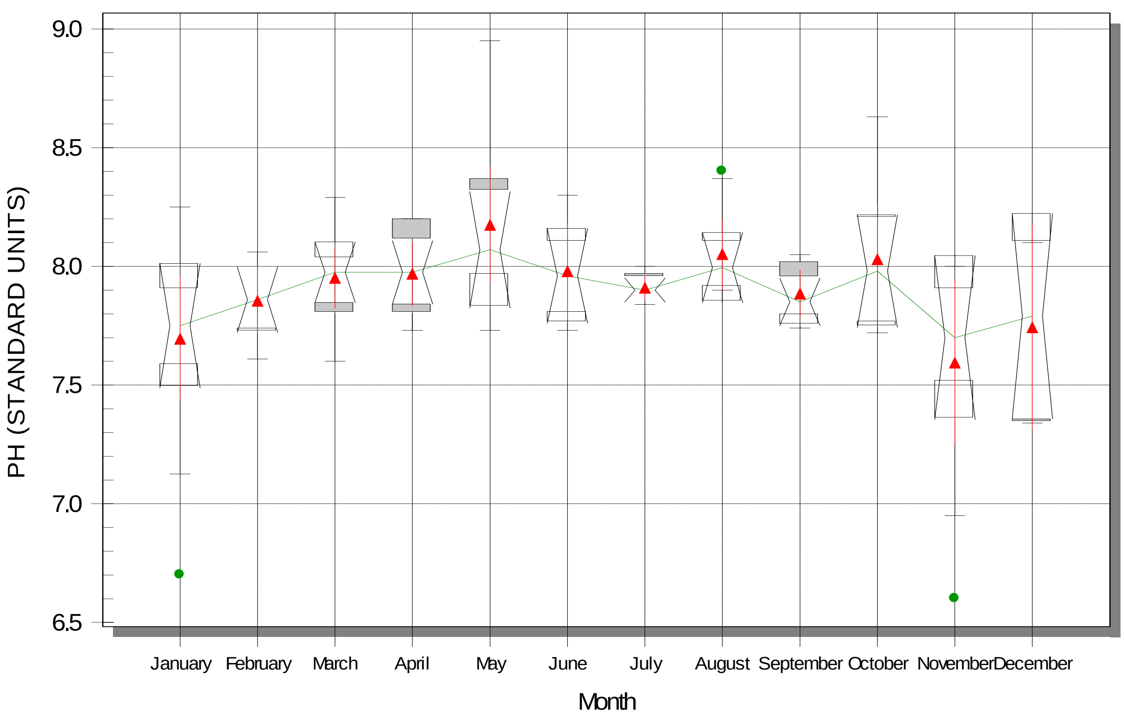


Figure 23. Monthly pH levels at select Jordan River monitoring stations including Bluffdale Road (segment 7, upper plot) and Cudahy Lane (segment 1, lower plot). Data shown considers all field measurements of pH collected during 1995-2005 including 82 measurements at Bluffdale Road and 174 measurements at Cudahy Lane.

3.1.2.9 Total Suspended Solids

TSS was previously used as a pollution indicator by DWQ to protect water bodies associated with a cold or warm water fishery beneficial use. The value previously used by DWQ for the Jordan River was 90 mg/l. TSS has been removed from Utah water quality standards and is no longer used for assessment purposes on the Utah 303(d) list of impaired water bodies. This constituent provides a measure of material suspended in the water column and can be used as an indicator of soil erosion from channel banks or land surfaces that contribute surface runoff to the Jordan River. Eroded sediment can also transport phosphorus to receiving water bodies as a consequence of phosphorus adsorption to soil particles.

Long-term mean TSS concentrations on the Jordan River increased substantially between the outlet of Utah Lake and the Narrows (Figure 24). TSS concentrations reached a maximum level at the Narrows monitoring station during all assessment periods. In general, mean TSS concentrations were greatest during 1999 – 2000 than during the other two assessment periods. TSS concentrations measured from tributaries and wastewater discharge were consistently lower than mainstem sites with the exception of Little Cottonwood Creek during 1999 – 2000.

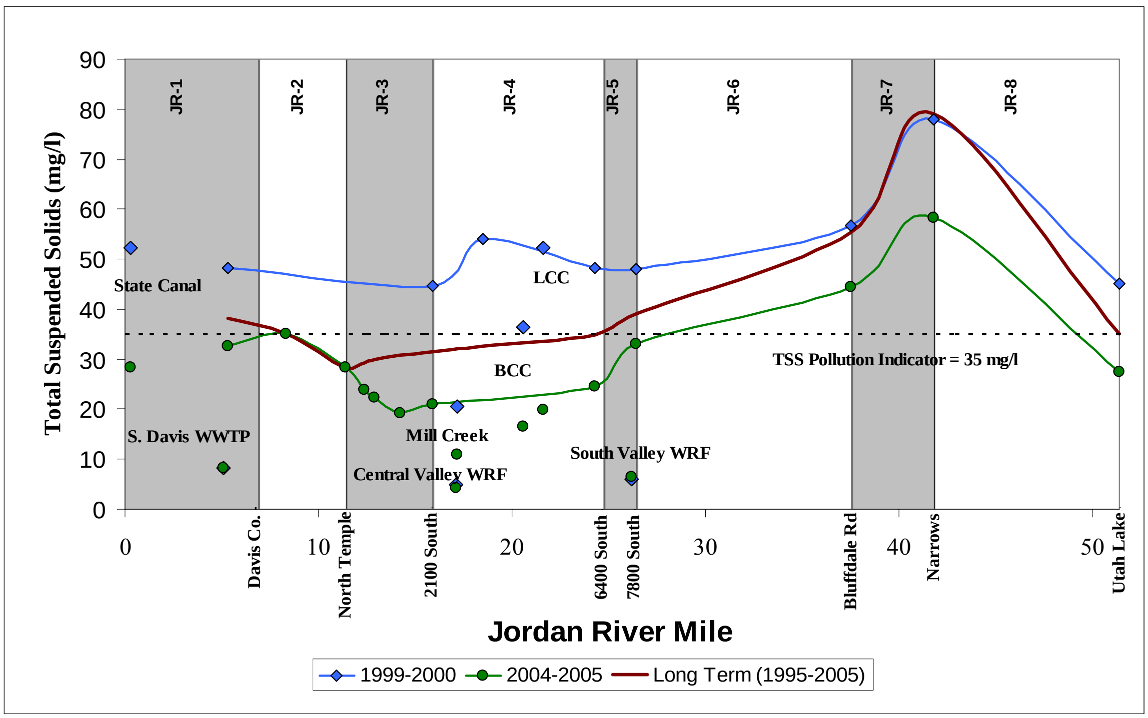


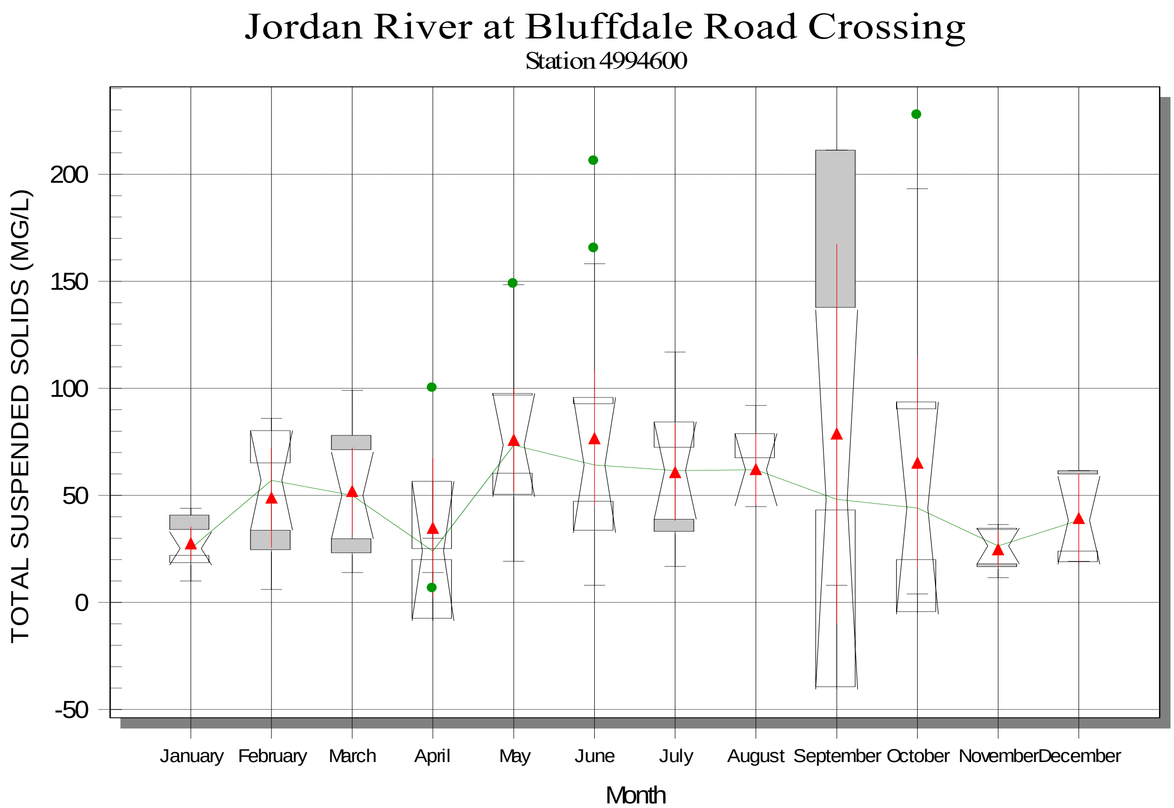
Figure 24. Mean concentrations of TSS measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Table 24. Mean TSS concentration and percent of samples in violation of pollution indicator levels.

		1999-2000		2004-2005		Long Term (1995-2005)	
Station	**Segment**	**Mean (mg/l)**	**n**	**Mean (mg/l)**	**n**	**Mean (mg/l)**	**n**
State Canal	-	52.2	17	28.4	10	42.2	71
S. Davis WWTP	1	8.2	17	8.3	8	9.0	75
Cudahy Lane	1	48.2	17	32.6	18	38.2	88
Redwood Road	2	na	0	35.1	9	na	na
North Temple	3	na	0	28.4	15	na	na
400 South	3	na	0	24.0	9	na	na
700 South	3	na	0	22.3	9	na	na
1300 South	3	na	0	19.1	9	na	na
2100 S	4	44.7	14	21.1	17	31.4	56
Central Valley WRF	4	4.9	17	4.2	9	5.2	73
Mill Creek	4	20.6	11	11.0	6	25.1	27
3300 S	4	54.0	8	19.1	5	32.6	27
BCC	4	36.3	11	16.5	6	33.4	27
LCC	4	52.4	11	19.9	6	39.3	27
5400 South	4	48.3	14	24.6	17	34.8	55
South Valley WRF	5	5.9	15	6.5	9	4.8	72
7800 S	5	48.0	14	33.1	8	39.1	46
Bluffdale Road	7	56.6	16	44.4	18	55.4	88
Narrows	8	78.0	10	58.2	6	79.1	26
Utah Lake	8	45.1	14	27.4	11	35.0	50

Information is based on data collected from the mainstem Jordan River, and select locations on diversions, tributaries and discharges to the Jordan River. Shaded rows indicate mainstem Jordan River stations. An assessment of long-term (1995-2005) conditions was not completed for sites with insufficient data.

Seasonal variation of TSS is shown in Figure 25 for Cudahy Lane and Bluffdale Road. In general, monthly concentrations of TSS were lower at the Cudahy Lane site than at Bluffdale Road. The maximum monthly concentration at both sites exceeded 50 mg/l. Monthly concentrations at Cudahy Lane showed a gradual increase from January through July and August when monthly concentrations peaked. Peak monthly concentrations at Bluffdale road occurred in May and June and again during September.



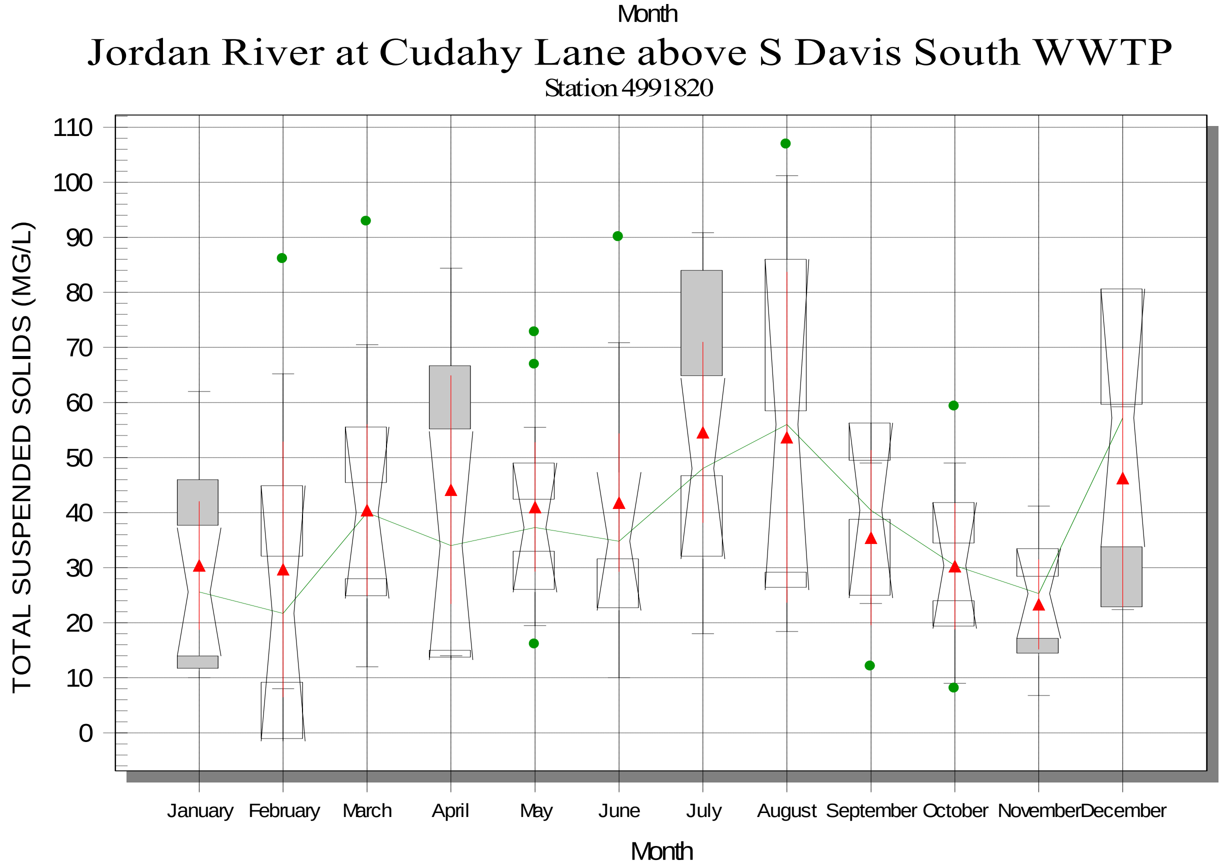


Figure 25. Monthly concentrations of TSS at select Jordan River monitoring stations including Bluffdale Road (Segment 7, upper plot) and Cudahy Lane (Segment 1, lower plot). Data shown considers all samples of TSS collected during 1995-2005 including 88 samples at Bluffdale Road and 88 samples at Cudahy Lane.

3.1.2.10 Specific Conductivity

No water quality standards are associated with Specific Conductivity. However, measurements of Specific Conductivity are generally related to TDS concentrations and provide supplementary information defining the location of loads from pollutant sources. Levels of mean Specific Conductivity are shown in Figure 26 and generally remained consistent from the outlet of Utah Lake through Segment 5. Specific Conductivity decreased significantly in Segment 4, likely as a result of fresh water inflow from perennial tributaries. Mean Specific Conductivity was consistently higher in 2004 – 2005 than during any other assessment period. The South Davis WWTP exhibited the highest mean concentration compared to any other monitoring site included in this assessment.

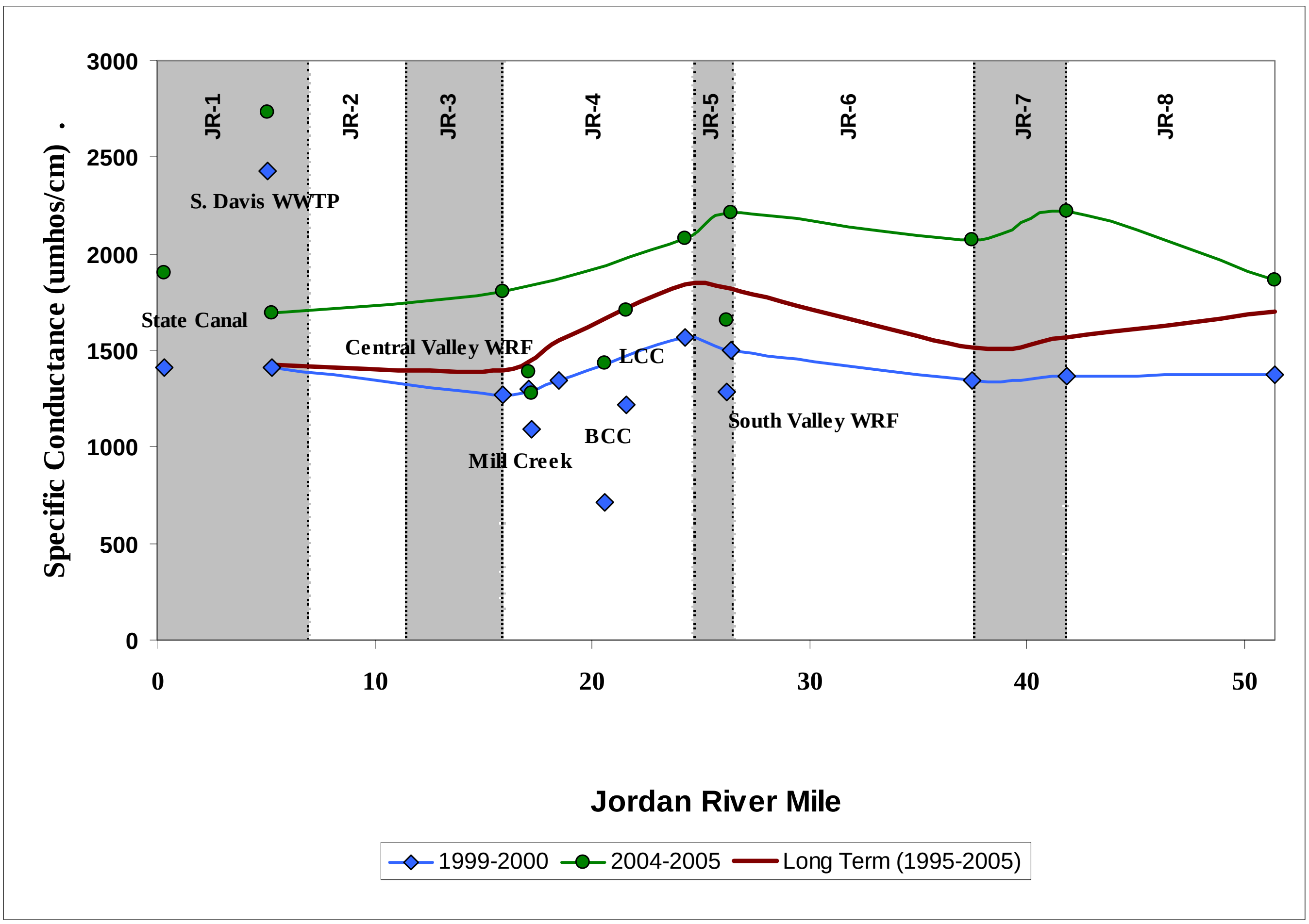


Figure 26. Mean levels of Specific Conductivity measured at intensive monitoring locations on the Jordan River. The plot background indicates relative positions of Jordan River Segments 1 (JR-1) through 8 (JR-8) with respect to monitoring locations.

Seasonal variation of Specific Conductivity measured on TDS impaired segments is shown in Figure 27 (above) for Bluffdale Road (Segment 7) and Cudahy Lane (Segment 1). The pattern of monthly Specific Conductivity is slightly offset between these two stations, and is similar to variations discussed earlier for TDS. Maximum and minimum monthly values are observed at the Bluffdale Road site approximately 1 – 2 months before similar events occur at Cudahy Lane.

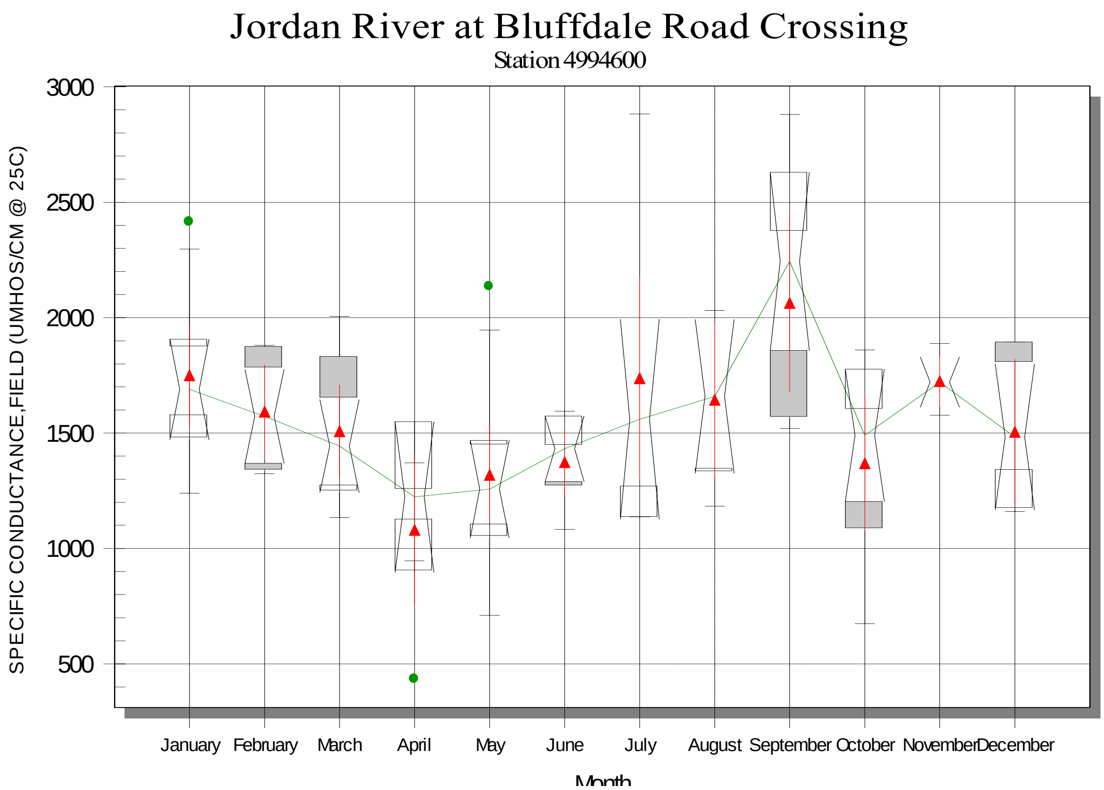
Field measurements of Specific Conductivity are routinely collected as part of DWQ water quality monitoring efforts, including time periods when TDS concentrations are not measured. Specific Conductivity measurements can be used to approximate TDS concentrations by calculating a linear relationship between Specific Conductivity and TDS. This information can then be used to further support TDS assessments at locations or during time periods where only limited TDS measurements are available. Figure 28 (above) shows an assessment of paired measurements of Specific Conductivity and TDS at the 7800 South and Bluffdale Road monitoring stations. The correlation coefficient r^2 is often used to indicate the strength of a linear relationship between two variables on a scale from 0 to 1. The r^2 values for the two sites shown in Figure 28 indicate that a moderate correlation exists between Specific Conductivity and TDS based on the 1995 – 2005 data set.

3.1.3 STREAM WATER QUALITY MONITORING – OTHER ORGANIZATIONS

Measurements of surface water quality have been collected by organizations other than the DWQ including the USGS, DERR, Salt Lake City, Central Valley WRF, South Valley WRF, South Davis South WWTP, KUCC, and JVWCD. The locations of monitoring sites visited by each entity were based upon data needs and regulatory programs. Section 2.0 above discussed water quality monitoring efforts completed by these entities and the years each site was visited. A total of four mainstem sites and one tributary site met these criteria. A statistical assessment of pollutants of concern measured at these sites is included in Table B-63 through Table B-67 in Appendix B.

A comparison of long-term mean concentrations with DWQ sites located at or near non DWQ sites indicates that water quality concentrations were similar. A meaningful comparison between DWQ and non DWQ sites is difficult due to differences in sample size and the period of record sampled. The longest period of record for non-DWQ sites was obtained at USGS sites including the Jordan River at 1700 South and Little Cottonwood Creek at Jordan River. Each of these sites typically had more water quality measurements during the long-term period than adjacent DWQ monitoring sites. As a result, these sites provide useful information for calculating pollutant loads.

Long-term trends were calculated for the entire period of record for selected water quality parameters measured at 1700 South, including DO, TDS, Temperature, and Fecal Coliform (Figure 29). The number of measurements collected for each parameter varied but generally included more than 300 samples collected over a period of more than 25 years. No E. coli measurements were available at this site so Fecal Coliform was used as a surrogate measure to determine coliform trends. The period of record for Fecal Coliform was limited to less than 200 samples collected at 1700 South during more than 20 years. Best-fit trend lines were used to indicate if the overall concentration of each parameter was increasing or decreasing. Based on this assessment, levels of DO and Temperature were observed to increase slightly while TDS decreased over time. No apparent trends were observed in Fecal Coliform levels during the period of record.



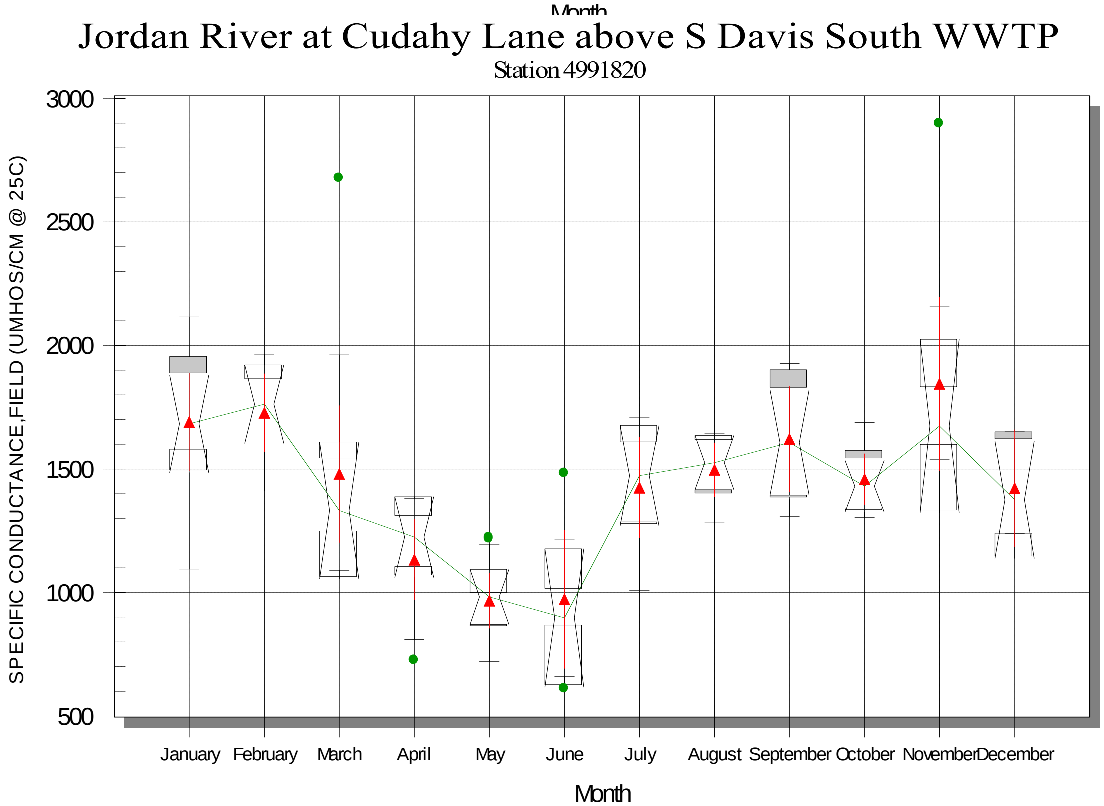
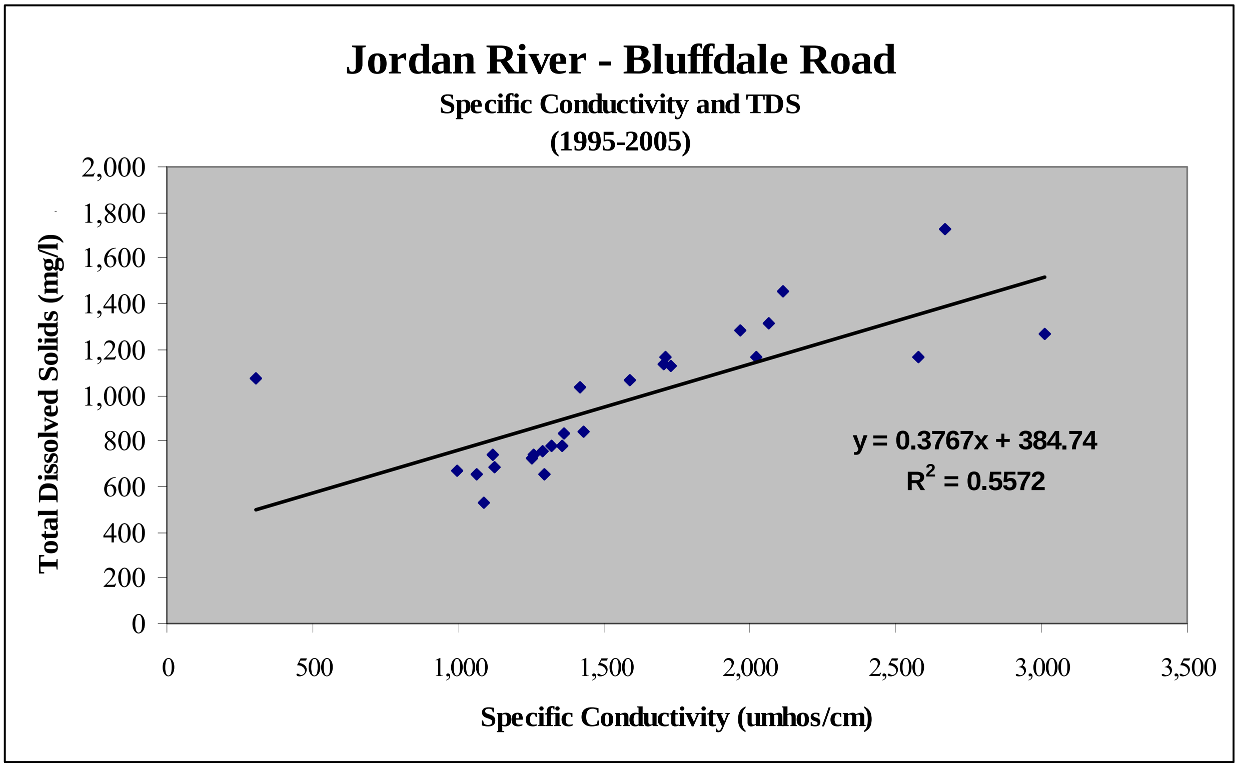


Figure 27. Monthly mean levels of Specific Conductivity at select Jordan River monitoring stations located on TDS impaired Jordan River segments including Bluffdale Road (segment 7, upper plot) and Cudahy Lane (segment 1, lower plot). Data shown considers all field measurements of Specific Conductivity collected during 1995-2005 including 83 samples at Bluffdale Road and 174 samples at Cudahy Lane.



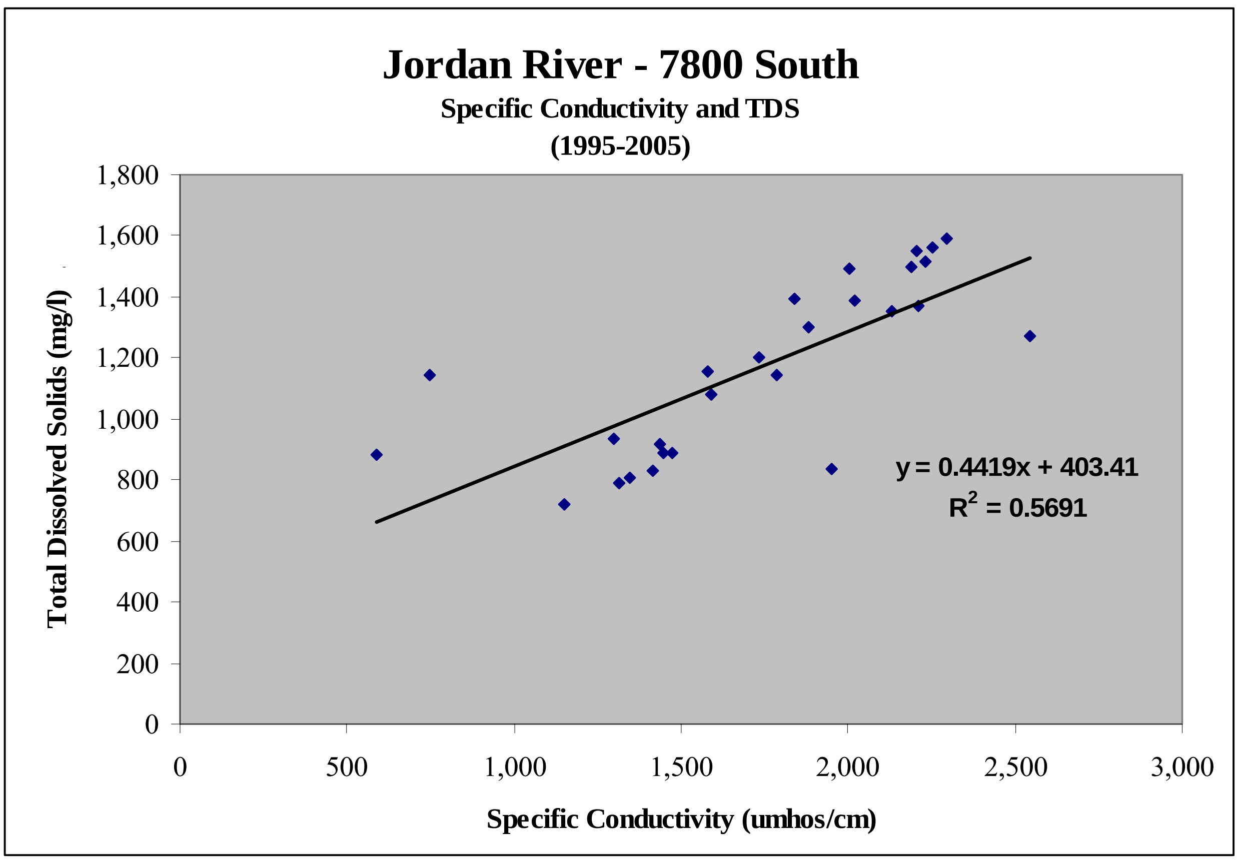


Figure 28. Linear correlation of Specific Conductivity and TDS at TDS impaired Jordan River segments including Bluffdale Road (Segment 7, upper plot) and 7800 South (Segment 5, lower plot). Data shown considers all paired samples of TDS and Specific Conductivity collected during 1995-2005 including 26 paired samples at Bluffdale Road and 27 paired samples at 7800 South.

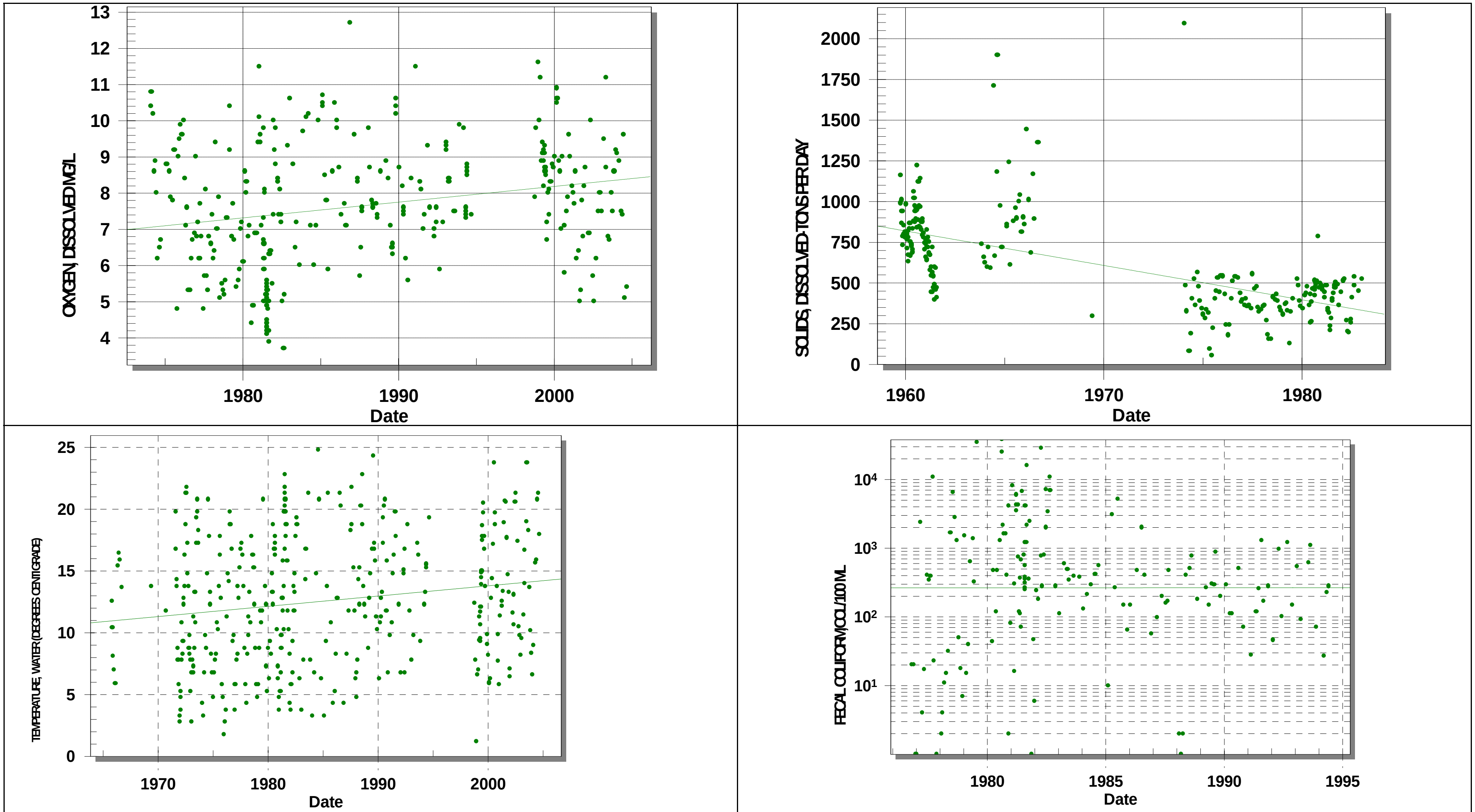


Figure 29. Historical trends for water quality parameters at Station 10171000 Jordan River at 1700 South. Plots include all measurements available for each water quality parameter including DO (358 samples), TDS (316 samples), Temperature (469 samples) and Fecal Coliform (159 samples).

3.1.4 DISCHARGE MONITORING

3.1.4.1 UPDES – point sources

All measurements of effluent water quality obtained from Discharge Monitoring Report (DMR) documentation and DWQ monitoring data have been reviewed. Mean water quality values from DWQ effluent monitoring were discussed in the previous section. This section reviews available DMR monitoring data collected by each permitted discharge facility.

A summary assessment of DMR water quality measurements is shown in Table 25, including percent of measurements that exceed standards included in the respective discharge permits. Water quality standards included in discharge permits are displayed in Table B-68 of Appendix B. The majority of effluent measurements were well within permitted standards with the exception of E. coli measurements collected from the South Davis Facility. However, based on the limited number of E. coli measurements currently available for this facility, no definitive conclusion can be made regarding a coliform problem exists at this facility. The period of record for each facility exceeded 5 years although some parameters were measured for as little as 1 year at some locations. A detailed statistical assessment of all water quality measurements provided in DMR documentation is included in Table B-69 – B-74 of Appendix B.

3.1.4.2 Stormwater

Stormwater discharge has been monitored by Salt Lake County and the Utah Department of Transportation Region 2 since 1992. Based on measurements of precipitation collected during storm runoff events, a representative storm for the Salt Lake City/Salt Lake County area is equivalent to a total accumulation of 0.62 inches and a duration of 6.4 hours, and a representative storm typically occurs during a wet period from March through October (Salt Lake County 2000). Event Mean Concentrations (EMCs) were calculated for six different parameters including sediment, metals, Total P, and BOD from composite samples collected during a 6-hour sample period corresponding to storm events. Results of EMC calculations are shown in Table 26 below. EMC values for Fecal Coliform and Fecal Streptococci were not calculated as a result of short holding times for coliform, storm events that occurred at night/weekends, and restricted lab hours.

Base grab samples and rise grab samples of stormwater were also collected prior to runoff and during the first 30 minutes of representative storm events, respectively. Results of this monitoring were submitted to the DWQ and Region 8 EPA on an annual basis. Measurements of Fecal Coliform from Jordan River outfall locations ranged from 24 to >400 cfu/100ml for base grab samples and from 1,800 to > Maximum Detection Limit for rise grab samples. Storm composite measurements of TDS from Jordan River outfall locations ranged from 106 – 810 mg/L while base grab samples and rise grab samples ranged from 151 to 1,080 mg/L and 115 to 352 mg/L, respectively.

Table 25. Statistical assessment of selected water quality constituents contained in Discharge Monitoring Reports for UPDES facilities located in the Jordan TMDL analysis area. The percent of samples exceeding water quality standards are based on information contained in UPDES permits associated with each facility.

	n	BDL	Date	Mean	Median	SD	Geo. Mean	Min	Max	% Exceed
Pollutants of Concern										
Dissolved Oxygen, Daily Minimum (mg/l)										
Central Valley Water Reclamation Facility	97	0	1998 - 2006	5.17	5.1	0.68	5.13	4.1	7.1	1
S. Davis Co. Sewer – South	62	0	2001 - 2006	5.98	5.45	1.10	5.89	5	9.1	0
South Valley Water Reclamation Facility	73	0	2000 - 2006	7.62	7.6	0.53	7.60	6.6	8.8	0
Total Dissolved Solids (mg/l)										
South Valley Water Reclamation Facility	69	0	2000 - 2006	958.40	960	53.02	956.90	850	1,090	0
Utah State Prison	7	0	2002 - 2005	1,711.00	1800	273.00	1,688.00	1,114	1,940	0
E. Coli(# / 100 ml)										
S. Davis Co. Sewer – South (7-day Average)	4	0	2005 - 2006	382.8	179.2	513.70	166.70	41	1131.8	50
South Valley Water Reclamation Facility (7-day Maximum)	73	0	2000 - 2006	24.63	9	113.80	8.99	1	980	1.4
Water Temperature (ºC)										
Central Valley Water Reclamation Facility	6	0	1996 - 1996	20.00	19.5	2.97	19.82	17	24	0
S. Davis Co. Sewer – South	1,826	0	1998 - 2002	17.25	16.69	3.98	16.76	0.22	25.67	0
South Valley Water Reclamation Facility	69	0	2000 - 2006	18.18	18	3.52	17.82	8.32	24	0
Utah State Prison	2	0	2002 - 2003	34.05	34.05	12.98	32.79	24.87	43.23	0
Associated parameters										
Fecal Coliform, 30-Day Average (# / 100 ml)										
Central Valley Water Reclamation Facility	97	0	1998 - 2006	34.27	27	21.09	29.83	6	140	0
S. Davis Co. Sewer – South	58	0	2001 - 2005	20.91	16	13.54	17.63	6	69	0
Total Phosphorus, 7-Day Average (mg/l as P)										
Rubber Engineering	62	2	2001 - 2006	0.02	0.004	0.03	0.01	<BDL>	0.07	na
S. Davis Co. Sewer – South	4	0	2005 - 2006	3.90	3.15	2.41	3.40	2.1	7.2	na
South Valley Water Reclamation Facility	19	1	2005 - 2006	3.88	3.92	0.46	3.86	<BDL>	4.6	na

Table 25. (cont'd) Statistical assessment of selected water quality constituents contained in Discharge Monitoring Reports for UPDES facilities located in the Jordan TMDL analysis area. The percent of samples exceeding water quality standards are based on information contained in UPDES permits associated with each facility.

	n	BDL	Date	Mean	Median	SD	Geo. Mean	Min	Max	% Exceed
Total Ammonia, Daily Maximum (mg/l as N)										
Central Valley Water Reclamation Facility	62	0	2001 - 2006	2.59	2.25	1.80	2.00	0.4	7.9	1.6
S. Davis Co. Sewer – South	58	0	2001 - 2005	6.33	6	2.34	5.95	3	15	6.9
South Valley Water Reclamation Facility	73	0	2000 - 2006	0.25	0.12	0.53	0.15	0.07	4.29	0
BOD, 5 Day, 30-Day Average (mg/l)										
Central Valley Water Reclamation Facility	97	0	1998 - 2006	3.42	3.4	0.77	3.35	2.1	7.7	0
Rubber Engineering	62	2	2001 - 2006	5.25	5	1.54	5.14	<BDL>	16	0
S. Davis Co. Sewer – South	62	0	2001 - 2006	17.52	17	3.73	17.16	12	30	3.2
South Valley Water Reclamation Facility	73	0	2000 - 2006	3.90	4	0.93	3.78	2	6	0
pH, Daily Minimum (SU)										
Central Valley Water Reclamation Facility	97	0	1998 - 2006	6.82	6.9	0.14	6.82	6.5	7.1	0
Rubber Engineering	24	0	2004 - 2006	7.83	7.7	0.43	7.82	7.3	9	0
S. Davis Co. Sewer – South	62	0	2001 - 2006	7.34	7.3	0.17	7.33	6.9	7.7	0
South Valley Water Reclamation Facility	73	0	2000 - 2006	7.36	7.4	0.17	7.36	7	7.7	0
Total Suspended Solids, 30-Day Average (mg/l)										
Central Valley Water Reclamation Facility	97	0	1998 - 2006	6.42	6.5	1.29	6.29	3.5	9.1	0
Rubber Engineering	62	1	2001 - 2006	4.89	3	6.18	3.07	<BDL>	38	1.6
S. Davis Co. Sewer – South	62	0	2001 - 2006	16.55	16	3.05	16.29	12	28	1.6
South Valley Water Reclamation Facility	73	0	2000 - 2006	6.63	6	1.91	6.38	4	13	0
Utah State Prison	5	0	2004 - 2005	19.20	18	11.21	16.48	6	37	0
Specific Conductance (umhos/cm)										
Utah State Prison	2	0	2002 - 2003	2,315.00	2315	573.50	2,279.00	1,909	2,720	0

Table 26. Event Mean Concentration (EMC) results for six constituents based on composite outfall monitoring during representative storm events in Salt Lake County.

Parameter	EMC (mg/l)
Total Suspended Solids	116
Total Copper	0.039
Total Lead	0.031
Total Zinc	0.181
Total Phosphorus	0.39
5-day BOD	13.2

3.2 GROUNDWATER QUALITY

Groundwater in the Jordan River basin generally occurs in four aquifer formations including (1) a confined artesian aquifer, (2) a deep unconfined aquifer located between the confined aquifer and the valley margins, (3) a shallow unconfined aquifer overlaying the artesian aquifer, and (4) local unconfined perched aquifers (Hely et al. 1971). The principal aquifer is generally composed of the confined artesian aquifer and the deep unconfined aquifer located near the valley margins. The ultimate source of the majority of groundwater used in Salt Lake County is the principal aquifer.

Water enters the aquifer from the mountains on the east, west, and south of the valley and moves towards the river, except for groundwater from the northern Oquirrh Mountains, which flows directly to the Great Salt Lake (Arnow 1965). Transmissivity of the aquifer ranges from less than 10,000 ft^2/day at the valley edges to over 50,000 ft^2/day around the creeks flowing out of the Wasatch Range (Lambert 1995).

Studies have estimated the hydraulic conductivity of the confining layer of the aquifer to be 0.016 ft/day near the Great Salt Lake and 0.049 ft/day between Holladay and Murray, UT (Hely et al. 1971). Holdsworth (1985) estimated hydraulic conductivity for unconsolidated base fill at 1 – 30 ft/day.

The condition of groundwater quality varies both horizontally and vertically and is dependent in part upon the material through which groundwater flows. Temporal changes in historical groundwater quality are generally believed to be minimal although some indications of increasing TDS levels have been reported at some locations in the analysis area. Development and waste management sites have accelerated degradation of groundwater resources. A summary of previous groundwater studies provides an indication of historical and more recent groundwater conditions.

3.2.1 PREVIOUS STUDIES

A summary of previous groundwater studies is provided in Table 27. An early review of groundwater in the Salt Lake Valley indicated that water quality varied with the source and nature of the deposits that water passed through. Early studies of groundwater indicated large differences in TDS throughout the Salt Lake Valley. Richardson (1906) observed that wells in the area contiguous to the Great Salt Lake maintained high salt concentrations and, in general, water produced by deeper wells was of higher quality than wells developed in shallow aquifers. Shallow wells located in lowland areas were characterized as rich in dissolved salts. Taylor and

Legette (1949) noted that groundwater in the Salt Lake Valley was relatively high in TDS with concentrations ranging from 100 to 600 mg/L in areas with intense development up to more than 25,000 mg/l in mineralized areas. Hely (1971) stated that TDS concentrations varied horizontally and vertically, with better quality water located near the center of aquifer formations in the Salt Lake Valley. This study noted that mixing between confined and unconfined aquifers was uncertain but unlikely at that time due to hydrogeologic gradients that transferred high-quality water from confined aquifers to unconfined aquifers with poor groundwater quality.

Table 27. Previous studies addressing groundwater quality in the Great Salt Lake Basin including the Jordan River and tributaries.

Reference	Extent of study	Description
Richardson 1906	Utah Lake and Jordan River watersheds	Identification of groundwater sources, recharge areas and chemical descriptions of well samples.
Taylor and Leggette 1949	Salt Lake Valley	Historical review of the physical and chemical characteristics of groundwater in the Salt Lake Valley from Utah Lake down to the Great Salt Lake. Water quality parameters included TDS, chloride, fluoride, hardness, and temperature.
Hely et al. 1971	Salt Lake County	General characterization of groundwater quality in the major aquifers of the Salt Lake Valley. Included as part of a larger study examining surface and groundwater resources. Water quality parameters included TDS and major cations/anions
Seiler and Waddell 1984	Salt Lake Valley	Investigation of flow and water chemistry in the shallow unconfined aquifer in the Salt Lake Valley. Water quality parameters included TDS, nitrate, trace elements, and organic chemicals.
Thiros 1995	Salt Lake Valley	Review of the chemical composition of groundwater in the Salt Lake Valley based on well monitoring data collected by the USGS from 1982 through 1992.
Thiros 2000	Great Salt Lake Basins	Review of nitrate and Volatile Organic Compound (VOC) datasets collected during 1980-1998 as part of the NAWQA monitoring effort in the Great Salt Lake Basins Study unit.
Thiros 2003	Salt Lake Valley	Assessment of groundwater quality monitoring data collected at 41 sites located in residential and commercial areas of Salt Lake Valley. Water quality parameters included major ions, nutrients, dissolved organic carbon, trace elements, radon, pesticides and VOCs.

A thorough review of the shallow unconfined aquifer was obtained during a USGS study of measurements collected from 55 observations wells in the Salt Lake Valley during 1982 (Seiler and Wadel 1984). Contamination was observed in the shallow unconfined aquifer from landfills, tailings areas, animal feeding sites, and urban/municipal neighborhoods. TDS concentrations were lower in wells along the east side of the Salt Lake Valley and greater in wells located near the Great Salt Lake in the northwest portion of the valley.

Thiros (1995, 2000, and 2003) examined groundwater quality in numerous private and public wells in the Salt Lake Valley. TDS concentrations were noted to follow the same patterns as observed in previous studies where relatively low concentrations were observed on the east side of the Salt Lake Valley, ranging from 100 to 500 mg/L in comparison to concentrations on the west side that commonly ranged from 1,000 mg/L to 3,000 mg/L (Thiros 2003), with readings as high as 20,900 in the northwest (Thiros 1995). Chloride concentrations increased steadily from the late 1950s through the early 1990s in artesian wells developed in the principal aquifer (Thiros 1995). A summary of predominant ions and TDS ranges in Salt Lake Valley groundwater as defined by Thiros is provided in Table 28.

Table 28. Predominant ions and TDS ranges in Salt Lake Valley groundwater (Thiros 1995).

Area	Predominant Ions	TDS range (mg/l)		
		Deep	Intermediate	Shallow
Southeast	Calcium, magnesium, bicarbonate	130-217	187-243	331-1,480
Southwest	Calcium, magnesium, bicarbonate, chloride, sulfate	572-2,070	408-3,890	850-4,340
Northeast	Sulfate	>500	355-735	614-1,420
Northwest	Sodium, chloride, bicarbonate	498-4,930	447-2,460	512-20,900

3.2.2 GROUNDWATER QUALITY MONITORING

Review of data available at the USGS-NWIS database indicated that groundwater quality has been monitored on an infrequent basis from both wells and springs. As mentioned previously, most samples collected from well and spring monitoring stations within the analysis area are limited to one or two observations. Available data from shallow (<101 ft) groundwater monitoring wells located within approximately 1.5 miles from the Jordan River were organized into three broad groups including (1) from Jordan Narrows to Little Cottonwood Creek, (2) East Bench above Jordan River from Little Cottonwood Creek to Mill Creek, (3) Little Cottonwood Creek to the Surplus Canal, and (4) the Surplus Canal to North Temple. Summary statistics for monitoring wells located on the east and west side of the Jordan River are shown in Tables 29 and 30, respectively.

Routine monitoring of groundwater occurs at several locations in the Jordan River basin that are recognized in the CERCLIS database. Three of these sites are located near the Jordan River or tributaries to the Jordan including Sharon Steel and Midvale Slag (Jordan River Segment 6 near 7800 South) and the Kennecott South Zone (adjacent to Bingham Creek and Jordan River Segment 6 near 10600 South). Monitoring at the Sharon Steel and Midvale Slag sites is primarily focused on arsenic and lead. Groundwater monitoring data from the Sharon Steel and Midvale Slag sites was reviewed and did not contain measurements of TDS or other pollutants of concern associated with this TMDL assessment.

Groundwater contamination at the Kennecott South Zone consists of elevated concentrations of Sulfate and metals and acidic conditions that are spreading out laterally over 50 square miles and vertically downward in the primary aquifer. One of the contaminant plumes is located in South Jordan, adjacent to the Jordan River, and maintains Sulfate concentrations ranging from 500 mg/L to 1,500 mg/L (DWQ 2004). Table 31 includes an assessment of groundwater quality data collected during 1999 – 2005 from contaminant plumes near Bingham Creek, approximately 1.5 miles from the Jordan River. Mean TDS concentrations measured in Barrier Wells 1 and 2 located near the downgradient edge of the plume range from 1,705 to 2,814 mg/l. Higher mean TDS concentrations were observed in groundwater samples collected from Acid Wells 1 and 2 located near the center of this plume. Measurements of Sulfate and Specific Conductivity followed the same pattern as TDS with higher values observed in Acid Wells 1 and 2. pH levels in Barrier Wells 1 and 2 were generally considered acceptable while mean pH levels near the center of the contaminant plume were considerably lower.

At present, Kennecott is involved with other local and state entities as part of the Southwest Jordan Valley Groundwater Project. One of the more recent remediation efforts involves extracting groundwater from contaminated plumes in the primary aquifer, treating it through reverse-osmosis, and delivering the treated, high-quality water to West Jordan, South Jordan, Riverton, and Herriman for municipal use. Since groundwater extraction began in 1997, the leading edge of the main Sulfate plume has contracted substantially, and Sulfate concentrations have decreased (KUCC 2005).

Table 29. Water quality measurements from all USGS wells located within 1.5 miles of east side of Jordan River. Data record for these wells is 1980 – 2001.

Parameter	Well	Jordan River Reach [1]	Date Range	n	Mean
Nitrate Nitrogen, Dissolved (mg/L as N)	(C- 2- 1)36cdd- 2	1	1990	1	1.92
	(D- 2- 1)17cda- 2	2	1990	1	0.73
Nitrogen, Ammonia, Dissolved (mg/L as N)	(D- 1- 1)31abc- 2	2	2000	2	0.01
	(B- 1- 1)26bad- 1	4	1999	1	0.01
	(C- 2- 1)23dac- 1	1	2001	1	0.02
Oxygen, Dissolved (mg/L)	(D- 1- 1)31abc- 2	2	2000	2	10.8
	(B- 1- 1)26bad- 1	4	1999	1	8.6
	(C- 2- 1)23dac- 1	1	1991-2001	2	4.6
Ph (Standard Units)	(C- 2- 1)36cdd- 2	1	1990-1991	2	8.25
	(D- 1- 1)31abc- 2	2	2000	2	8.4
	(B- 1- 1)26bad- 1	4	1999	1	8.2
	(C- 1- 1)26dba- 4	3	1983	1	7.4
	(C- 2- 1)23dac- 1	1	1991-2001	3	7.47
	(D- 2- 1)17cda- 2	2	1990	1	7.2
	(C- 3- 1) 1bbc- 1	1	1995-2001	6	7.45
Phosphorus, Dissolved (mg/L as P)	(D- 1- 1)31abc- 2	2	2000	2	0.011
	(B- 1- 1)26bad- 1	4	1999	1	0.006
	(C- 2- 1)23dac- 1	1	2001	1	0.004
	(C- 3- 1) 1bbc- 1	1	1995-1999	3	0.02
Phosphorus, Dissolved Orthophosphate (mg/L as P)	(D- 1- 1)31abc- 2	2	2000	2	0.0075
	(B- 1- 1)26bad- 1	4	1999	1	0.005
	(C- 2- 1)23dac- 1	1	2001	1	0.01
Phosphorus, Total (mg/L as P)	(D- 1- 1)31abc- 2	2	2000	2	0.0275
	(B- 1- 1)26bad- 1	4	1999	1	0.008
Specific Conductance (Umhos/cm @ 25C)	(C- 2- 1)36cdd- 2	1	1990-1991	2	750
	(D- 1- 1)31abc- 2	2	2000	2	584.5
	(B- 1- 1)26bad- 1	4	1999	1	465
	(C- 1- 1)26dba- 4	3	1983	1	1740
	(C- 1- 1)26dba- 6	3	1983	1	521
	(C- 2- 1)23dac- 1	1	1991-2001	3	1063.33
	(D- 2- 1)17cda- 2	2	1990	1	1080
	(C- 2- 1)14bdb- 1	1	1982	1	1580
	(C- 3- 1) 1bbc- 1	1	1995-2001	7	1130

Table 29. (cont'd) Water quality measurements from all USGS wells located within 1.5 miles of east side of Jordan River. Data record for these wells is 1980 – 2001.

Parameter	Well	Jordan River Reach [1]	Date Range	n	Mean
Temperature, Water (Degrees C)	(C- 2- 1)36cdd- 2	1	1990-1991	2	14.5
	(D- 1- 1)31abc- 2	2	2000	2	8.65
	(B- 1- 1)26bad- 1	4	1999	1	12.9
	(C- 1- 1)26dba- 4	3	1983	1	12.5
	(C- 1- 1)26dba- 6	3	1983	1	12
	(C- 2- 1)23dac- 1	1	1991-2001	3	15.83
	(D- 2- 1)17cda- 2	2	1990	1	15.5
	(C- 3- 1) 1bbc- 1	1	1995-2001	7	16.29

[1] Reach Definition:
1 – Jordan River from Narrows to Little Cottonwood Creek.
2 – East Bench above Jordan River from Little Cottonwood Creek to Mill Creek.
3 – Jordan River from Little Cottonwood Creek to Surplus Canal diversion.
4 – Jordan River from Surplus Canal diversion to Cudahy Lane.

Table 30. Water Quality Measurements in Wells on West Side of Jordan River, Post-1980.

Parameter	Well	Location[1]	Date Range	n	Mean
Nitrogen, Ammonia, Dissolved (mg/L as N)	(C- 1- 1)11bac- 1	4	1982-2001	2	0.025
Oxygen, Dissolved (mg/L)	(C- 1- 1)11bac- 1	4	2001	2	6.9
Ph (Standard Units)	(C- 2- 1)35bab- 1	1	1983	1	6.9
	(C- 3- 1) 3acc- 1	1	1983	1	7.3
Solids, Dissolved-Sum Of Constituents (mg/L)	(C- 2- 1)35bab- 1	1	1983	1	2,430
	(C- 3- 1) 3acc- 1	1	1983	1	972
Specific Conductance (Umhos/cm @ 25C)	(C- 2- 1)35bab- 1	1	1983	2	2,975
	(C- 3- 1) 3acc- 1	1	1982-1983	2	1,565
Temperature, Water (Degrees C)	(C- 2- 1)35bab- 1	1	1983	1	9.5
	(C- 3- 1) 3acc- 1	1	1983	1	14.5

[1] Reach Definition:
1 – Jordan River from Narrows to Little Cottonwood Creek.
4 – Jordan River from Surplus Canal diversion to Cudahy Lane.

Table 31. Assessment of water quality measurements collected from groundwater monitoring wells at Kennecott Utah Copper Corporation South Zone near Bingham Creek.

	n	BDL	Date	Mean	Median	STD	Geo Mean	Min	Max
B2G1193 - Kennecott Barrier Well 1									
pH (Standard Units)	38	0	1999 - 2005	7.069	7.06	0.46	7.06	6.46	9.12
Specific Conductance (umhos/cm @ 25 C)	37	0	1999 - 2005	3038	3,020	258.5	3,027	2,440	3,790
Temperature, Water (ºC)	24	0	1999 - 2005	15.18	15	1.50	15.11	13	19
Total Dissolved Solids (mg/l)	50	0	1999 - 2005	2,814	2,930	274.3	2,799	1,960	3,220
Total Suspended Solids (mg/l)	50	47	1999 - 2005	1.918	1.47	1.528	1.47	<BDL>	8
Sulfate, Total (mg/l as SO4)	50	0	1999 - 2005	1,640	1,645	163.3	1,632	1,070	2,010
BFG1200 - Kennecott Barrier Well 2									
pH (Standard Units)	15	0	2002 - 2005	7.159	7.16	0.20	7.16	6.93	7.71
Specific Conductance (umhos/cm @ 25 C)	15	0	2002 - 2005	1,918	2,010	502.7	1,743	200	2,440
Sulfate, Total (mg/l as SO4)	18	0	2001 - 2005	890.7	906.5	63.8	888.5	736	1,010
Total Dissolved Solids (mg/l)	18	0	2001 - 2005	1,705	1,710	98.79	1,703	1,540	1,981
Total Suspended Solids (mg/l)	18	14	2001 - 2005	2.412	2.20	1.08	2.20	<BDL>	5
B2G1201 - Kennecott Acid Well 2									
Specific Conductance (umhos/cm @ 25 C)	11	0	2003 - 2005	11,340	11,170	750	11,310	9,980	12,500
Sulfate, Total (mg/l as SO4)	11	0	2003 - 2005	12,500	12,300	1,438	12,430	10,500	15,000
Temperature, Water (ºC)	11	0	2003 - 2005	13.89	15	3.59	13.12	3.8	18
Total Dissolved Solids (mg/l)	11	0	2003 - 2005	17,790	17,900	1,780	17,710	15,600	20,700
Total Suspended Solids (mg/l)	11	4	2003 - 2005	5.952	4	5.40	3.98	<BDL>	17
ECG1146 - Kennecott Acid Well 1									
pH (Standard Units)	21	0	1999 - 2005	3.404	3.42	0.16	3.40	3.1	3.76
Specific Conductance (umhos/cm @ 25 C)	23	0	1999 - 2005	18,590	18,670	2,224	18,450	12,780	21,700
Temperature, Water (ºC)	12	0	2002 - 2005	14.75	15	1.288	14.7	12	17
Total Dissolved Solids (mg/l)	33	0	1999 - 2005	40,570	41,500	4,131	40,360	31,500	46,000
Total Suspended Solids (mg/l)	33	6	1999 - 2005	8.201	6	8.861	5.49	<BDL>	46
Sulfate, Total (mg/l as SO4)	33	0	1999 - 2005	28,770	29,600	4,160	28,470	20,800	37,400

3.3 SUMMARY OF WATER QUALITY

This review of stream and discharge water quality monitoring by both DWQ and non DWQ data sources provides a detailed characterization of pollutants of concern (i.e., DO, TDS, Temperature, and E. coli) for impaired segments of the Jordan River. Based on the methodology used by DWQ to assess water quality, including numeric criteria, indicator values, and percent exceedance, this review confirms the 2006 303(d) list of Jordan River segments.

DO levels measured at DWQ stations located on Segments 1 and 2 are below state standards. In addition, a large number of DO measurements violate numeric criteria at DWQ stations located on the State Canal and Segment 3. No routine DO measurements are available for the downstream end of Jordan River Segment 1 except for limited diurnal DO measurements collected at Burnham Dam. It is not known at this time if DO measurements collected from the State Canal during routine monitoring are representative of DO levels in the downstream portion of Jordan River Segment 1. In general, low DO concentrations were much more evident during the 2004-2005 intensive monitoring period than during other time periods. It is likely that low flow conditions influenced DO levels during this time.

The long-term assessment of TDS monitoring data indicated that roughly 20 percent of samples collected from Jordan River Segments 7 and 8 exceeded criteria. Approximately seven percent of samples collected from Jordan River Segment 1 exceeded criteria during this same time period. Similar to DO measurements, the greatest exceedance of TDS criteria for listed segments occurred during the 2004-2005 intensive monitoring period.

No exceedance of criteria were observed during intensive monitoring periods at stations located on Jordan River segments that were considered impaired for high temperature levels. However, greater exceedances of temperature criteria were noted in the long-term assessment of temperature data, ranging from approximately 11 – 19 percent. Diurnal temperature monitoring data collected during June and August of 2007 indicated that significant portions of each diurnal period were spent in violation of temperature criteria.

A limited amount of E. coli data was collected during the 2004 – 2005 intensive monitoring period. The current E. coli data set is insufficient to accurately determine pollutant loads and assign pollutant load allocation needed to complete a TMDL for impaired Jordan river segments. Data collected during 2004 – 2005 included the only E. coli measurements during the recent time period that met minimum qualifications for sample size and frequency as specified by DWQ. Fecal coliform was also reviewed even though this parameter is no longer included in Utah water quality standards. The percent of E. coli samples exceeding Criteria 1 (single sample maximum < 940 col/100 ml) in listed segments ranged from 11 – 22 percent and from 0 – 100 percent for Criteria 2 (geometric mean < 206 col/100 ml). The highest percent exceedance of Criteria 1 occurred in Jordan River Segments 1 and 2. All E. coli geometric means exceeded criteria 2 in Jordan River Segments 1 and 3.

Additional assessments of water quality parameters that could influence pollutants of concern were also completed. Ammonia levels were consistently below state criteria for all segments. In contrast, levels of Dissolved and Total Phosphorus were consistently in violation of pollution indicator levels for all segments. Phosphorus levels increased dramatically below discharge points from UPDES facilities located adjacent to the Jordan River. Specific Conductivity measurements showed a moderate level of correlation with TDS measurements and could provide supporting information at locations where TDS measurements are limited.

A review of data collected at non DWQ monitoring sites was completed to determine additional water quality measurements that could be used to support the TMDL assessment. In general, additional data was limited in terms of years data was collected as well as the number of samples collected within a given year.

Reviewed stream and groundwater quality data from other agencies is generally not directly comparable to the DWQ data because of the sampling locations, sampling and analytical methods employed, and the water quality parameters addressed. However, to the extent that data from other agencies is comparable, it supports the conclusions suggested by DWQ data. A substantial amount of data was identified at two USGS NAWQA sites including Jordan River at 1700 South and the confluence of Little Cottonwood Creek. In addition, the Jordan Water Conservancy District has monitored water quality at the Narrows since 1991. In general, water quality measurements at these sites agreed with DWQ monitoring data and where applicable, can be used to support TMDL calculations for listed segments.

Gaps and shortcomings in the reviewed information include the limited number of DO measurements in Segment 1, limited E. coli data, and general limits to the sample size of flow and water quality measurements at several DWQ monitoring stations on listed segments. The implications of these issues for completion of a defendable TMDL may result in a decreased ability to define impairment on listed segments as well as calculate seasonal pollutant loads at some DWQ monitoring stations. Recommendations for future monitoring to offset these gaps and shortcomings are discussed below in Section 7.

4.0 FLOW CONDITIONS

This section summarizes and interprets the data reviewed in regard to surface and groundwater flows, as identified in Section 2.3. The section concludes with a summary of findings suggested by the data analyzed and the previous studies reviewed. Accurate flow measurements from streams, stormwater outfall, and irrigation canals are a critical component of any TMDL analysis. Flow data carried into detailed analysis in this section includes instantaneous flow measurements collected during water quality sampling efforts, continuous flow measurements collected at USGS and DWR flow gage stations, and groundwater monitoring in permanent and temporary wells.

4.1 SURFACE FLOW

Surface flow measurements have been collected from streams and irrigation diversions since the mid-1800s, usually in response to concerns over water rights. The most accurate flow measurements are generally provided by the USGS at continuous streamflow monitoring sites. The length of time over which surface flow measurements are made can influence annual or monthly average values, particularly if flow records are limited solely to wet or dry periods. Instantaneous flow measurements can also be biased because they do not capture the full range of flows over a given period of time.

Flow in the Jordan River is largely controlled through releases from Utah Lake according to water rights and legal agreements that protect property that borders the lake from flooding. As mentioned previously, diversions from the Jordan River and tributaries significantly influence flow regimes during the irrigation season.

4.1.1 PREVIOUS STUDIES

A review of previous flow studies was conducted to identify sources and losses of water in the Jordan River. This information will be utilized during successive work elements to calculate pollutant loads and model Jordan River water quality. A list of flow studies that were reviewed as part of this assessment is provided in Table 32.

Large discrepancies were noted between some studies with regard to Jordan River water budget components. Table 33 provides a summary of relevant flow measurements provided by each study. Discrepancies between studies are mainly the result of different project objectives associated with each study, different time periods during which data was assessed, and the manner that water balance results were reported.

Table 32. Previous studies addressing surface flow in the Jordan River Basin including the mainstem Jordan River and tributaries.

Reference	Extent of Study	Description
Harris 1964	Jordan River downstream of 2100 South.	Characterization of the existing and future water demands on the Lower Jordan River.
Hely 1971	Salt Lake County.	Summarized water resources in Salt Lake County to accommodate anticipated growth.
Hely et al 1971	Salt Lake County.	Described water resource system and potential schemes for water supply development.
Utah Division of Water Resources 1997	Jordan River – Utah Lake River Basin.	Identified potential conservation and development projects to meet water resource demands in the Jordan River –Utah Lake Basin.
Borup and Haws 1999	Jordan River from Utah Lake to Farmington Bay.	Analysis of flows along the Jordan River for use in TMDL studies as related to the four wastewater treatment plants. The flow rates in this report reflect a low-flow period to ensure river water quality even during "dry periods".
CH2MHill 2005	Jordan River from Turner Dam to Farmington Bay.	Evaluation of future water reuse projects on Jordan River flows downstream of Turner Dam.

Table 33. Summary of water balance information collected from previous flow studies completed for the Jordan River Basin.

	Flow (AF/yr)				
	Hely 1971	**Hely et al. 1971**	**Utah Division of Water Resources 1997**	**Borup and Haws 1999**	**CH2MHill 2005**
Sources					
Outflow – Utah Lake	253,200	206,300	308,000	224,802	115,300
Tributary Streams	135,600	156,350	177,800	31,131	81,000
Precipitation	402,000	404,000	na	na	na
Groundwater	200,000	na	na	5,828	44,700
WWTP	na	na	93,000	116,564	87,600
Other	na	20,000[1]	na	5,611[2]	77,600
Subtotal	**990,800**	**786,650**	**578,800**	**383,936**	**406,200**
Losses					
Industrial	66,100	66,100	na	na	na
Canals	219,000	244,600	140,000	368,335	147,400
Irrigation [3]	na	39,770	na	na	na
Water Supply [3]	93,700	53,250	68,190	na	na
Groundwater Recharge	68,000	20,000	20,000	na	na
Other	na	na	107,700[4]	na	na
Subtotal	**249,700**	**423,720**	**335,890**	**369,204**	**147,400**
Total	**741,100**	**362,930**	**242,910**	**15,601**	**258,300**

[1] Includes runoff from Wasatch Range.
[2] Conduits.
[3] From Wasatch Mountain Streams.
[4] Supply to wet/open areas, secondary, private industrial.

In general, flow studies completed within the past 10 years provided a good summary of hydrologic data in the analysis area that could be used to support a TMDL assessment. CH2MHill (2005) included a highly detailed assessment of hydrologic conditions during wet, average, and dry conditions in the Jordan River Basin. A summary table of low flow conditions as defined by CH2MHill (2005) for historic, current, and future (year 2030) time periods is provided in Table 34.

Table 34. Jordan River inflows and outflows during dry conditions as reported by CH2MHill (2005). All units shown are in acre-feet.

Category	1945	2003	2030[2]
Return flows	105,700	165,200	211,300
- WWTP effluent	9,100	87,600	119,600
- Groundwater	34,200	49,500	53,800
- Surface water	62,600	28,100	38,000
Natural groundwater inflows	43,000	44,700	44,700
Utah Lake release[1]	288,100	115,300	114,300
Tributaries (streams and storm drains)	93,100	81,000	78,300
Canal diversions	329,500	147,400	138,800
Outflow (Surplus Canal and Jordan River at Cudahy Lane)	200,000	258,300	309,300

[1] Utah Lake releases include groundwater and surface inflows between Utah lake and Turner Dam.
[2] Includes 18,000 acre-feet of reuse water.

4.1.2 SURFACE FLOW MONITORING

Review of instantaneous flow data indicated that flow measurements are typically collected along with water quality samples at DWQ monitoring stations. Where possible, DWQ field crews obtain these measurements from nearby USGS gages. Instantaneous flow measurements are limited in their ability to characterize flows to the days and times when they are collected. As a result, storm events and peak flows are typically not accounted for in flow averages that are based on instantaneous measurements. A list of DWQ monitoring stations located on the mainstem Jordan River, tributaries, discharges, and diversions is presented above in Section 2.

Table 35 summarizes instantaneous flow measurements at DWQ monitoring stations, providing average annual flows for stations that met review criteria. Mean flow values at most stations were based on less than 100 samples over the time period considered (1980 – 2006). The standard deviation of flow remained below mean flow values at all stations downstream of Big Cottonwood Creek. All mainstem Jordan River monitoring stations upstream of Big Cottonwood Creek exhibited standard deviations that exceeded mean flows. Distance from mean flow, as shown by the standard deviation, indicates a higher level of variation in stream flow values. Variation in stream flow values can be influenced by a number of different factors including extreme flow events or changes in management of irrigation diversions or flood control facilities such as the Surplus Canal.

Table 35. Statistical assessment of flow (cfs) measurements collected at DWQ monitoring sites from 1980-2006.

Station	Date	n	Mean (cfs)	Max	Min	STD	Variance
4990880 – State Canal	1980 -2006	157	72.4	500	0	59.6	3,557.0
4991820 – Cudahy Lane	1981 - 2003	155	187.0	1,400	26.8	151.8	23,034.4
4991890 – 500 North	1984 - 1986	10	270.8	311.1	242	22.7	515.7
4992290 – 1700 South	1983 - 1992	13	147.2	305	2.5	67.6	4,563.4
4992320 – 2100 South	1983 - 2002	68	619.5	2,720	3	489.6	239,668.7
4992540 – Mill Creek	1983 - 2005	54	33.1	143.6	5	28.7	821.2
4992880 – 3300 South	1996 - 2004	14	582.8	1,514	85	454.0	206,100.3
4992970 – Big Cottonwood Creek	1994 - 2005	35	60.1	380	5	84.5	7,147.1
4993580 – Little Cottonwood Creek	1994 - 2004	36	49.9	300	0.5	72.8	5,300.4
4994090 – 5400 South	1994 - 2006	36	272.4	1,836	11	361.3	130,534.3
4994170 – 7800 South	1986 - 2006	55	325.6	2,340	10.8	404.3	163,456.3
4994270 – 9000 South	1980 - 1992	66	481.1	2,330	50	558.2	311,569.1
4994590 – Utah State Prison	1985 - 2003	43	0.0	0.5	0	0.1	0.0
4994600 – Bluffdale Road	1982 - 2005	99	478.3	2,740	5.2	657.6	432,461.2
4994720 – Narrows	1989 - 2005	48	190.7	830	5	227.0	51,542.4
4994790 – Utah Lake Outlet	1981 - 2006	104	456.0	2,980	0	621.4	386,156.8

A total of 37 continuous flow gage stations were identified in the analysis area (Table 8 above) which, as discussed in Section 2.3, are the main source of flow data carried into this analysis. A statistical assessment of continuous flow data collected at monitoring stations in the analysis area is shown below in Table 36. Recent (1980 – present) mean flow values for diversions are all greater than historic (prior to 1980) mean flow values with the exception of the Utah Lake Distributing Canal. The number of years included in each time period is similar and of sufficient length to incorporate cycles of dry and wet periods that occur in the analysis area. Mean flow values at all mainstem gage stations show an increase with respect to historic levels, including discharge from Utah Lake.

Table 36. Statistical assessment of continuous flow data measured at USGS and Utah Division of Water Rights gages located on the mainstem Jordan River, tributaries, permitted discharges, and diversions.

Station	Name	Date	n	Mean Flow (cfs)	STD	Variance	Min	Max
Utah Div. of Water Rights	**Utah Lake Outflow**	1950-1979	10,957	367	299	89,281	0	1,410
		1980-2005	9,279	518	525	276,044	0	3,029
10166605	**Jordan River at Lehi Bridge**	1985-1987	489	1,323	575	330,337	0	2,390
10167000	**Jordan River at Narrows**	1935-1979	32,325	344	306	93,740	0	1,410
		1980-1991	8,224	659	596	355,763	0	3,030
Utah Div. of Water Rights	Utah Lake Distributing Canal	1950-1979	5,785	53	31	957	0	135
		1980-2006	4,669	66	40	1,597	0	157
Utah Div. of Water Rights	Utah & Salt Lake Canal	1950-1979	6,878	129	93	8,566	0	332
		1980-2006	4,996	109	71	5,017	0	255
Utah Div. of Water Rights	East Jordan Irrigation Company	1950-1979	6,087	106	64	4,061	0	249
		1980-2006	5,013	90	46	2,153	0	193
Utah Div. of Water Rights	Utah & Salt Lake Canal	1950-1979	6,878	129	93	8,566	0	332
		1980-2006	4,996	109	71	5,017	0	255
Utah Div. of Water Rights	South Jordan Canal	1951-1979	6,909	72	54	2,881	0	153
		1980-2004	4,680	63	34	1,151	0	158
Utah Div. of Water Rights	Jordan & Salt Lake Canal	1950-1978	4,527	35	20	414	0	80
		1980-2003	4,086	21	9	82	0	44
10167001	**Jordan River below Turner Dam**	1979-1979	184	22	18	335	7	88
		1980-1983	2,372	372	266	70,824	11	1,040
Utah Div. of Water Rights	North Jordan Irrigation Company	1950-1979	10,048	28	25	623	0	103
		1980-2006	5,998	7	9	89	0	58
10167230	**Jordan River at 9000 S**	1979-1979	13	41	2	5	37	45
		1980-2004	9,029	420	530	280,571	4	2,790
10167240	9000 S Conduit	1980-1984	1,502	6	16	251	0	187
10167244	Overland flow outfall nr Midvale	1981-1982	630	2	3	11	0	30
UT0024384	South Valley WRF	2000-2006	72	27	1	2	25	31
10167242	I-215 median drain nr Murray	1984-1986	1,490	2	1	0	1	8
10167300	**Jordan River at 5800 S**	1980-1985	4,018	953	625	390,176	118	2,850

Table 36. (cont'd) Statistical assessment of continuous flow data measured at USGS and Utah Division of Water Rights gages located on the mainstem Jordan River, tributaries, permitted discharges, and diversions.

Station	Name	Date	n	Mean Flow (cfs)	STD	Variance	Min	Max
10168000	*Little Cottonwood Creek*	1980-2003	11,984	47	89	7,899	0	898
10169500	*Big Cottonwood Creek*	1979-1979	92	25	8	67	17	65
		1980-1988	2,715	77	113	12,673	10	964
UT0024392	Central Valley WRF	2001-2006	62	53	5	20	46	72
10170250	*Mill Creek*	1980-1988	2,175	32	22	488	8	181
10170490	**Jordan River at Surplus Canal**	1942-1979	13,545	373	205	41,989	89	1,760
		1980-2003	8,309	794	662	438,834	184	4,510
10170500	Surplus Canal	1942-1979	13,545	233	203	41,094	0	1,640
		1980-2003	8,309	646	649	421,454	3	4,250
10170900	**2100 S Conduit**	1980-1981	528	6	2	4	3	29
10171000	**Jordan River at 1700 S**	1942-1979	13,545	140	41	1,685	0	337
		1980-2003	8,674	147	48	2,337	2	327
10172350	*1300 S Conduits*	1980-1988	1,461	32	53	2,825	4	371
10172351	*1300 S Conduits - South Conduit*	1980-1988	1,461	9	16	252	0	110
10172352	*1300 S Conduits - North Conduit*	1980-1988	1,461	23	37	1,400	-1	261
10172370	800 S Conduits	1980-1982	468	3	5	22	0	17
10172371	800 S Conduits - South Conduit	1980-1981	386	0	0	0	0	4
10172372	800 S Conduits - Middle Conduit	1980-1981	502	0	1	1	0	8
10172373	800 S Conduits - North Conduit	1980-1981	510	0	1	0	0	6
10172520	*N Temple Conduit*	1980-1982	553	6	9	77	1	53
10172550	**500 North**	1974-1979	1,918	175	56	3,086	101	550
		1980-2002	7,002	220	86	7,362	33	863
10172600	**Cudahy Lane**	1963-1968	1,827	153	41	1,665	39	348
UT0021628	South Davis South WWTP	2001-2006	62	3	4	2	0	0
	State Canal	1993-1994	549	78	19	373	0	200

Note: Assessment includes a recent (1980 – present) and historical(before 1980) assessment where data is available.

Station names in bold text are located on the mainstem Jordan River, those in italics are tributary streams to the Jordan River, and shaded rows indicate flow measurements that were collected before 1980.

A comparison of mean flow at mainstem gage stations during historic and recent time periods is biased in some instances due to limited historic data and high flow years (1980 – 1983) that occurred in recent time periods. A comparison between the flow values shown in Tables 35 and 36 for DWQ and continuous flow monitoring stations, respectively, indicated the influence of high flow years and the length of record on mean annual flows. Stations with measurements that were limited to primarily wet years were typically greater than stations with a longer period of record that included both wet and dry periods since 1980.

In an ideal setting, flow and water quality measurements should be closely spaced over both temporal and spatial scales in order to determine when pollutant loads change due to natural stream dynamics, regulation of flows by large irrigation systems, or storage within and discharge from a reservoir. Although continuous flow records provide the highest level of detail, this information may not cover certain time periods and locations of interest in this assessment. In these cases, instantaneous flow measurements will be used, where applicable, to support pollutant loads in the TMDL assessment.

Where possible, monthly flow averages will be calculated from continuous flow records maintained by the USGS and DWR. These monthly averages will then be paired with monthly average water quality concentrations to determine monthly loads. These loads will provide a seasonal assessment of loading patterns as well as a meaningful total annual load at locations where sufficient data exists. Continuous flow records will also be used to develop flow duration curves which represent the percentage of time (days) during which a given flow value is equaled or exceeded. The flow duration curve can also be associated with numeric water quality criterion or indicator values to produce a load duration curve. Daily loads are then calculated from water quality sample data and compared to the curve to determine if these loads exceed the "allowable" load shown by the load duration curve. A detailed review of pollutant loads and methodologies used to calculate pollutant loads will be provided in the Work Element 2 report for the Jordan River TMDL.

4.1.3 Flow Seasonality

Despite the fact that the Jordan River drains a major basin in Utah, flows in the river cannot be determined by a normal watershed analysis (Borup and Haws 1999). To a large extent, flows in the Jordan River are controlled artificially. Flows in this river are directly associated with highly regulated water releases from Utah Lake. In addition, as water enters the river, most is diverted through irrigation canals based on seasonal water rights. Much of the diverted water returns to the river through several hundred inlet drains distributed along the river. Flows along the river increase and decrease according to the river mile and the time of the year. Flow regimes in tributary streams to the Jordan River are likewise influenced by diversions for irrigation, municipal and industrial use, and inflow from stormwater or irrigation canals. Tributary flow on the west side of the basin is largely seasonal or intermittent, in contrast to east side tributaries which are perennial (UDWR 1997).

A comparison of mean annual flows was completed for the irrigation season (May – October) and the non-irrigation season (November – April). Results of this comparison are shown for selected monitoring locations in Table 37. Mean flow values at mainstem Jordan River monitoring sites with a substantial data record were typically greater during the irrigation season than during the non-irrigation season. Stations that were primarily limited to wet years (1980 – 1983) such as Jordan River below Turner Dam and Jordan River at 5800 South, had highest mean flow values during the non-irrigation season. An exception to this is the Jordan River at 9000 South which has a data record from 1980 – 2004 yet also shows highest mean flow during the non-irrigation season. However, flow at this station was likely influenced by major irrigation diversions found upstream of this location. The standard deviation at mainstem Jordan River monitoring sites was typically large and exceeded the difference between mean flow values calculated for the irrigation and non-irrigation season.

Monthly mean flow is shown in Figure 30 for mainstem Jordan River monitoring stations with a consistent record between 1980 – 2006. Peak monthly flow for each station occurred May – July at most stations with the exception of Jordan River at 9000 South. Monthly flow values at 9000 South February – March were consistently less than 500 cfs. This is consistent with the seasonal flow assessment shown in Table 37 and likely indicates the seasonal influence of irrigation diversions located upstream of 9000 South.

Table 37. Seasonal flow assessment for an irrigation season (May October) and a non irrigation season (November – April) at selected continuous monitoring locations in the analysis area. Stations with bold text are located on the mainstem Jordan River. This assessment accounts for available flow data at each monitoring station from 1980 – 2006.

Station	Name	River Segment	n	Date	Season	Mean (cfs)	STD	Variance	Min	Max
Utah Division of Water Rights	**Utah Lake Outflow**	8	4,784	1980 - 2005	May - Oct	610	515	265,096	0	3,029
			4,495	1980 - 2005	Nov - Apr	421	519	269,525	0	2,321
10167000	**Jordan River at Narrows**	7	4,048	1980 - 1990	May - Oct	762	619	383,308	6	3,030
			4,176	1980 - 1991	Nov - Apr	559	556	309,035	0	1,920
Utah Division of Water Rights	Utah Lake Distributing Canal	7	4,347	1980 - 2006	May - Oct	70	38	1,473	0	157
			322	1981 - 2002	Nov - Apr	25	38	1,431	0	120
Utah Division of Water Rights	Utah & Salt Lake Canal	7	4,563	1980 - 2006	May - Oct	116	68	4,632	0	255
			433	1980 - 2002	Nov - Apr	32	52	2,658	0	221
Utah Division of Water Rights	East Jordan Canal	7	4,622	1980 - 2006	May - Oct	95	43	1,850	0	193
			391	1981 - 2004	Nov - Apr	29	43	1,825	0	152
Utah Division of Water Rights	South Jordan Canal	7	4,380	1980 - 2004	May - Oct	66	32	1,020	0	158
			300	1981 - 2000	Nov - Apr	19	32	1,045	0	118
Utah Division of Water Rights	Jordan and Salt Lake Canal	7	3,427	1980 - 2003	May - Oct	23	8	62	0	44
			659	1980 - 2003	Nov - Apr	15	12	138	0	44
10167001	**Jordan River below Turner Dam**	7	1,104	1980 - 1982	May - Oct	216	172	29,432	14	762
			1,268	1980 - 1983	Nov - Apr	508	259	67,211	11	1,040
Utah Division of Water Rights	North Jordan Canal	6	1,954	1980 - 2006	May - Oct	14	13	163	0	58
			4,044	1980 - 2006	Nov - Apr	4	5	21	0	52
10167230	**Jordan River at 9000 S**	6	4,564	1980 - 2004	May - Oct	354	503	252,568	4	2,790
			4,465	1980 - 2004	Nov - Apr	489	548	300,021	6	2,380
10167240	9000 S Conduit	6	972	1980 - 1984	May - Oct	8	19	368	0	187
			530	1980 - 1981	Nov - Apr	2	4	16	0	39
10167244	Overland flow outfall nr Midvale	6	268	1981 - 1982	May - Oct	4	4	20	0	30
			362	1981 - 1982	Nov - Apr	1	1	2	0	8
10167242	I-215 median drain nr Murray	4	846	1984 - 1986	May - Oct	3	1	0	2	5
			644	1984 - 1986	Nov - Apr	2	0	0	1	8

Table 37. (cont'd) Seasonal flow assessment for an irrigation season (May October) and a non irrigation season (November – April) at selected continuous monitoring locations in the analysis area. Stations with bold text are located on the mainstem Jordan River. This assessment accounts for available flow data at each monitoring station from 1980 – 2006.

Station	Name	River Segment	n	Date	Season	Mean (cfs)	STD	Variance	Min	Max
10167300	**Jordan River at 5800 S**	4	2,146	1980 - 1985	May - Oct	829	673	453,325	118	2,850
			1,872	1980 - 1985	Nov - Apr	1,096	529	279,954	121	2,230
10168000	Little Cottonwood Creek	4	6,160	1980 - 2003	May - Oct	80	113	12,830	1	898
			5,824	1980 - 2003	Nov - Apr	12	17	305	0	214
10169500	Big Cottonwood Creek	4	1,410	1980 - 1988	May - Oct	113	144	20,723	12	964
			1,305	1980 - 1988	Nov - Apr	38	32	1,055	10	307
10170250	Mill Creek	4	1,226	1980 - 1988	May - Oct	38	27	720	8	181
			949	1980 - 1988	Nov - Apr	24	10	91	8	120
10170490	**Jordan River at Surplus Canal**	3	4,201	1980 - 2003	May - Oct	814	721	519,268	193	4,510
			4,108	1980 - 2003	Nov - Apr	774	597	355,871	184	3,660
10170500	Surplus Canal	3	4,201	1980 - 2003	May - Oct	659	712	506,571	81	4,250
			4,108	1980 - 2003	Nov - Apr	632	578	334,137	3	3,550
10170900	2100 S Conduit	3	342	1980 - 1981	May - Oct	6	2	5	3	29
			186	1980 - 1981	Nov - Apr	6	2	3	4	16
10171000	**Jordan River at 1700 S**	3	4,385	1980 - 2003	May - Oct	153	48	2,321	2	327
			4,289	1980 - 2003	Nov - Apr	140	48	2,274	4	316
10172350	1300 S Conduits	3	736	1980 - 1988	May - Oct	34	57	3,264	6	371
			725	1980 - 1988	Nov - Apr	29	49	2,371	4	319
10172351	1300 S Conduits - South Conduit	3	736	1980 - 1988	May - Oct	10	17	291	1	110
			725	1980 - 1988	Nov - Apr	9	15	212	0	94
10172352	1300 S Conduits - North Conduit	3	736	1980 - 1988	May - Oct	25	40	1,612	2	261
			725	1980 - 1988	Nov - Apr	21	34	1,180	-1	225
10172370	800 S Conduits	3	181	1980 - 1981	May - Oct	2	3	7	0	15
			287	1980 - 1982	Nov - Apr	4	5	30	0	17
10172371	800 S Conduits - South Conduit	3	306	1980 - 1981	May - Oct	0	0	0	0	4
			80	1980 - 1981	Nov - Apr	0	1	0	0	3

Table 37. (cont'd) Seasonal flow assessment for an irrigation season (May October) and a non irrigation season (November – April) at selected continuous monitoring locations in the analysis area. Stations with bold text are located on the mainstem Jordan River. This assessment accounts for available flow data at each monitoring station from 1980 – 2006.

Station	Name	River Segment	n	Date	Season	Mean (cfs)	STD	Variance	Min	Max
10172372	800 S Conduits - Middle Conduit	3	321	1980 - 1981	May - Oct	0	1	1	0	8
			181	1980 - 1981	Nov - Apr	0	1	1	0	8
10172373	800 S Conduits - North Conduit	3	329	1980 - 1981	May - Oct	0	1	1	0	6
			181	1980 - 1981	Nov - Apr	0	0	0	0	3
10172520	N Temple Conduit	2	290	1980 - 1981	May - Oct	10	11	118	1	53
			263	1980 - 1982	Nov - Apr	3	2	3	1	11
10172550	**500 North**	2	3,529	1980 - 2002	May - Oct	238	95	8,945	89	863
			3,473	1980 - 2002	Nov - Apr	202	71	5,104	33	524

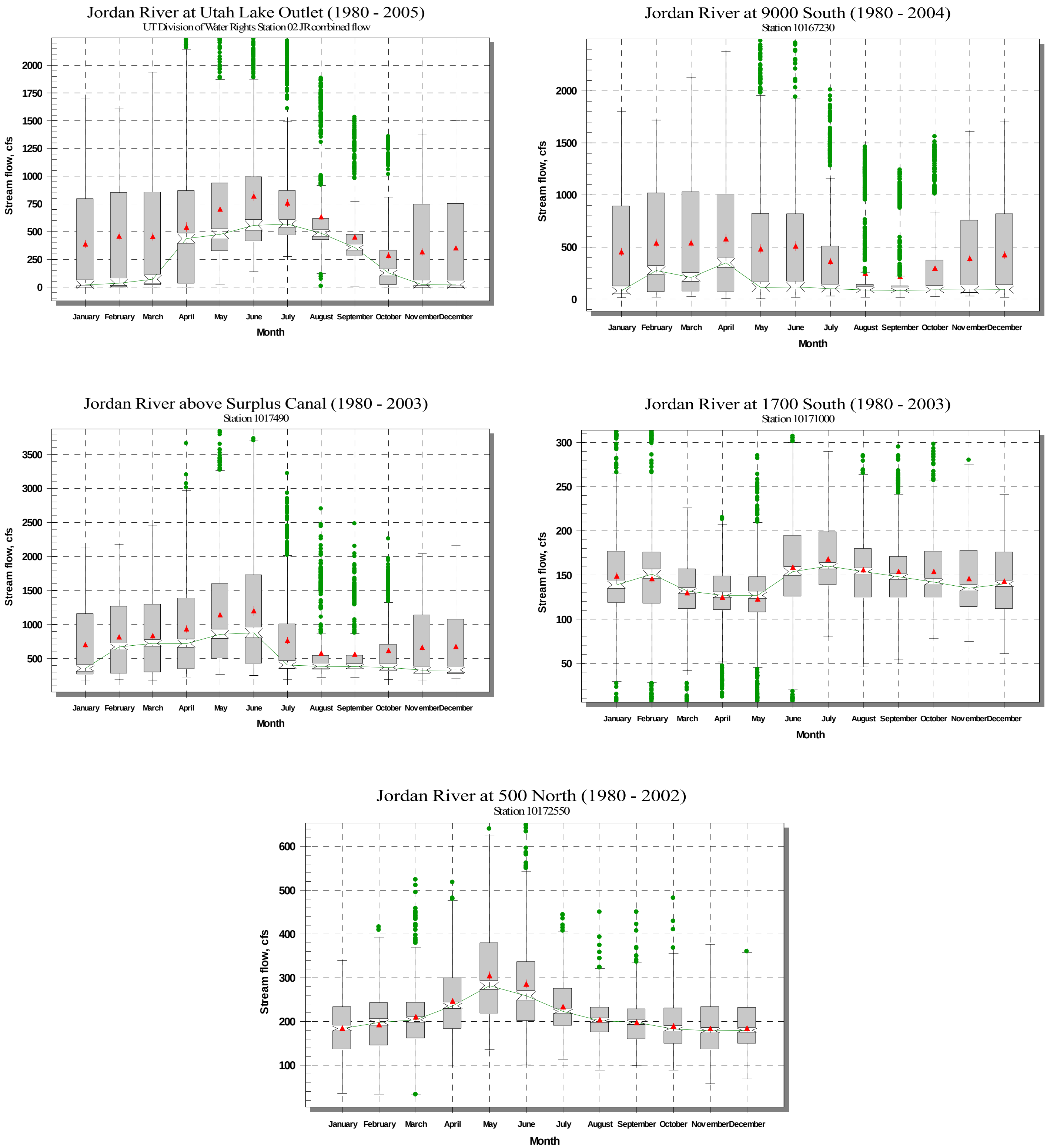


Figure 30. Monthly flow values for mainstem Jordan River monitoring locations. Stations included in this assessment had a minimum of 22 years of data collected since 1980. Note the length of data record indicated in each plot title.

4.2 GROUNDWATER FLOW

Measurements of groundwater contributions to the Jordan River have been collected less frequently than surface flow measurements. General patterns of flow have been defined based on knowledge of the physical characteristics and extent of local geologic features that define aquifers and recharge areas in the Salt Lake Valley. Measurements of groundwater flow are used later in the TMDL assessment to determine pollutant loads contributed by groundwater.

In general, the amount of flow in the Jordan River contributed by groundwater is a function of annual and seasonal recharge volumes. These water volumes are generated by precipitation, snowmelt runoff, seepage from irrigation canals, flood irrigation, and any other source that contributes water to aquifer formations discharging to the Jordan River. Groundwater flow in the Salt Lake Valley is generally toward the Jordan River, although flow paths on the west side of the analysis area move away from the river and toward the Great Salt Lake near Magna and along the west side of Salt Lake City. Groundwater discharge occurs through springs, evaporation, transpiration, seepage to drains in areas of shallow groundwater, and artesian and pumped (non-flowing) wells.

Early groundwater studies in the Salt Lake Valley provided a description of flow patterns and aquifer characteristics that was used to plan development of groundwater resources. As development has occurred in the area, more emphasis has been placed upon protection of groundwater and characterizing the nature and extent of human caused impacts. A list of previous studies addressing groundwater flow in the Jordan River is shown in Table 38.

Table 38. Previous studies addressing groundwater flow in the Jordan River Basin including the mainstem Jordan River and tributaries.

Reference	Extent of study	Description
Richardson 1906	Utah Lake and Jordan River watersheds.	Review of the distribution of groundwater including depth to groundwater, general flow patterns, and location of springs and artesian wells.
Taylor and Leggette 1949	Salt Lake Valley	Description of the presence and extent of aquifers and physical properties of aquifers. Estimates of groundwater contributions to the Jordan River collected during November 1932.
Arnow 1965	Salt Lake Valley	General characterization of the physical properties of aquifers in the Salt Lake Valley, recharge and discharge areas, and patterns of groundwater flow.
Hely et al. 1971	Salt Lake County	Provides estimates of groundwater inflow to Jordan River from 1964-1968.
Herbert et al 1985	Salt Lake County.	Seepage study of six large canals in Salt Lake County during 1982-1983.
Lambert, P.M. 1995	Salt Lake Valley	Computer modeling of groundwater flow in the Salt Lake Valley, including groundwater flow contributions to the Jordan River.
Thiros 2003	Areas of shallow groundwater located in urban/residential areas of Salt Lake County.	Provides measurements of physical properties for shallow aquifers including hydraulic conductivity and transmissivity. Brief descriptions of water level fluctuations in monitoring wells from 1999 - 2001.
Burden et al. 2005	Developed groundwater areas in Utah including the Jordan River Basin.	Report of water level fluctuations in long-term monitoring wells. Summary of groundwater withdrawals in the Salt Lake Valley.
CH2MHill 2005	Jordan River from Turner Dam to Farmington Bay.	Calculated groundwater inflow to the Jordan River from natural, irrigation and non-irrigation sources.

Arnow (1965) characterized the general patterns of groundwater flow into six districts that are still used today when describing groundwater flow. Two of these districts border Jordan River Segments 1 and 2, including the Northwest Lake Plain and East Plain districts. Groundwater flow in the north end of the Northwest Lake Plain District is generally toward the Great Salt Lake. The amount of groundwater contributed to the Jordan River was measured by Taylor and Legette (1949) during baseflow conditions in 1932. A total gain (exclusive of tributaries) of 165 cfs was noted to occur in the Jordan River from the Narrows downstream to Second South in Salt Lake City. The greatest gain per mile was calculated at 8.2 cfs/mile from the Bluffdale Road down to 6400 South. No groundwater gains were observed between 3300 South and 2000 South. Hely et al. (1971) calculated a total annual groundwater discharge of 170,000 acre-feet to the Jordan River. This report also indicated that no groundwater discharge occurred to the Jordan River below 2100 South.

Burden et al. (2005) indicated that total groundwater withdrawals from the Salt lake Valley in 2004 were about 125,000 acre-feet and 9,000 acre-feet less than the annual average withdrawals based on the 1994 – 2003 data record. Water levels were noted to rise in many of the observation wells in the principal aquifer of the Salt Lake Valley. This was believed to be a response to decreased withdrawals and higher than normal precipitation levels during the previous winter season. Long-term trends in groundwater levels throughout the valley were noted to generally be declining over the period 1975 – 2005. The overall decline was attributed to increased withdrawals and the influence of long-term drought conditions. However, some long-term increases were noted for specific areas, including Salt Lake City proper and the northwestern part of the valley.

CH2MHill (2005) modeled groundwater inflows to the Jordan River for natural and irrigation sources during average hydrologic conditions. Model results indicated that groundwater inflow from natural sources was approximately 40,000 acre-feet/year and approximately 50,000 acre-feet/year from irrigation sources. A technical memorandum (Hansen 2005) included in CH2MHill (2005) defined groundwater inflows by Jordan River segment. The results of this assessment are included in Table 39. Groundwater contributions during wet and dry years showed relatively minor differences. The greatest flow contribution from groundwater during all years occurred between 9400 South and 13200 South and decreased steadily with distance downstream to 2100 South. Total annual groundwater flow to the Jordan River ranged from approximately 111,000 – 128,000 acre-feet.

Table 39. Groundwater contributions to Jordan River Segments (Hansen 2005) as shown in Appendix K of CH2MHILL (2005).

	1990	**1981**	**1984**
River Reach	**Dry Flow**	**Average Flow**	**Wet Flow**
13200 South to Joint Division	21.66	22.84	23.49
9400 South to 13200 South	42.47	45.30	45.58
7000 South to 9400 South	17.30	19.19	19.76
4500 South to 7000 South	6.55	7.36	7.47
2800 South to 4500 South	3.86	4.50	5.23
2100 South to 2800 South	2.24	2.61	3.47
500 North to 2100 South	19.94	18.92	22.68
1700 North to 500 North	6.68	5.92	7.14

Table 39. (cont'd) Groundwater contributions to Jordan River Segments (Hansen 2005) as shown in Appendix K of CH2MHILL (2005).

	1990	1981	1984
River Reach	**Dry Flow**	**Average Flow**	**Wet Flow**
Cudahy Lane to 1700 North	5.05	4.45	5.32
Great Salt Lake to Cudahy Lane	3.70	3.13	3.79
Total Flow (cfs)	129.44	134.23	143.94
Total Flow (ac-ft)	93.71	97.17	104.21

4.3 SUMMARY OF FLOW CONDITIONS

A review of the existing flow monitoring locations has identified five USGS stream gages on the mainstem Jordan River that are currently active as well as a number of inactive gages that have sufficient data to characterize seasonal flow patterns. Data records from the DWR can also be used to calculate flow diversions from the Jordan. Flow measurements from the DWQ will be used to supplement flow data sets where applicable. A review of previous studies as well as existing flow data records indicates that flow in the upper segments of the Jordan River is largely controlled by releases from Utah Lake. The influence of Utah Lake releases on the flow and water quality of impaired Jordan River segments will be defined further during future work elements with the use of computer modeling and a more detailed review of flow patterns.

A literature review of flow conditions in the Jordan River indicates fairly significant differences in terms of characterizing flow contributions from groundwater and tributaries and flow losses to irrigation diversions and groundwater recharge. These differences could be the result of the data record used or reflect a particular method used for calculation of the water budget. A clear understanding of the amount of groundwater contributions and tributary flow volumes and rates that enter the Jordan River should be should be reached between stakeholders and the DWQ prior to completing Phase 1 of the TMDL.

The data record of irrigation diversions in the Salt Lake Valley is fairly complete and adequately defines the diversion process along the Jordan River including 303(d) listed segments. Some groundwater flow and irrigation return flow information has been defined by CH2MHill (2005) that can be used to support loading calculations in future work elements. Recommendations for supplementing groundwater flow measurements are included in Section 7.

5.0 BIOLOGICAL CONDITIONS

This section summarizes and interprets the data reviewed in regard to macroinvertebrates, fish, and periphyton, as identified in Section 2.4. The section concludes with a summary of findings suggested by the biological data analyzed and the previous studies reviewed.

5.1 PREVIOUS STUDIES

Table 40 summarizes the documented biological surveys of the Jordan River identified through our review. Many of these reports are published in the format of conference proceedings, university documents, theses/dissertations, and government reports that are not widely circulated. As a result, some of them have not been reviewed individually but were identified in bibliographies that summarize previous research on the Jordan River. Listing them here may facilitate future efforts to locate the original documents.

Given the limited quantity of recent data available, previous studies play a more significant role in characterizing these biological parameters than the water quality and flow variables discussed above. Therefore, key conclusions of previous studies are incorporated into the following discussions of macroinvertebrates, fish, and periphyton rather than being discussed separately.

5.2 MACROINVERTEBRATES

The relationship between the biological health of a water body and the composition of the macroinvertebrate community it supports has led to the use of macroinvertebrates as a surrogate measure of water quality. While some species of macroinvertebrates are very sensitive to water quality and only exist in streams and lakes where water quality is high, other species are somewhat tolerant or highly tolerant of pollution and can exist under a wide range of water quality conditions.

Early studies of macroinvertebrates focused on the role of these organisms as a source of food for other aquatic populations including game fish (Giddings and Stephens 1999). As knowledge increased regarding the habitat requirements of macroinvertebrates, investigation of their use as water quality indicators began. Hinshaw (1967) utilized macroinvertebrates as a biological indicator of degraded water quality conditions in the Jordan River. Other studies have been completed in headwater areas of tributary streams to the Jordan River. Red Butte Creek has been utilized both historically and in the NAWQA program as a reference site for macroinvertebrate research due to the lack of development in this area. Whitney (1951) found that macroinvertebrate populations in Emigration Canyon were impaired as compared to Red Butte Canyon.

The DWQ routinely collects macroinvertebrates at locations throughout the Jordan River watershed. The available macroinvertebrate data collected by DWQ includes measurements of invertebrate abundance from 1985 to 2003. Samples have been collected during spring and fall at monitoring stations located in the Jordan River and adjacent canals.

The Family Level Biotic Index (FBI; Hilsenhoff 1988) was calculated using the most current macroinvertebrate data available from the DWQ. This index represents the average weighted pollution tolerance value for all arthropods present in a sample, with the exemption of organisms that are too immature or damaged to be identified as well as organisms that have not yet been assigned a pollution tolerance value. The FBI rating system is shown in Table 41.

Table 40. Biological studies completed on the Jordan River.

Reference	Location	Fish	Macroinvertebrates	Algae	Habitat	Description
Madsen, 1931	City Creek		x			List and taxonomy of invertebrates in City Creek.
Moffett, 1935	Mill Creek, City Creek		x			Colonization rates of invertebrates after flooding events.
Samuelson, 1950	Red Butte Creek, Emigration Creek			x		Comparison of algae populations in Red Butte Creek and Emigration Creek.
Whitney, 1951	Red Butte Creek, Emigration Creek		x			Comparison of aquatic invertebrates in Red Butte Creek and Emigration Creek.
Quinn, 1958	Jordan River and tributaries			x		Assessment of the impact of sugar beet wastes on periphyton communities of the Jordan River.
Hinshaw 1966	Jordan River and tributaries		x			Comprehensive evaluation of water quality and pollution concerns based on macroinvertebrate populations in the Jordan River.
Baumann, 1967	Mill Creek, Big Cottonwood Creek		x			Taxonomy, distribution, and emergence patterns of stoneflies.
U.S. EPA, 1973	Jordan River, Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek	x	x	x		Survey of fish, algae, benthic invertebrates, and bacteria in Jordan River.
Cather, 1974	Mill Creek		x			Life history and general habits of six species of stoneflies.
Adamus, 1975	Mill Creek		x			Diversity of population and drift of benthic organisms related to environmental factors.
Environmental Dynamics, 1975	Jordan River, Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek	x	x	x		Baseline conditions of fish, invertebrates, and algae in Jordan River, some information on pollutants.
Utah DWR, 1975	City Creek, Red Butte Creek, Big Cottonwood Creek, Little Cottonwood Creek	x				Fish distribution, status; Jordan River tributaries.
EDAW Inc., 1979	Jordan River, Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek	x				Fish population survey.
Geer, 1981	Little Cottonwood Creek	x				Trout fishery condition; Little Cottonwood Creek.
Jensen, 1985	Lower segments of Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek.	x	x	x	x	Summarizes biological information collected and determines if streams are meeting beneficial use designations.
Holden and Crist, 1987	Jordan River, Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek	x	x			Status and limiting factors of aquatic community; Jordan River.
Nabrotzky, 1987	Jordan River above confluence with Mill Creek		x			Survey of macroinvertebrates associated with wetlands; Jordan River

Table 40. (cont'd) Biological studies completed on the Jordan River.

Reference	Location	Fish	Macroinvertebrates	Algae	Habitat	Description
Wilson, 1987	Jordan River, Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek	x			x	Evaluation of Jordan River Fisheries with suggestions for restoring fish populations due to habitat degradation in Jordan River. Includes summary of unpublished aquatic surveys completed on the Jordan River by DWR in 1963, 1976, 1985 and 1986.
Holden and Crist, 1989	Jordan River	x			x	Summary results of eight aquatic sampling visits to the Jordan River conducted during 1988.
Jensen, 1990	Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek.		x			Monitoring of invertebrates.
Crist and Holden, 1991	Jordan River from confluence w/Mill Creek to Farmington Bay	x				Distribution and reproduction of fish; lower Jordan River.
Jensen, 1991	Mill Creek, Big Cottonwood Creek, Little Cottonwood Creek.		x			Monitoring of invertebrates.
Giddings and Stephens, 1999	Great Salt Lake Basins study unit, including the Jordan River.	x	x	x	x	Bibliography of 234 aquatic biological investigations conducted in the GSL Basins from 1875 – 1998.
Waddell, 2004	Little Cottonwood Creek, Red Butte Creek, Jordan River	x				Evaluation of trace elements and organic compounds in bed sediment and fish tissue.
Jensen, 2006	Jordan River and tributaries	x	x	x	x	Unpublished bibliography of biological and water quality assessments completed on the Jordan River.

Table 41. Water quality ratings for the Family-level HBI (from Hilsenhoff 1988).		
FBI Value	**Water Quality Rating**	**Degree of Organic Pollution**
≤ 3.75	Excellent	Unlikely
3.76-4.25	Very good	Possible - slight
4.26-5.00	Good	Some - probable
5.01-5.75	Fair	Fairly substantial
5.76-6.50	Fairly poor	Substantial - likely
6.51-7.25	Poor	Very substantial
> 7.26	Very poor	Severe

The FBI is an index of organic pollution and is based on the response of a community to the combination of high organic loading and decreased DO levels. Pollution tolerance values are assigned to the family level of each of the organisms identified. Lower values represent pollution intolerant families. The index is season dependent; higher values may occur during the summer because the organisms present during this season, characterized by lower water flows and higher water temperatures, generally tend to be more tolerant of pollution than the organisms that are present during spring.

The FBI was calculated for samples collected in the analysis area by the DWQ from 1995 through 2003. The summary values for each date at each location are shown in Table 42. A table identifying the abundance of specific taxa, and their tolerance values, can be found electronically on the CD's which accompany this report.

In general, these results indicate that water quality at the stations surveyed by the DWQ was fairly poor to very poor. Average FBI values calculated for stations located on the Jordan River ranged from 6.3 to 9.7, suggesting a substantial degree of organic pollution. No trend in Jordan River water quality was indicated by FBI scores. The most downstream monitoring station on the mainstem Jordan River was located at 1700 South. It had the lowest average FBI score, indicating higher water quality than upstream Jordan River monitoring stations. This station is part of the USGS NAWQA monitoring program.

The highest average FBI score indicated in Table 42 was 12.5 for Station 4990880 which is located on the State Canal (a diversion from the Jordan River). Individual FBI values at the State Canal indicated that water quality was very poor on all measurement dates and included the highest FBI values for any monitoring station reviewed in this TMDL assessment. No major seasonal differences were apparent, but there were some annual differences in FBI, most noticeably at the State Canal, where higher values (indicating poorer water quality) were recorded in 2000 and 2003.

Table 42. Summary of FBI ratings at monitoring sites located on the mainstem Jordan River, tributaries and diversions.

Station Name	Station ID	Date	FBI	Average FBI
Jordan River at State Canal Road Crossing	4990880	12/1/1995	8.60	12.5
		1/7/2000	9.23	
		5/3/2000	8.36	
		10/31/2000	11.41	
		5/22/2001	10.87	
		11/21/2001	9.63	
		5/21/2002	16.90	
		5/12/2003	19.69	
		11/24/2003	17.97	
Jordan River at 1700 S at SLC	10171000	8/29/2000	6.34	6.3
Jordan River below 123000 South	4994500	10/21/2003	9.66	9.7
Little Cottonwood Creek at Jordan River near SLC	10168000	8/16/1999	6.10	7.0
		8/28/2000	7.36	
		7/10/2001	7.17	
		8/5/2002	7.17	
Reach B		7/10/2001	7.09	7.1
Reach C		7/13/2001	6.88	6.9
Jordan River at 7800 South Crossing above South Valley WWTP	4994170	10/28/1999	7.49	7.2
		5/13/2000	6.96	
Jordan River at Bluffdale Road Crossing	4994600	3/23/1995	7.86	7.4
		10/21/1995	7.44	
		10/26/1999	7.29	
		5/2/2000	6.71	
		10/12/2000	6.39	
		3/30/2001	7.48	
		10/18/2001	8.42	
		5/22/2002	7.20	

5.3 FISH

Early observations by local residents of the Salt Lake Valley indicate that a coldwater fishery existed in the Jordan River as far downstream as 1700 South. It included several species of trout (Lockerbie 1949). The earliest fish survey on the Jordan River was completed by David Jordan at a location upstream of the Mill Creek confluence when six species of varying abundance were observed, including game and non-game aquatic species (Holden and Crist 1989). Exotic fish species (carp) were stocked throughout Utah as a food source beginning in 1881 (Holden et al. 1996). Near the end of the 1800s, sport fishing became popular and stocking practices began to focus on supporting populations of game species. During the first half of the 20th century, impacts on fisheries habitat and stream water chemistry greatly reduced the potential for a coldwater fishery in the Jordan River. Defendable measurements of Jordan River fish populations prior to these stream alterations do not exist (Wilson 1987).

Unpublished surveys completed by the Utah Division of Wildlife Resources (DWR) from 1963 through 1986 indicate that warmwater game species were more common at locations near Utah Lake as were most other species (Table 43). For all stations surveyed, non-game species, including carp and sucker, were generally the most common (Wilson 1987). No indication was provided in the 1963 DWR survey as to how many individual fish were included in each status description. The Jordan River was divided into five segments with common habitat characteristics during the 1976 survey, which generally correspond to individual segments or groups of segments as currently classified by the DWQ. Aquatic habitat in this reach was described as poor due to channelization and low turbidity. Channel substrate was considered to be unsuitable for macroinvertebrate and fish spawning habitat (Wilson 1987). However, flow velocity and discharge were considered suitable for a warmwater fishery.

Table 43. Number of fish captured during surveys completed on the Jordan River by the Utah DWR from 1963 – 1986 (Wilson 1987).

	1963			1976			1985-86		
Location	**# Non-Game**	**# Warm Water**	**# Cold Water**	**# Non-Game**	**# Warm Water**	**# Cold Water**	**# Non-Game**	**# Warm Water**	**# Cold Water**
Cudahy Lane	Rare	0	0	NA	NA	NA	NA	NA	NA
17th South	Many	Rare	0	13	0	0	138	10	0
41st South	Many	0	Rare	11	0	1	35	5	0
123rd South	Common	Many	Rare	70	0	3	34	3	1
146th South	Common	0	Uncommon	25	124	0	37	7	0
Narrows	Uncommon	Many	Rare	NA	NA	NA	11	28	0

A more comprehensive fish survey was completed by Holden and Crist in 1986 on lower Jordan River segments from 3300 South downstream to 1000 North (Holden and Crist 1989). Objectives of the study were to determine what species of fish spawn in the Jordan River, when and where spawning occurs, and what habitats are utilized by adults and juveniles. The greatest number of species identified was at the 1700 South site where 18 different species were identified. Ten species were observed at the 1000 North site. In general, the number of species that were identified seemed to be directly related to the diversity of habitat at a given location. Non-game fish species were the most common group of fish identified at any location in Jordan River segments that were surveyed, which primarily consisted of carp and Utah suckers. A summary of previous fish survey results is provided in Table 44.

A study by the Central Valley Water Reclamation Board (CVWRB 1992) identified game fish spawning sites in the Surplus Canal at the North Point Diversion Dam, in the Goggin Canal at its divergence from the Surplus Canal immediately upstream of 1700 South, and in Decker Drain. This study also found the stations at 1700 South and 1000 South to have the greatest and least number of fish species, respectively.

Table 44. Results of documented fish surveys completed on the mainstem Jordan River and Surplus Canal.

		1000 N			1700 S			12300 S			14600 S			Above Mill Creek			Below Mill Creek			Surplus Canal		
Date	**Units**	**Non-game**	**Warm Water**	**Cold Water**	**Non-game**	**Warm Water**	**Cold Water**	**Non-game**	**Warm Water**	**Cold Water**	**Non-game**	**Warm Water**	**Cold Water**	**Non-game**	**Warm Water**	**Cold Water**	**Non-game**	**Warm Water**	**Cold Water**	**Non-game**	**Warm Water**	**Cold Water**
1976	# fish				13	0	0	70	0	3	25	124	0									
1985-86	# fish				138	10	0				37	7	0									
1986	# fish				258	19	8	102	23	0	174	13	0									
1986	#fish/1000sec	67	0	0	75	1	0							64	5	0	50	1	0			
1988	#fish/1000sec	88	0	0	180	1	0							108	1	0	86	3	0	121	1	0
1990	Avg. # fish/ 1000sec	32	1	4	78	12	5							152	1	0	100	3	1	70	3	0
Apr 1991	#fish/min	1	0	0	5	0	0							8	0	0	4	0	0			
Jul 1991	#fish/min	1	0	0	1	0	0							1	0	0	1	0	0	1	0	0
Aug 1991	#fish/min	1	0	0	1	0	0							1	0	0	1	0	0	2	0	0
Sep 1991	#fish/min				1	0	0							2	0	0	1	0	0	1	0	0
Nov 1991	#fish/min	1	0	0	2	0	0							2	0	0	2	0	0	1	0	0

Evidence of reproducing fish in Jordan River segments was determined by Holden and Crist (1989) based on the presence of early life stage aquatic species as well as reproductively mature adults. A comparison of this survey to previous surveys indicates a steady increase in the number of species and overall aquatic populations in the Jordan River since 1972. Holden and Crist (1989) indicated this is likely due to improvements in water quality and increased reproduction in some areas. They also noted that the primary reason for impairment was likely habitat degradation and not poor water quality. CVWRB (2002) found evidence of low rates of reproduction of game species, and attributed this to lack of spawning habitat.

Fish stocking data obtained from the Utah Division of Wildlife Resources is presented in Table 45. Discussion with agency personnel indicated that typical stocking practices for the Jordan River only involve sport fish species, namely channel catfish and rainbow trout. Peak stocking numbers occurred in 1993 when nearly 90,000 fish were placed in the Jordan River with most of these placed in lower segments below 2100 South. Since that time, approximately 10,000 fish have been placed in the river every year, including nearly 20,000 fish in the year 2000.

Table 45. Fish stocking completed by Utah Division of Wildlife Resources on the Jordan River (1980 – 2004).

Year	Location	Number Stocked	Species	Annual Total
1980	14600 South - Utah County Line	2,433	Rainbow Trout	3,441
	90000 South - 146000 South	1,008	Rainbow Trout	
1981	14600 South - Utah County Line	638	Rainbow Trout	3,898
	90000 South - 146000 South	2,480	Rainbow Trout	
	Great Salt Lake - 2100 South	780	Rainbow Trout	
1982	14600 South - Utah County Line	2,001	Rainbow Trout	3,502
	90000 South - 146000 South	1,001	Rainbow Trout	
	Great Salt Lake - 2100 South	500	Rainbow Trout	
1983	14600 South - Utah County Line	763	Rainbow Trout	763
1987	90000 South - 146000 South	3,014	Rainbow Trout	3,014
1988	90000 South - 146000 South	5,899	Rainbow Trout	5,899
1989	Great Salt Lake - 2100 South	22,462	Channel Catfish	25,490
	90000 South - 146000 South	3,028	Rainbow Trout	
1990	2100 South - 90000 South	12,816	Channel Catfish	33,632
	2100 South - 90000 South	1,001	Rainbow Trout	
	90000 South – 146000 South	5,000	Rainbow Trout	
	Great Salt Lake - 2100 South	12,816	Channel Catfish	
	Great Salt Lake - 2100 South	1,999	Rainbow Trout	
1991	90000 South – 146000 South	8,202	Rainbow Trout	10,202
	Great Salt Lake - 2100 South	2,000	Rainbow Trout	
1992	Great Salt Lake - 2100 South	82,495	Channel Catfish	89,492
	90000 South – 146000 South	4,999	Rainbow Trout	
	Great Salt Lake - 2100 South	1,998	Rainbow Trout	
1993	90000 South – 146000 South	3,000	Rainbow Trout	6,000
	Great Salt Lake - 2100 South	3,000	Rainbow Trout	
1994	90000 South – 146000 South	5,503	Rainbow Trout	7,516
	Great Salt Lake - 2100 South	2,013	Rainbow Trout	
1995	90000 South – 146000 South	11,004	Rainbow Trout	14,005
	Great Salt Lake - 2100 South	3,001	Rainbow Trout	
1996	90000 South – 146000 South	5,000	Rainbow Trout	7,000
	Great Salt Lake - 2100 South	2,000	Rainbow Trout	
1997	Utah County Line - Utah Lake	10,000	Channel Catfish	17,000
	90000 South – 146000 South	5,000	Rainbow Trout	
	Great Salt Lake - 2100 South	2,000	Rainbow Trout	
1998	Utah County Line - Utah Lake	10,000	Channel Catfish	14,000
	90000 South – 146000 South	2,000	Rainbow Trout	
	Great Salt Lake - 2100 South	2,000	Rainbow Trout	
1999	Utah County Line - Utah Lake	10,000	Channel Catfish	14,500
	90000 South – 146000 South	3,500	Rainbow Trout	
	Great Salt Lake - 2100 South	1,000	Rainbow Trout	

Table 45. (cont'd) Fish stocking completed by Utah Division of Wildlife Resources on the Jordan River (1980 – 2004).

Year	Location	Number Stocked	Species	Annual Total
2000	2100 South - 90000 South	7,624	Channel Catfish	19,625
	Great Salt Lake - 2100 South	10,000	Channel Catfish	
	90000 South – 146000 South	2,001	Rainbow Trout	
2001	Great Salt Lake - 2100 South	10,000	Channel Catfish	12,004
	90000 South – 146000 South	2,004	Rainbow Trout	
2002	Great Salt Lake - 2100 South	10,000	Channel Catfish	12,000
	90000 South – 146000 South	2,000	Rainbow Trout	
2003	Great Salt Lake - 2100 South	10,000	Channel Catfish	10,000
2004	Great Salt Lake - 2100 South	10,000	Channel Catfish	10,000

5.4 PERIPHYTON

As noted above (Section 2.4), data on periphyton from two sites included in the NAWQA database was assessed in this analysis. A literature search identified several documents including unpublished thesis/dissertations and agency reports dealing with this parameter. If and when this information is obtained, it will be reviewed and included in the final TMDL report as appropriate.

Samples collected at the two sites, on the Jordan River at 1700 South and on Little Cottonwood Creek at its confluence with the Jordan River, were evaluated using software that calculates and standardizes 17 water quality indices and six ecological indices. The complete report on this analysis is included in Appendix D. To summarize, both the number of species and the diversity indices at both sites were relatively high. The 17 water quality indices, standardized to range from 1 (worst) to 20 (best) yielded values from 5.7 to 15.9 for the 1700 South site and from 6.3 to 14.1 for the Little Cottonwood Creek site. These figures suggest water quality values that are relatively high compared to other, more direct measures at both sites.

In terms of ecological indices, the Table 46 summarizes the values for the van Dam index (van Dam 1994) , which includes more separate parameters than the other indices.

Based on this assessment of periphyton measurements, the aquatic habitat appears to be relatively high in pH (not unusual for waters of the Great Basin), with somewhat elevated salinity, moderate to high oxygen saturation, and in a generally eutrophic condition. Results from the two sites were similar, though the 1700 South site appeared to be slightly more alkaline, better oxygenated, and marginally more eutrophic.

Table 46. Diatom-based ecological indices (van Dam) based on NAWQA data, 1999 – 2000.

	Jordan River at 1700 South [1]	Little Cottonwood Creek at Jordan River Confluence[1]
pH:		
- Acidobiontic	0	0
- Acidophilous	0	0
- Neutrophilous	13.8	31.8
- Alcaliphilous	81.5	59.2
- Alcalibiontic	2.2	2.9
- Indifferent	0	0
Salinity:		
- Fresh	4.0	2.0
- Fresh Brackish	69.3	66.2
- Brackish Fresh	26.3	24.7
- Brackish	1.7	1.5
N-Heterotrophy:		
- Autrophic Sensitive	2.7	4.0
- Autotrophic Tolerant	64.4	47.1
- Heterotrophic Facultative	24.7	25.5
- Heterotrophic Obligate	2.6	5.9
Oxygen:		
- Continuously High (≤100% Sat.)	8.9	17.3
- Fairly High (≤75% Sat.)	42.0	16.6
- Moderate (≤50% Sat.)	33.0	38.3
- Low (≤30% Sat.)	8.7	8.6
- Very Low (≤10% Sat.)	1.7	2.2
Saprobity:		
- Oligosapropobous	1.7	3.4
- Mesosapropobous	52.3	33.3
- Alphamesosaproprobous	32.6	36.8
- Alphmeso-polysaproprobous	6.9	5.5
- Polysaproprobous	1.3	5.9
Trophic State:		
- Oligotraphentic	0.6	2.7
- Oligo-mesotraphentic	0	0.7
- Mesotraphentic	0.6	1.0
- Meso-eutraphentic	9.4	8.9
- Eutraphentic	75.3	51.3
- Hyper-eutraphentic	2.8	6.2
- Oligo to Eutraphentic	7.6	15.8
Moisture:		
- Aquatic Strict	13.2	14.5
- Aerophilous Occasional	18.0	15.6
- Aquatic to Sub-aerian	60.8	52.8
- Aerophilous Strict	1.9	1.7
- Terrestrial	0	0

[1]Figures are percentage of sample.

5.5 SUMMARY OF BIOLOGICAL CONDITIONS

This review of biological data indicates that the Jordan River corridor has changed dramatically over the past century due to human-caused factors associated with development of the Salt Lake Valley. These changes have impacted the overall health and diversity of species that utilize the Jordan River itself as well as the riparian areas adjacent to the river.

Many reports assessing the biological health of the Jordan River are published in the format of conference proceedings, university documents, theses/dissertations, and government reports that are not readily available. Most of the available information, including actual measurements and published reports, are focused on fish and macroinvertebrate communities. A very limited data set was found to define the current status of phytoplankton in the Jordan River.

The distribution and abundance of macroinvertebrate families at stations in the Jordan River indicate a high tolerance to pollutant loading. The FBI was used to assess macroinvertebrate data, reflecting the response of a community to a combination of high organic loading and decreased DO levels. FBI levels did not exhibit trends with distance downstream from Utah Lake, as did most direct water quality monitoring data. However, though trends were not evident, FBI levels did indicate low water quality in segments identified as impaired by direct monitoring. In general, average FBI ratings at mainstem Jordan River stations ranged between 6.3 and 9.7, indicating fairly poor to very poor water quality as well as a substantial degree of organic matter loading.

Fish populations have been surveyed in the Jordan River at various times during the past 40 years. All of the surveys reviewed indicate that most segments of the Jordan River are dominated by non-game species including carp and sucker. The number of warmwater and coldwater fish in the Jordan River generally increases with distance upstream toward Utah Lake. Review of previous surveys indicated that flow velocities and volumes observed in Jordan River segments below the confluence of Little Cottonwood Creek were suitable for a warmwater fishery. Impairment to aquatic populations in the Jordan River was generally considered to be the combined result of degraded water quality and loss of habitat.

Stocking data obtained from the Utah Division of Wildlife Resources indicates that large numbers of sport fish have been placed in the Jordan River beginning in 1980 and continuing through the present time. It is not known why these sport fish species have not been recorded in number reflecting this stocking effort in fish surveys conducted to date.

Phytoplankton data was located from one location on the mainstem Jordan River for one sample date. Assessment of this data set indicated that water quality was somewhat high in pH, salinity, and oxygen saturation levels and in a generally eutrophic condition.

Gaps and shortcomings in the biological data include recent measurements of Jordan River fish populations as well as more detailed information on historic and current status of periphyton and macrophyte communities. Fish stocking data indicates large numbers of sport fish that were not encountered in historic fish surveys completed on the Jordan River. Although biological data records for the Jordan River are limited, they do provide supporting information that can be used to define the linkage between low DO and stream productivity. Recommendations for future monitoring to meet these needs is discussed in Section 7.

6.0 GIS DATA

A list of GIS data sources is included in Table B-75 of Appendix B. Maps depicting the GIS information collected for the Jordan River TMDL study area that are not shown in the main body of this document are included in Figures A-1 through A-12 of Appendix A. The Cirrus team anticipates that additional GIS data will need to be obtained from agencies and stakeholders within the analysis area, including but not limited to stormwater flow paths and geographic locations of flow measurements archived by the DWR. Cirrus will likely need to generate a small amount of supplementary GIS data to assist in defining locations of pollutant loadings required for the final TMDL analysis. It is anticipated this data can be obtained with minimal effort and will likely be produced through a combination of field work and viewing of aerial photographs or digital orthophoto-quads (DOQs).

7.0 RECOMMENDATIONS

Based on the review of available water quality, flow, and biological data for the Jordan River Basin, it is proposed that additional information be collected to support the TMDL. This data will provide greater spatial coverage for impaired segments of the Jordan River as well as define input variables needed for computer modeling of flow and water quality. The use of qualified stakeholders to collect additional data is encouraged. All water quality samples should be processed through EPA-certified laboratories.

7.1 FLOW MONITORING SITES

In general, flow measurements at DWQ monitoring locations are limited. Although there are several USGS streamflow gages located on the mainstem Jordan River that will be used to supplement DWQ flow measurements, additional data is needed to calculate average flow values. Based on previous work associated with this TMDL, staff gages or other instrumentation are being installed at the locations shown in Table 47 to provide a quick yet accurate method for measuring flow during all stages of discharge. These instruments will provide an efficient means of increasing the number of flow measurements throughout any given year. The selection of these sites was based on the location of active USGS gage stations as well as STORET monitoring sites with a good distribution of water quality measurements that lack sufficient flow data to calculate pollutant loads.

Table 47. Recommended locations for additional flow monitoring.

Site Description	Corresponding STORET site
UT Lake outlet at North Saratoga Road (U121 crossing)	4994790
Jordan River at Bangeter Highway crossing	4904600 (~1.5 miles upstream)
Jordan River at Draper-Riverton Road (12300 South)	4994490
Jordan River at Bluffdale Road	4994600
Jordan River at 5400 South	4994090 (at pedestrian bridge)
Jordan River at 3300 South	4992880

7.2 WATER QUALITY MONITORING SITES

The DWQ is currently scheduled to complete routine measurements of water quality and flow at eight long-term sites on the mainstem Jordan River during 2006 – 2007. Based on previous work associated with this TMDL, four additional stations will be monitored during this same time period. The proposed locations are included in Table 48. The location of these sites was based on the distribution of the eight scheduled sites as well as previous monitoring activities. It is recommended that all sites scheduled for monitoring during 2006 – 2007 be visited at least one time per month for an entire year. Measurements of this type will support an assessment of seasonal changes in water quality and flow.

Measurements of diurnal DO were discussed earlier in this report. Based on previous work associated with this TMDL, additional diurnal measurements of DO will be collected at the locations shown in Table 48 during a moderate or average flow period (June) as well as during a baseflow period (August – October). It is also recommended that diurnal measurements of DO be collected at multiple depths at one location from DO impaired segments of the Jordan River, either at Cudahy Lane or the Redwood Road crossing. Based on a review of existing data and knowledge of channel characteristics and flow patterns in Jordan River Segments 1 and 2, it is anticipated that DO conditions may be stratified vertically and possibly horizontally. If this is the case, placement of DO probes could significantly impact the diurnal flux of measurements.

Table 48. Recommended locations for additional water quality monitoring in the Jordan River, including routine monitoring and diurnal measurements of DO.

Routine Water Quality monitoring	
Description	**Station ID**
Jordan River above Burnham Dam and State Canal diversion.	NA
Jordan River at 1800 N. Redwood Rd. Bridge	4991860
Jordan River at 10600 South crossing	NA
Jordan River at 12300 South crossing	NA
Diurnal DO monitoring	
Description	**Station ID**
Jordan River at Cudahy Lane (Segment 1)	4991820
Jordan River at Redwood Road (Segment 2)	4991860
Jordan River at North Temple (Segment break 2-3)	4991910
Jordan River at 2100 South above Surplus Canal diversion (Segment 4)	4992320
Jordan River at 5400 South (Segment 4)	4994090

7.3 WATER QUALITY PARAMETERS

It is recommended that certain water quality parameters be measured at the 12 monitoring sites, including the eight scheduled sites currently being visited by DWQ during 2006-07 and the four recommended sites shown in Table 48. A list of the recommended water quality parameters is presented in Table 49. Parameters included in the basic list will be used to develop the Jordan River TMDL. Parameters included on the non-conventional list are needed for either model calibration or assessment of beneficial use impairment.

Water quality parameters need to be measured at a frequency that will allow definition of any seasonal trends that may occur in impaired segments of the Jordan River. It is recommended that visits occur to each monitoring site at least once every month for an entire year. For purposes of E. coli monitoring, state criterion require geometric means be calculated from a minimum of 5 samples measured within a 30-day time period. It is therefore recommended that E.coli measurements be collected at this frequency at least once every quarter for an entire year.

It is particularly important that pollutants of concern listed in Table 49 be measured during future water quality monitoring efforts on the Jordan River. As shown in Section 3, a very limited amount of E. coli data has been collected to date. The current E. coli data set is insufficient to accurately determine pollutant loads and assign pollutant load allocations needed to complete a TMDL for impaired Jordan River segments. Temperature measurements collected during the 2004 – 2005 intensive monitoring period indicated no violation of criteria. This result is likely influenced by the time of day during which measurements were collected. It is therefore recommended that, where possible, field measurements be collected at times that correspond to diurnal temperatures peaks, as shown by monitoring data presented in Section 3.

A Sampling Analysis Plan (SAP) for synoptic monitoring of the Jordan River and tributaries to the river is included as Appendix E to this report. The SAP includes a list of all sample parameters that will be collected during the 2006-2007 Jordan River synoptic monitoring effort as well as discussion on sample frequency and sample locations. Information from this effort will be used for water quality model calibration and validation in support of the Jordan River TMDL.

Table 49. Recommended water quality parameters to be measured at eight routine and four recommended water quality monitoring sites in the Jordan River TMDL Project Area.

Basic Parameters	**Non-conventional Parameters**
Flow	Carbonaceous Oxygen Demand
Total Dissolved Solids	Sediment Oxygen Demand
Dissolved Oxygen (concentration and % saturation)	Nitrate + Nitrite
Phosphorus (Total, Dissolved, and Ortho-phosphate)	Total Kjeldahl Nitrogen (as N)
Ammonia	Organic content of TSS
Bio-chemical Oxygen Demand	Macrophyte biomass
Temperature	Diatom speciation
Total Suspended Solids	Periphyton as chlorophyll a
Specific Conductivity	Stream channel substrate
Chlorophyll a	Synoptic flow (August or September of 2006)
pH	Macroinvertebrates (at least one sample from each listed segment)
E. Coli	Fish survey (either population or presence/absence survey)

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