S A N D I E G O R I V E R P A R K
F O U N D A T I O N

LOWER SAN DIEGO RIVER
WATER QUALITY 2013

WY13 Water Quality Monitoring Report

RiverWatch Water Quality Monitoring Results (October 2012 - October 2013)

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November 2013

Lower San Diego River Water Quality - 2013

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Questions regarding the San Diego River WQM database or interpretation of results expressed in this report can be directed to the attention of John C. Kennedy, through contacting SDRPF at info@SanDiegoRiver.org, or the RiverWatch Coordinator at 619-297-7380.

Section 1 - Introduction

This report provides a summary of patterns and trends in water quality monitoring results gathered by SDRPF's RiverWatch citizen volunteers. WQM data collected monthly over the last 9 years at 15 sites within the Lower San Diego River (LSDR) watershed have been aggregated, in conjunction with hydrologic data on stream flow into a numeric water quality index (WQI). Basic monthly data regarding individual water quality parameters and river hydrology for each of the sites monitored are maintained in an excel database available at the SDRPF offices; this report examines Water Year 2013 (WY13) data in comparison to previous results. The LSDR watershed and water quality monitoring site locations are shown on **Figure 1-1**.

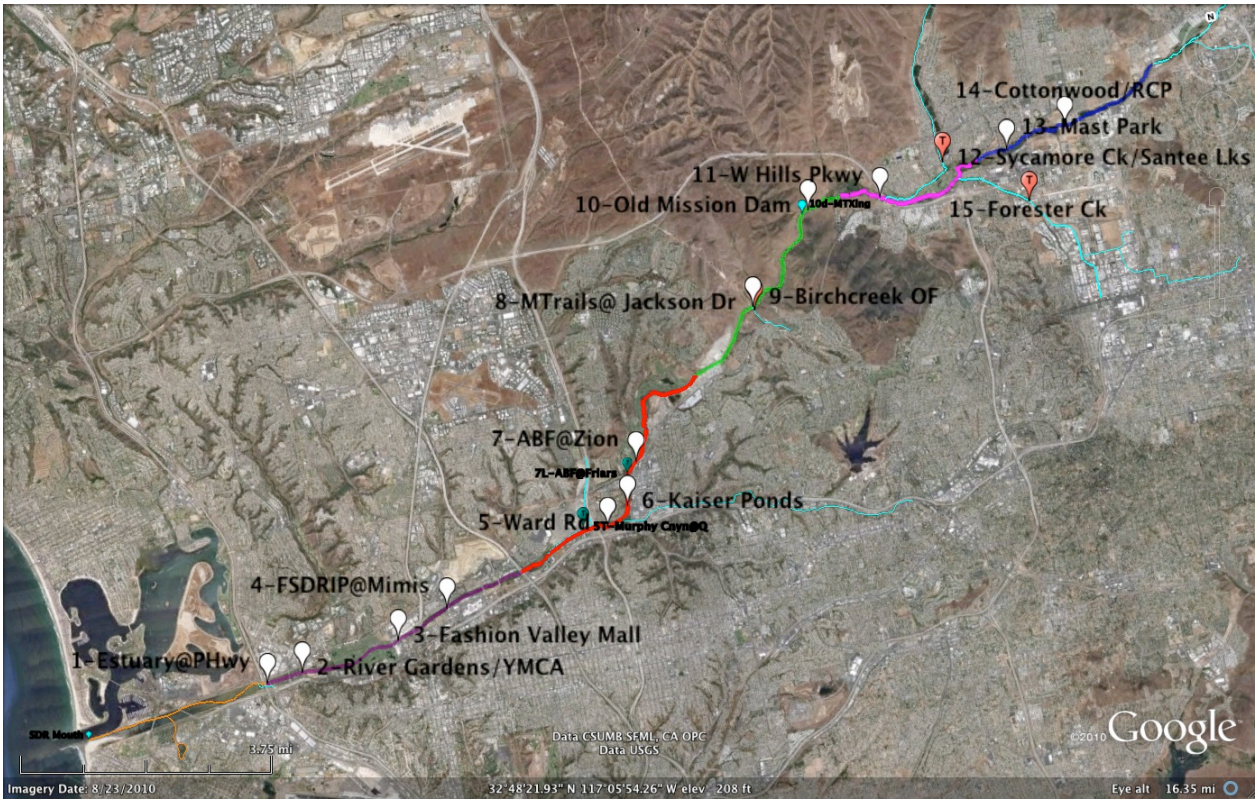


Figure 1-1 LSDR Watershed and Water Quality Monitoring Sites

Color Code for LSDR reaches on figure above: Estuary (orange), Lower Mission Valley (purple), Upper Mission Valley (red), Mission Gorge (dark green), Lower Santee Basin (pink), Upper Santee Basin (dark blue), Lakeside to El Capitan Reservoir (light green) and principal tributaries (light blue)

Figure 1-1 can be viewed in greater detail through Google Earth by accessing file "Fig1.1WQMR.kmz" from the SDRPF website/River Monitoring page at: http://www.sandiegoriver.org/riverwatch.php>. The RiverWatch monthly water quality monitoring data at each site, as well as associated WQI values, are also provided on this webpage at: http://www.ecolayers.biz/sdrpf%2Driverwatch/> through clicking on access to 'Web-based Information Center'. In addition to water quality monitoring data, the portal also contains: River Blitz data, SDR Conservancy Project information, SD StreamTeam Bio-assessment data, 401 Project information and USGS realtime streamflow data on daily peak discharge and gauge height for the San Diego River stations.

The RiverWatch monitoring team's water quality index (WQI) represents SDRPF's response to general questions regarding water quality in the Lower San Diego River. The index is a numeric (0-100) where increasing value indicates better water quality. The numerical index encapsulates basic physical, chemical and bacteriological water quality data by integrating six parameters: temperature (Temp), pH, specific conductivity (SpC), dissolved oxygen (DO and/or %DO), mean coliform count (MCC) and streamflow (Q); through determination of weighted factors for each. The resulting values are then aggregated to arrive at an overall score for each site, reach, section and the river (LSDR) as a whole. The SDR WQI values, grade, color codes and general conventions employed are presented in **Table 1.1.**

Table 1.1 LSDR Water Quality Index

SDR WQI (0-100)	Grade	Color Code	Percentile Range	Water Quality Threshold	General
75 or >	A - Very Good	Dark Blue	25%	Well Above Acceptable WQ Criteria	Optimal (>50)
50 - 74	B - Good	Light Blue	25%	Exceeds Acceptable Criteria	
35 - 49	C - Fair	Green	15%	Meets General WQ Criteria	Intermediate (25-49)
25 - 34	D - Marginal	Yellow	10%	Meets Limited Minimum Criteria	
10 - 24	E - Poor	Brown	15%	Meets Few Minimum Criteria	Substandard(< 24)
0 - 9	F - Very Poor	Red	10%	Well Below Minimum Criteria	

In general, sites with WQI values of 50 or above exceed expectations for acceptable water quality and are indicative of 'Optimal' conditions. Scores between 25 and 49 describe 'Intermediate' quality levels where evidence exists regarding failure to meet acceptable water quality criteria at all times. Water quality with scores of 24 or below do not meet minimum expectations and are considered 'Substandard'. For WQ parameters monitored by RiverWatch, the index expresses results relative to levels necessary to maintain designated beneficial water uses based on State of California Water Quality Standards. Where criteria are non-specific, results are expressed relative to norms for southern California coastal area rivers and streams. The index is not valued for estuaries or open ocean waters.

The WQI has been computed using two formulas; one involving four key parameters (Temp, SpC and DO) monitored by RiverWatch combined with streamflow (Q), the second with two additional parameters (pH and MCC) also combined with streamflow. The equations used for both formulas (WQI_4 and WQI_6) are presented in Appendix B. Differences between the two determinations were found to be small, although the first determination (WQI_4) typically presented a broader range (from low to high value) than the second as the 'normalizing' effect of pH and MCC (both of which present less spatial and temporal variance) is excluded. The broader range WQI_4 values are presented in this report. Although the index has been developed specifically for the San Diego RiverWatch Program, it can also be applied to other coastal area watercourses where comparable water quality parameters are monitored on a regular basis.

Section 2 - Spatial Water Quality Data Comparison WY13 and WY12

Average annual water quality values for each of the 15 monitoring sites for WY13 and WY12 are presented in **Table 2.1**. Monthly water quality data collected and recorded at each site by RiverWatch used to determine annual averages, seasonal patterns and trend lines are presented in the appendices together with supplemental data collected by other monitoring organizations for streamflow (USGS) and coliform counts (SD CoastKeepers). The data are also available through the SDRPF web site.

Table 2.1 Average Annual WQ Data by Site, Reach and Section for This Year and Last

Site:	*LSDR Reach & Section*		Temp, oC	SC, mS/cm	pH	DO, mg/L	DO %Sat	Flow, cfs	WQI Value [a], (Change), & Grade	
1	LMV	West	18.6/20.0	6.98/7.04	7.8/7.8	6.2/5.9	66/67	11/19	39/37 (+2)	C/C
2			18.5/18.8	2.79/2.58	7.7/7.8	4.3/4.4	43/46		29/30 (-1)	D/D
3			18.8/18.9	2.65/2.53	7.9/7.8	5.4/4.4	57/46		35/30 (+5)	C-/D
4			19.0/19.4	2.56/2.44	7.8/7.7	6.8/6.4	72/68		43/43 (0)	C/C
5	UMV		16.7/17.4	2.73/2.49	7.7/7.6	4.9/4.9	49/50	10/15	31/35 (-4)	D/C-
6			17.6/18.2	2.79/2.37	7.6/7.6	3.8/4.3	38/44		25/32 (-7)	D-/D
7			17.8/18.3	2.42/2.26	7.5/7.5	5.9/6.0	60/63		38/41 (-3)	C/C
8	MG	Mid	16.3/17.1	2.61/2.61	7.7/7.6	7.4/7.3	73/75	9/11	46/50 (-4)	C/B-
9 [b]			14.1/14.9	5.03/5.32	7.9/7.9	9.5/9.7	92/96		33/39 (-6)	D/C
10			17.2/18.3	2.34/2.37	8.0/7.9	7.4/6.9	75/73	5/7	42/47 (-5)	C/C
11	LSB	East	16.1/16.7	2.36/2.41	7.6/7.4	6.5/6.3	66/64		36/41 (-5)	C-/C
12 [b]			16.0/18.0	1.60/1.79	8.1/8.0	7.9/7.1	80/75		45/44 (+1)	C/C
15 [b]			17.2/18.6	2.77/2.95	8.0/7.9	5.5/6.6	56/71		26/36 (-10)	D-/C-
13	USB		17.8/18.2	2.04/1.96	7.8/7.6	1.6/0.9	16/9	2/3	8/5 (+3)	F/F
14			17.2/18.1	1.68/1.66	7.9/7.9	3.1/2.9	32/31		16/18 (-2)	E/E
(1-15)	**LSDR**		**17.3/18.0**	**2.49/2.38**	**7.8/7.7**	**5.7/5.6**	**58/58**	**9/15**	**31/34 (-3)**	**D/D+**

a) Average annual water quality index value, change (+/-) over last 12 months and resultant WQ letter grade; declines in index values from last year's (WY12) results are expressed in red. Ten sites showed declines; five showed improvements.
b) Lower San Diego River tributary stream monitoring sites.

Average annual, seasonal and minimum-to-maximum range water quality values for this year (WY13) and last (WY12) are presented in **Table 2.2** by river reach, section and overall. The spatial water quality values listed in Tables 2.1 and 2.2 for the Lower San Diego River system monitoring sites are expressed in subsequent **Charts 2.1** (Water Quality Data) and **2.2** (Water Quality Index and Streamflow). The overall water quality index is down three points to 31 from last year's value of 34. Only four sites (1, 3, 12 & 13) present higher WQI values than last year. Index values are down considerably from last year's averages

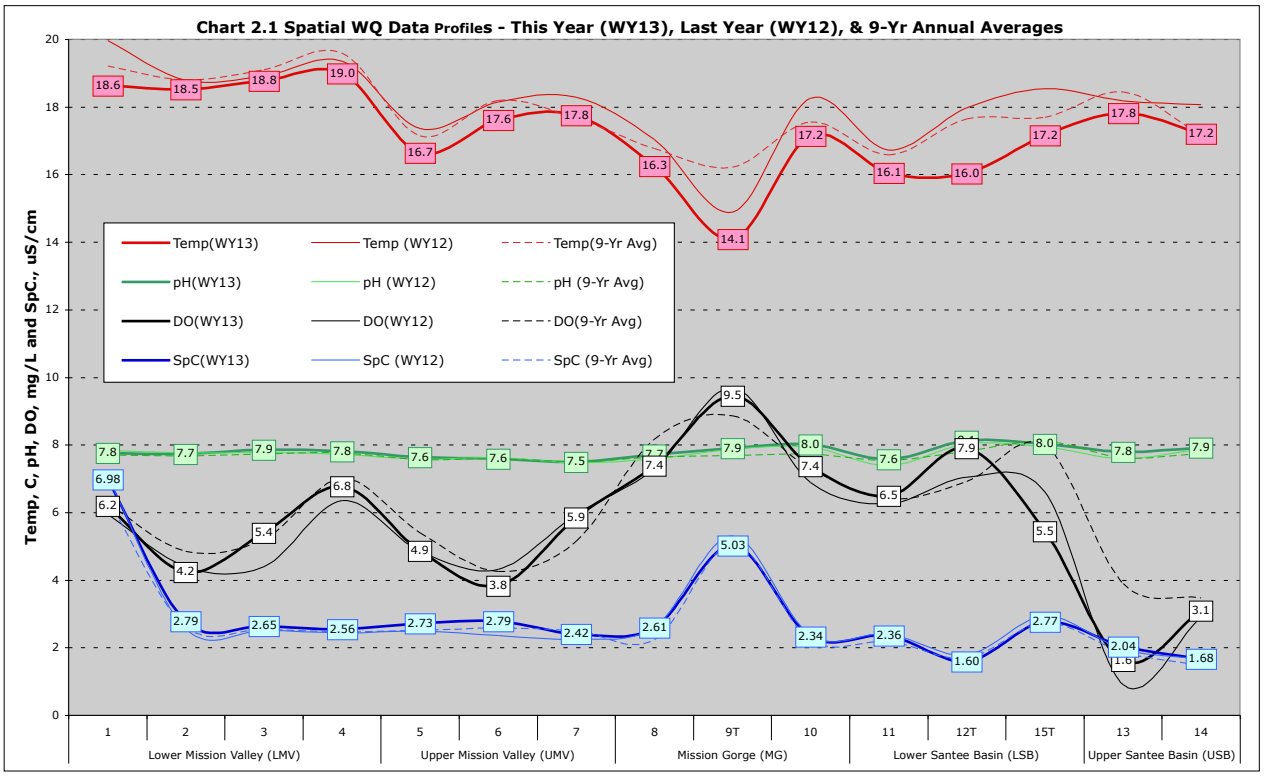
in three (LSB, MG & UMV) of the five reaches. All three average annual section values are lower than the previous year.

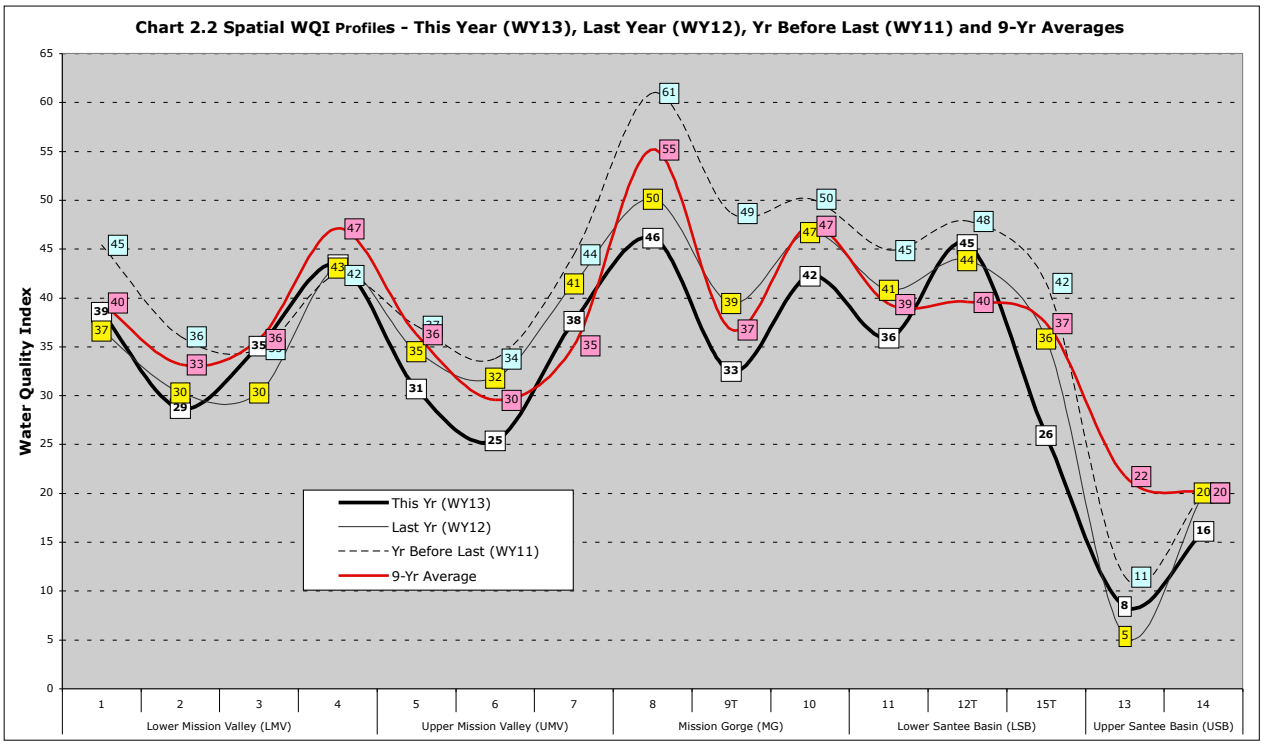
Table 2.2 Average Annual Water Quality Data by Season, Reach and Section for WY13/WY12

Parameter, units		Temp, oC	SC, mS/cm	pH	DO, mg/L	DO %Sat	Flow, cfs	WQI Value, [a] (Change), & Grade	
Maximum Month		22.1/24.3	3.26/3.36	8.2/8.1	7.8/9.7	72/92	28/33	56/51(+5)	B/B-
Winter (D,J,F,M)		12.4/13.6	2.02/1.69	7.9/7.9	7.2/7.7	68/75	22/28	50/44 (+6)	B-/C
Annual Average		**17.3/18.0**	**2.49/2.38**	**7.8/7.7**	**5.7/5.6**	**58/58**	**9/15**	**31/34 (-3)**	**D/D+**
Summer (J,J,A,S)		22.9/21.6	3.07/3.12	7.7/7.6	4.0/4.0	47/46	1.1/1.7	13/20 (-7)	E/E+
Minimum Month		9.2/10.4	1.46/1.33	7.0/7.4	3.3/2.5	39/27	0.4/1.3	7/13 (-6)	F/E
LSDR Section Averages:									
East	SB	17.2/17.9	2.18/2.14	7.9/7.7	4.2/4.2	42/44	7/13	22/25 (-3)	E/D-
Mid	MG	16.2/17.1	2.47/2.49	7.9/7.8	8.2/8.1	81/82	10/20	44/48 (-4)	C/C+
West	MV	18.1/18.7	2.66/2.44	7.7/7.7	5.3/5.2	55/55	25/33	34/35 (-1)	D/C-
LSDR Reach Averages:									
USB	East	17.6/18.2	1.95/1.86	7.9/7.7	2.1/1.6	22/16	6/10	11/10 (+1)	E-/E-
LSB		16.7/17.7	2.41/2.43	7.9/7.5	6.2/6.5	64/68	8/18	33/40 (-7)	D/C
MG	Mid	17.3/18.0	2.47/2.49	7.9/7.8	8.2/8.1	81/82	12/22	44/48 (-4)	C/C+
UMV	West	17.4/17.9	2.65/2.37	7.6/7.6	4.9/5.0	49/52	20/28	31/36(-5)	D/C-
LMV		18.7/19.3	2.67/2.51	7.8/7.8	5.5/5.1	57/53	26	36/35 (+1)	C-/C-

a) Average annual water quality index value, change (+/-) over last 12 months and resultant WQI letter grade. Declines in water quality index values from last year's (WY12) results are expressed in red.

Chart 2.1 presents average annual water quality values for Temp (red), pH (green), DO (black) and SpC (blue) at each monitoring site and river reach in order of their location upstream for WY13 (Oct'12-Sept'13), last year (WY12) and the 9-yr average. The heavy solid lines with values shown are this year's average annual results, the light solid lines without values are last year's (WY12) results and the dashed lines represent 9-yr averages for each site. Average annual water temperatures are generally lower than last year's values at most sites while pH and SpC values are approximately the same as for WY12. DO levels are, with exception of two sites (6 and 15), slightly higher than last year's results. The average annual SpC and water temperature values tend to increase from upstream to downstream with exception of tributary sites. Average DO values show the greatest variation between sites. Lowest values are typically recorded in the Upper Santee Basin (Sites 13 and 14) whereas highest values are measured in the Mission Gorge (middle reach) section. Approximately half the sites present DO levels above the 9-yr averages while the other half are equal or below for WY13.





The WQI, an aggregate or composite index of average annual water quality monitoring results for WY13, WY12, WY11 and the 9-yr norms are presented in **Chart 2.2**. The two sites furthest upstream, 13 (Mast Park) and 14 (RCP/Cottonwood), continue to experience poor-to-very poor water quality. On an average annual basis, highest values continue to be associated with the Mission Gorge reach. The overall WQI

profile for WY13 (heavy black line) is noticeably lower than last year's averages (light black) and the year before (dashed) at all sites and also below the 9-yr averages (solid red) with exception of Sites 7 (ABF) and 12T (CarltonOaks Dr.-Sycamore Ck).

Section 3 -Temporal Water Quality Data Comparison WY13 and WY12

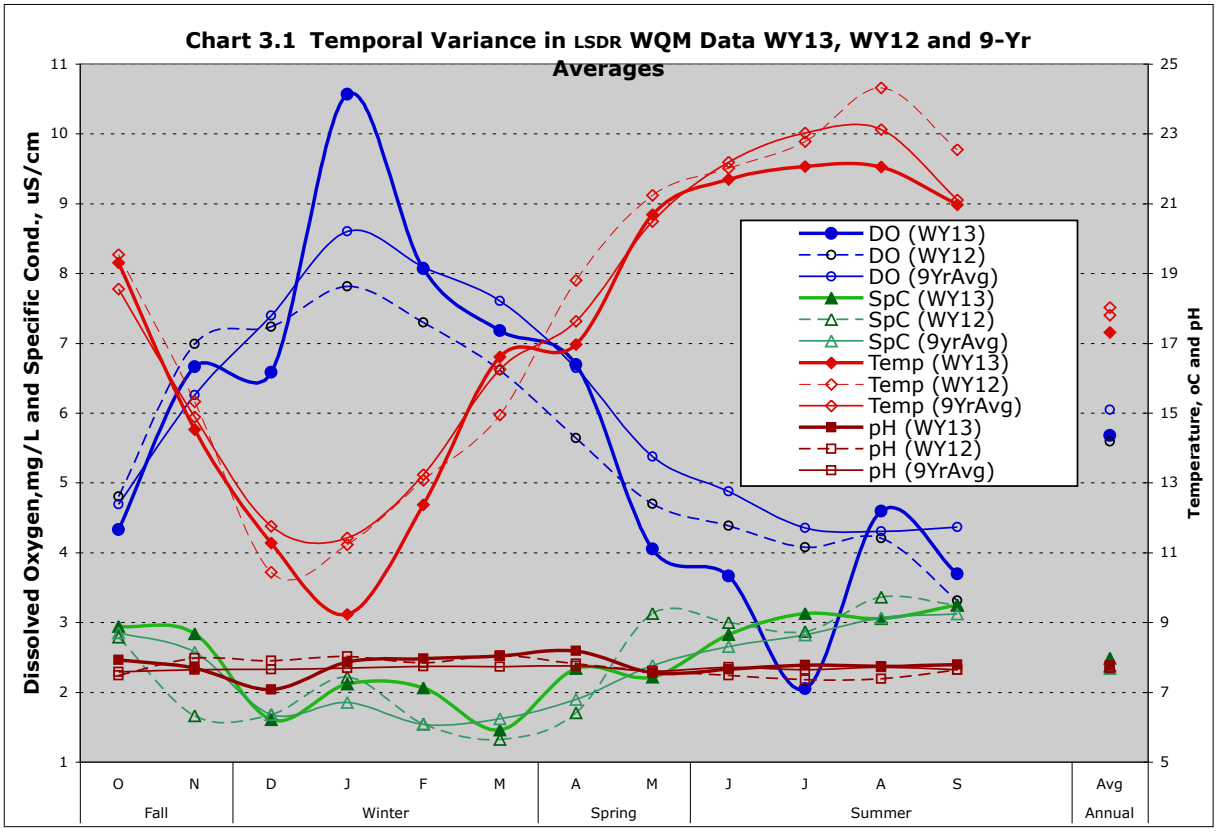
Monthly and seasonal water quality monitoring data and WQI averages for the Lower San Diego River are presented in **Table 3.1** for WY13 and WY12. Eight out of the past 12 months have shown declines in overall river water quality as expressed by the index. Winter (Dec-March) was the only season in WY13 that presented improvement, rising from C(44) to B-(50), in LSDR quality over the same period of monitoring a year ago.

Table 3.1 LSDR WQM Data by Month and Season for WY13/WY12

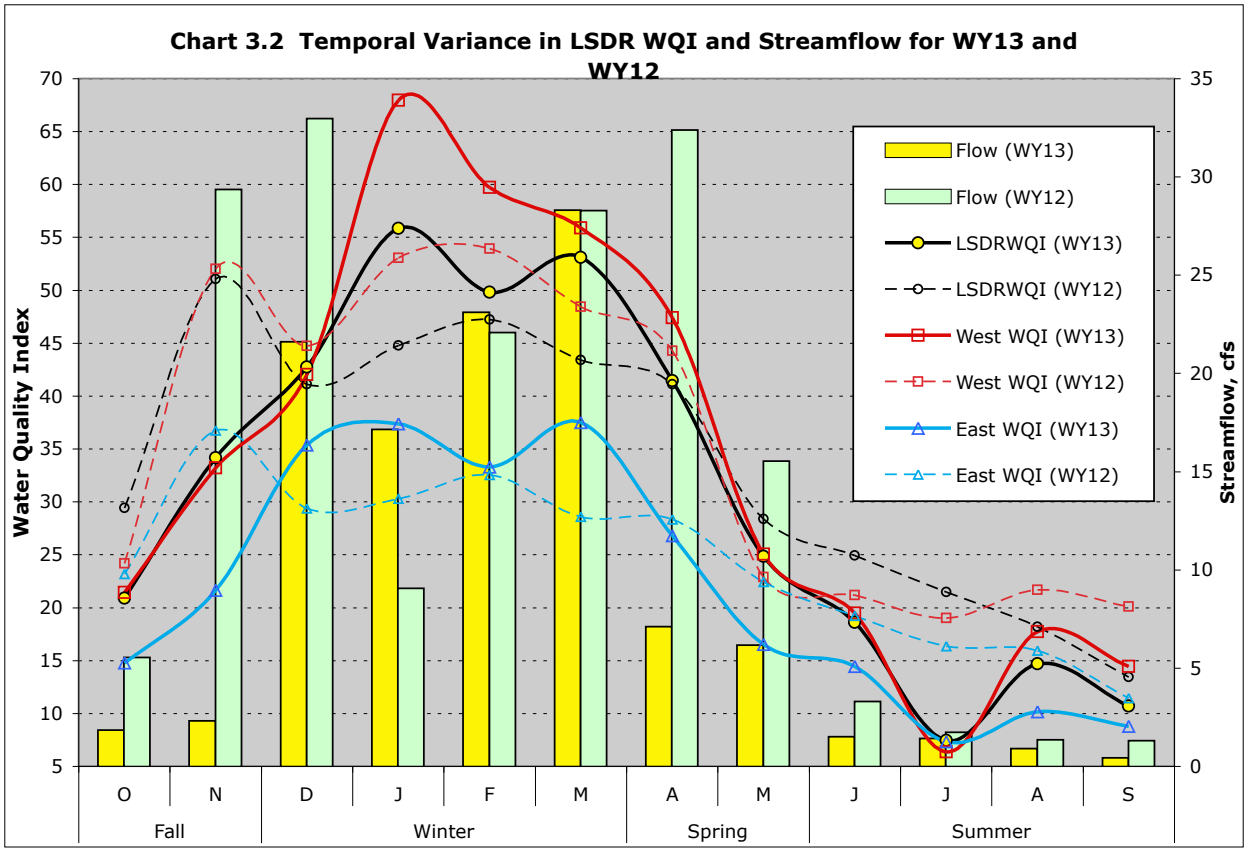
		Temp	SC	pH	DO	DO%	Flow	WQI [a]	
Month	*Season:*	*oC*	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
Oct	Fall	19.3/19.5	2.95/2.79	7.9/7.5	4.33/4.80	47/53	4.6/29	21/29	E/D
Nov		14.5/15.3	2.84/1.66	7.7/8.0	6.66/6.99	66/70	31/25	34/51	D/B-
Dec	Winter	11.3/10.4	1.61/1.68	7.1/7.9	6.59/7.24	60/64	16/303	43/41	C/C
Jan		9.2/11.2	2.12/2.22	7.9/8.0	10.57/7.82	93/72	11/46	56/45	B/C
Feb		12.4/13.1	2.07/1.55	8.0/7.9	8.07/7.30	76/70	17/82	50/47	B-/C
Mar		16.6/15.0	1.46/1.33	8.0/8.1	7.18/6.62	74/65	26/62	53/43	B-/C
Apr	Spring	17.0/18.8	2.35/1.71	8.2/7.8	6.70/5.64	69/61	20/20	41/41	C/C
May		20.7/21.2	2.22/3.13	7.6/7.6	4.05/4.70	45/53	7/11	25/28	D-/D
June	Summer	21.7/22.0	2.83/3.00	7.7/7.5	3.67/4.39	42/51	3.0/5.7	19/25	E/D-
July		22.1/22.8	3.13/2.87	7.8/7.4	2.06/4.08	24/48	1.5/2.4	7/21	F/E
Aug		22.1/24.3	3.06/3.36	7.8/7.4	4.60/4.21	53/51	1.3/1.3	15/18	E/E
Sept		21.0/22.6	3.26/3.25	7.8/7.7	3.69/3.32	42/39	1.2/1.5	11/13	E/E
Season Averages									
Fall (O&N)		16.9/17.4	2.89/2.23	7.7/7.6	5.50/5.90	57/61	12/20	28/40	D/C
Winter (D,J,F,M)		12.4/12.6	2.02/1.69	7.7/8.0	8.10/7.24	76/68	20/17	50/44	B-/C
Spring (A&M)		18.8/20.0	2.28/2.42	7.7/8.0	5.38/5.17	57/57	5/9	33/35	D/C-
Summer (J,J,A,S)		21.7/22.6	3.07/3.12	7.8/7.5	3.50/4.00	40/47	0.4/1.6	13/20	E/E
Annual Avg (O-S)		**17.3/18.0**	**2.49/2.38**	**7.8/7.7**	**5.68/5.59**	**58/58**	**8/11**	**31/34**	**D/D+**

a) Calculated values based on SD RiverWatch physical-chemical parameters (WQI_4) combined with USGS recorded stream flow for eastern (West Hill Pkwy) and western sections (Fashion Valley). This year and last year values (WY13/WY12) and letter grades; declines in value over the past 12 months are listed in red.

Monthly and seasonal variances in the monitoring results for the past two water years are also expressed in **Charts 3.1** (WQM Data) and **3.2** (LSDR Water Quality Index). The temporal patterns in the WY13 and WY12 water quality monitoring data for the overall LSDR system are shown in **Chart 3.1**. Dissolved Oxygen and streamflow values are highest during the winter months (Dec-March) whereas specific conductivity and water temperatures are greatest during the driest summer months (June-Sept). Mean coliform count (MCC) and pH values exhibit considerably less seasonal fluctuation than other water quality parameters considered, although slight variance in monthly values does occur. **Chart 3.2** provides an overall perspective of temporal variance in WQI values for the average (LSDR), Eastern (Santee Basin) and Western (Mission Valley) sections of the river during WY13 and WY12. As shown in the tables, the WQI values for WY13 are less than those in WY12 for all but the four winter months (Dec-March) of the water year. The most significant decline in WQI values occurs during summer period (June-Sept) as streamflow rapidly diminishes and water temperatures increase. Significant depletion in dissolved oxygen levels combined with low flow are the primary drivers in declining index values.



In general, water quality for the Lower San Diego River system is highest (in B-Good range) in winter months with largest streamflow and lowest (D-Marginal to F-Very Poor) during summer (minimum-flow) months. The overall annual average WQI for the LSDR in WY13 is 31 (D), down 3 units from 34 (D+) last year; remaining in the Marginal category. Both spatial and temporal trends in monitored data and resultant WQI are presented in the final section of this report.



Section 4 - Water Quality Data and Index Trends WY05 through WY13

Annual and seasonal LSDR WQI values are presented in **Table 4.1** (next page) by river reach, section, and overall (LSDR) average for each water year over the last 9 years (WY05-WY13) of RiverWatch monitoring. Trend lines (12-month running averages) have been calculated for individual water quality parameters (**Charts 4.1-4.4**) and the resultant water quality index (**Chart 4.5**) are summarized in **Table 4.2.**

Temporal WQ data trend lines (12 month running averages) are presented by section and reach in **Charts 4.1-4.4**. Water temperature running averages, plus maximums and minimums for all sites (**Chart 4.1**) have changed little over the past 9 years. With a mean temperature of 18.0°C for the lower segment; the monitoring sites present a repetitive annual cyclic pattern ranging from 8°C (winter minimums) to 30°C (summer maximums) with minimal change in running averages. Specific conductivities (**Chart 4.2**) seem to be trending slightly upward since 2005, however, the changes are small and likely reflective of prevailing streamflow conditions. As shown in **Chart 4.3**, pH running averages increased noticeably in 2010, especially minimum values. Replacement of a deteriorating pH probe giving low readings in mid-WY06 is thought to be the principal cause of this change as pH averages have remained fairly consistent since then. Dissolved oxygen running averages (**Chart 4.4**) show a steady slow decline since February 2010. Sustained minimum monthly values monitored throughout the year in the Upper Santee Basin reach (Sites 14 & 15) is considered the primary cause of this trend.

Table 4.1 - Average Annual and Seasonal WQI by Reach and Section (WY05-WY13)

Annual Avg.	LMV Reach	UMV Reach	MV Section	MG Section	LSB Reach	USB Reach	SB Section	Overall Average LSDR	
WY05	49	44	46	65	31	18	25	41	C (highest)
WY06	40	33	37	55	35	22	29	37	C-
WY07	37	28	33	51	41	27	34	37	C-
WY08	39	31	36	47	41	36	38	39	C
WY09	38	29	34	47	43	34	38	38	C
WY10	36	33	35	49	39	18	28	35	C-
WY11	40	38	39	56	45	15	30	39	C
WY12	35	36	35	48	40	10	25	34	D+ (low)
WY13	**36**	**31**	**34**	**44**	**33**	**11**	**22**	**31**	**D (lowest)**
9-Yr Avg	*39*	*34*	*37*	*51*	*39*	*21*	*30*	*37*	*C- Fair*
Winter Avg	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	64	67	65	86	45	33	39	59	B (highest)
WY06	55	47	51	61	41	29	35	47	C +
WY07	50	42	46	64	57	41	49	51	B-
WY08	57	48	53	55	53	52	53	53	B-
WY09	57	46	53	62	62	55	58	56	B
WY10	55	55	55	67	57	29	43	52	B-
WY11	57	57	57	67	55	27	41	53	B-
WY12	48	52	50	60	46	14	30	44	C (lowest)
WY13	**58**	**54**	**56**	**68**	**51**	**21**	**36**	**50**	**B-**
9-Yr Avg	*56*	*52*	*54*	*65*	*52*	*34*	*43*	*52*	*B- Good*
Summer Avg	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	32	25	29	47	20	6	13	26	D-
WY06	23	15	20	46	32	19	25	27	D- (highest)
WY07	23	15	20	36	24	13	19	22	E
WY08	24	20	23	34	29	23	26	26	D-
WY09	21	14	18	33	25	16	21	22	E
WY10	21	18	20	34	27	9	18	22	E
WY11	23	17	21	38	31	5	18	23	E
WY12	22	18	21	26	27	4	16	20	E
WY13	**17**	**12**	**15**	**16**	**16**	**4**	**10**	**13**	**E (lowest)**
9-Yr Avg	*23*	*17*	*21*	*34*	*26*	*11*	*18*	*22*	*E Poor*

Table footnotes.

WQI Letter/Color Code: A (>75) = Very Good (dark blue), B (50-74) = Good (light blue), C (35-49) = Fair (green), D (25-34) = Marginal (yellow), E (10-24)= Poor (brown), and F (0-9) = Very Poor (pink); WQI values in red are below 9-Yr Averages (expressed in italics) for the same reach or section.

The WQI trend lines since WY05 up to the present are shown on **Chart 4.5**. The continued decline in the running averages for the LSDR is a function of depressed oxygen levels at a number of sites combined with diminished mean streamflow (**Chart 4.6**) throughout the system. Specific trends in the WQI expressed by individual river reach are presented in Appendix A (Charts A.1-A.6). WQI values are expected to increase when streamflow returns to more normalized patterns and improvements are undertaken along specific reaches of the lower river system. Greater minimum values are likely to result in a return to positive gradients for trend lines (running averages) in due course.

WQI trend lines for the SDR reaches, sections and the aggregated average value (LSDR) shown in Section 4 and Appendix A charts are summarized in **Table 4.2.** The present (WY13) running average WQI value of 31 (D marginal) for the LSDR system is 3 points below last year's average of 34 (D+ marginal) and 6 points below the 9-yr average of 37 (C-). The current running average WQI for the Upper Santee Basin reach of 11 (E- poor) is 10 points below the 9-yr average of 21 (E). The current average for the Mast Park site of 8 (F+ very poor) is 14 points below the 9-yr average WQI of 22 E (poor).

Table 4.2 Summary of LSDR WQI Trend Line Values

	Chart	High/WY	Low/WY	9-Yr Avg.	End WY13[a]
East Section:	D.1, D.2	70(B) WY09	7(F) WY13	30(D)	22(E) Poor
USB	D.1	68(B) WY09	3(F) WY11-WY13	21(E)	11(E-) Poor
LSB	D.2	71(B) WY09	11(E) WY13	39(C)	33(D) Marginal
Mid Section	D.3	90(A) WY05	8(F) WY13	51(B-)	44(C) Fair
West Section:	D.4, D.5	73(B+) WY05	6(F) WY13	37(C-)	34(D+) Marginal
UMV	D.4	72(B) WY05	8(F) WY13	34(D+)	31(D) Marginal
LMV	D.5	79(A) WY05	5(F) WY13	39(C)	36(C-) Fair
LSDR Overall Average	D.6	**59(B) WY05**	**20(E) WY12**	**37(C-)**	**31(D) Marginal**
Best Site (#8)	D.3	86(A) WY05	27(D) WY12	55(B)	46(C) Fair
Greatest Range (#12)	D.2	63(B) WY10	7(F) WY05	39(C)	45(C) Fair
Poorest site (#14) Overall	D.1	41(C) WY09	9(F+)WY05,07&11	20(E)	16(E) Poor
Poorest site (13) Currently	D.1	62(B) WY09	2(F-) WY12	22(E)	8(F+) Very Poor

a) End of WY13 (Sept) running averages shown in red are 3 or more points below 9-yr average trend line values.
b) Highest overall WQI winter values are associated with Site 8 (Jackson Dr) in the Mission Gorge Reach/Mid-Section of LSDR.
c) Lowest overall WQI summer values are associated with sites 13 (Mast Park) and 14 (Cottonwood/RCP) in USB reach.

Water year 2013 presented the lowest overall LSDR WQI (31 D) with both winter and summer values of 55 (B Good) and 13 (E Poor), respectively, running well below 9-yr annual (37 C) and seasonal averages (52 B winter & 22 E summer). Next year (WY14) is anticipated to be nearer to normal in annual rainfall and streamflow (runoff). Average annual LSDR water quality values are expected to improve over this year's results. However, upper reaches in both the Santee Basin and Mission Valley sections are expected to present poorer water quality values during the summer period than found in the lower reaches and mid-section (Mission Gorge) of the river. Overall, the downward trend in water quality index values that has occurred over the past several years is expected to plateau unless WY14 ends up being a well below normal rainfall year with associated declines in stream discharge.

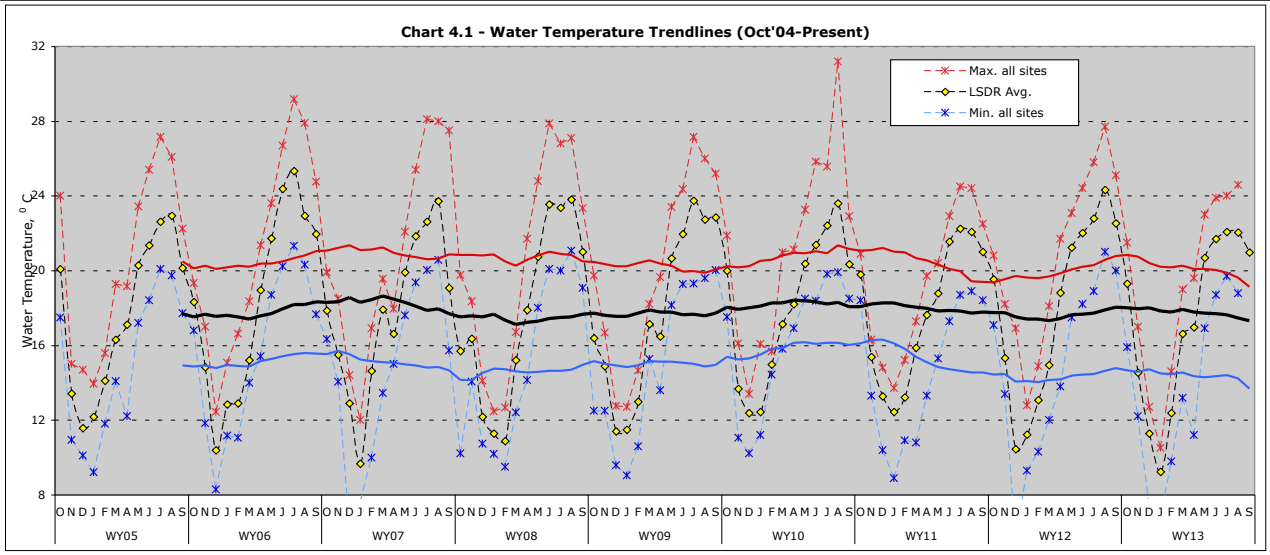


Chart 4.1 - Water Temperature Trendlines (Oct'04-Present)
Water Temperature, ° C
Max. all sites
LSDR Avg.
Min. all sites
32
28
24
20
16
12
8
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13

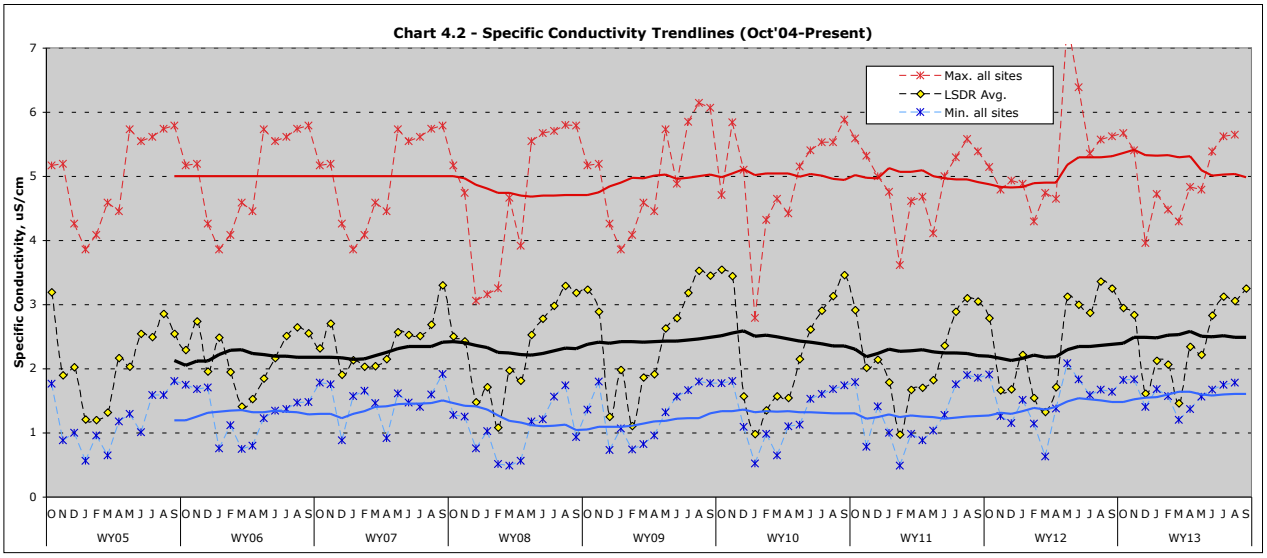


Chart 4.2 - Specific Conductivity Trendlines (Oct'04-Present)
Specific Conductivity, uS/cm
Max. all sites
LSDR Avg.
Min. all sites
7
6
5
4
3
2
1
0
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13

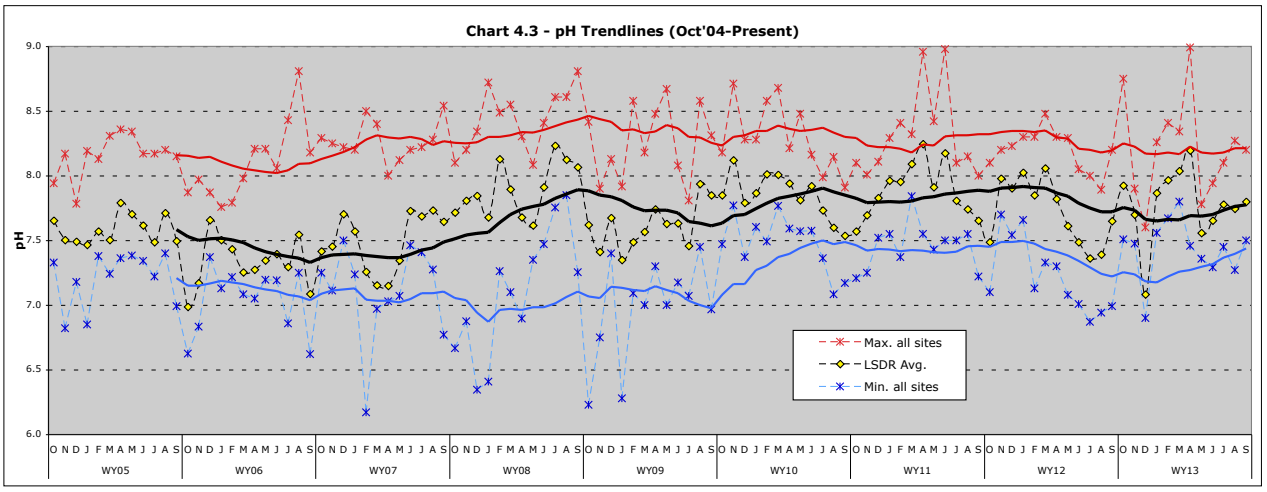


Chart 4.3 - pH Trendlines (Oct'04-Present)
pH
Max. all sites
LSDR Avg.
Min. all sites
9.0
8.5
8.0
7.5
7.0
6.5
6.0
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13

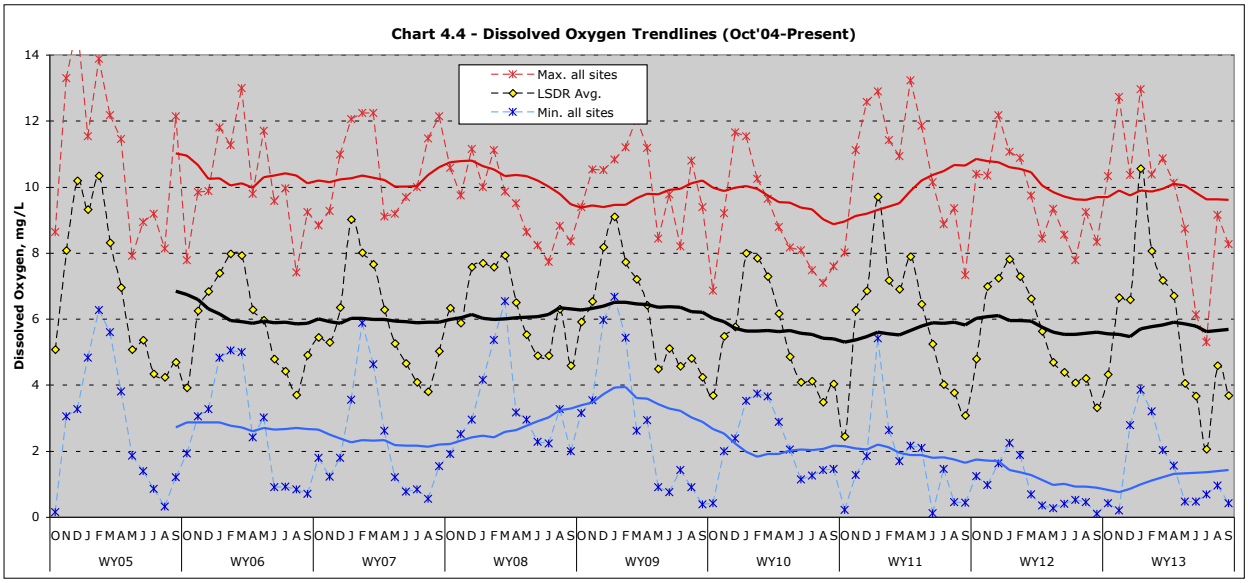


Chart 4.4 - Dissolved Oxygen Trendlines (Oct'04-Present)
Max. all sites
LSDR Avg.
Min. all sites
Dissolved Oxygen, mg/L
0
2
4
6
8
10
12
14
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13

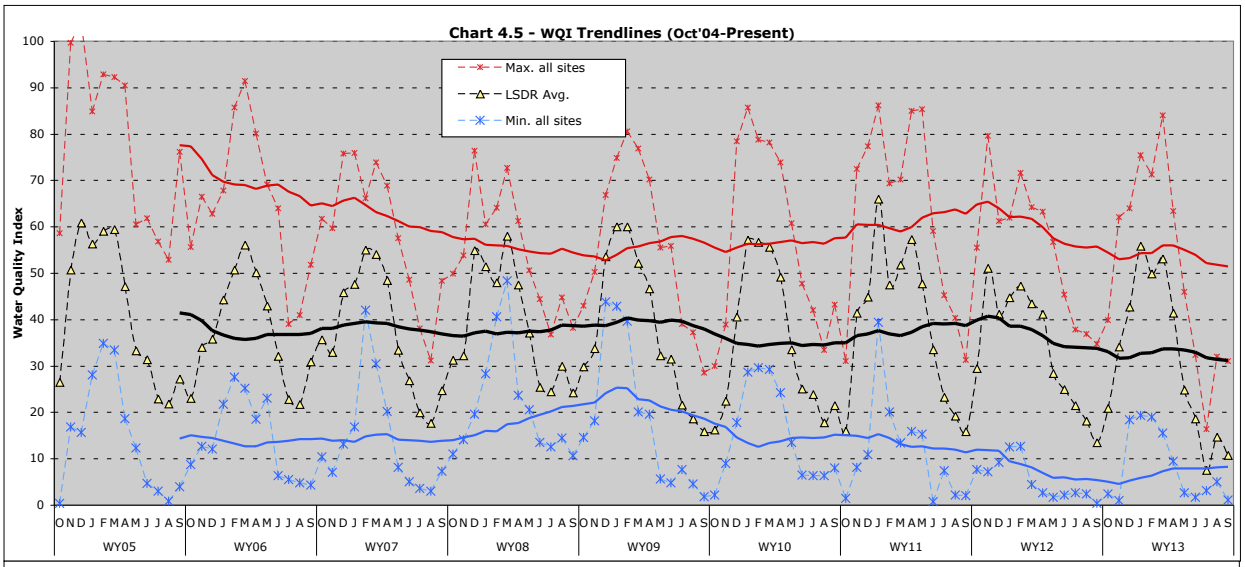


Chart 4.5 - WQI Trendlines (Oct'04-Present)
Max. all sites
LSDR Avg.
Min. all sites
Water Quality Index
0
10
20
30
40
50
60
70
80
90
100
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13

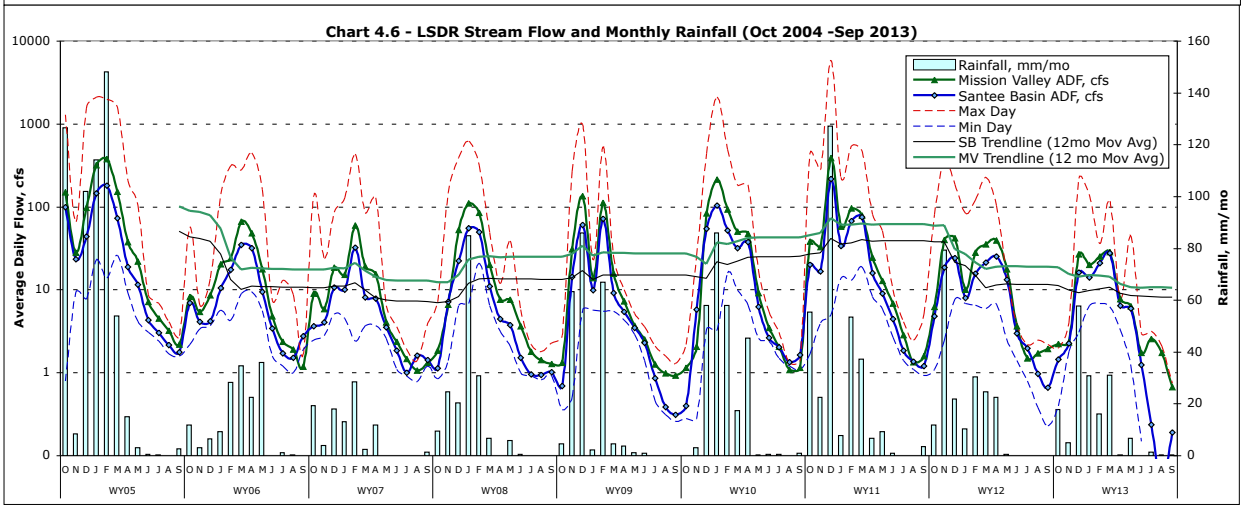
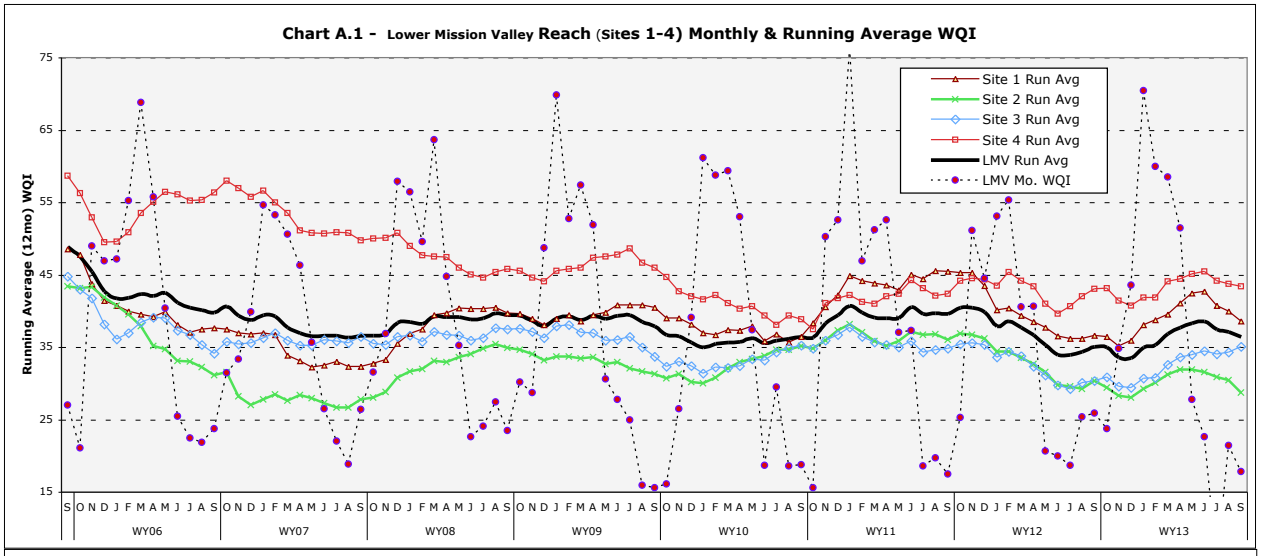
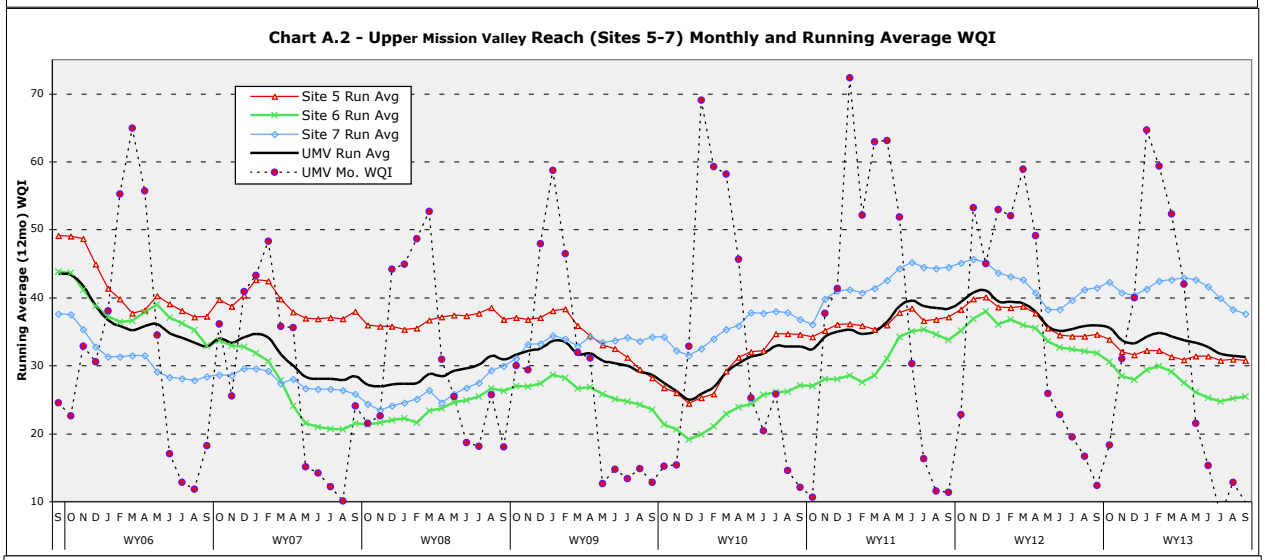


Chart 4.6 - LSDR Stream Flow and Monthly Rainfall (Oct 2004 -Sep 2013)
Rainfall, mm/mo
Mission Valley ADF, cfs
Santee Basin ADF, cfs
Max Day
Min Day
SB Trendline (12mo Mov Avg)
MV Trendline (12 mo Mov Avg)
Average Daily Flow, cfs
Rainfall, mm/mo
0
1
10
100
1000
10000
0
20
40
60
80
100
120
140
160
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13

Appendix A - WQI Values & TrendLine Charts by River Reach





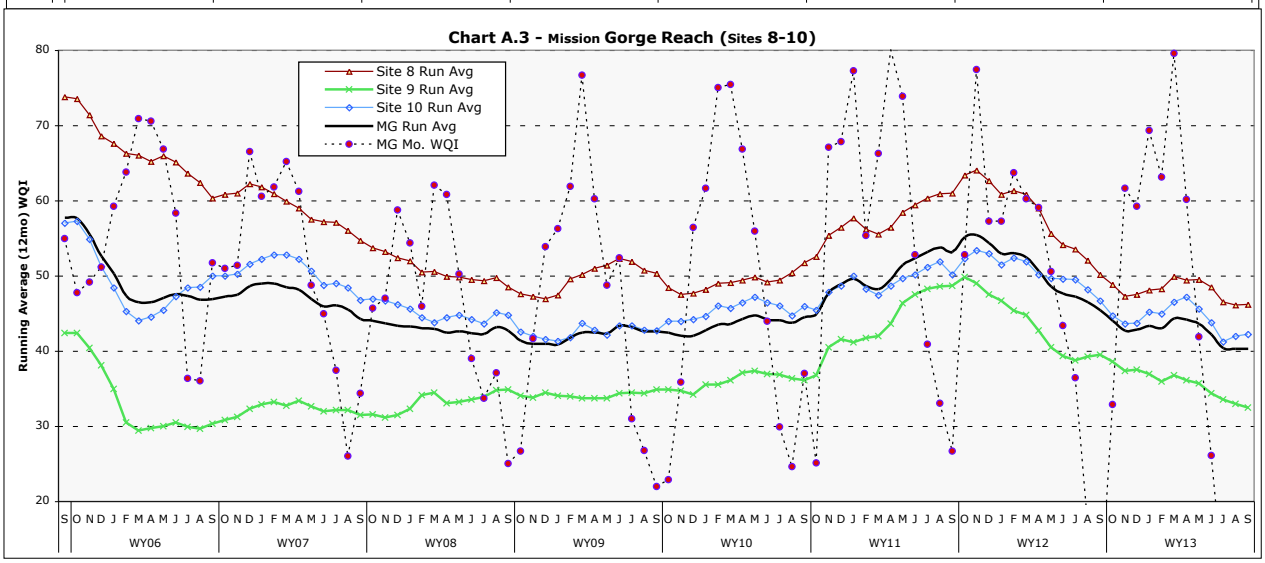


Chart A.4 Lower Santee Basin Reach (Sites 11, 12 & 15) Monthly and Running Average WQI

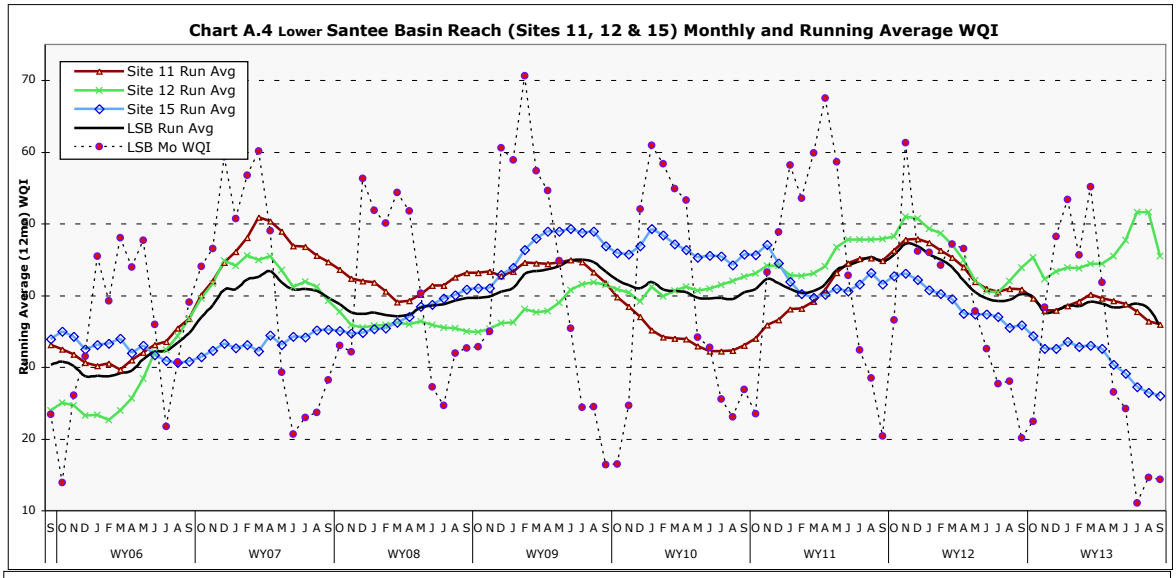


Chart A.5 - Upper Santee Basin Reach (Sites 13 & 14) Monthly and Running Average WQI

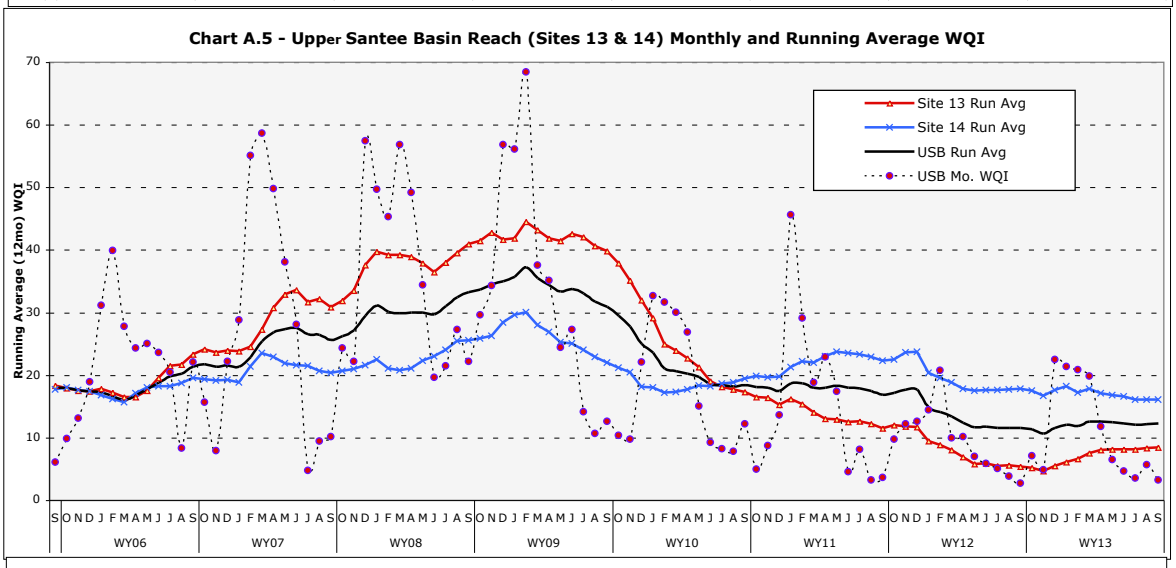
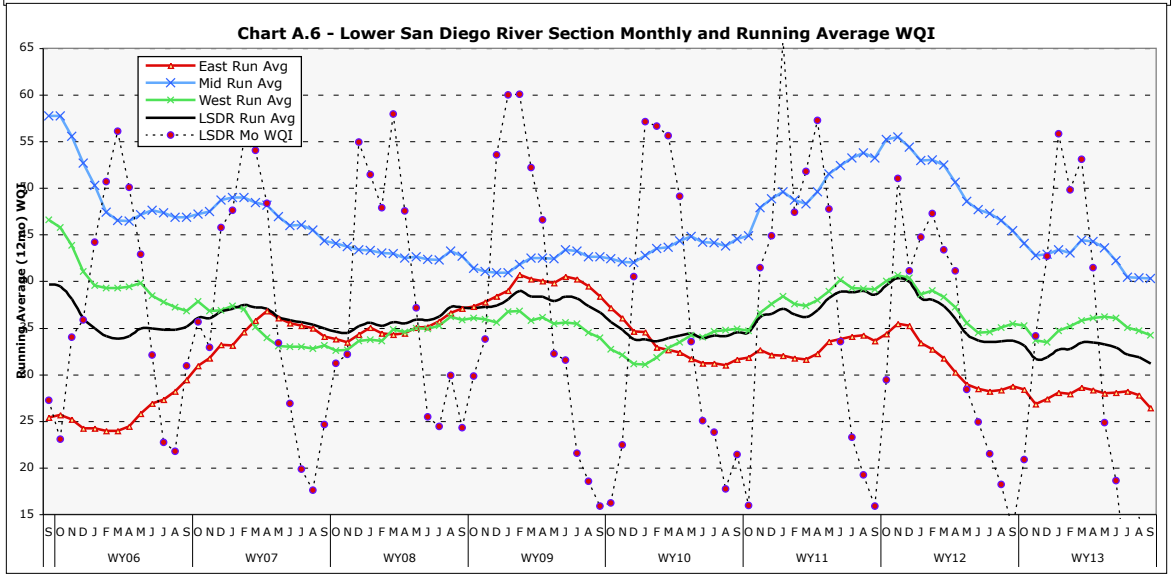


Chart A.6 - Lower San Diego River Section Monthly and Running Average WQI



Appendix B - Glossary

Abbreviations:

AADF - Average Annual Daily Flow
ACC - Average Coliform Count (arithmetic mean of fecal coliform, e-Coli & total coliform in MPN/100mL)
ADF – Average Daily (stream) Flow or discharge
AFY - acre-foot per year
Avg– Average
cfs - cubic feet per second (flow/discharge)
Ck – Creek
CY - Calendar Year (Jan 1 - Dec 31)
DO – Dissolved Oxygen
DO%Sat – Dissolved Oxygen expressed as percentage of DO level at saturation point
d/s – downstream // {u/s – upstream}
E – East // {W –West}
FSDRIP – First San Diego River Improvement Project
ft. – feet // {mi. - mile}
gal – gallon
Ln(x) - natural logarithm of (x) to base-e (2.718)
log(x) - common logarithm of (x) to base-10
L//U – lower//upper (as in river reaches)
LSDR – Lower San Diego River
max//min – maximum//minimum
MCC - Mean Coliform Count (geometric mean of fecal coliform, e-Coli & total coliform in MPN/100mL)
mg/L – milligrams per litre
mi. - mile
mS/cm – milliSeimens per centimetre (1 mS/cm = 1000 *u*S/cm)
MG – Mission Gorge (mid-section of LSDR)
MV – Mission Valley (West section of LSDR)
MPN - Most Probable Number (of coliform organisms)
SB – Santee Basin (East section of LSDR)
PDMWD – Padre Dam Municipal Water District
pH – measure of acidity or basicity (decimal logarithm of hydrogen ion activity)
ppm – parts per million
Q - stream flow or discharge
SB – Santee Basin
SpC – Specific Conductivity (also Conductivity or Conductance); also commonly abbreviated SC
SD – Standard Deviation (also San Diego)
SDRPF – San Diego River Park Foundation
TDS – Total Dissolved Solids
Temp. – Temperature
TN/TP – Total Nitrogen/ Total Phosphorus (nutrients)
USGS – U.S. Geological Survey
*u*S/cm –microSeimens per centimetre (1 *u*S/cm = 0.001 mS/cm)
u/s - upstream // {d/s - downstream}
W - West // {E - East}
WQI – Water Quality Index (WQI_a)
WQI(4) - WQI using 4 parameters
WQI(6) - WQI using 6 parameters
WY – Water Year (Oct 1 – Sept 31)
% - percent
°C – degrees Celsius
°F – degrees Fahrenheit

Formulas:

$^oC = (^oF-32) \times 5/9$
$^oF = (^oC*9/5) + 32$

Flow (cfs) = Velocity (ft/sec)*Cross-sectional area (sq ft)

Constituent Load (lbs/day) = Q (mgd)*Concentration (ppm)*8.34; or Q (cfs)*Concentration (mg/L)*5.39 where Q is streamflow/discharge.

Total Dissolved Solids (TDS in mg/L) = 670*Specific Conductivity, (where SC is in mS/cm). An approximate relationship for Lower SDR watershed; other variables (e.g., temperature, pressure, specific ions) are considered negligible.

DO - DO%Sat relationship is defined by the following polynomial equation:
$DO(mg/L)=DO\%Sat*[0.004*T^2-0.343*T+14.2]/100$;
$DO\%Sat = DO(mg/L)*100/[0.004* T^2-0.343T+14.2]$,
where T = temperature is in °C.
Other variables, incl. barometric pressure, elevation and conductivity (SC), have negligible impact on the DO-DO%Sat relationship within the LSDR watershed.

SDR Water Quality Index (WQI) is calculated using the following set of equations:

WQI_4 = DO%Sat*2.5*T factor*Q factor/log(SC);
where SC is expressed in *u*S/cm; the T factor = $0.0055T^3-0.163T^2+1.37T-2.5$, and the
Q factor =
$0.56+0.173LnQ-0.002LnQ^2-0.0033LnQ^3$ (M Valley);
$0.72+0.15LnQ-0.0051LnQ^2-0.004LnQ^3$ (M Gorge);
$0.87+0.107LnQ-0.018LnQ^2-0.003LnQ^3$ (Santee);
$0.1+0.05LnQ-0.042LnQ^2-0.0011LnQ^3$ (Tributaries)

WQI_6 = Avg.[$DO\%f*wt_{(DO)}$, $SCf*wt_{(SC)}$, $pHf*wt_{(pH)}$, $MCCf*wt_{(MCC)}$, $Qf*wt_{(Q)}$, $Tempf*wt_{(T)}$]^1.75
where $wt_{(DO)} = 3$, $wt_{(SC)} = 2$, $wt_{(pH)} = 1$, $wt_{(MCC)} = 1$, $wt_{(Q)} = 2$ and $wt_{(T)} = 1$

The SDR WQI has been developed specifically for the SDRPF RiverWatch Monitoring Program, however, the equations can also be applied to water quality and hydrologic data for other coastal area watercourses.

Water Equivalents:

1 cf = 7.48 gal = 62.4 lbs of water
1 AF = 43,560 cf = 325,900 gal
1 psi = 2.31 ft of water
1 mg/L = 1 ppm (in water)
1 cfs = 450 gpm = 0.646 mgd =1.98 AF/day = 724 AFY
1 mgd = 694 gpm =1.547 cfs = 3.06 AF/day = 1,120 AFY
1000 gpm=1.436 mgd=2.23 cfs=4.42 AF/day=1,614 AFY
1 inch (rainfall) = 25.4 mm

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Appendix D - SDRPF's RiverWatch Team

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Kym Hunter (2006 - 2007)

Rob Hutsel (2004 - 2005)

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Amy Cook
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Bill Martin
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Brent Redd
Calvin Vine*
Cameron Bradley
Carl Abulencia
Celena Cui
Chris Peter
Clint Williams
Conrad Brennen
Craig McCartney
Dani Tran
David Lapota
Demitrio Duran
Doug Taylor
Ebony Quilteret
Edward Garritty
Erin Babich
Fred Ward
Gabriel Martinez Mercado
Gary Strawn*
George Liddle*
Gina Martin
Jack Greco
Jalil Ahmad
Jim Thornley
Joan Semler
John Kennedy*
Joyce Nower
Katharyn Morgan
Kathryn Stanaway
Kelly Brown
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Krissy Lovering
Krystal Tronboll
Laqueta Strawn
Linda King
Lois Dorn
Linda Tarke
Lindsey Dornes
Lindsey Teunis
Lucas Salazar
Madison McLaughlin
Maesa Hanhan
Marcus King
Mark Carpenter
Mark Hammer
Martin Offenhauer*
Mary Hansen
Matt Olson
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