LOWER SAN DIEGO RIVER
WATER QUALITY 2005 - 2015

WY15 Annual Water Quality Monitoring Report

Creeping water primrose (*Ludwigia peploides, L. grandiflora*)*

RiverWatch Water Quality Monitoring Results (October 2004 - September 2015)

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October 2015

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Lower San Diego River Water Quality 2005 - 2015

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[a] *Appendices D-I are provided in a supplemental document under separate cover.*

Questions regarding the San Diego RiverWatch WQM database or interpretation of results expressed in this and similar SDR WQ data monitoring reports can be directed to the attention of John C. Kennedy, through contacting SDRPF at info@SanDiegoRiver.org or the WQM Coordinator, Shannon-Quigley Raymond, at 619-297-7380.

Section 1 - Introduction

This report provides a summary of monthly values, seasonal patterns and annual trends in water quality monitoring data gathered and evaluated by SDRPF's RiverWatch citizen volunteers. WQM data collected monthly over the past 11 years at 15 sites within the Lower San Diego River (LSDR) watershed have been aggregated, in conjunction with hydrologic stream flow data to develop 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 extensive Excel database file available at the SDRPF offices; this report examines Water Year 2015 (WY15) data in comparison to previous year results and 11-yr averages (norms). 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 1-1 above: Estuary (orange), Lower Mission Valley (purple), Upper Mission Valley (red), Mission Gorge (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 at: http://www.ecolayers.biz/sdrpf%2Driverwatch/> through clicking on access to 'Web-based Information Center' on the RiverWatch webpage. 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 two San Diego River USGS stations (Fashion Valley & Mast Bridge in Santee).

The SDRPF RiverWatch water quality index (WQI) represents the monitoring team's response to general questions and concerns regarding overall health of the Lower San Diego River. The index is a numeric (0-100) where increasing values signify improving water quality. The numerical index incorporates basic physical, chemical and bacteriological water quality data by integrating six parameters: temperature (Temp), pH, specific conductivity (SpC), dissolved oxygen (DO and/or %DOSat), mean coliform count (MCC) and streamflow (Q); through determination of weighted factors for each parameter. The resulting values are aggregated to arrive at an overall score for each site, reach, section and the lower watershed (LSDR) as a whole. The index 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	Healthy (>50)
50 - 74	B - Good	Light Blue	25%	Exceeds Acceptable WQ Criteria	
38 - 49	C - Fair	Green	12.5%	Meets Many but not all WQ Criteria	Impaired/Ailing (25-49)
25 - 37	D - Marginal	Yellow	12.5%	Meets Limited Minimum WQ Criteria	
13 - 24	E - Poor	Brown	12.5%	Meets Few Minimum WQ Criteria	Unhealthy (< 25)
0 - 12	F - Very Poor	Pink/ Rose	12.5%	Well Below Minimum WQ Criteria	

Note: The WQI has been developed for freshwater quality metrics only; it is not applicable to/for estuarine or ocean waters.

In general, sites with WQI values of 50 or above exceed expectations for acceptable water quality and are indicative of 'Healthy' conditions. Scores between 25 and 49 describe 'Impaired or Ailing' quality levels where solid evidence exists regarding failure to meet acceptable minimum water quality criteria at all times. Water quality with scores of less than 25 do not meet minimum expectations and are considered 'Unhealthy' or highly stressful to many aquatic life forms. For WQ parameters monitored by RiverWatch, the index expresses results relative to levels necessary to sustain designated beneficial water uses for the LSDR (Hydrologic Area 907.1) based on State of California Water Quality Standards. Where criteria are non-specific, results are expressed relative to Southern California coastal area freshwater norms. The index can not, without loss of relevancy, be applied to estuaries and ocean waters.

Index values have 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) combined with streamflow. The equations used for both formulas (WQI_4 and WQI_6) are presented in Appendix B. Differences between the two determinations have been found to be small. The initial determination (WQI_4) typically presents 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 variances) are excluded. The broader range WQI_4 values are expressed in this report.

The index, developed specifically for the San Diego RiverWatch program, can also be applied to other Southern California coastal area watercourses where comparable water quality metrics (DO, SpC, Water Temp and stream flow) have been or are monitored on a regular and consistent basis. A special report comparing relative water qualities in three San Diego County watercourses; Los Penasquitos Creek below Poway, the Santa Margarita River below Temecula and near Fallbrook, and the Lower San Diego River below Santee and in Mission Valley has recently been compiled by the SDRPF RiverWatch program.

Section 2 - Spatial Comparison of WY15 Water Quality Data and 11-Yr Norms

Monthly water quality data collected and recorded at each site by the RiverWatch WQM Team volunteers are used to determine annual averages, seasonal patterns and trend lines as presented in this report and various appendices. Supplemental data collected by other monitoring organizations for streamflow (USGS) and coliform counts (SD CoastKeepers) are also incorporated. The annual average water quality values for each of the 15 monitoring sites for WY15 as well as the 11-Yr norms (average values calculated over past 11 years of monitoring) are presented in **Table 2.1**. WY15 values greater than the 11-yr norms are shown in blue, whereas lower values are in red.

Table 2.1 Annual WQ Metrics for WY15 and 11-Yr Norms by Site, Reach and Section

Site:	*LSDR Reach & Section*		Temp, oC	SpC, mS/cm	pH	DO, mg/L	DO %Sat	Flow, cfs	WQI Value [a], (Change), & Grade	
1	LMV	West	20.1/19.4	8.50/7.43	7.7/7.7	4.7/6.0	52/66	15/31	30/38 (-8)	D/C
2			19.6/18.9	2.07/2.61	7.6/7.7	3.3/4.5	35/47		24/31 (-7)	E+/D
3			19.6/19.1	1.96/2.51	7.6/7.7	2.4/4.7	26/49		17/32 (-15)	E/D
4			20.0/19.6	1.94/2.43	7.6/7.7	3.0/6.2	31/51		22/42 (-20)	E/C
5	UMV		17.8/17.2	2.28/2.55	7.7/7.6	3.0/5.0	33/55	12/28	22/33 (-11)	E/D
6			18.9/18.3	2.23/2.60	7.6/7.6	1.8/3.8	19/40		13/26 (-13)	E-/D-
7			19.1/17.9	2.23/2.50	7.7/7.5	4.5/5.0	49/52		32/34 (-2)	D/D
8	MG	Mid	18.2/16.9	2.28/2.27	7.8/7.6	6.3/7.7	66/79	8/19	44/52 (-8)	C/B-
9 [b]			15.7/16.1	4.63/5.03	7.9/7.7	9.7/8.8	99/91		41/36 (+5)	C/D
10			18.4/17.7	2.37/2.24	7.9/7.8	7.1/7.3	75/76	7/17	49/48 (+1)	C/C
11	LSB	East	17.4/16.7	2.31/2.22	7.7/7.6	6.2/6.3	65/61		41/39 (+2)	C/C
12 [b]			21.1/17.8	1.82/1.70	8.1/7.9	7.9/7.0	89/71		36/34 (+2)	D/D
15 [b]			20.1/17.9	2.84/2.73	8.0/8.1	8.8/7.8	98/73	4/9	51/39 (+12)	B-/C
13	USB		18.8/18.5	2.07/1.91	7.8/7.6	1.7/3.4	18/35	2/5	8/19 (-11)	F/E
14			17.1/17.2	1.77/1.54	8.0/7.8	2.8/3.3	29/33		15/18 (-3)	E/E
(1-15)	**LSDR Avg.**		**18.7/17.9**	**2.19/2.04**	**7.8/7.7**	**4.7/5.7**	**50/58**	**11/24**	**29/35 (-6)**	**D/D**

a) Average annual water quality index value, change (+/-) and resultant WQ letter grade for WY15 and the 11-yr norm; values below the norms for each metric are expressed in red; values above norms are shown in blue.
b) Lower San Diego River tributary stream water quality monitoring sites.

Five sites, located in the Mission Gorge (9&10) and Lower Santee Basin (11,12&15) portions of the watershed, show WY15 index values above the 11-yr norms. The greatest positive change (12 index points) is associated with Forester Creek (Site 15T) whereas the greatest negative change (-20 points) is the FSDRIP location (Site 4) in mid-Mission Valley. Water temperatures at nearly all sites are above the norms and overall up nearly one degree (0.8°C) from the 11-yr average. Specific Conductivity values in

Mission Valley are running below norms for WY15 whereas they are running slightly above at upstream sites. Overall SpC (average all sites) is slightly above the 11-yr norm. DO values are slightly higher than norms at four sites but somewhat lower at the other 11; overall DO values are below the 11-yr LSDR norm by one mg/L, representing a modest improvement over last year (WY14) when overall DO concentration reached the lowest level (at 4.1 mg/L) since RiverWatch monitoring began in Sept. 2004.

Average annual, seasonal and minimum-to-maximum range water quality metrics for this year (WY15) and the 11-Yr norms are presented by reach and section in **Table 2.2.** The only section of the river to show positive change above norms (5 index points) in WY15 is the Lower Santee Basin reach (Sites 11,12&15); the greatest negative change (-13 points) was in the Lower Mission Valley reach.

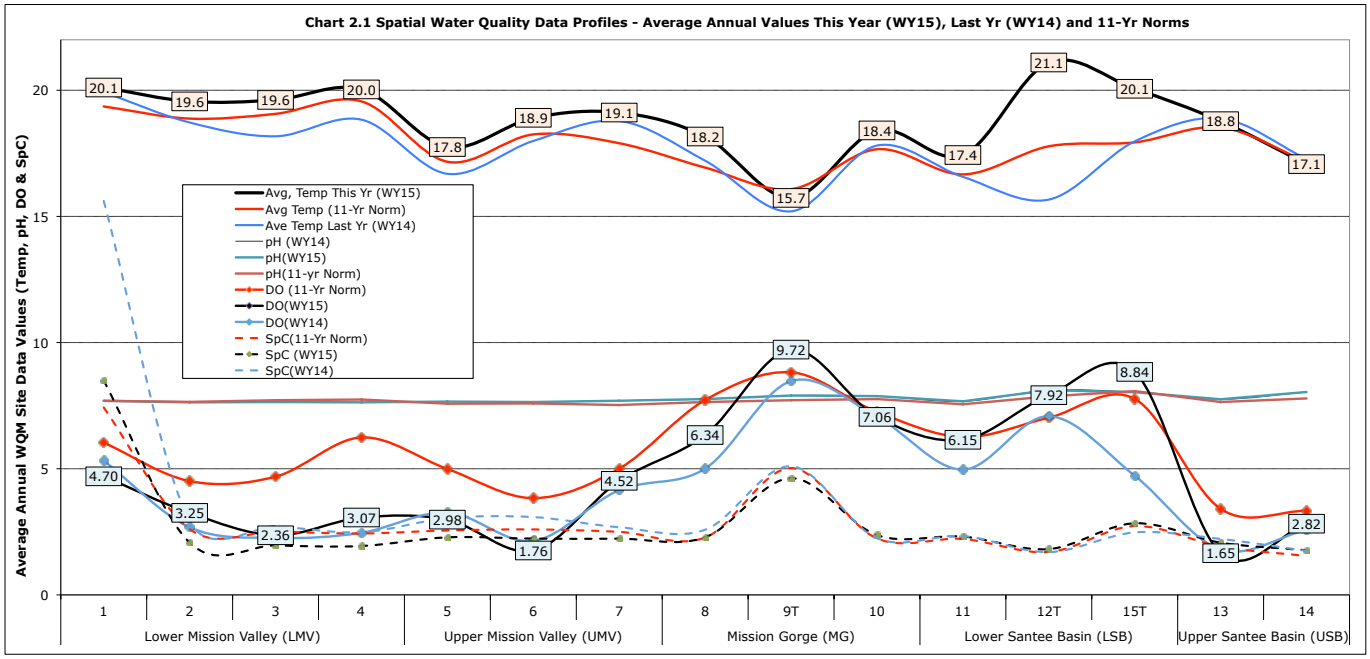
Table 2.2 Water Quality Metrics for WY15 and 11-Yr Norms by Season, Reach and Section

Parameter, units		Temp, oC	SpC, mS/cm	pH	DO, mg/L	DO %Sat	Flow, cfs	WQI Value, [a](Change) & Grade	
Maximum Month		23.7/25.3	3.01/3.56	8.1/8.3	7.3/8.4	77/76	56/388	56/66(-10)	B/B
Winter (D,J,F,M)		15.7/14.4	1.89/1.74	7.9/7.7	5.5/7.1	55/68	26/72	37/48(-11)	D/C+
Avg. Annual		**18.7/17.9**	**2.19/2.35**	**7.6/7.7**	**4.7/5.7**	**50/58**	**11/24**	**29/35 (-6)**	**C/D**
Summer (J,J,A,S)		22.9/22.4	2.18/2.86	7.8/7.7	3.9/4.3	45/49	14/3	21/21 (0)	E/E
Minimum Month		12.6/9.2	1.70/0.98	7.6/7.0	2.9/3.8	35/44	0.7/0.7	8/8 (0)	F/F
LSDR Section Averages:									
East	SB	18.6/17.7	2.18/2.02	7.8/7.7	4.9/5.2	53/50	7/18	27/28 (-1)	D/D
Mid	MG	17.1/17.0	2.33/2.26	7.9/7.7	8.0/7.8	83/81	9/20	46/50 (-4)	C/B-
West	MV	19.3/18.6	2.85/2.59	7.6/7.6	3.2/5.4	34/57	16/31	23/34(-11)	E/D
LSDR Reach Averages:									
USB	East	18.3/18.1	1.99/1.80	7.8/7.7	2.1/3.4	22/34	3/9	10/19 (-9)	F/E
LSB		19.0/17.4	2.37/2.25	7.9/7.8	7.3/6.8	79/66	7/18	43/38 (+5)	C/C-
MG	Mid	17.8/17.1	2.33/2.26	7.9/7.7	7.2/7.9	73/81	9/20	46/50 (-4)	C/B-
UMV	West	18.6/17.8	2.25/2.55	7.6/7.7	3.1/4.6	33/47	13/28	22/31 (-9)	E/D
LMV		19.8/19.2	2.02/2.55	7.5/7.6	2.9/5.1	31/54	17/32	23/36(-13)	E/D+

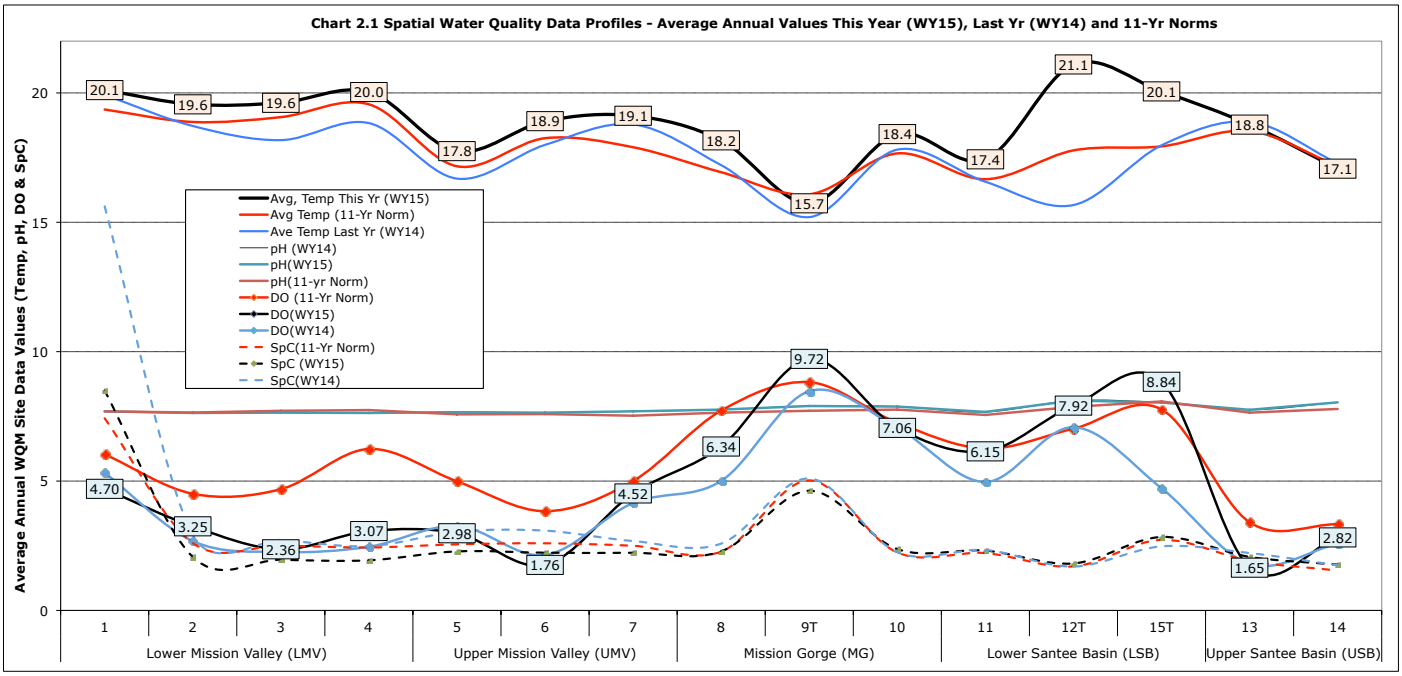
a) Average annual water quality index value, change (+/-) over past 12 months and resultant WQI letter grade. Values/grades below 11-Yr norms are expressed in red; values above in blue.

The spatial water quality values expressed in Tables 2.1 and 2.2 for the Lower San Diego River system monitoring sites are also presented in **Charts 2.1** (Water Quality Data Profile) and **2.2** (Water Quality Index and LSDR Streamflow) on the next page. The overall water quality index for WY15 of 29 (D Marginal) is 6 points below the 11-Yr norm of 35 (D Marginal). The current value is, however, up 7 points from last year's record low of 22 (E Poor) and rising.

Average annual water quality values for Temp (red), pH (green), DO (black) and SpC (blue) at each monitoring site, river reach and section in order of their location upstream for WY15 (Oct'14-Sept'15), last year (WY14) and the 11-Yr norms are provided in **Chart 2.1**. The heavy solid lines with values shown are this year's average annual results; the blue lines are last year's (WY14) results and the red lines are 11-yr annual norms for each site. Average annual water temperatures for WY15 are higher than last year's values at all but one site (9T) while pH values are nearly the same as for WY14 and the 11-Yr norms. DO levels, with exception of several tributary sites (9T and 15T), are significantly lower than the norms but above last year's values that were the lowest monitored over the past 11 years. With exception of the two tributary sites 9T and 15T, average annual SpC generally increase from upstream to downstream with little change from year to year in values. DO values show the greatest variation between sites. Lowest values are typically recorded in the Upper Santee Basin (Sites 13&14) and below Kaiser Ponds (site 6) whereas highest values are observed in the Mission Gorge (middle reach) section.



The WQI, an aggregate or composite index of water quality monitoring results for WY15, the 11-Yr norms and the best (WY05) and worst (WY14) overall year are presented in **Chart 2.2**. As shown by the solid black line, the two sites furthest upstream, 13 (Mast Park) and 14 (RCP/Cottonwood), continue to experience Very Poor (F grade) water quality for WY15. On an average annual basis, highest values continue to be associated with the Mission Gorge reach (sites 8-10). The overall WQI profile for WY15 is noticeably greater than last year's averages (grey line profile) but well below the 11-Yr norms (red) and best year (blue line profile) at all but site 12T (Santee Lakes). Greatest departures (variance) from the 11-Yr WQI norms for WY15 are found in the Mission Valley portion, especially the lower reach (Sites 1-4). Water quality conditions throughout Mission Valley (both Upper and Lower reaches) in WY15 are on par with last year's (WY14) results.



Section 3 - Temporal Comparison of WY15, WY14 Data and 11-Yr Norms

Monthly, seasonal and annual water quality monitoring data and WQI results for the Lower San Diego River are presented in **Table 3.1** for WY15 and WY14 with comparison to 11-Yr norms (values in parentheses). Values above the norms are in blue; values below in red. In general temporal water quality improved in WY15 over WY14 but is still below monthly and seasonal norms.

Table 3.1 LSDR WQM Metrics for WY15, WY14 and 11-Yr Norms by Month and Season

		Temp	SpC	pH	DO	DO%	Flow	WQI [a]	
Month	*Season:*	*oC*	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
Oct	Fall	20.2/16.9 (18.6)	3.32/2.73 (2.90)	7.3/7.7 (7.6)	2.34/4.42 (4.43)	45/45 (46)	0.4/2.9 (14)	8/23 (24)	F/E (D-)
Nov		15.5/15.2 (15.0)	2.67/2.59 (2.59)	7.6/7.9 (7.7)	3.95/4.53 (5.98)	45/45 (59)	3.5/2.4 (12)	23/22(34)	E/E (D)
Dec	Winter	13.6/11.5 (11.9)	1.41/1.73 (1.71)	7.8/7.5 (7.7)	5.61/6.07 (7.01)	56/56 (64)	35/5.9 (53)	40/42 (45)	C/C (C)
Jan		12.6/10.5 (11.5)	1.86/2.54 (1.90)	7.8/7.7 (7.7)	6.68/6.89 (8.38)	62/62 (76)	11/2.9 (47)	43/33(51)	C/D (B-)
Feb		16.2/14.1 (13.6)	2.32/2.39 (1.71)	8.0/7.8 (7.8)	4.11/4.20 (7.39)	41/41 (71)	6.4/7.5 (55)	33/24 (48)	D/E+ (C+)
Mar		18.8/17.5 (16.6)	1.97/1.95 (1.70)	7.8/7.8 (7.7)	4.61/4.14 (6.89)	43/43 (70)	14/21 (31)	31/30 (49)	D/D (C+)
Apr	Spring	17.7/18.5 (17.7)	2.47/2.32 (2.00)	7.7/7.7(7.7)	5.41/3.68 (6.18)	39/39 (65)	2.3/5.9 (15)	30/24 (44)	D/E (C)
May		18.2/19.6 (20.2)	1.57/2.64 (2.34)	8.1/7.7 (7.7)	7.27/4.71 (5.31)	52/52 (58)	14/1.4 (7.2)	56/24 (36)	B/E (D)
June	Summer	21.7/21.2 (22.1)	2.57/2.84 (2.68)	8.0/7.7 (7.8)	5.77/4.00 (4.72)	45/45 (54)	2.2/0.7 (2.6)	31/18 (27)	D/E (D)
July		22.7/22.3 (22.9)	2.08/3.02 (2.78)	7.8/7.6 (7.7)	3.39/2.27 (3.83)	26/26 (44)	20/0.6 (3.2)	16/9 (19)	E/F (E)
Aug		23.7/23.2 (23.2)	2.52/2.95 (3.01)	7.6/7.4 (7.7)	2.94/2.19 (4.00)	26/26 (46)	1.6/0.7 (1.2)	12/8 (18)	F+/F (E)
Sept		23.5/23.9 (21.6)	1.55/3.29 (2.99)	7.6/7.4 (7.6)	3.40/2.04 (3.90)	24/24 (44)	6.5/1.2 (1.6)	26/9 (20)	D-/F (E)

Values based on SD RiverWatch physical-chemical metrics (WQI_4) combined with USGS recorded stream flow for eastern (West Hills Pkwy) and western sections (Fashion Valley). Values/grades below 11-yr norms are shown in red; above in blue.

Table 3.1 (Continued) Seasonal and Annual Averages

		Temp	SpC	pH	DO	DO%	Flow	WQI [a]	
Month	*Season:*	*oC*	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
Fall (O&N)		17.8/16.1 (16.8)	3.00/2.66 (2.74)	7.4/7.7 (7.6)	3.15/4.48 (5.21)	33/45 (53)	1.8/2.7 (12.9)	16/22 (29)	E/E (D)
Winter (D,J,F,M)		15.3/13.4 (13.4)	1.89/2.24 (1.74)	7.9/8.0 (7.7)	5.50/5.32 (7.09)	55/50 (68)	17/9.4 (46.7)	37/32 (48)	D+/D (C+)
Spring (A&M)		18.0/19.0 (19.0)	2.02/2.48 (2.17)	7.9/7.6 (7.7)	6.34/4.20 (5.54)	67/46 (62)	8.2/3.7 (11.0)	43/24 (40)	C/E= (C)
Summer (J,J,A,S)		22.9/22.7 (22.4)	2.18/3.02 (2.86)	7.8/7.5 (7.7)	3.87/2.63 (4.11)	45/41 (49)	7.6/0.8 (2.1)	21/11 (21)	E/F (E)
Annual (O-S)		**18.7/17.9 (17.9)**	**2.19/2.58 (2.35)**	**7.7/7.8 (7.7)**	**4.70/4.09 (5.67)**	**50/42 (58)**	**9.7/4.4 (20.3)**	**29/22 (35)**	**D/E (D)**

a) Values based on RiverWatch physical-chemical metrics (WQI_4) combined with USGS stream flow for eastern (West Hills Pkwy) and western sections (Fashion Valley). WY15/WY14 values/grades below 11-yr norms are shown in red, above in blue. 11-yr norms are expressed in parentheses.

Monthly and seasonal variances in monitoring metrics for the past two water years and 11-Yr norms are also expressed in **Charts 3.1** (WQM Data) and **3.2** (LSDR Water Quality Index and streamflow) on the following page. Temporal patterns in WY15 and WY14 water quality monitoring data for the overall LSDR watershed are shown in **Chart 3.1**. Dissolved Oxygen values are highest during the winter months (Dec-March) whereas specific conductivity and water temperatures are greatest during the dry summer months (June-Sept). Mean coliform count (MCC) and pH values exhibit very little seasonal fluctuation, although slight variances in monthly values are noticed. **Chart 3.2** provides an overall perspective of temporal variance in WQI values and streamflow for the LSDR, during WY15, WY14 compared to monthly averages over the past 11-year period.

As listed in the tables and shown in **Chart 3.2**, the WQI values for WY15 (green bars) are lower than the 11-year norms (white bars) with exception of May, June and September. Last year's (WY14) results (pink bars) were the lowest on record for all 12 months. The relationship between stream flow (both wet weather and dry) and water quality continues to have a strong effect on results. Depletion in dissolved oxygen levels combined with well below normal flows constitute the primary drivers in low index values. In general, water quality for the Lower San Diego River watershed was highest (C-Good) during the initial winter months with greatest streamflow and lowest (F Very Poor) during the hottest, minimal flow months of summer. The overall annual average WQI for the LSDR in WY15 of 29 (E-Poor) is 6 units below the 11-Yr average of 35, but 7 points higher than last year's result. If it were not for the unusual late rainstorm events occurring in May, July and September, streamflows would have likely been comparable to last year's. The continuing below average results throughout the Mission Valley section is believed to be associated with un-purged biomass buildup from invasive plants. DO deficits remained present throughout the dry weather period.

Trends over the past 11 years in both monitored WQ metrics and the resultant WQI by river reach and section are presented in Sections 4 and 5, respectively, of this report.

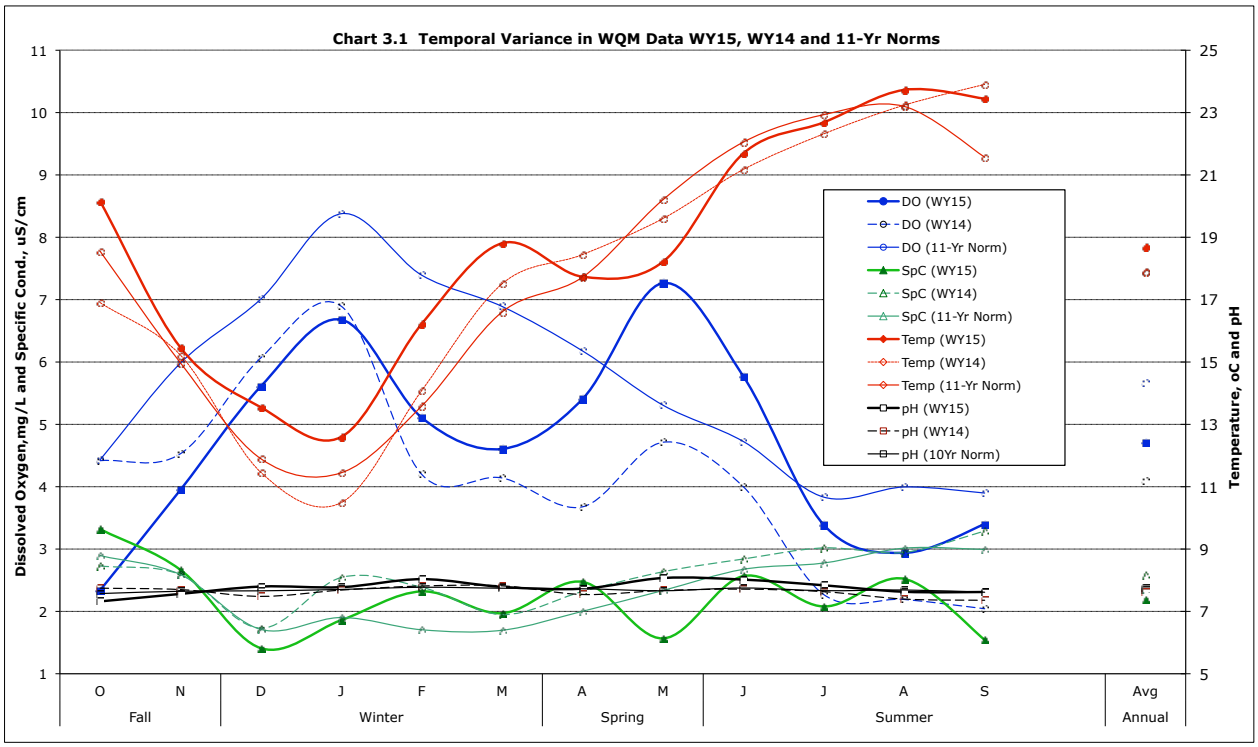


Chart 3.1 Temporal Variance in WQM Data WY15, WY14 and 11-Yr Norms
Dissolved Oxygen,mg/L and Specific Cond., uS/cm
Temperature, oC and pH
DO (WY15)
DO (WY14)
DO (11-Yr Norm)
SpC (WY15)
SpC (WY14)
SpC (11-Yr Norm)
Temp (WY15)
Temp (WY14)
Temp (11-Yr Norm)
pH (WY15)
pH (WY14)
pH (10Yr Norm)
O N D J F M A M J J A S Avg
Fall
Winter
Spring
Summer
Annual

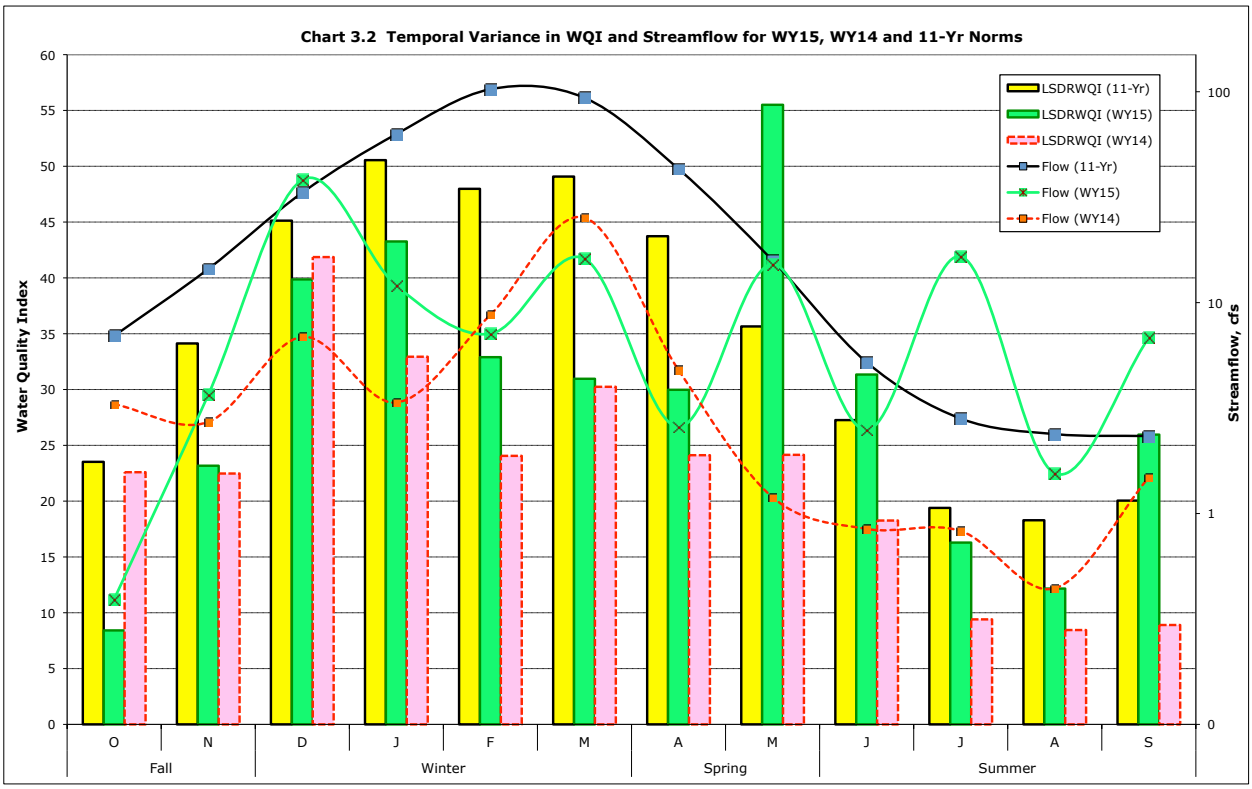


Chart 3.2 Temporal Variance in WQI and Streamflow for WY15, WY14 and 11-Yr Norms
Water Quality Index
Streamflow, cfs
LSDRWQI (11-Yr)
LSDRWQI (WY15)
LSDRWQI (WY14)
Flow (11-Yr)
Flow (WY15)
Flow (WY14)
O N D J F M A M J J A S
Fall
Winter
Spring
Summer

Section 4 - Trends in Water Quality Metrics (WY05 through WY15)

Trends in SDRPF water quality monitoring metrics, based on data collected by RiverWatch from September 2005 through September 2015, are discussed in this chapter. The metrics include water temperature, specific conductivity, pH, dissolved oxygen, streamflow and the water quality index. Twelve Running 12-month average values represent a rational indication of treading over the past 11 years of continual monitoring for each metric.

Table 4.1 presents 12-month running average values for each of the water quality metrics monitored over the past 11 years. Running averages above 11-yr norms are presented in blue; values below norms are listed in red.

Table 4.1 - Running Average WQM Metrics (FY05-FY15)

	Temp	SpC	pH	DO	DO%	Flow	WQI [a]	
	oC	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
WY05	17.68	2.131	7.58	6.84	67	63.6	41	C Fair
WY06	18.32	2.191	7.33	5.87	58	11.9	37	D+ Marginal
WY07	17.7	2.419	7.7	5.91	59	8.4	37	D+ Marginal
WY08	17.67	2.323	8.08	6.28	65	16.1	38	C- Fair
WY09	17.73	2.493	7.72	6.17	64	17.8	37	D+ Marginal
WY10	18.08	2.362	7.7	5.4	57	28.6	35	D Marginal
WY11	17.77	2.211	7.85	5.82	61	41.4	38	C- Fair
WY12	18.03	2.388	7.47	5.59	58	13.1	33	D Marginal
WY13	17.32	2.499	7.75	5.68	58	7.9	32	D Marginal
WY14	17.86	2.582	7.52	4.09	42	4.4	22	E Poor
WY15	18.69	2.192	7.78	4.7	50	9.7	29	D Marginal
Norm	**17.9**	**2.345**	**7.68**	**5.67**	**58**	**20.3**	**35**	**D Marginal**

Values based on SD RiverWatch physical-chemical metrics (WQI_4) combined with USGS recorded stream flow for eastern (West Hill Pkwy) and western sections (Fashion Valley). Values/grades below 11-yr norms shown in red; above in blue.

Running average, maximum and minimum monthly monitoring site water temperature values for the LSDR watershed are presented on **Chart 4.1**. Running average water temperatures that remained fairly steady between WY05 and mid-WY14, increased by 1.7 degrees celsius (17.1 to 18.8 ^oC) over the last 16 months. Average river water temps are expected to return toward the 11-year norm (17.7 ^oC) as air temperatures normalize and streamflows improve. The typical running average variance in water temperature over the past decade is in the range of 3% above to 3% below norms, however, over the past two years the temperature variance rose from 4.2% below (Oct. 2013) to 5.1% above (March 2015) the 11-yr norm. Maximum monthly water temperatures have also trended higher than monthly minimums over

the past several years. Higher running average water temperatures observed over the past two years are a direct result of higher 24-hr average, daytime and nighttime lows in both air and ground temperatures that have been experienced in San Diego as well as throughout the Southern California region. There were only two months (Dec. & Jan.) in 2015 when minimum water temperatures dropped below 12°C while there were five months (March, June, July Aug. and Sept) when maximum water temperatures were monitored above 24 °C. Typically there are 3-to-4 months a year where minimum water temperatures are below 12 °C and only 2-to-4 months with maximum temps above 24 °C.

Trends in monthly monitored Specific Conductivity (SpC) values for the lower SDR watershed are presented in **Chart 4.2**. Minimum and maximum running averages for all sites monitored have varied little over the 11-yr period, however the overall LSDR running average rose from the low 2 mS/cm range during the first several years (WY05-WY06) to the 2.6-2.7 mS/cm in WY12, WY13 and WY14. Greater rainfall during the summer months and resultant elevated (well above normal) dry-weather streamflows in WY15 caused SpC values to decline below 11-yr norm of 2.5 mS/cm over this past water year. The current LSDR running average SpC of 2.1 mS/cm for WY15, is 16% below the 11-yr norm. Running average values are expected to continue trending downward with greater monthly rainfall and higher average daily streamflow anticipated in WY16. Conductivities are expected to remain elevated, however, should drought conditions persist through 2016.

Trends in monthly pH values are presented in **Chart 4.3**. The overall or general trend in minimum and average values monitored for the LSDR has been increasing slightly over the past six years beginning back in late 2009. It is possible that the lowest monthly minimum readings (between 6.3 and 6.8) recorded prior to 2009 were a result of a faulty probe. Minimum monthly readings since a replacement probe was acquired in 2009 have seldom been below 7.0. Maximum monthly site readings in 8.0-8.5 range have, on the other hand remained steady. Excluding the initial three year's overall running average for LSDR, there has been minimal variance from the 11-yr norm (7.7) over the past eight years (WY08-WY15) of monitoring.

Dissolved oxygen running average values and monthly minima-maxima are presented in **Chart 4.4.** A steady decline in average and minimum values for the lower watershed sites from Jan. 2009 through Dec. 2014 can be seen. WY15 LSDR average, minimum and maximum monthly values have increased somewhat (from WY14 lows) but are still significantly below the 11-yr norms. The current running average DO value of 4.8 mg/L (Sept 2015) is over 20% below the LSDR norm, while the minimum running average of 0.8 mg/L is nearly 70% below the 11-yr norm of 2.6 mg/L. Depressed dissolved oxygen levels monitored throughout large segments of the lower river are the result of low flows, especially during the dry-weather months, combined with above average water temperatures and a large build up of oxygen demanding organic material (biomass). With the lack of significant flushing action during recent (over past four years) mild storm flow events a large amount of decaying biomass* has accrued within and along the river channel. Running average DO values are expected to noticeably improve following one or more major storm flow events involving significant channel scouring, displacement of organic-rich sediments and major reduction of invasive aquatic plant species.

The overall water quality index (WQI) for LSDR as well as minimum and maximum running average values for monitoring sites within the watershed are presented in **Chart 4.5.** The WQI provides an overall indication of the relative condition of the river based on the water quality parameters monitored by RiverWatch and streamflow (discharge) as measured at various stations by the USGS. Similar to trends in DO (Chart 4.4), running average WQI values have generally been in decline from WY09 through WY14. LSDR running averages reached their lowest value of 21 (grade E, Poor) in Oct. 2014, some 39% below the 11-yr norm of 35 (grade D, Marginal). The current WQI (Sept 2015) of 29 (grade D, Marginal) remains 16% below the 11-yr average but rising. An above average rainfall year in WY16 is expected to result probable return to running average index values in mid 30's as previously experienced in WY09 and WY11.

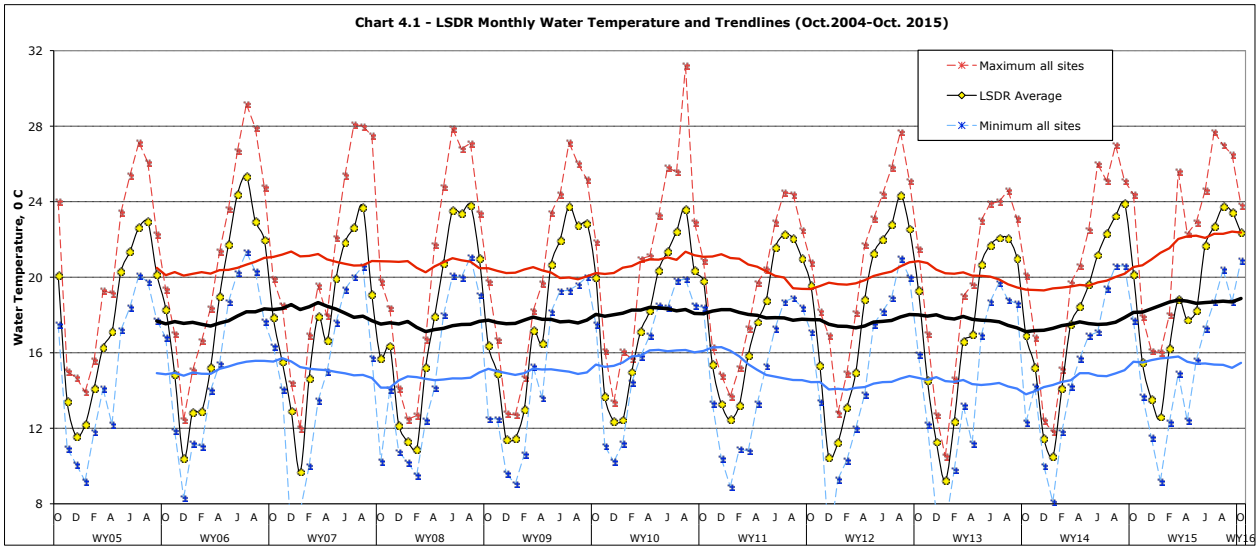


Chart 4.1 - LSDR Monthly Water Temperature and Trendlines (Oct.2004-Oct. 2015)
Maximum all sites
LSDR Average
Minimum all sites
Water Temperature, 0 C
32
28
24
20
16
12
8
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

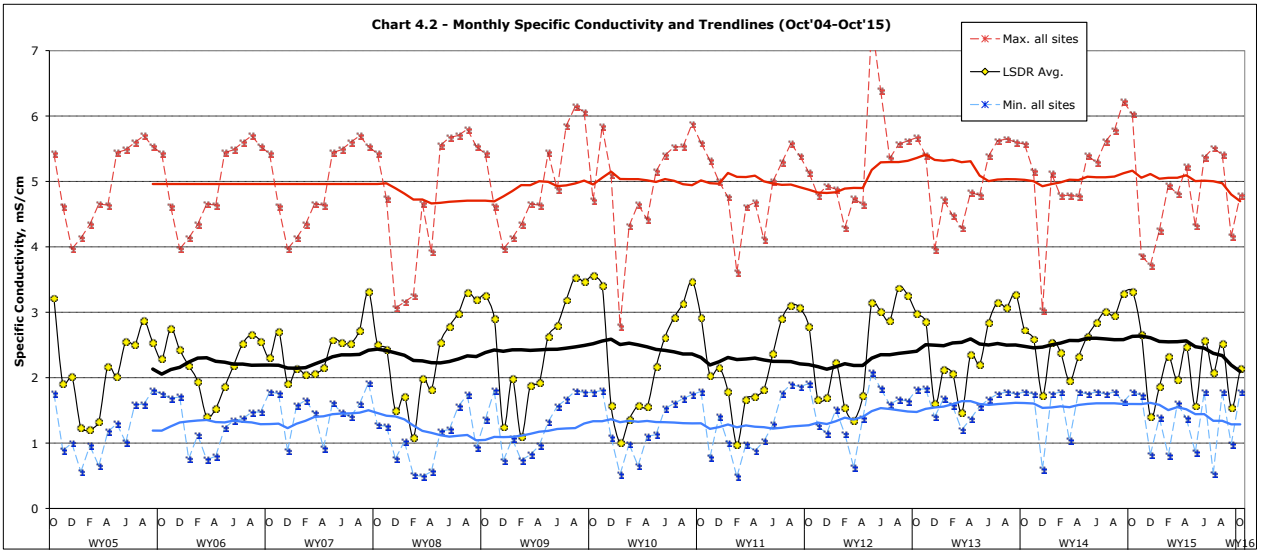


Chart 4.2 - Monthly Specific Conductivity and Trendlines (Oct'04-Oct'15)
Max. all sites
LSDR Avg.
Min. all sites
Specific Conductivity, mS/cm
7
6
5
4
3
2
1
0
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

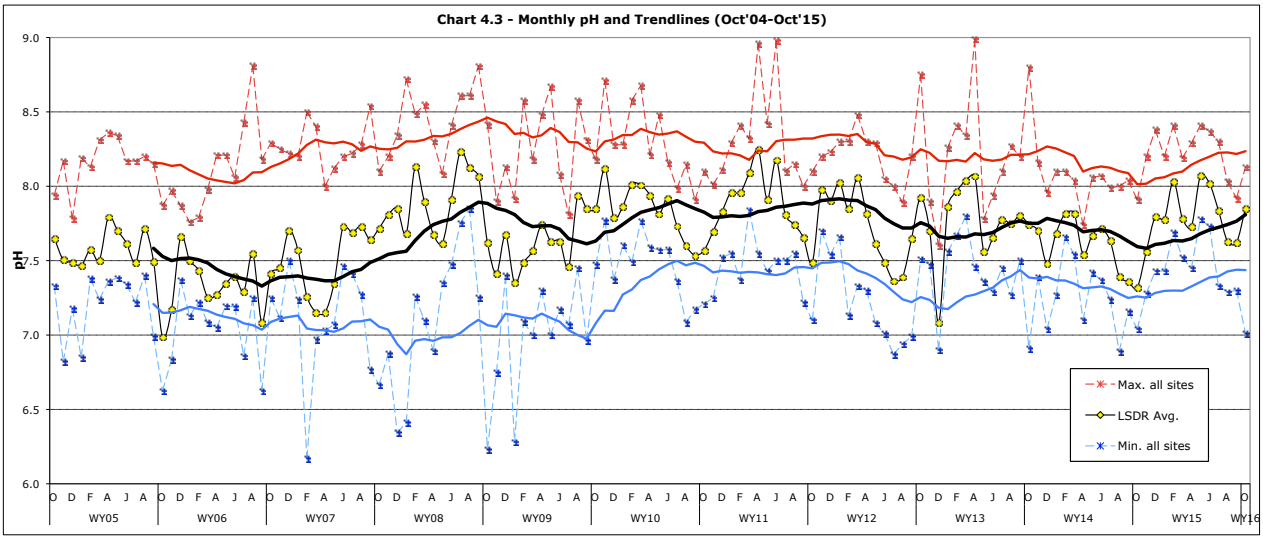


Chart 4.3 - Monthly pH and Trendlines (Oct'04-Oct'15)
Max. all sites
LSDR Avg.
Min. all sites
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

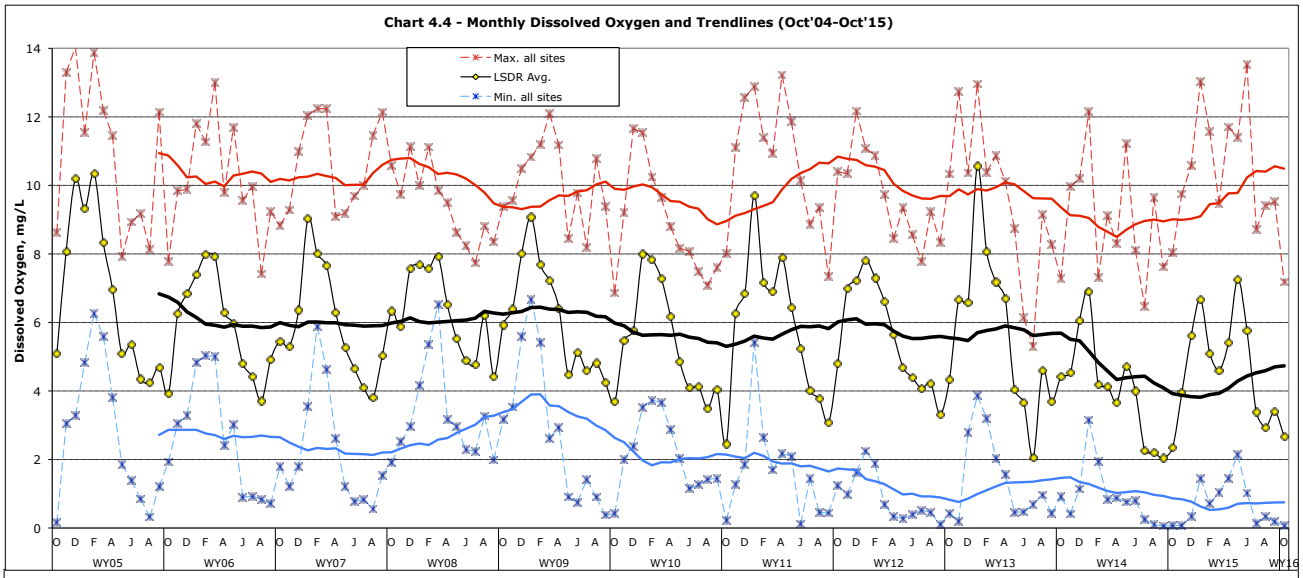


Chart 4.4 - Monthly Dissolved Oxygen and Trendlines (Oct'04-Oct'15)
Max. all sites
LSDR Avg.
Min. all sites
Dissolved Oxygen, mg/L
0
2
4
6
8
10
12
14
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

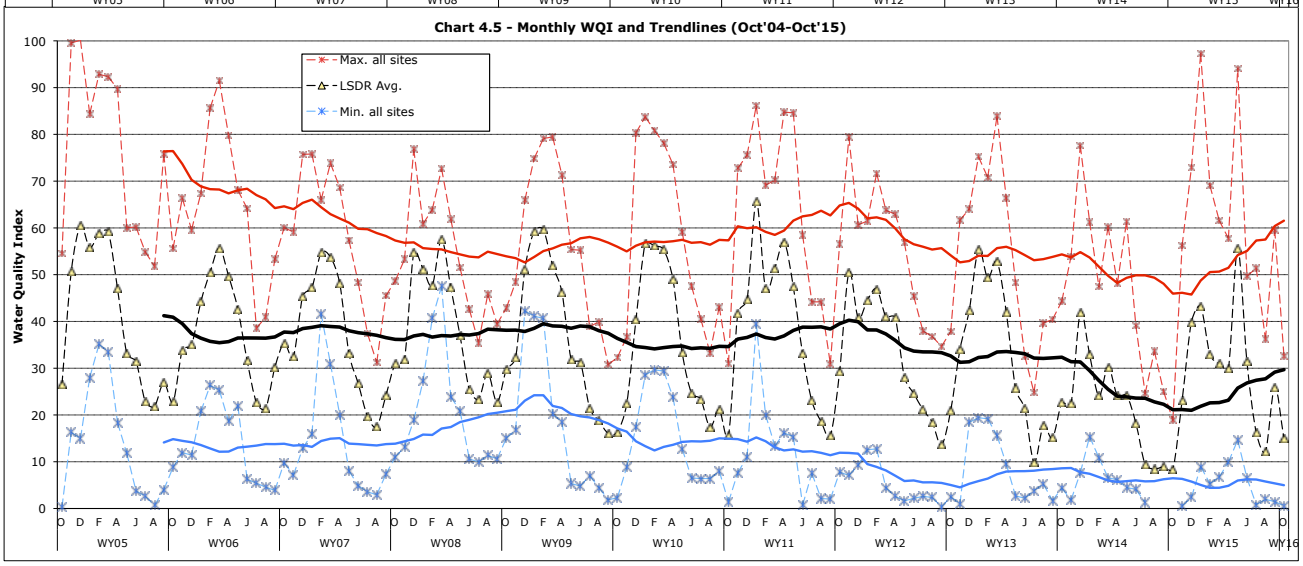


Chart 4.5 - Monthly WQI and Trendlines (Oct'04-Oct'15)
Max. all sites
LSDR Avg.
Min. all sites
Water Quality Index
0
10
20
30
40
50
60
70
80
90
100
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

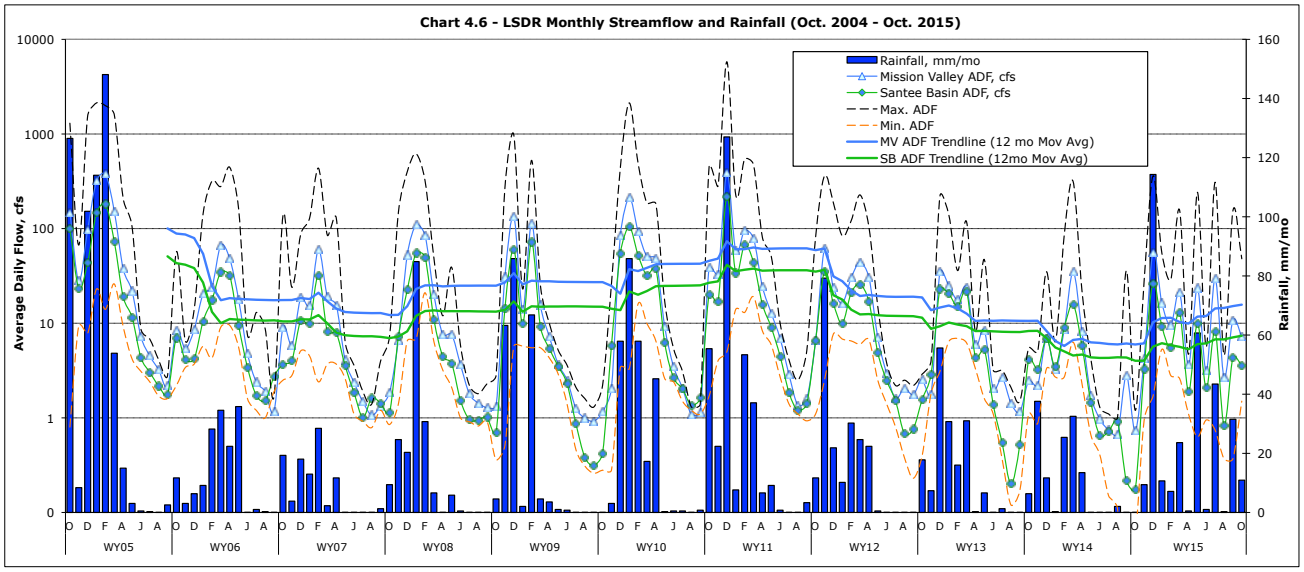


Chart 4.6 - LSDR Monthly Streamflow and Rainfall (Oct. 2004 - Oct. 2015)
Rainfall, mm/mo
Mission Valley ADF, cfs
Santee Basin ADF, cfs
Max. ADF
Min. ADF
MV ADF Trendline (12 mo Mov Avg)
SB ADF Trendline (12mo Mov Avg)
Average Daily Flow, cfs
0
1
10
100
1000
10000
Rainfall, mm/mo
0
20
40
60
80
100
120
140
160
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15

Trend lines for total monthly rainfall and running average streamflows in the Santee Basin (SB) and Mission Valley (MV) are presented in **Chart 4.6.** The trend in average daily streamflow throughout the lower SDR fell by an order of magnitude (from 100 cfs to 10 cfs) from WY05 to WY06, then slowly rose to 80 cfs in WY11. Lowest running average streamflow of 7-8 cfs for Mission Valley and 3 cfs for the Santee Basin, was computed in WY14. Due to the distribution and magnitude of rainfall in WY15, running average streamflow are back up around 12 cfs (Mission Valley) and 8 cfs (Santee Basin), still well below the 11- yr norms.

The trends and relative variances in water quality metrics as shown in Charts 4.1-4.6 are interrelated. Declining rainfall results in less streamflow which results in declining dissolved oxygen levels and increased Specific Conductivities. As all of the parameters are incorporated within computation of the water quality index, the trends over the past 11 years are similar. The river experienced its best water quality during the wettest year (WY05) followed by a steady decline during the well-below average rainfall and river discharge period from WY12 through WY14. The river experienced its poorest water quality during the driest, lowest streamflow year (WY14) monitored over the last 11 years. An uptrend toward normalized values has been evident over the past 12 months of WY15. WY16 would, based on all indications, continue this past water year's uptrend in water quality conditions.

Section 5 - Trends in LSDR Water Quality Index (WY05 through WY15)

Annual and seasonal LSDR WQI values are presented in **Table 5.1** by river reach, section, and overall (LSDR) average for each water year (WY05-WY15) of RiverWatch monitoring. Values and grades above 11-yr norms for each reach and section are in blue; below 11-yr norms (expressed in black italics) are shown in red. The WY15 values, expressed in bold font, are somewhat higher than last year's results, but remain below the 11-yr norms with the exception of the Lower Santee Basin reach. WQI for the LSB reach (Sites 11,12T&15T) rose by an entire grade point from last year during both the winter, summer and transitional (spring/fall) periods of this water year primarily because of improved water quality metrics monitored at the Forester Creek sites.

Table 5.1 - Average Annual and Seasonal WQI by Reach and Section (WY05-WY15)

Annual Avg.	LMV Reach	UMV Reach	MV Section	MG Section	LSB Reach	USB Reach	SB Section	LSDR Overall Avg.	
WY05	49	43	46	65	31	18	24	41	C (highest)
WY06	40	33	37	55	34	22	28	37	D+
WY07	37	28	33	51	40	27	34	37	D+
WY08	39	31	36	47	40	34	37	38	C-
WY09	38	29	34	46	42	32	37	37	D+
WY10	36	33	35	49	38	18	28	35	D
WY11	40	38	39	56	44	15	29	38	C-
WY12	35	35	35	49	39	9	24	33	D
WY13	37	32	35	46	35	11	23	32	D
WY14	18	19	18	37	28	10	19	22	E-(lowest)
WY15	**23**	**22**	**23**	**46**	**43**	**10**	**27**	**29**	**D**
11-Yr Norm	*36*	*31*	*34*	*50*	*38*	*19*	*28*	*35*	*D Marginal*
Winter	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	64	65	64	86	44	33	39	59	B (highest)
WY06	54	47	51	61	40	29	35	46	C
WY07	50	42	46	64	55	41	48	50	B-
WY08	57	48	53	55	52	52	52	53	B
WY09	57	47	53	62	61	50	55	55	B
WY10	55	54	55	67	55	29	42	52	B-
WY11	57	57	57	67	54	27	40	52	B-
WY12	48	49	49	60	45	14	29	43	C
WY13	58	54	56	68	49	21	35	50	B-
WY14	25	26	26	55	40	15	27	32	D (lowest)
WY15	**33**	**28**	**31**	**59**	**52**	**11**	**32**	**37**	**D+**
11-Yr Norm	*51*	*47*	*49*	*64*	*50*	*29*	*39*	*48*	*C+ Fair*

Summer	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	31	25	29	47	20	5	13	26	D-
WY06	23	14	19	46	31	19	25	26	D- (highest)
WY07	23	15	20	36	24	13	18	22	E
WY08	24	20	23	34	29	18	24	25	D-
WY09	21	14	18	33	25	16	20	22	E
WY10	21	18	20	34	26	9	18	22	E
WY11	23	17	20	38	30	5	17	23	E
WY12	22	18	21	26	27	4	16	19	E
WY13	18	13	16	20	23	5	14	16	E
WY14	10	11	10	12	16	8	12	11	F (lowest)
WY15	15	**11**	13	**34**	**38**	**9**	**23**	**21**	E
11-Yr Norm	*21*	*16*	*19*	*33*	*26*	*10*	*18*	*21*	*E Poor*

Table 5.1 WQI Letter/Color Code: A (>75) Very Good (dark blue), B (50-74) Good (light blue), C (38-49) Fair (green), D (25-37) Marginal (yellow), E (13-24) Poor (brown), and F (0-12) Very Poor (red). WQI values in red are below 11-Yr norms (expressed in italics) for the same reach or section of the river; values above 11-Yr norms are in blue.

Running average WQI values from the past 11 years of monitoring are summarized in **Table 5.2**. With exception of the Lower Santee Basin reach (Sites 11, 12T & 15T), both WY15 annual and winter running averages remain below the 11-Yr norms although not as low as last year's (WY14) results. The running averages as well as variances in monthly index values for each reach of the lower river system are presented in a series of charts (5.1 through 5.6) on pages 19 and 20.

Table 5.2 Summary of LSDR WQI Running Average (Trending) Values

	Chart	High / WY	Low / WY	11-Yr Norm	WY14	WY15[a]
East Section (SB):	5.6	67 (B) WY09	8 (F) WY13	*28 (D)*	19 (E)	27 (D Marginal)
Upper Santee Basin	5.5	66 (B) WY09	3 (F) WY11	*19 (E)*	10 (F)	10 (F Very Poor)
Lower Santee Basin	5.4	71 (B) WY09	11 (E) WY13	*38 (C-)*	28 (D)	43 (C Fair)
Mid Section (MG)	5.3	90 (A+) WY05	8 (F) WY13	*50 (B-)*	37 (D+)	46 (C Fair)
West Section (MV):	5.6	73 (B+) WY05	6 (F) WY13	*34 (D)*	18 (E)	23 (E Poor)
Upper Mission Vly	5.2	72 (B) WY05	8 (F) WY13	*31 (D)*	19 (E)	22 (E Poor)
Lower Mission Vly	5.1	79 (A-) WY05	5 (F) WY13	*36 (D+)*	18 (E)	23 (E Poor)
LSDR Overall Avg.	5.6	**65 (B) WY05**	**8 (F) WY14**	***35 (D)***	**22 (E)**	**29 (D Marginal)**
Best Site (#8)	5.3	95 (A+) WY05	2 (F-) WY14	*52 (B-)*	32 (D)	44 (C Fair)
Greatest Range (#4)	5.1	100 (A+) WY10	0 (F-) WY05	*42 (C)*	15 (E)	22 (E Poor)
Poorest Site (#13)	5.5	62 (B) WY09	2 (F-) WY12	*19 (E)*	9 (F)	8 (F Very Poor)

a) End of WY14 and WY15 running averages (September) shown in red are below 11-yr norms; above norms in blue.
b) Highest overall WQI values are associated with Site #8 (Jackson Dr) located in the Mission Gorge (mid) section of LSDR.
c) Lowest overall WQI values are associated with Site #13 (Mast Park) in the Upper Santee Basin reach.
d) The greatest range in WQI values (0 to 100) is associated with Site #4 (FSDRIP at Mission Center Rd.)

Over the past decade, as shown on **Chart 5.1**, average monthly WQI values associated with the **Lower Mission Valley Reach** (Sites 1-4) of the river system have varied from a high of 75 (A- Very Good) in January 2011 to a low of 4 (F Very Poor) in September 2014, the last month of WY14. The general trend in running average WQI for the reach, as well as for four individual monitoring sites, has declined from the lower 40's (C Fair) during WY's 05 and 06 to the mid-teens (E Poor) by late WY14 and into the first half of WY15 (Oct-March). The running average WQI has improved to near the mid-20's during the second half (April-Sept) of WY15. Site 3 (Fashion Valley Mall) has consistently recorded the lowest running average WQI throughout WY15 while Site 4 (FSDRIP at Mission Valley Rd.) has consistently presented the highest values for the reach since January of 2014. The most significant decline in the WQI for the reach over the 11-year monitoring period occurred in WY14. Although there has been some partial recovery during WY15, the overall trend remains one of general decline similar to other reaches of the lower river system.

As shown in **Chart 5.2** , the range in monthly WQI values for the **Upper Mission Valley Reach** (Sites 5-7) of the river are roughly comparable to those downstream in Lower Mission Valley. Site 6 (Kaiser Ponds at Mission Valley Rd) has continuously presented lowest running average WQI values since WY07 while Site 7 (Admiral Baker Field at Zion), situated just upstream of the ponds, has presented the highest values on a continuous basis since WY09. The highest monthly WQI reading for the Upper Mission Valley reach of 72 (B Good) was monitored in Jan. 2011 whereas the lowest reading of 5 (F Very Poor) was experienced this year during the final month (Sept) of WY15. The overall trend in running average WQI values from WY05 through WY15 has been a general decline with several years (WY08, WY10 and WY11) showing slight improvements (recovery). The overall trend since January of 2012, however, has been one of steady decline.

Running average WQI for the **Mission Gorge Reach** (Sites 8-10) of the river, as shown in **Chart 5.3**, has also declined, especially during WY's 12, 13 and 14. Highest monthly WQI values of 80 (A Very Good) monitored in Feb. 2011 and 2013 and in April 2015, contrast with lows of 5 (F Very Poor) in Sept. 2012 and Aug. 2014. In general running average WQI for this reach is the best of the five lower river reaches with average WQI the 37 to 49 range (C Fair). The trends in Mission Gorge WQI are comparable to those in the Mission Valley reaches. General decline in index values from WY06 through WY09, followed by a slight upturn in WY10 and WY11, and a more significant decline during WY's 12, 13 and 14 to a low of 34 (D Marginal). WY 15 witnessed a 10-point recovery in the running average WQI reaching 44 (C Fair) by September.

The **Lower Santee Basin Reach** (Sites 11, 12T and 15T) monthly WQI values and running averages are shown in **Chart 5.4**. The range from winter month highs in the 50-70 range (B- Good) to summer lows in the 13-24 range (E Poor) are common. Water quality improved in this reach from WY06 through WY11, then declined throughout WY's 12, 13 and 14, reaching a running average low of 29 (D Marginal) in September 2014, before recovering to the low 40's (C Fair) by the second half of WY15. Completion of the Forester Creek enhancement project extending from Prospect Ave. to the Mission Gorge Rd. over this past year has had a significant positive effect on overall river quality in the Lower Santee Basin portion of the river system.

Chart 5.5 presents monthly and running average WQI values for the **Upper Santee Basin Reach** (Sites 13 & 14) of the river system. This reach represents the lowest water quality values of all five sections of the lower river watershed. Monthly values have seldom exceeded 20 (E Poor) since the summer of 2011 and are typically less than 12 (F Very Poor) throughout most months. The running average WQI for this reach has declined from highs above 30 (D Marginal) in WY09 to continuously around 12 (F Very Poor) from WY12 through WY15.

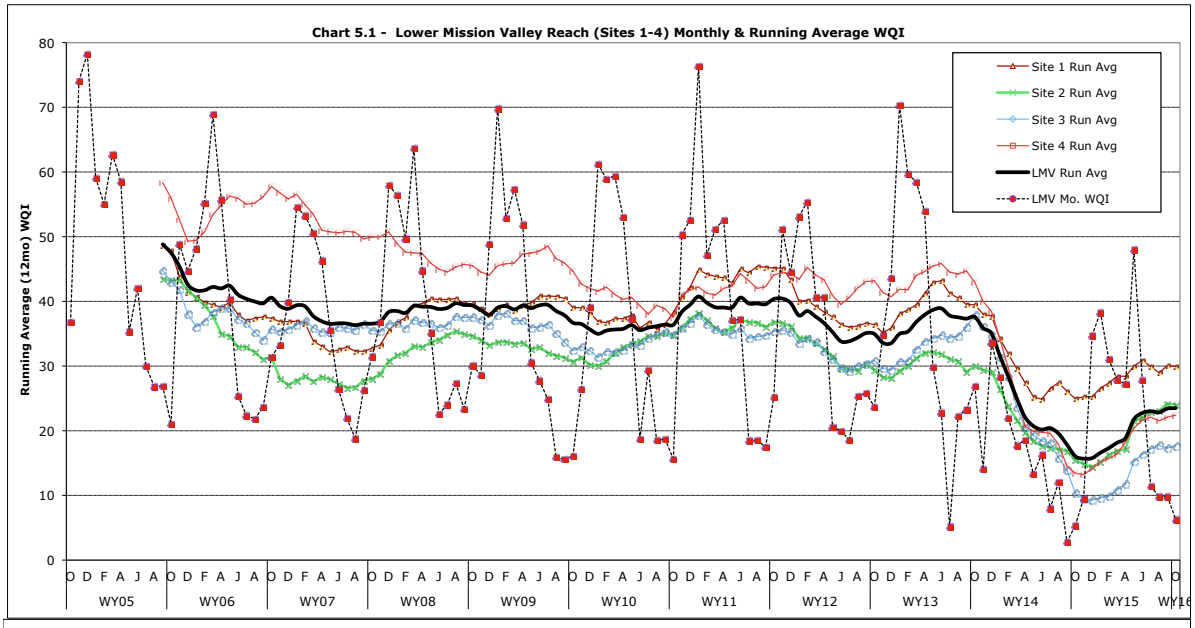


Chart 5.1 - Lower Mission Valley Reach (Sites 1-4) Monthly & Running Average WQI
Running Average (12mo) WQI
Site 1 Run Avg
Site 2 Run Avg
Site 3 Run Avg
Site 4 Run Avg
LMV Run Avg
LMV Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15

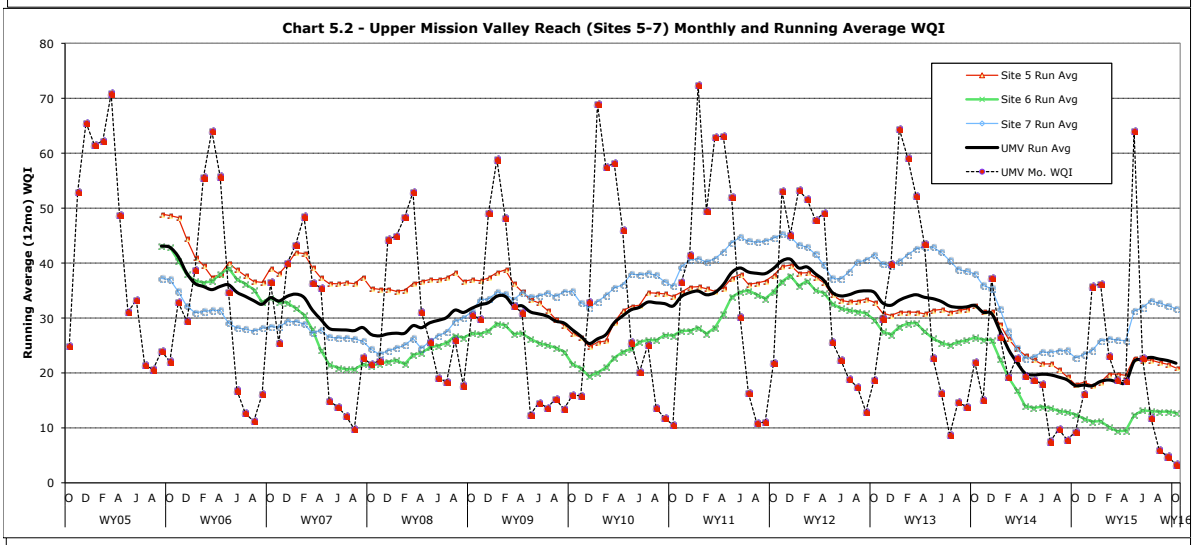


Chart 5.2 - Upper Mission Valley Reach (Sites 5-7) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 5 Run Avg
Site 6 Run Avg
Site 7 Run Avg
UMV Run Avg
UMV Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15

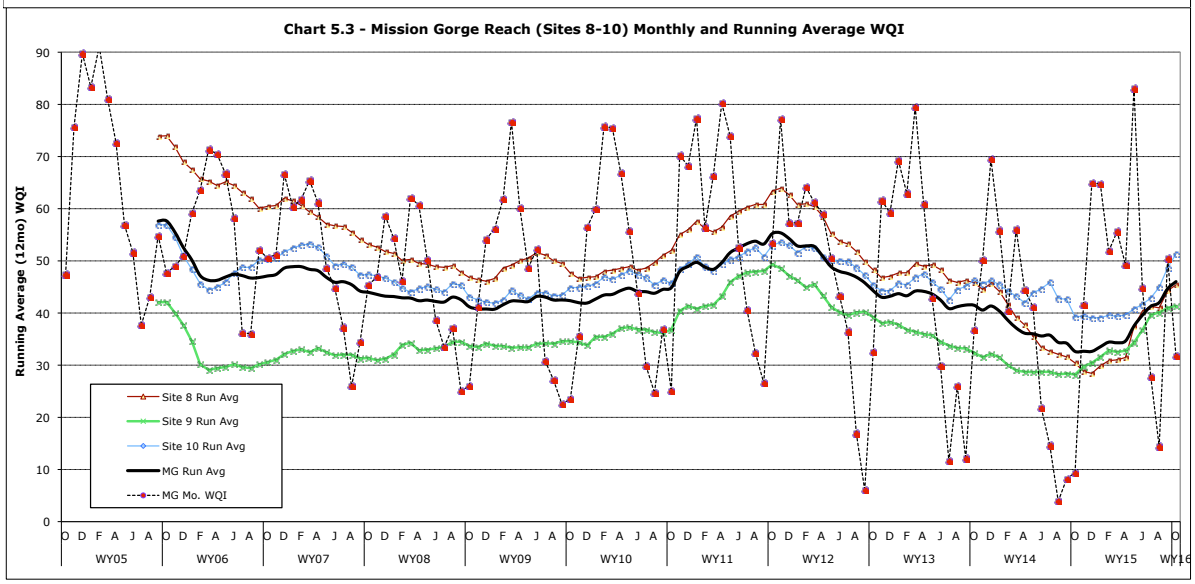


Chart 5.3 - Mission Gorge Reach (Sites 8-10) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 8 Run Avg
Site 9 Run Avg
Site 10 Run Avg
MG Run Avg
MG Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15

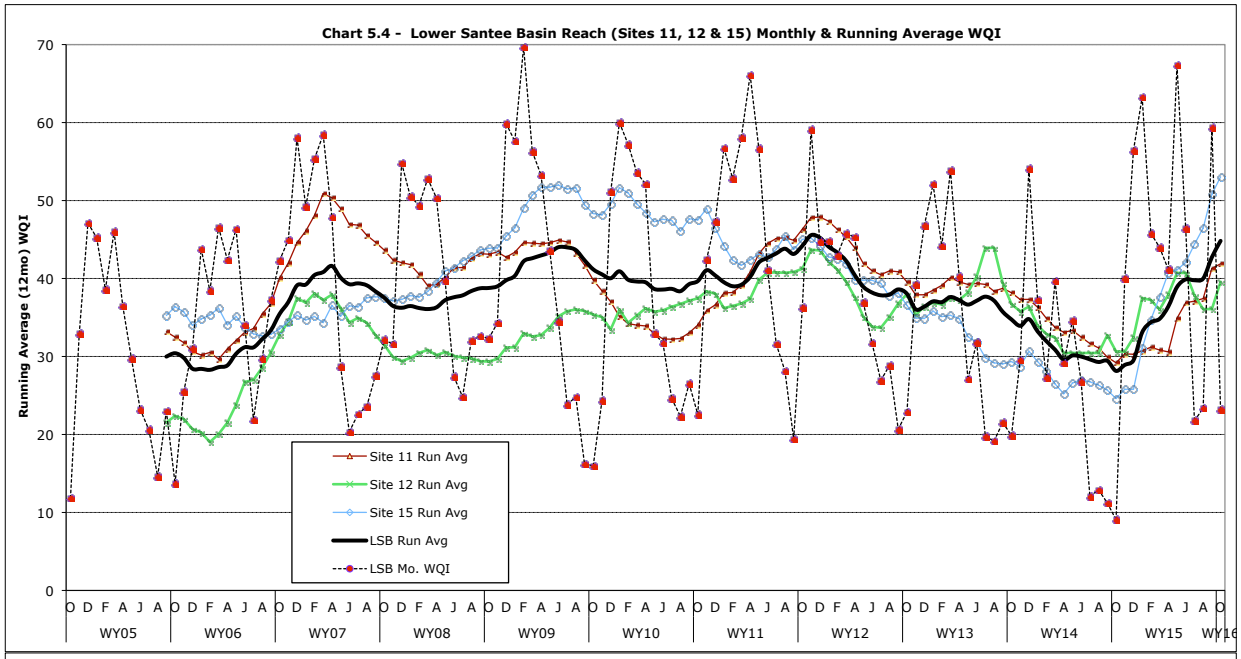


Chart 5.4 - Lower Santee Basin Reach (Sites 11, 12 & 15) Monthly & Running Average WQI
Running Average (12mo) WQI
Site 11 Run Avg
Site 12 Run Avg
Site 15 Run Avg
LSB Run Avg
LSB Mo. WQI
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

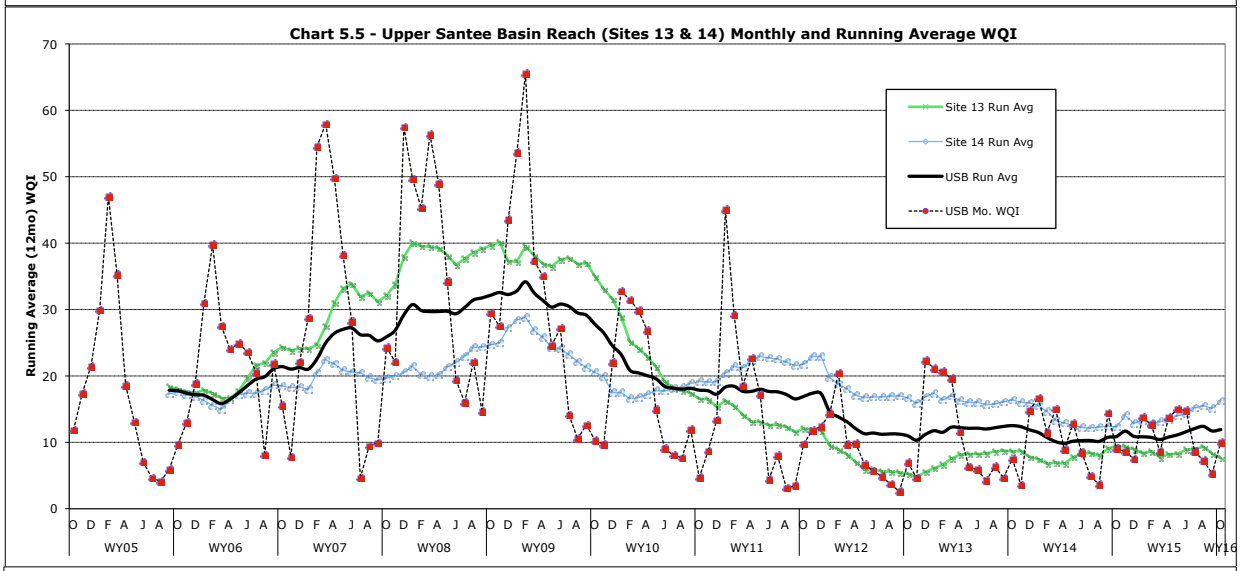


Chart 5.5 - Upper Santee Basin Reach (Sites 13 & 14) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 13 Run Avg
Site 14 Run Avg
USB Run Avg
USB Mo. WQI
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

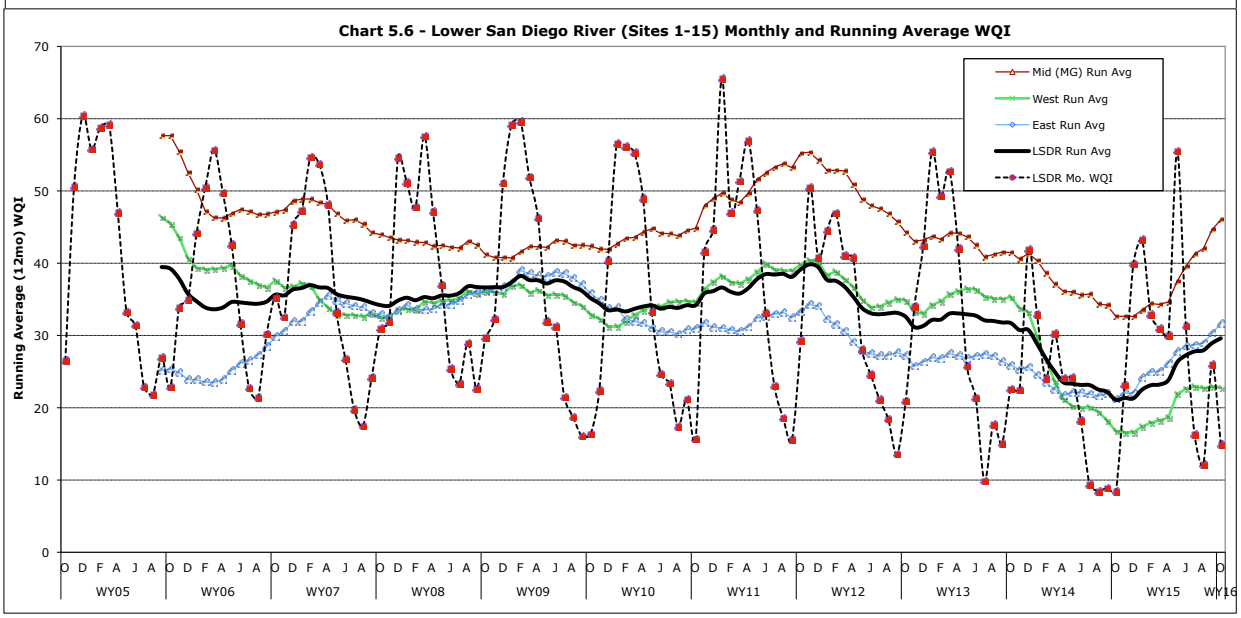


Chart 5.6 - Lower San Diego River (Sites 1-15) Monthly and Running Average WQI
Running Average (12mo) WQI
Mid (MG) Run Avg
West Run Avg
East Run Avg
LSDR Run Avg
LSDR Mo. WQI
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16

Very low dissolved oxygen levels (often less than 2 mg/L) in conjunction with minimal streamflow are the primary causes of low index values. The low DO concentrations are believed to be the result of extensive eutrophication due to bio-mass buildup, accrual of organic-rich detritus and constrained water movement. Until the prolific spread of creeping water primrose (L*udwigia peploides)** can be better controlled and managed, water quality in these sections of the river are expected to remain much inferior to portions of the river where improved circulation, mixing and natural re-oxygenation occurs.

The monthly and running average variation in WQI values for the three main sections of the lower river (i.e., Santee Basin, Mission Gorge and Mission Valley) and the overall **Lower San Diego River** system (composite of all 15 monitoring sites) are presented in **Chart 5.6.** WQI running averages have recovered from this last year's (WY14) lows for all three sections of the river during WY15. The Mission Gorge section (Chart 5.3) has improved in water quality the most, while the lower section (Mission Valley) is responding more slowly. Overall the current LSDR running average WQI of 29 (D Marginal) is a full grade level above last September's 22 (E Poor) and six points below the 11-yr norm of 35 (D Marginal). The highest running average WQI for the river of 65 (B Good) occurred during the wet-weather (winter) months of WY05, whereas the lowest overall LSDR running average of 8 (F Very Poor) was reached during the late summer months of last year (July-Oct) 2014. The overall trend in running average WQI for the LSDR remained fairly steady in the range of 35 to 40 between WY06 and WY11, but then declined to the low 20's by the end of WY14.

The overall decline in running averages is a function of depressed oxygen levels at multiple sites that are exacerbated by elevated water temperatures and protracted record low streamflows. WQI values are expected to improve as streamflows return to more normalized patterns and invasive aquatic growth abatement measures are undertaken or occur by flushing for specific reaches of the river. Higher minimum values during the summer months are quite likely to result in positive gradients for trend lines (12-mo. running averages) in the course of time. The present (WY15) running average WQI value of 29 (D Marginal) for the LSDR system is 6 points (17%) below the 11-Yr norm of 35 (D Marginal). The current running average WQI for the Upper Santee Basin reach of 10 (F Very Poor) is 9 points below the 11-yr norm whereas the current running average for the best section (Mission Gorge) of 46 (C Fair) is only 4 points below the 11-yr WQI norm of 50 (B Good).

The overall running average LSDR WQI of 29 (D Marginal) as well as winter and summer values of 32 (D Marginal) and 11 (F Very Poor), respectively, are currently running consistently below the 11-yr annual norms of 34 (D Marginal), 49 (C+ Fair) in winter and 21 (E Poor) in summer. Conditions this coming year (WY16) are anticipated to be abnormally high in terms of wet weather precipitation levels and streamflow (runoff). Average annual LSDR water quality values are expected to continue improving over this year's results. Upper reaches in both the Santee Basin and Mission Valley sections are, however, expected to continue to present poorer water quality values than found in the lower reaches and mid-section (Mission Gorge) due to invasive non-native aquatic plant infestations. Overall, the upward trend in water quality index values occurring over the past water year are expected to continue as 2016 is predicted to be an abnormally wet year witnessing well above average precipitation, storm events and streamflow.

** Ludwigia hexapetala, L. peploides, L. grandiflora is a productive emergent aquatic perennial native to South and Central America, parts of the USA, and likely Australia (USDA-ARS, 1997). It was introduced in France in 1830 and has become one of the most damaging invasive plants in that country (Dandelot et al., 2008). It has been more recently introduced to areas beyond its native range in the USA, where it is often considered a noxious weed (INVADERS, 2009; Peconic Estuary Program, 2009).* ***L. peploides is adaptable, and tolerates a wide variety of habitats where it can transform ecosystems both physically and chemically. It sometimes grows in nearly impenetrable mats; can displace native flora and interfere with flood control and drainage systems, clog waterways and impact navigation and recreation. The plant also has allelopathic activity that can lead to dissolved oxygen crashes, the accumulation of sulphide and phosphate, 'dystrophic crises' and intoxicated ecosystems (Dandelot et al., 2005).*** Emergent creeping water primrose, shown on the cover of this report, is believed to be a primary factor in protracted dissolved oxygen deficits, diminished aquatic bio-diversity and noxious odors throughout multiple reaches of the Lower San Diego River.

Appendix A - 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
DOD- Dissolved Oxygen Deficit (level below minimum)
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; sometimes 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
%Sat - percent of DO saturation value
^oC – degrees Celsius
^oF – 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 SpC 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 ^oC.
Other variables, incl. barometric pressure, elevation and conductivity (SpC), 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(SpC); where SpC 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.[$DO\%f*wt_{(DO)}$, $SpCf*wt_{(SC)}$, $pHf*wt_{(pH)}$, $MCCf*wt_{(MCC)}$, $Qf*wt_{(Q)}$, $Tempf*wt_{(T)}$]^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 is developed specifically for the SDRPF RiverWatch Monitoring Program, however, the equations have also be applied to water quality and hydrologic data for other coastal area watercourses where the same metrics are monitored and recorded.

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 (head)
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
1,000 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 C - SDRPF RiverWatch WQM Team

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