LOWER SAN DIEGO RIVER
WATER QUALITY 2005 - 2016

WY16 Annual Water Quality Monitoring Report

Creeping water primrose (*Ludwigia hexapetala*) downstream of Kaiser Ponds (WQM site 7)

RiverWatch Water Quality Monitoring Results (October 2004 - September 2016)

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Lower San Diego River Water Quality 2005 - 2016

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

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)

The water quality sites on Figure 1-1 and monthly RiverWatch water quality data can be viewed in detail from the RiverWatch page on the SDRPF website available at <www.sandiegoriver/river_watch.html>. Clicking on the right hand side of the page allows access to the data portal. In addition to water quality monitoring data, the portal also contains: San Diego StreamTeam Bio-assessment data, 401 Project information and USGS real-time streamflow data regarding daily peak discharge and gauge height for the two San Diego River gauging stations (Fashion Valley & Mast Bridge near 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 fresh water 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 streamflow) 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 (SUMP), and the Lower San Diego River below Santee and in Mission Valley has been compiled by the SDRPF RiverWatch program.

Section 2 - Spatial Comparison of WY16 Water Quality Data and 12-yr Norms

Monthly water quality data collected and recorded at each site by RiverWatch WQM Team volunteers are used to determine annual averages, seasonal patterns and trends as presented in this report and appendices. Supplemental data collected by other monitoring organizations for streamflow (USGS) and coliform counts (SD CoastKeepers) are also included. The annual average water quality values for each of the 15 monitoring sites for WY16 as well as the 12-yr norms (average values calculated over past 12 years of monitoring) are presented in **Table 2.1**. WY16 values greater than 12-yr norms are shown in blue, whereas values for this past water year below norms are in red.

Table 2.1 Annual WQ Metrics for WY16 and 12-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], (Difference) & Grade	
1	LMV	West	20.5/*19.5*	2.52/2.64	7.9/7.7	6.5/*6.1*	73/66	20/*30*	39/*38* (+1)	C/*C*
2			19.4/*18.9*	2.50/2.60	**7.7**/7.7	4.7/*4.5*	50/48		33/*31* (+2)	D/*D*
3			19.6/*19.1*	2.45/2.51	7.8/7.7	4.1/*4.6*	44/49		29/*32* (-3)	D/*D*
4			20.4/*19.6*	2.48/2.44	7.9/7.8	5.6/*6.2*	62/67		38/*42* (-4)	C/*C*
5	UMV		17.4/*17.2*	2.59/2.56	**7.6**/7.6	3.1/*4.8*	31/49	18/*27*	22/*32* (-10)	E/*D*
6			18.5/*18.3*	2.28/2.57	**7.6**/7.6	2.0/*3.7*	21/38		15/*25* (-10)	E/*D-*
7			18.6/*18.0*	2.29/2.48	**7.5**/7.5	4.2/*4.9*	43/51		29/*33* (-4)	D/*D*
8	MG	Mid	17.6/*17.0*	2.23/2.27	**7.7**/7.7	6.5/*7.6*	66/78	12/*20*	42/*50* (-8)	C/*B-*
9 [b]			15.0/*16.0*	4.62/4.98	8.0/7.7	9.9/*8.9*	99/92		32/*36* (-4)	D/*D+*
10			18.2/*17.7*	2.20/2.23	7.9/7.8	6.5/*7.2*	68/75	12/*17*	39/*45* (-6)	C/*C*
11	LSB	East	16.9/*16.7*	2.37/2.23	7.5/7.6	6.2/*6.3*	65/61		34/*39* (-5)	C/*C*
12 [b]			17.1/*17.7*	1.48/1.68	8.0/7.9	8.0/*7.1*	83/72		41/*35* (+6)	C/*D*
15 [b]			19.1/*18.0*	2.89/2.74	8.1/8.1	8.9/*7.9*	96/75	6/*10*	47/*40* (+7)	C/*C*
13	USB		17.7/*18.5*	1.94/1.92	7.6/7.7	1.4/*3.2*	14/*33*	4/*5*	7/*18* (-11)	F/*E*
14			16.3/*17.1*	1.32/1.52	7.8/7.9	2.5/*3.3*	26/*32*		13/*18* (-5)	E-/*E*
(1-15)	**LSDR Avg.**		18.2/***17.9***	2.30/***2.34***	**7.7**/***7.7***	4.9/***5.6***	51/***57***	13/***20***	29/***34*** **(-5)**	D/***D+***

a) Average annual water quality index value, change (+/-) and resultant WQ letter grade for WY16 (bold)and the 12-yr norms (italics); values below the norms for each metric are expressed in red; values above norms are shown in blue.
b) Lower San Diego River water quality monitoring sites located on tributary (T) streams.

Four sites, located in the Mission Valley (#1&2) and Lower Santee Basin (#12&15) sections of the watershed, present WY16 average annual WQI values above the 12-yr norms. The greatest positive change (+7 points) is associated with Forester Creek (Site #15) whereas the greatest negative change (-11 points) is just upstream at Mast Park (#13). Average annual water temperatures in WY16 are greater than

the 12-yr norms at all but four sites (#9,12,13&14) and overall up 0.3 degrees (18.2 C) from the LSDR 12-yr annual average of 17.9 C. WY16 Specific Conductivity values are running below the 12-yr norms in Mission Valley and Mission Gorge and slightly above at several upstream sites. Overall SpC (average all sites) are nearly the same as the 12-yr average annual norm of 2.34 mS/cm. WY16 DO values are slightly higher than norms at five sites (#s1,2,9,12&15) and lower at ten other sites; overall DO values are below the 12-yr LSDR average annual norm of 5.6 by 0.7 mg/L. DO values for WY16 are, however, up from last year by 0.6 mg/L and the previous year (WY14) by 0.9 mg/L. WY14 witnessed the lowest DO values (2.89 mg/L or 31% Sat.) monitored over the past 12 years of record. The highest average annual DO levels on the river were monitored in WY05 at 6.80 mg/L (72% Sat.).

Average annual, seasonal and monthly min.-max. range water quality metrics for this year (WY16) and the 12-yr norms are also presented by river reach and section in **Table 2.2.** All sections and reaches of the lower river present lower water quality values in WY16 than their associated 12-yr norms. Average annual water temperatures for all reaches and sections were higher in WY16 than the norms. Dissolved oxygen values in WY16 were below the 12-yr norms for each reach and section of the river. WY16 stream flows were also below the 12-yr norms for all reaches and sections of the river within the lower watershed.

Table 2.2 Water Quality Metrics for WY16 and 12-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](Diff) & Grade	
Maximum Month		23.5/25.3	3.47/3.56	8.5/8.5	7.8/8.4	74/98	94/*259*	52/*66*(-14)	B/*B*
Winter (D,J,F,M)		14.1/13.5	1.73/1.75	7.9/7.7	6.5/7.1	63/67	33/*46*	41/*47*(-6)	C/C+
Average Annual		18.2/**17.9**	2.30/**2.34**	**7.7/7.7**	4.9/**5.6**	51/**57**	14/**20**	28/**34** (-6)	D/**D**
Summer (J,J,A,S)		21.9/22.4	3.16/2.89	7.5/7.7	3.2/4.1	37/48	0.5/*1.8*	13/20 (-7)	E-/E
Minimum Month		10.9/9.2	1.46/0.98	7.1/7.0	2.6/1.7	30/20	**0.3**/*0.3*	**8**/*8* (0)	**F**/F
LSDR Section Averages:									
East	SB	**17.7**/17.7	2.13/2.03	7.7/7.7	4.6/5.1	48/50	12/17	23/28 (-5)	E/D
Mid	MG	17.4/17.1	2.21/2.26	7.9/7.7	7.2/7.6	73/79	9/20	40/48 (-8)	C/C+
West	MV	19.2/18.7	2.44/2.54	7.7/7.7	4.3/5.0	46/53	20/30	29/33(-4)	E/D
LSDR Reach Averages:									
USB	East	17.6/18.0	1.81/1.80	7.7/7.7	1.6/3.2	17/33	4/5	8/18 (-10)	F/E
LSB		17.9/17.4	2.45/2.27	7.7/7.8	6.6/6.7	**71**/67	7/18	37/38 (-1)	D+/C
MG	Mid	17.4/17.1	2.21/2.26	7.9/7.7	7.2/7.6	73/79	9/20	40/48 (-8)	C/C+
UMV	West	18.2/17.8	2.39/2.54	7.6/7.6	3.1/4.5	32/46	18/27	22/30 (-8)	E/D
LMV		20.0/19.3	2.49/2.55	7.8/7.7	4.8/5.1	52/54	20/32	35/36(-1)	D/D+

a) Average annual water quality index value, difference (+/-) from 12-year norm and resultant WQI letter grade. Values/grades below 12-year norms are expressed in red; values above in blue.

Spatial water quality values expressed in Tables 2.1 and 2.2 for the fifteen Lower San Diego River system monitoring sites are presented in **Chart 2.1** (Water Quality Data Profile) and **Chart 2.2** (Water Quality Index and LSDR Streamflow) on the following page. The overall water quality index for WY16 of 29 (D Marginal) remains four points below the 12-yr average annual norm of 33 (D Marginal), the same as the river's overall average for WY15. This and last year's average annual index values are seven points above the lowest annual WQI of 22 (E Poor) experienced in WY14. The river's highest overall average annual index of 41 (Fair) occurred in WY05.

Average annual water quality values for water temperature, pH, dissolved oxygen and specific conductivity at each monitoring site, river reach and section in order of their location upstream for WY16 (Oct'15-Sept'16) and the 12-yr norms are shown in **Chart 2.1**. Heavy solid lines in black with values shown are this year's average annual results; blue lines are last year's (WY15) results and the red lines are 12-yr annual norms for each site. Average annual water temperatures for WY16 are greater than 12-yr norms at most sites but not as high as last year's averages. Downstream site water temperatures are typically higher than monitored at upstream sites. There is little variance in average pH values at each site from one year to the next, although slightly elevated pH values area associated with several upstream sites (i.e., #12,15 &10). DO levels, with exception of three tributary sites (#9,12&15), are lower than 12-yr norms. Average annual DO values at four sites (#5,6,13&14) remain in the hypoxic (<4 mg/L) range, comparable to last year's results. With exception of two tributary sites (#9&15), Average annual SpC values generally increase from upstream to downstream with minimal change from year-to-year. DO values represent the greatest variation between sites. Lowest values are typically recorded in the Upper Santee Basin (Site #13&14) and Upper Mission Valley below Kaiser Ponds (site #5&6). Highest DO values are observed in the Mission Gorge section (middle reach sites 8,9&10) and Forester Ck (15T).

The WQI, an aggregate or composite index of water quality monitoring results for WY16, the 12-yr norms and the overall best (WY05) and worst (WY14) years are presented in **Chart 2.2**. As shown by the solid black line and bars, the two sites furthest upstream, #13 (Mast Park) and 14 (RCP/Cottonwood), continue to experience Very Poor (F grade) water quality in WY16. On an average annual basis, highest WQI values continue to be associated with Forester Creek (#15T) and the Mission Gorge (#8&10) sites. The overall WQI profile for WY16 (black line) remains well below the 12-yr norm (heavy blue line) but well above WY14 lows at all but site #10 (Santee Lakes) and 13 (RCP/Cottonwood). Greatest departures (variance) from the 12-yr WQI norms for WY16 are found in the Upper Mission Valley portion. Water quality conditions throughout Mission Valley (both Upper and Lower reaches) in WY16 are 'on par' with last year's (WY15) monitoring results. Forester Ck (#15) monitoring results represent the greatest overall improvement in water quality above 12-yr norms. River water quality profiles are expected to remain relatively unchanged for WY17 should the watershed remain within the current hydrologic cycle of extended below normal rainfall and reduced runoff (dry weather streamflow). Above normal streamflow resulting from above normal precipitation levels would have a predictable beneficial effect on overall river water quality.

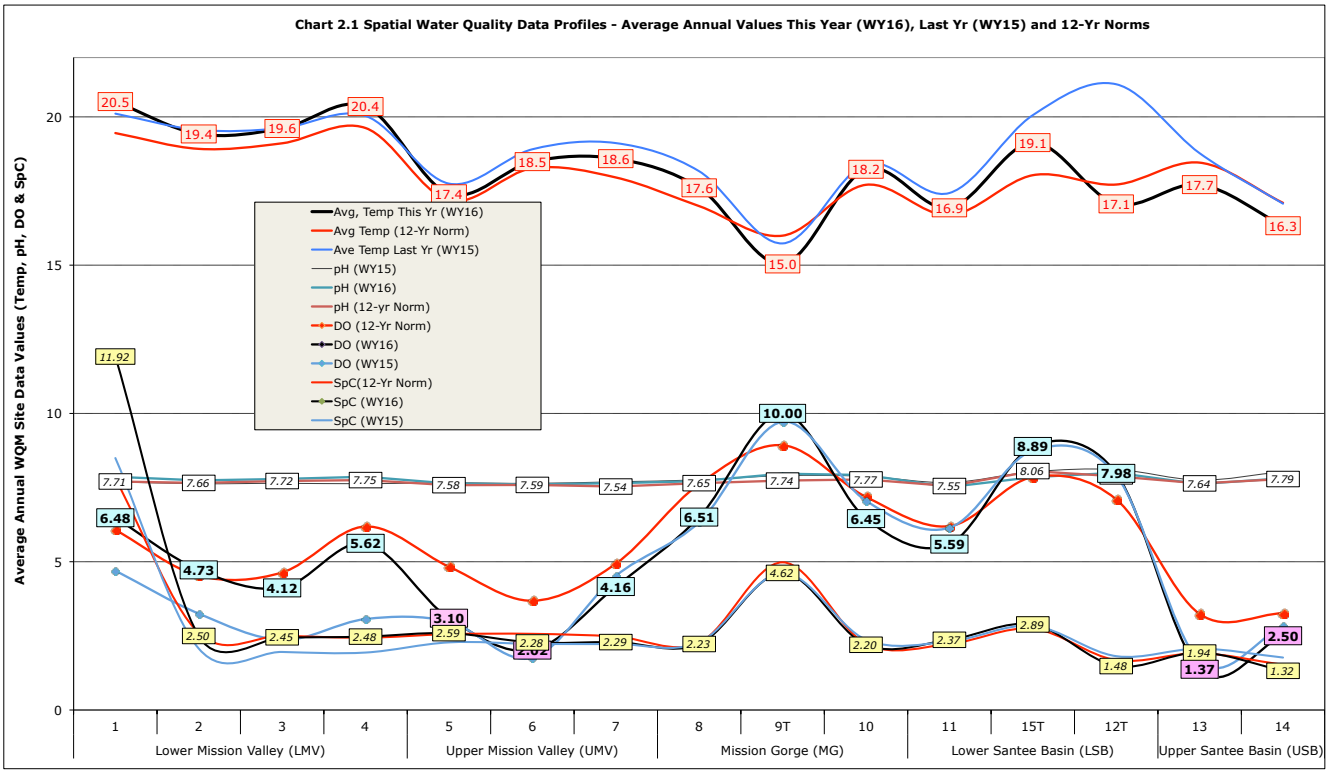


Chart 2.1 Spatial Water Quality Data Profiles - Average Annual Values This Year (WY16), Last Yr (WY15) and 12-Yr Norms
Average Annual WQM Site Data Values (Temp, pH, DO & SpC)
Avg, Temp This Yr (WY16)
Avg Temp (12-Yr Norm)
Ave Temp Last Yr (WY15)
pH (WY15)
pH (WY16)
pH (12-yr Norm)
DO (12-Yr Norm)
DO (WY16)
DO (WY15)
SpC(12-Yr Norm)
SpC (WY16)
SpC (WY15)
Lower Mission Valley (LMV)
Upper Mission Valley (UMV)
Mission Gorge (MG)
Lower Santee Basin (LSB)
Upper Santee Basin (USB)

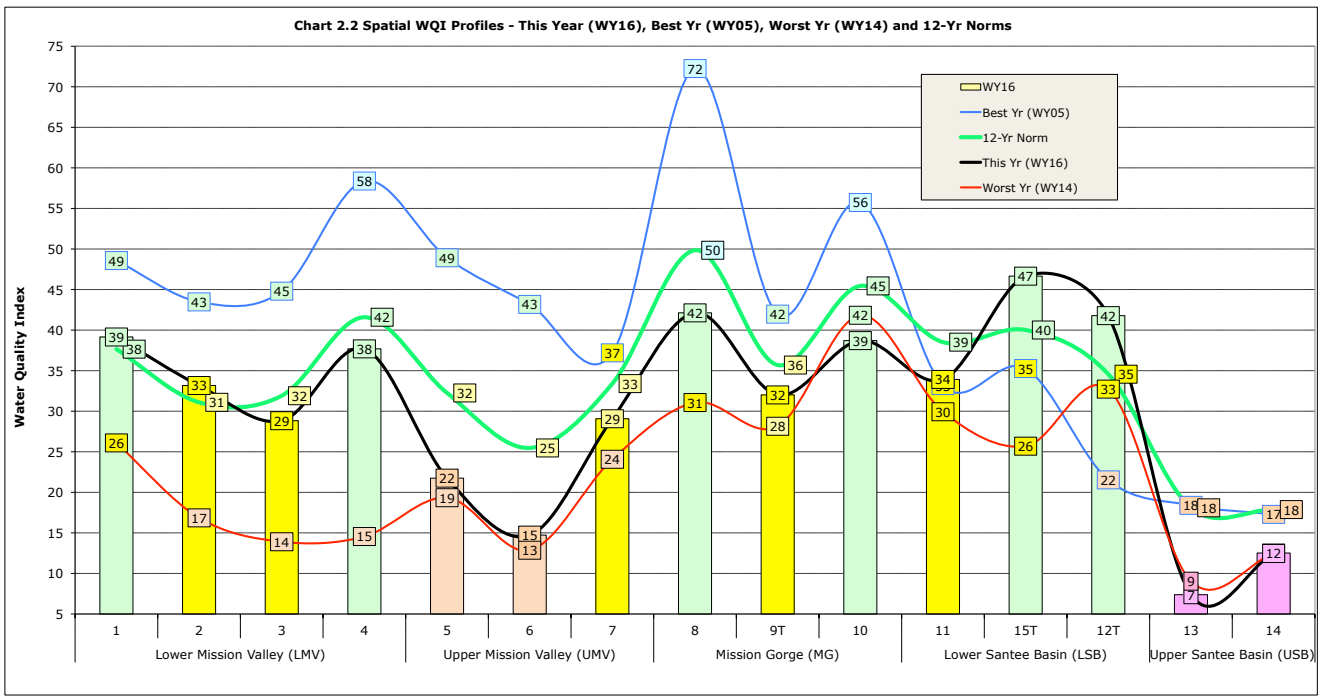


Chart 2.2 Spatial WQI Profiles - This Year (WY16), Best Yr (WY05), Worst Yr (WY14) and 12-Yr Norms
Water Quality Index
WY16
Best Yr (WY05)
12-Yr Norm
This Yr (WY16)
Worst Yr (WY14)
Lower Mission Valley (LMV)
Upper Mission Valley (UMV)
Mission Gorge (MG)
Lower Santee Basin (LSB)
Upper Santee Basin (USB)

Section 3 - Temporal Comparison of WY16/15 Data and 12-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 this year (WY16) and last year (WY15) in comparison to 12-yr norms (italicized values shown in parentheses). Values above the 12-yr norms are in blue; values below in red. In general, temporal water quality in WY16 improved slightly over WY15 in the Fall and Winter months, but fell below last years values during Spring and Summer, both years remaining below 12-yr norms.

Table 3.1 LSDR WQM Metrics for WY16/15 and 12-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	**22.4**/20.2 *(18.9)*	**2.13**/3.32 *(2.83)*	**7.3**/7.7 *(7.6)*	**2.56**/2.17 *(4.40)*	**30**/24 *(46)*	**0.4**/2.9 *(14)*	**14**/8 *(22)*	**F**/E *(E)*
Nov		13.5/15.5 *(14.9)*	2.13/2.67 *(2.55)*	**7.6**/7.9 *(7.7)*	**5.55**/3.66 *(6.00)*	**53**/37 (59)	**3.5**/2.4 *(12)*	**29**/23 *(33)*	**D**/E *(D)*
Dec	Winter	**10.9**/13.6 *(11.9)*	1.82/1.41 (1.72)	**7.8**/7.5 (7.7)	**7.04**/5.57 (7.07)	**64**/54 (65)	**35**/5.9 (53)	**38**/40 *(44)*	**C**/C *(C)*
Jan		**12.0**/12.6 *(11.5)*	1.46/1.86 (1.86)	7.8/7.7 (7.7)	**7.82**/6.64 (8.40)	**73**/63 (76)	**11**/2.9 (47)	52/43 *(51)*	**B**/D *(B-)*
Feb		**15.4**/16.2 *(13.7)*	**2.00**/2.32 (1.73)	**8.0**/7.8 (7.8)	**6.10**/5.01 (7.40)	**62**/52 (71)	**6.4**/7.5 (55)	**40**/32 *(47)*	**C**/D *(C)*
Mar		**18.3**/18.8 *(16.8)*	1.66/1.97 (1.69)	**7.8**/7.8 (7.7)	**5.02**/4.52 (6.89)	**54**/49 (70)	**14**/21 (31)	**34**/31 *(48)*	**D**/D *(C+)*
Apr	Spring	**18.7**/17.7 *(17.8)*	1.65/2.47 (1.97)	**7.7**/7.7 (7.7)	**6.80**/5.17 (6.17)	74/55 (65)	**2.3**/5.9 (15)	**49**/29 *(44)*	**C**/D *(C)*
May		**19.8**/18.2 *(20.2)*	2.16/1.57 (2.32)	**8.1**/7.7 (7.7)	**5.29**/7.38 (5.27)	**59**/79 (58)	**14**/1.4 (7.2)	**34**/54 *(35)*	**D**/B *(D)*
June	Summer	**20.9**/21.7 *(22.0)*	2.68/2.57 *(2.68)*	**8.0**/7.7 *(7.8)*	**3.87**/5.41 *(4.64)*	**44**/62 *(53)*	**2.2**/0.7 *(2.6)*	**20**/31 *(26)*	**E**/D *(D)*
July		**23.4**/22.7 *(23.0)*	**3.10**/2.08 *(2.81)*	7.8/7.6 *(7.7)*	**3.09**/3.09 *(3.74)*	**37**/36 *(43)*	20/0.6 *(3.2)*	**13**/15 *(18)*	**E**/E *(E)*
Aug		**23.5**/23.7 *(23.2)*	**3.39**/2.52 *(3.05)*	**7.6**/7.4 *(7.7)*	**2.71**/2.50 *(3.84)*	**32**/30 *(44)*	**1.6**/0.7 *(1.2)*	**8**/12 *(17)*	**F**/F+ *(E)*
Sept		**19.9**/23.5 *(21.4)*	**3.47**/1.55 *(3.04)*	**7.6**/7.4 *(7.7)*	**3.11**/3.24 *(3.78)*	**34**/38 *(42)*	**6.5**/1.2 *(1.6)*	**12**/26 *(19)*	**F+**/D- *(E)*

Table 3.1 (Continued) Seasonal and Annual Averages

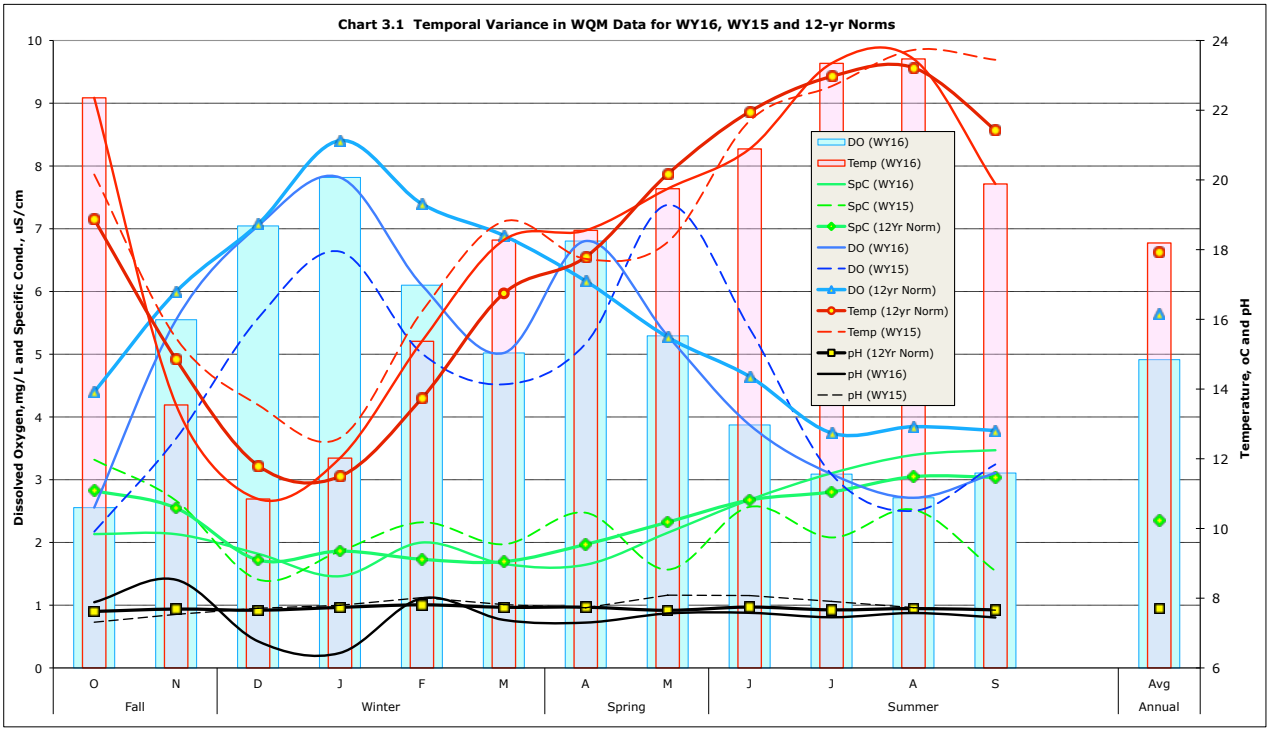
		Temp	SpC	pH	DO	DO%	Flow	WQI [a]	
Month	*Season:*	*oC*	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
Fall (O&N)		**18.0**/17.8 *(16.9)*	**3.00**/2.66 *(2.74)*	**8.2**/7.4 *(7.6)*	**4.06**/3.15 *(5.20)*	**42**/33 *(53)*	**1.8**/2.7 *(12.9)*	**21**/16 *(28)*	**E**/E *(D)*
Winter (D,J,F,M)		**15.3**/13.4 *(13.5)*	**1.89**/2.24 *(1.74)*	**7.8**/7.9 *(7.7)*	**6.50**/5.50 *(7.44)*	**63**/55 *(71)*	**17**/9.4 *(46.7)*	**41**/36 *(47)*	**C**/D *(C)*
Spring (A&M)		**18.0**/19.0 *(19.0)*	**2.02**/2.48 *(2.17)*	**7.4**/7.9 *(7.7)*	**6.05**/6.34 *(5.72)*	**67**/67 *(61)*	**8.2**/3.7 *(11.0)*	**41**/42 *(40)*	**C**/C *(C)*
Summer (J,J,A,S)		**22.9**/22.7 *(22.4)*	**2.18**/3.02 *(2.86)*	**7.5**/7.8 *(7.7)*	**3.20**/3.87 *(4.00)*	**37**/45 *(46)*	**7.6**/0.8 *(2.1)*	**13**/21 *(20)*	**E-**/E *(E)*
Annual (O-S)		**18.7**/17.9 *(17.9)*	2.19/2.58 *(2.35)*	**7.7**/7.7 *(7.7)*	**4.91**/4.53 *(5.57)*	**51**/48 *(57)*	**9.7**/4.4 *(20.3)*	**29**/29 *(34)*	**D**/D *(D)*

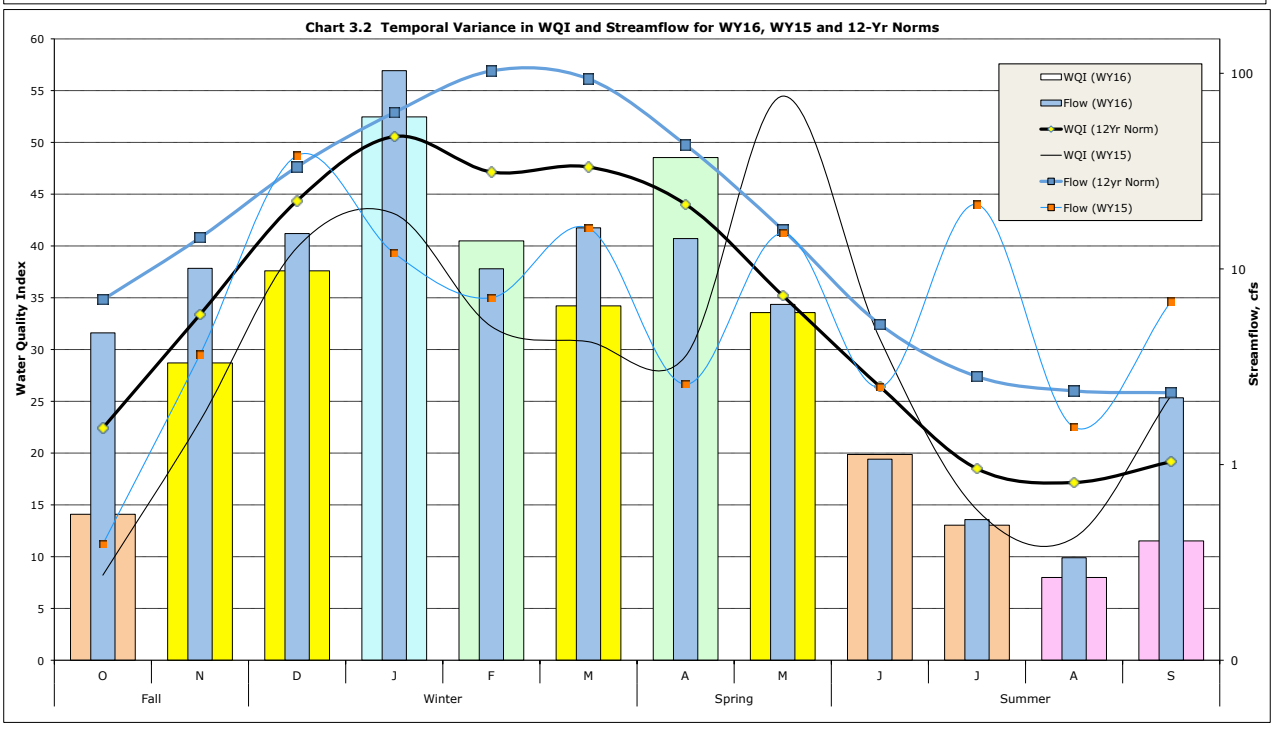
a) Values based on RiverWatch physical-chemical metrics (WQI_4) combined with USGS stream flow for eastern (West Hills Pkwy) and western sections (Fashion Valley). WY16/15 values/grades below the 12-yr norms (expressed in italics within parentheses) are shown in red, above in blue.

Monthly and seasonal variances in water quality monitoring data metrics for the past two water years and 12-yr norms are also expressed in **Chart 3.1.** (WQM Data) on the next page. 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). Coliform counts and pH values show very little seasonal fluctuation, although small variances in monthly values are evident. The broad range in DO and temperature values consistently monitored at all sites throughout the year provide the best indications of the temporal variance in water quality. Seasonal variances between this year's data (WY16), shown as bars with solid lines, last year's results (dashed lines) and the 12-yr norms (heavy solid lines with monthly markers) are comparable. In general, temporal variance in WY16 water quality data more closely matches patterns in 12-yr norms than did last year's data. WY15 anomalies in late Winter (Feb/March) and Spring metrics caused in part by uncommon seasonal rainfall and resultant elevated dry weather storm flows, were not the case in WY16. This year's temporal water quality pattern was much more indicative of typical occurrences.

Chart 3.2 provides an overall perspective of temporal variance in WQI values and streamflow throughout WY16 compared to monthly averages over the previous water year (WY15) and the 12-year monthly norms. As listed in the right-hand columns of **Table 3-1** and shown in **Chart 3.2**, the WQI values for WY16 (color-shaded bars) remain lower than the 12-yr norms (heavy black line) with exception of January and April. The relationship between flow (both wet weather and dry) and water quality continues to effect results. Depletion in DO levels combined with well-below normal dry-weather flows constitute the primary drivers in low index values. In general, water quality for the Lower San Diego River watershed was highest (C-, Good) in January when flows were greatest and lowest in August when flows were least. The overall annual average WQI for the LSDR in WY16 of 28 (E-, Poor) is one point less than last year and six points below the 12-yr norm of 34. The continuing below average results occurring at many sites and throughout most sections is believed to be associated with buildup of decayed biomass from non-native invasive aquatic plants. DO deficits remained at multiple sites throughout the dry

weather period. Trends over the past 12 years in the monitored WQ metrics and resultant WQI by river reach and section are presented in Sections 4 and 5, respectively, of this report.





Section 4 - Trends in Individual Water Quality Metrics (WY05 through WY16)

Trends in SDRPF monitored water quality metrics, based on data collected by RiverWatch from September 2005 through September 2016, are presented in this chapter. The metrics include water temperature, specific conductivity, pH, dissolved oxygen, streamflow and the water quality index. Twelve month running average values represent a rational indication of trends over the past 12 years of monitoring for each metric.

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

Table 4.1 - Running 12-mo. Average WQM Metrics (WY05-WY16)

	Temp	SpC	pH	DO	DO%	Flow	WQI [a]	
	oC	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
WY05	17.68	2.131	7.63	6.96	68	65	41	C Fair
WY06	18.32	2.191	7.44	5.96	59	12	37	D+ Marginal
WY07	17.70	2.419	7.53	5.94	60	8	36	D+ Marginal
WY08	17.67	2.323	7.89	6.24	64	16	38	C- Fair
WY09	17.73	2.493	7.66	6.15	64	18	37	D+ Marginal
WY10	18.08	2.362	7.85	5.43	56	29	35	D Marginal
WY11	17.77	2.211	7.85	5.80	60	42	38	C- Fair
WY12	18.03	2.388	7.67	5.47	56	13	33	D Marginal
WY13	17.32	2.499	7.77	5.58	57	8	32	D Marginal
WY14	17.86	2.582	7.67	3.92	40	4	22	E Poor
WY15	18.69	2.192	7.78	4.53	48	9	29	D Marginal
WY16	**18.20**	**2.304**	**7.69**	**4.91**	**51**	**13**	**29**	**D Marginal**
Norms	*(17.92)*	*(2.341)*	*-7.70*	*(5.57)*	*(57)*	*((19.8)*	*(34)*	*(D Marginal)*

Values based on SD RiverWatch physical-chemical metrics (WQI_4) combined with USGS recorded streamflow for eastern (West Hills Pkwy) and western (Fashion Valley) stations. Values/grades below 12-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 approximately one degree celsius over the past 24 months. The typical running average variance in water temperature over the past decade is in the range

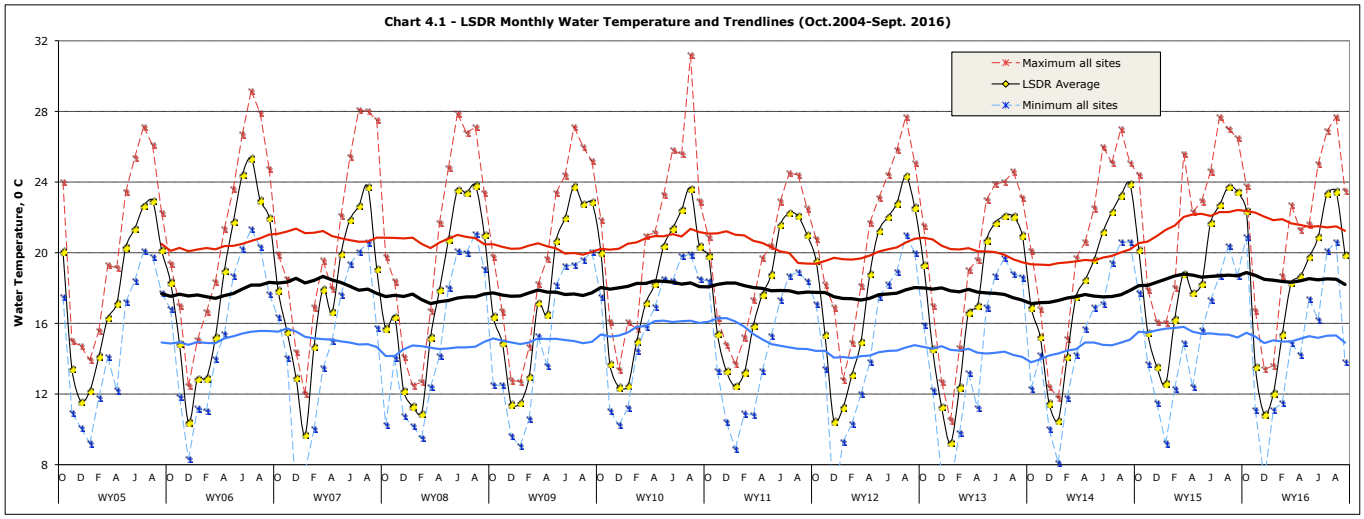


Chart 4.1 - LSDR Monthly Water Temperature and Trendlines (Oct.2004-Sept. 2016)
Water Temperature, 0 C
Maximum all sites
LSDR Average
Minimum all sites
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

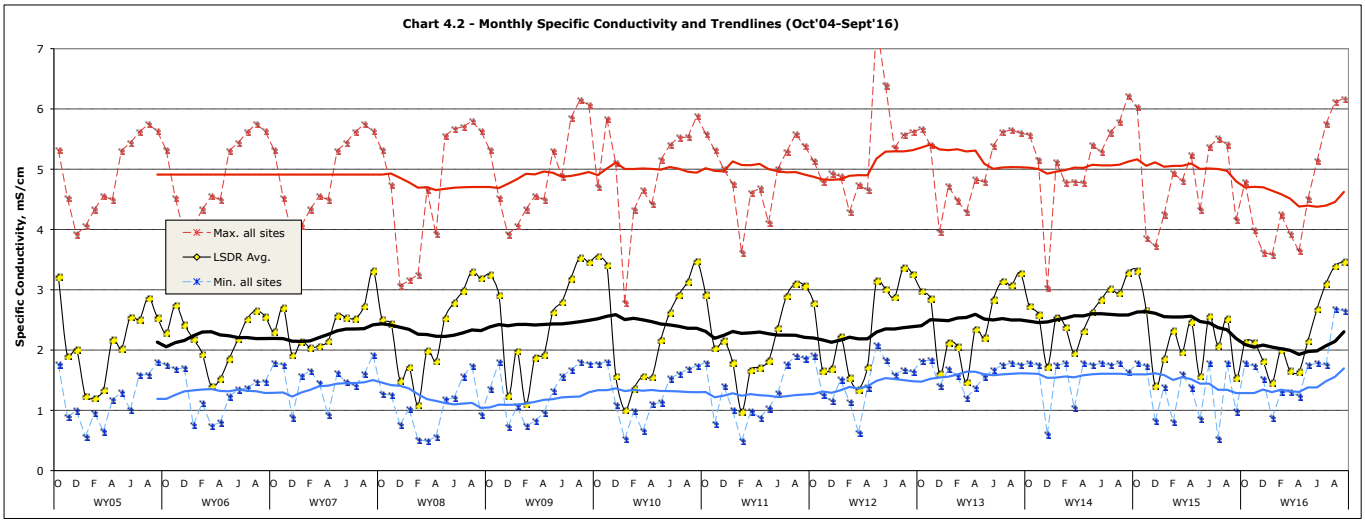


Chart 4.2 - Monthly Specific Conductivity and Trendlines (Oct'04-Sept'16)
Specific Conductivity, mS/cm
Max. all sites
LSDR Avg.
Min. all sites
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

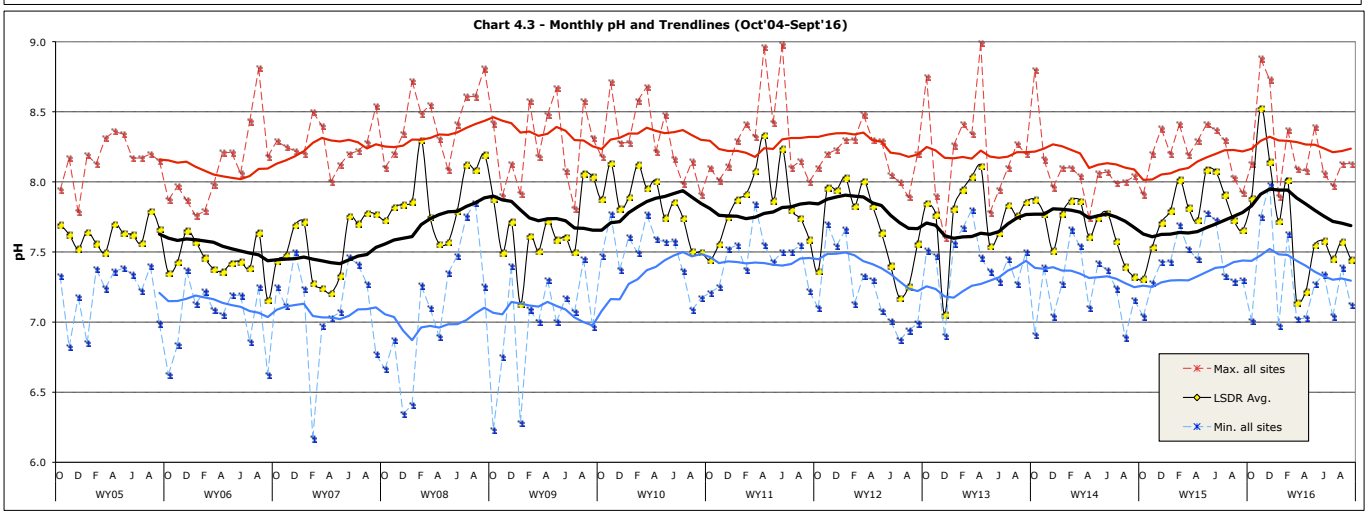


Chart 4.3 - Monthly pH and Trendlines (Oct'04-Sept'16)
pH
Max. all sites
LSDR Avg.
Min. all sites
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

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 12-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 experienced in San Diego as well as throughout the Southern California region. There were only two months (Dec. & Jan.) in WY16 when average water temperatures were at or below 12°C while there were four months (Oct., June, July & Aug.) when water temperatures were above 21°C.

Trends in monthly monitored **Specific Conductivity** (SpC) values for the LSDR watershed are presented in **Chart 4.2**. Minimum and maximum running averages for all sites monitored have varied little over the 12-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 significantly below the 12-yr norm. The current LSDR running average SpC of 2.3 mS/cm for WY16, is only slightly below (-3.8%) the 12-yr norm of 2.53 mS/cm. Running average values are expected to continue trending downward with greater monthly rainfall and average daily streamflow anticipated in WY17. Should drought conditions persist through 2017, however, average conductivities may remain below long-term norms.

Trends in monthly **pH** values are presented in **Chart 4.3**. The overall or general trend in values monitored for the LSDR has been relatively steady during the past eight years (WY09-WY16). 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 the 8.0-8.5 range, have on the other hand remained fairly steady. Excluding the initial three year's, there has been minimal variance (<2%) in the overall running average pH from the 12-yr norm of 7.70.

Running average **dissolved oxygen (DO)** values and monthly minima-maxima are presented in **Chart 4.4.** A steady general decline in average and minimum values for the lower watershed sites from Jan. 2009 through Feb. 2015 is evident. LSDR average, minimum and maximum monthly values for WY16 have increased somewhat (from WY14/15 lows) but are still significantly below the 12-yr norms. The current running average DO value of 4.56 mg/L (Sept 2016) remains 12% below the LSDR norm. 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 oxygen demanding organic material (biomass). With the lack of significant flushing action during recent (over past five 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 improve noticeably following one or more major storm flow events involving significant channel scour, displacement of organic-rich sediments and sizable reduction of invasive aquatic plants.

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 individual water quality parameters monitored by RiverWatch and streamflow (river discharge) measured by the USGS at two gauging stations. Similar to trends in DO (Chart 4.4), running average WQI values were in general decline from late WY09 to early WY15. LSDR running averages reached their lowest value of 21 (grade E, Poor) in Oct. 2014, at 38% below the 12-yr norm of 33 (grade D, Marginal). The current WQI (Sept 2016) of 29 (grade D, Marginal) remains 14% below the 12-yr average. An above average rainfall year in WY17 would be expected to result probable return to running average index values in mid 30's as previously experienced in WY09 and WY11.

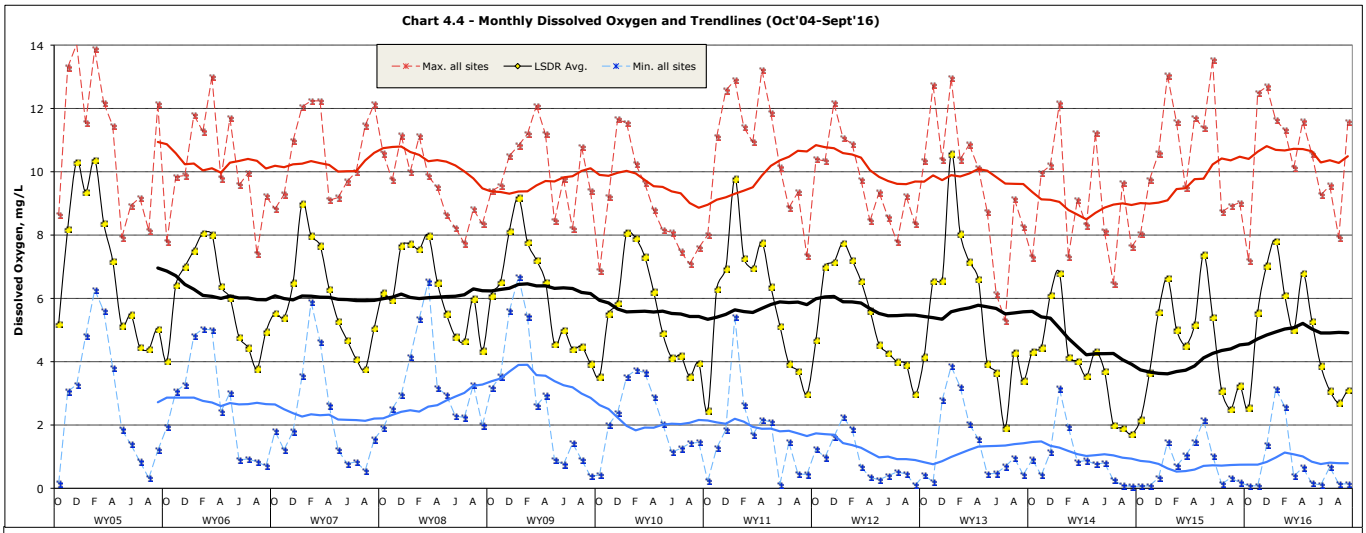


Chart 4.4 - Monthly Dissolved Oxygen and Trendlines (Oct'04-Sept'16)
Max. all sites
LSDR Avg.
Min. all sites
Dissolved Oxygen, mg/L
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

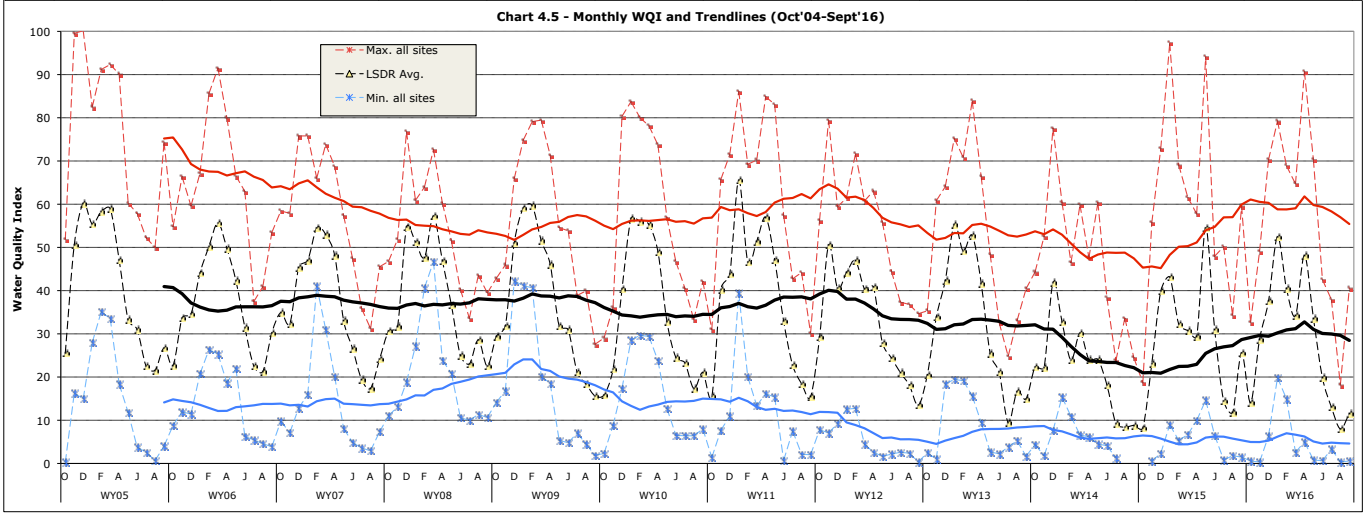


Chart 4.5 - Monthly WQI and Trendlines (Oct'04-Sept'16)
Max. all sites
LSDR Avg.
Min. all sites
Water Quality Index
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

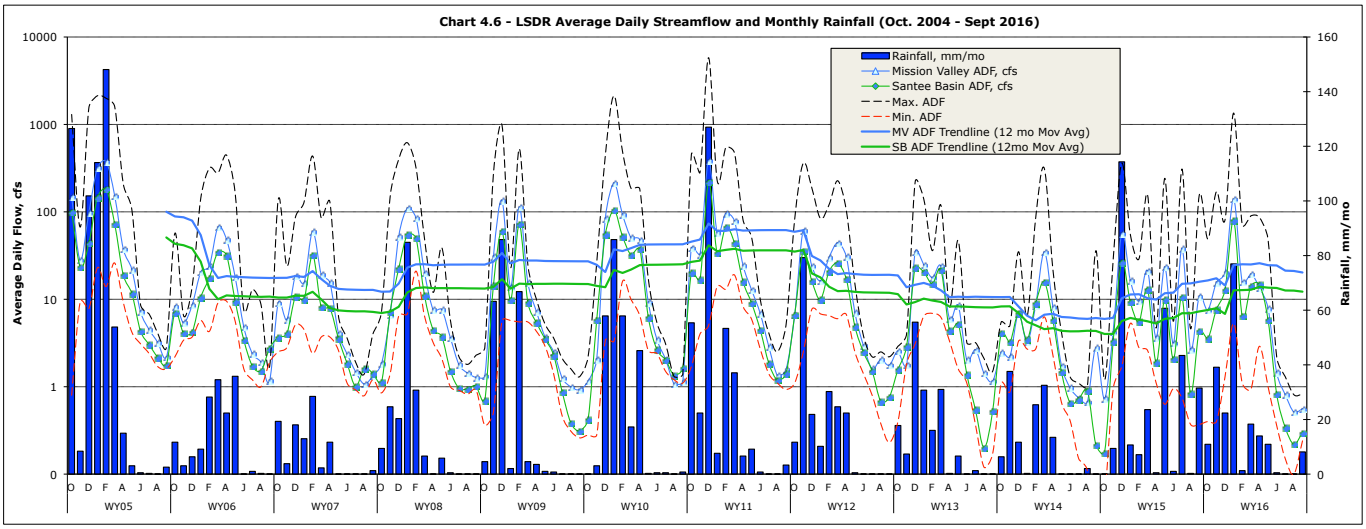


Chart 4.6 - LSDR Average Daily Streamflow and Monthly Rainfall (Oct. 2004 - Sept 2016)
Rainfall, mm/mo
Mission Valley ADF, cfs
Santee Basin ADF, cfs
Max. ADF
Min. ADF
MV ADF Trendline (12 mo Mov Avg)
SB ADF Trendline (12mo Mov Avg)
Average Daily Flow, cfs
Rainfall, mm/mo
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

Trend lines for total monthly rainfall and running average streamflows in the Santee Basin (SB) and Mission Valley (MV) sections are presented in **Chart 4.6.** The trend in average daily streamflow throughout the LSDR 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 monitored in WY14. Due to the distribution and magnitude of rainfall in WY15, running average streamflows were back up around 12 cfs (Mission Valley) and 8 cfs (Santee Basin), still well below the 12- yr norms. WY16 average daily flows are -18% below the Santee Basin norm of 15 cfs and -22% below the Mission Valley norm of 26 cfs.

The trends and relative variances in water quality metrics as shown in Charts 4.1-4.6 are clearly 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 12 years are similar. The lower river system experienced its best water quality during the wettest year (WY05) followed by a general 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 12 years. An uptrend toward normalized values has been evident over the past two years (WY15 and WY16). WY17 would, based on early predictions, perpetuate this past water year's uptrend in water quality. WY16 results are on average the same as those for WY15 although the past wet weather season was better (than WY15) while the dry season was somewhat poorer. Details by reach and segment are presented in Section 5.

Section 5 - Trends in LSDR Water Quality Index (WY05 through WY16)

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-WY16) of monitoring. Values and grades above 12-yr norms are listed in blue; below 12-yr norms (expressed in black italics) are shown in red. The WY16 values, expressed in bold font, are lower than last year's results for the upper portions of the river extending from Mission Gorge to Lakeside (east). WY16 results for the downstream (Mission Valley) reaches were higher than last year. Overall the LSDR average annual WQI declined one point (to 28) from last year (29) remaining in the Marginal (D) water quality range.

Table 5.1 - Average Annual and Seasonal WQI by Reach and Section (WY05-WY16)

Annual Avg.	LMV Reach	UMV Reach	MV Section	MG Section	LSB Reach	USB Reach	SB Section	LSDR Overall Avg.	
WY05	49	43	46	64	31	18	24	41	C (highest)
WY06	40	33	37	54	34	22	28	37	D+
WY07	37	28	33	50	40	27	34	37	D+
WY08	39	31	36	45	40	34	37	38	C-
WY09	38	29	34	45	42	32	37	37	D+
WY10	36	33	35	48	38	18	28	35	D
WY11	40	38	39	54	44	15	29	38	C-
WY12	35	35	35	48	39	9	24	33	D
WY13	37	32	35	44	35	11	23	32	D
WY14	18	19	18	36	28	10	19	22	E-(lowest)
WY15	23	22	23	44	43	10	27	29	D
WY16	**35**	**22**	**29**	**40**	**37**	**8**	**23**	**29**	**D**
12-yr Norm	*36*	*30*	*33*	*48*	*38*	*18*	*28*	*34*	*D Marginal*
Winter	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	64	65	64	85	44	33	39	58	B (highest)
WY06	54	47	51	60	40	29	35	46	C
WY07	50	42	46	62	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	66	54	27	40	52	B-
WY12	48	49	49	59	45	14	29	43	C
WY13	58	54	56	67	49	21	35	50	B-
WY14	25	26	26	55	40	15	27	32	D (lowest)
WY15	33	28	31	58	52	11	32	36	D+
WY16	**44**	**38**	**42**	**58**	**52**	**14**	**33**	**41**	**C**
12-yr Norm	*50*	*46*	*49*	*63*	*50*	*28*	*39*	*47*	*C+ Fair*

Summer	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	31	25	29	45	20	5	13	25	D-
WY06	23	14	19	45	31	19	25	26	D- (highest)
WY07	23	15	20	35	24	13	18	22	E
WY08	24	20	23	32	29	18	24	25	D-
WY09	21	14	18	31	25	16	20	22	E
WY10	21	18	20	33	26	9	18	22	E
WY11	23	17	20	37	30	5	17	22	E
WY12	22	18	21	25	27	4	16	19	E
WY13	18	13	16	18	23	5	14	16	E
WY14	10	11	10	12	16	8	12	11	F (lowest)
WY15	15	11	13	31	37	9	23	21	E
WY16	**17**	**6**	**12**	**18**	**20**	**5**	**12**	**13**	**E-**
12-yr Norm	*21*	*15*	*18*	*30*	*26*	*10*	*18*	*20*	*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 12-yr norms (expressed in italics) for the same reach or section of the river; values above 12-yr norms are in blue.

The range in running average WQI values determined over the past 12 years of monitoring are summarized in **Table 5.2**. WY16 values, similar to WY15, remain below the 12-yr norms for all reaches of the lower watershed. The only reach that showed noticeable improvement over last year was Lower Mission Valley. 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	12-yr Norm	WY15	WY16[a]
East Section (SB):	5.6	68 (B) WY09	6 (F) WY16	*28 (D)*	27 (D)	**23 (E Poor)**
Upper Santee Basin	5.5	66 (B) WY09	0 (F) WY16	*18 (E)*	10 (F)	**8 (F Very Poor)**
Lower Santee Basin	5.4	70 (B) WY09	9 (E) WY15	*38 (C-)*	43 (C)	**37 (D+ Marginal)**
Mid-Section (MG)	5.3	89 (A+) WY05	4 (F) WY14	*48 (C)*	44 (C)	**40 (C Fair)**
West Section (MV):	5.6	75 (B+) WY05	5 (F) WY16	*33 (D)*	23 (E)	**29 (D Marginal)**
Upper Mission Vly	5.2	72 (B) WY05	3 (F) WY16	*30 (D)*	22 (E)	**22 (E Poor)**
Lower Mission Vly	5.1	78 (A-) WY05	3 (F) WY13	*36 (D+)*	23(E)	**35 (D Marginal)**
LSDR Overall Avg.	*5.6*	*66 (B) WY05*	*8 (F) WY14*	*34 (D)*	*29 (D)*	***29 (D Marginal)***
Best Site (#8)	5.3	92 (A+) WY05	2 (F-) WY14	*50 (B-)*	42 (C)	**42 (C Fair)**
Greatest Range (#4)	5.1	100 (A+) WY10	0 (F-) WY05	*42 (C)*	22 (E)	**37 (D+ Marginal)**
Poorest Site (#13)	5.5	77 (B) WY09	0 (F-) WY16	*18 (E)*	8 (F)	**7 (F Very Poor)**

a) WY15 and WY16 running averages (September) shown in red are below 12-yr norms; above in blue.
b) Highest overall WQI values are associated with Site #8 (Jackson Dr/Suycott Xing) located in the Mission Gorge (mid) Section.
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 lower river system have varied from a high of 75 (A-, Very Good) in January 2011 to a low of 5 (F, Very Poor) in September 2014 and October 2015 (WY16). The general trend in running average WQI for the reach, as well as for four individual monitoring sites, declined from the low 40's (C, Fair) during WY's 05 and 06 to the mid-teens (E, Poor) by late WY14/early WY15. The running average WQI has improved to the mid-30's during the second half (April-Sept) of WY16. Site 3 (Fashion Valley Mall) has consistently exhibited the lowest running average WQI, while Site 4 (FSDRIP at Mission Valley Rd.) has consistently witnessed the highest values for the reach. The most significant decline in the WQI for the reach over the 12-year monitoring period occurred in WY14. There has been a steady, partial recovery during the second half of WY15 and throughout WY16. Further recovery from a Marginal (D) to Fair (C) grade, as experienced between WY07 and WY13, is not anticipated without substantial changes in stream hydraulics and improved management and control of invasive non-native aquatic plants.

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 fairly comparable to those 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 an extended 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 in Sept. 2015 and again in August of this year. The overall trend in running average WQI values from WY05 through WY16 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 decline as growth of invasive aquatic plants has proliferated.

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 WYs 12, 13 and 14. Highest monthly WQI values of 89 (A, Very Good) monitored in Nov. 2004, and Feb. 2005, contrast with a low of 4 (F, Very Poor) in Aug. 2014. In general running average WQI for this reach is the best of the five reaches with average WQI of 48 (C+, Fair). The trend in Mission Gorge WQI values are, however, 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 in subsequent water years to a low of 32 (D, Marginal) in early WY15. WY16 has witnessed an overall five-point recovery in the running average WQI reaching 37 (D+, Marginal) in September. Additional recovery in the Mission Gorge index is anticipated in WY17, unless well below normal rainfall remains the case.

The **Lower Santee Basin Reach** (Sites 11, 15T and 12T) 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 in subsequent water years, reaching a running average low of 28 (D, Marginal) in Oct. 2015, before recovering to the mid-40s (C, Fair) throughout WY16. Completion of the Forester Creek enhancement project extending from Prospect Ave. to the Mission Gorge Rd. has been a positive effect on overall river quality in the Lower Santee Basin portion of the river system. Unless well below normal rainfall is experienced in WY17, the Lower Santee Basin index is expected to remain in the mid-40s.

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 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 between 10 and 12 (F, Very Poor) during the last four years. Little change in the running average index is anticipated in WY17.

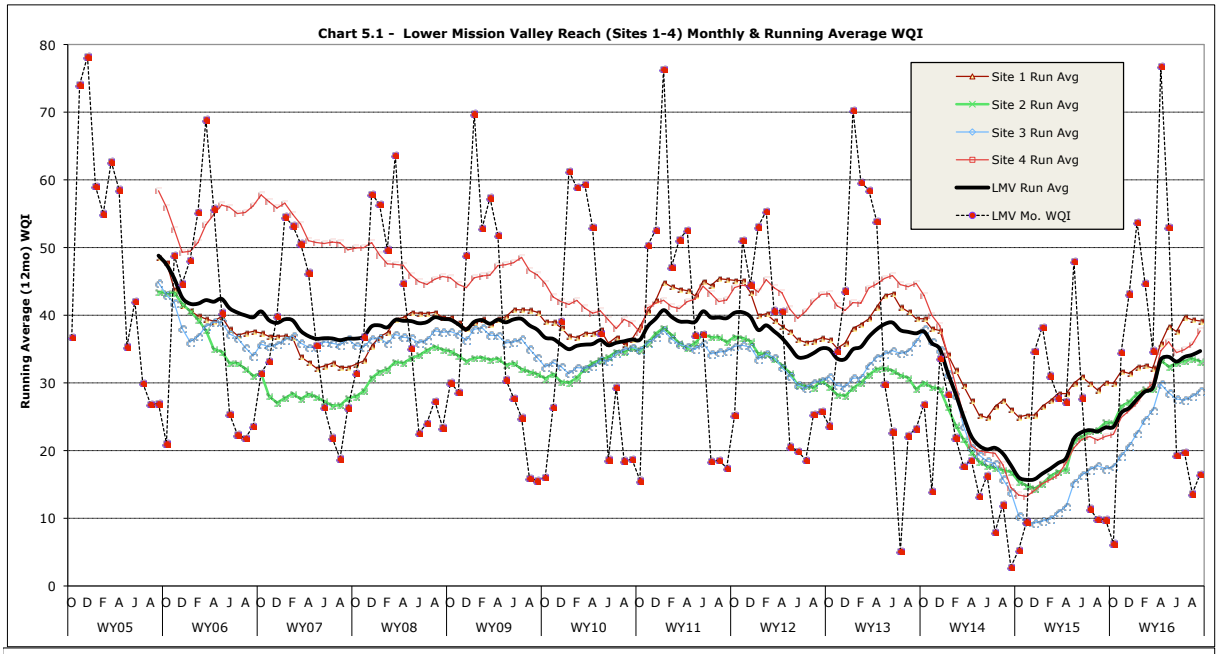


Chart 5.1 - Lower Mission Valley Reach (Sites 1-4) Monthly & Running Average WQI
Running Average (12mo) WQI
Site 1 Run Avg
Site 2 Run Avg
Site 3 Run Avg
Site 4 Run Avg
LMV Run Avg
LMV Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

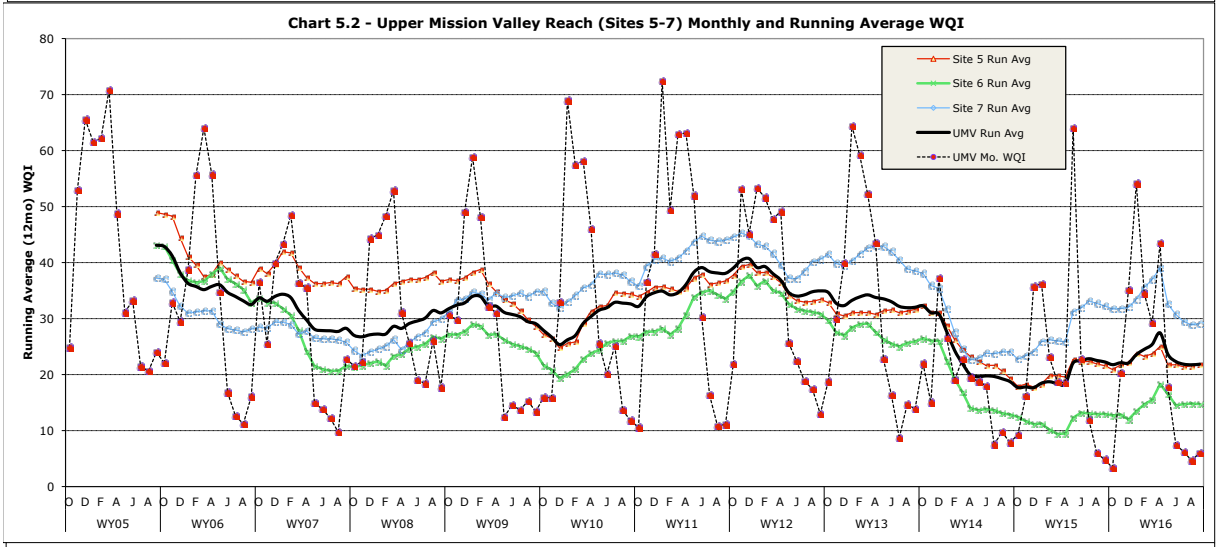


Chart 5.2 - Upper Mission Valley Reach (Sites 5-7) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 5 Run Avg
Site 6 Run Avg
Site 7 Run Avg
UMV Run Avg
UMV Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

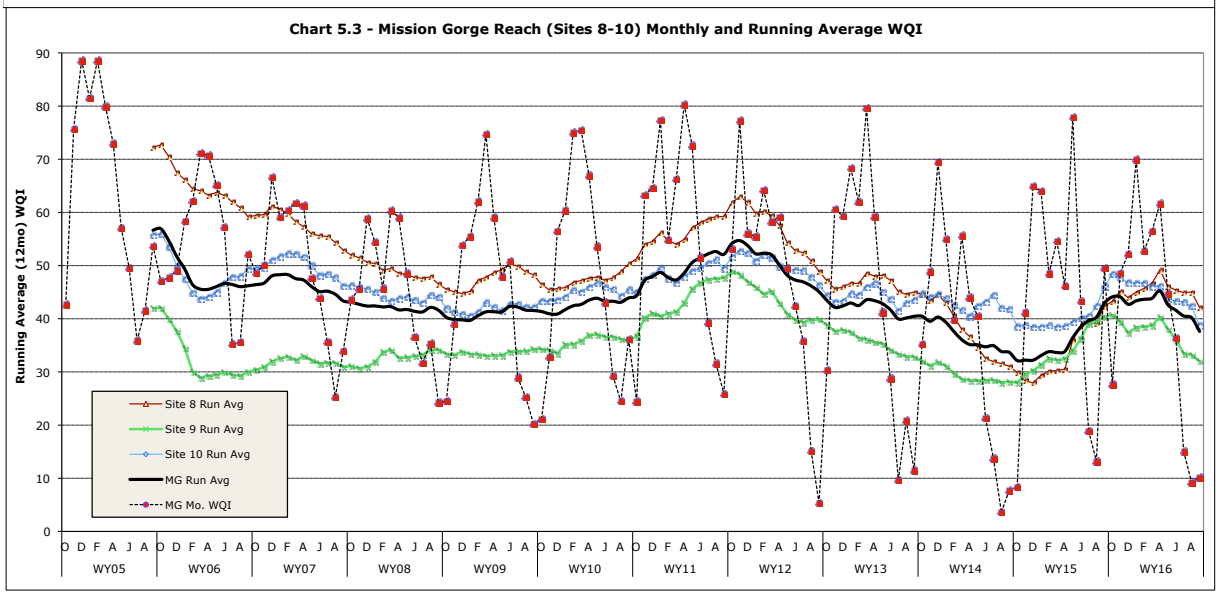


Chart 5.3 - Mission Gorge Reach (Sites 8-10) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 8 Run Avg
Site 9 Run Avg
Site 10 Run Avg
MG Run Avg
MG Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

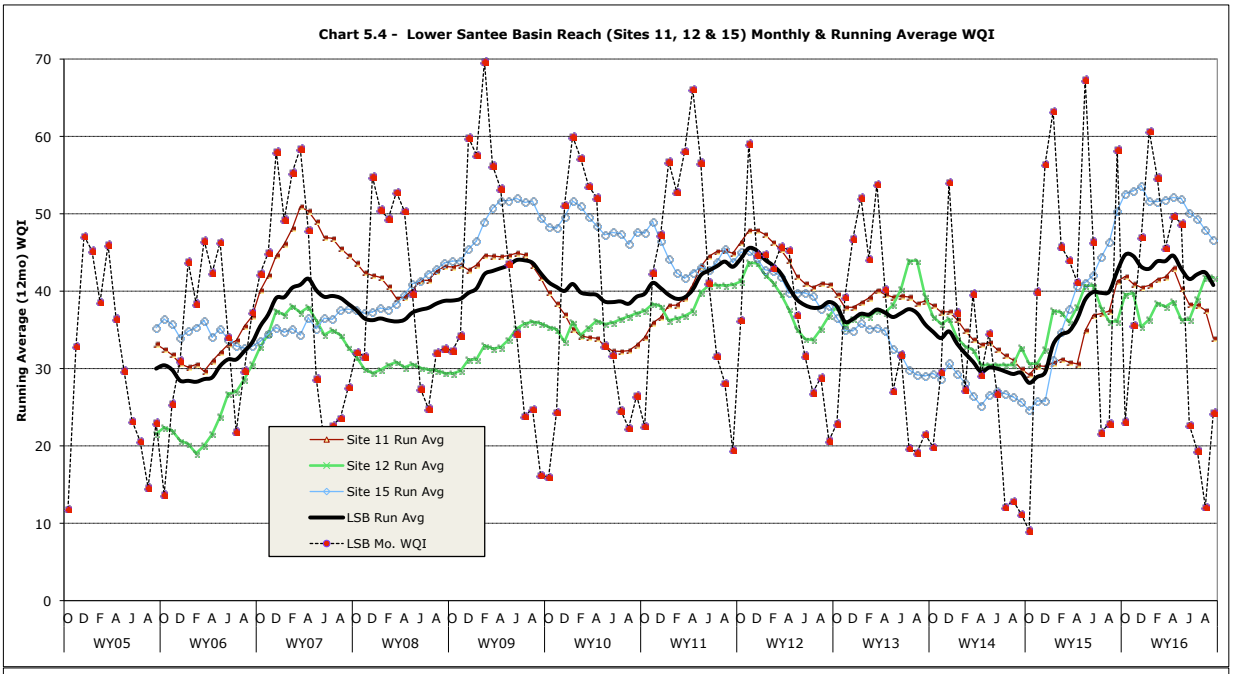


Chart 5.4 - Lower Santee Basin Reach (Sites 11, 12 & 15) Monthly & Running Average WQI
Running Average (12mo) WQI
Site 11 Run Avg
Site 12 Run Avg
Site 15 Run Avg
LSB Run Avg
LSB Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

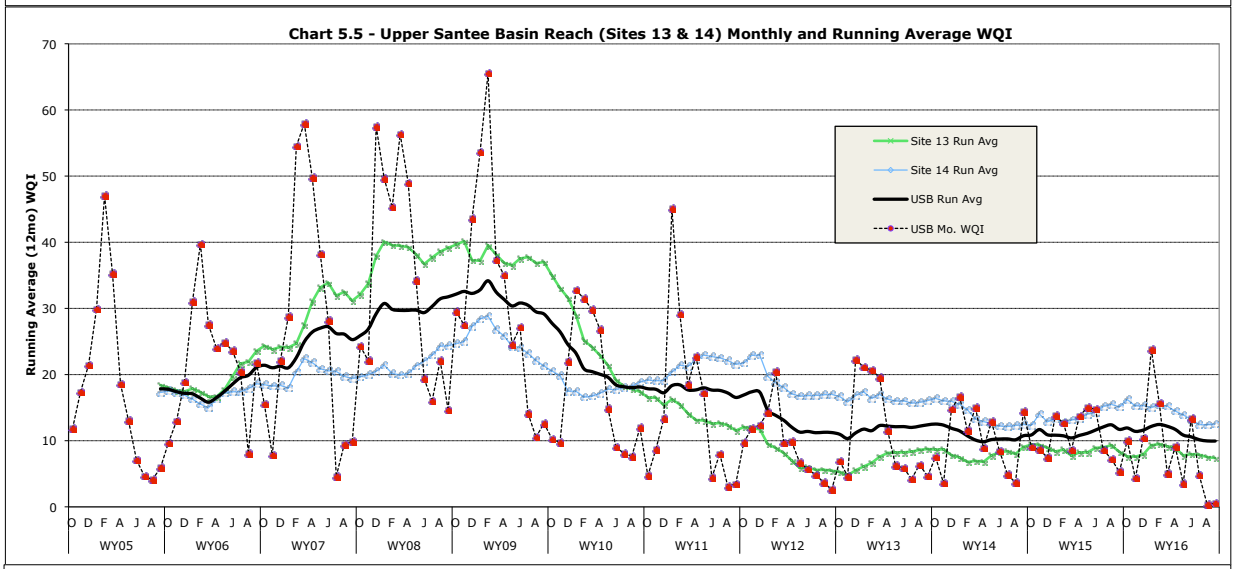


Chart 5.5 - Upper Santee Basin Reach (Sites 13 & 14) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 13 Run Avg
Site 14 Run Avg
USB Run Avg
USB Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

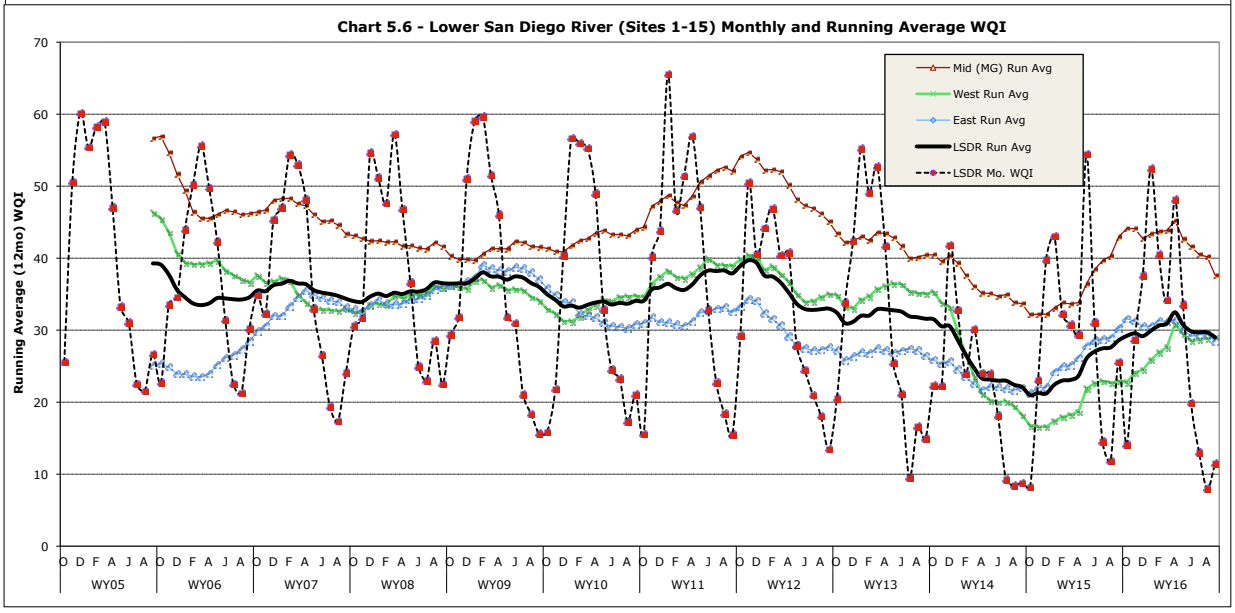


Chart 5.6 - Lower San Diego River (Sites 1-15) Monthly and Running Average WQI
Running Average (12mo) WQI
Mid (MG) Run Avg
West Run Avg
East Run Avg
LSDR Run Avg
LSDR Mo. WQI
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16

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 WY14 lows for all three sections of the river during WY15 and the first half of WY16. The Mission Gorge section (Chart 5.3) has improved in water quality the most, while the downstream section (Mission Valley) responded more slowly. Overall, the current LSDR running average WQI of 29 (D, Marginal) is a grade level above the low of 21 (E, Poor) early last water year (Oct. Nov. & Dec.) and only four points below the 12-yr norm of 34 (D, Marginal). The highest running average WQI for the river of 40 (C, Fair) occurred in Nov. 2011, whereas the lowest overall LSDR running average of 21 (E, Poor) was experienced during the last three months of 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, then declined to the low 20's in WY14 and early WY15, returning to the low 30s/high 20's in WY16.

The overall decline in running averages is a function of depressed oxygen levels at multiple sites which are exacerbated by elevated water temperatures and protracted record low streamflows. WQI values are expected to improve should streamflow return to more normalized patterns and invasive aquatic growth abatement measures are successfully undertaken or occur by natural 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) over time. The present (WY16) running average WQI value of 29 (D, Marginal) for the LSDR system is four points (12%) below the 12-Yr norm of 33 (D, Marginal). The current running average WQI for the Upper Santee Basin reach of 8 (F,Very Poor) is ten points below the 12-yr norm of 18 (E, Poor), whereas the current running average for the best section (Mission Gorge) of 40 (C, Fair) is eight points below the 12-yr WQI norm of 48 (C+, Fair).

Depressed dissolved oxygen levels (often less than 3 mg/L) in conjunction with minimal streamflow are the primary causes of low water quality index values. The low DO concentrations are believed to be the result of extensive and persistent eutrophication from bio-mass buildup of organic-rich detritus combined with restricted water movement. Until the spread of creeping water primrose (L*udwigia hextapetala)** can be better controlled and effectively managed, water quality in multiple reaches of the lower river system is expected to remain below par compared to portions of the river where improved circulation, mixing and natural re-oxygenation takes place.

** 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 Unites States where it is often considered a noxious weed (INVADERS, 2009; Peconic Estuary Program, 2009).* ***L. hextapetala 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 properties that can lead to dissolved oxygen crashes, the accumulation of sulphide and phosphate, 'dystrophic crises' and intoxicated ecosystems (Dandelot et al., 2005).* 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 monitored and observed throughout multiple reaches of the Lower San Diego River watershed.

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 comparable 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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Kym Hunter (2006 - 2007)

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Chris Peter
Clint Williams
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Craig McCartney
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George Liddle**
Gina Martin
Jack Greco
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Janae Fried
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Joan Semler
John Kennedy**
Joyce Nower
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Kathryn Stanaway
Katy Robinson
Kelly Brown
Kenneth Santos
Kevin Bernaldez
Krissy Lovering
Krystal Tronboll
Laqueta Strawn
Linda King
Linda Tarke
Lindsey Dornes
Lindsey Teunis
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Madison McLaughlin
Maesa Hanhan
Marcus King
Mark Carpenter
Mark Dreiling**
Mark Hammer
Marlene Baker
Martin Offenhauer**
Mary Hansen
Matt Olson
Melissa Garret
Melissa Maigler
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Michael Sowadski
Mike Hanna**
Mike Hunter
Mitchell Manners
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Wendy Kwong
Yang Jiao
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*** Team Leaders; most recent WY16 3x volunteers are listed in blue*