APPENDIX A

Dry-Weather Sampling – Los Cerritos Channel
(*Monitoring Stations within Impaired Reach*)

Date	Station	Hardness (mg/L)		Dissolved Copper (µg/L)	
				CMC	CCC
6/5/01	**Stearns St.**	**160**	**Measured result**	14	
			Standard	20.9	13.38
			Exceedence	No	***Yes***
8/16/01	**Stearns St.**	**170**	**Measured result**	16	
			Standard	22.2	14.09
			Exceedence	No	***Yes***
5/9/02	**Stearns St.**	**130**	**Measured result**	16	
			Standard	17.2	11.21
			Exceedence	No	***Yes***
9/5/02	**Stearns St.**	**180**	**Measured result**	6.7	
			Standard	23.4	14.8
			Exceedence	No	No
5/20/03	**Stearns St.**	**154**	**Measured result**	14	
			Standard	20.2	12.95
			Exceedence	No	***Yes***
9/10/03	**Stearns St.**	**202**	**Measured result**	3.4	
			Standard	26.1	16.33
			Exceedence	No	No
5/4/04	**Stearns St.**	**176**	**Measured result**	7.7	
			Standard	22.9	14.52
			Exceedence	No	No
8/31/04	**Stearns St.**	**180**	**Measured result**	9.8	
			Standard	23.4	14.8
			Exceedence	No	No
5/25/05	**Stearns St.**	**180**	**Measured result**	8.4	
			Standard	23.4	14.8
			Exceedence	No	No
8/18/05	**Stearns St.**	**270**	**Measured result**	12	
			Standard	34.3	20.93
			Exceedence	No	No
5/11/06	**Stearns St.**	**140**	**Measured result**	15	
			Standard	18.5	11.94
			Exceedence	No	***Yes***
9/7/06	**Stearns St.**	**130**	**Measured result**	7.5	
			Standard	17.2	11.21
			Exceedence	No	No
5/17/07	**Stearns St.**	**180**	**Measured result**	12	
			Standard	23.4	14.8
			Exceedence	No	No
9/26/07	**Stearns St.**	**140**	**Measured result**	27	
			Standard	18.5	11.94
			Exceedence	***Yes***	***Yes***
5/7/08	**Stearns St.**	**150**	**Measured result**	11	
			Standard	19.69	12.66
			Exceedence	No	No
5/7/09	**Stearns St.**	**120**	**Measured result**	13	
			Standard	15.96	10.47
			Exceedence	No	***Yes***
3/3/09	**CC-01-A**	**120**	**Measured result**	11	
			Standard	15.96	10.47
			Exceedence	No	***Yes***

Date	Station	Hardness (mg/L)		Dissolved Copper (µg/L)	
				CMC	CCC
4/9/09	**LB9-CU2-CC-A**	**110**	**Measured result**	15	
			Standard	14.70	9.72
			Exceedence	***Yes***	***Yes***
5/11/09	**CC-A**	**300**	**Measured result**	5.7	
			Standard	37.84	22.90
			Exceedence	No	No
5/11/09	**CC-H**	**300**	**Measured result**	6.6	
			Standard	37.84	22.90
			Exceedence	No	No
5/11/09	**PV-A**	**250**	**Measured result**	16	
			Standard	31.86	19.59
			Exceedence	No	No

Source 1. Excel spreadsheet "Long Beach – Los Cerritos summary 20-Mar-08.xls" provided by Tom Leary, City of Long Beach, to Peter Kozelka, USEPA, 3/22/08.

Source 2. City of Long Beach Stormwater Monitoring Reports from 2002 to 2007.

Source 3. Excel spreadsheet submitted via email from M. Stevenson, Kinnetics Laboratories, Inc., to K. Graves, USEPA Region 9, 10/21/09.

Wet-Weather Sampling – Los Cerritos Channel Monitoring Station

Year 2000-2001

Event 1 (1/27/01) – hardness = 22

	Zinc (ZN)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	32.49, 32.75	3.20, 2.46	12.02, 0.47
Measured Value	42	11	1.1
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 2 (2/10/01) – hardness = 49

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	64.03, 64.55	6.9, 4.87	29.47, 1.14
Measured Value	75	11	1.0U
Exceeds?	***Yes, both***	***Yes, both***	No

Event 3 (2/23/01) – hardness = 41

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	55.05, 55.55	5.8, 4.18	24.17, 0.94
Measured Value	51	12	1.1
Exceeds?	No	***Yes, both***	***Yes, CCC only***

Event 4 (4/7/01) – hardness = 67

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	83.46, 84.14	9.2, 6.36	41.65, 1.61
Measured Value	66	3.6	1.0U
Exceeds?	No	No	No

Event 5 (4/21/01) – hardness = 150

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	165.22, 166.57	19.7, 12.66	100.13, 3.87
Measured Value	150	12	1.4
Exceeds?	No	No	No

Year 2001-2002

Event 1 (11/13/01) – hardness = 68

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	84.52, 85.21	9.30, 6.44	42.33, 1.64
Measured Value	48	7.4	3.1
Exceeds?	No	***Yes, CCC only***	***Yes, CCC only***

Event 2 (11/25/01) – hardness = 27

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	38.64, 38.96	3.9, 2.93	15.14, 0.59
Measured Value	78	7.9	1.7
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Year 2002-2003

Event 1 (11/10/02) – hardness = 38

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	174.5, 175.93	5.4, 3.92	22.2, 0.86
Measured Value	160	19	7.6
Exceeds?	No	***Yes, both***	***Yes, CCC only***

Event 2 (12/17/02) – hardness = 27

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	38.64, 38.96	3.9, 2.93	15.14, 0.59
Measured Value	60	8.1	1.4
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 3 (2/13/03) – hardness = 17

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	26.11, 26.32	2.5, 1.97	8.98, 0.35
Measured Value	35	5	0.79
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 4 (2/25/03) – hardness = 21

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	31.23, 31.49	3.1, 2.36	11.4, 0.44
Measured Value	63	5.6	0.97
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

<u>Year 2003-2004</u>

Event 1 (2/3/04) – hardness = 32.1

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	44.74, 45.11	4.6, 3.39	18.38, 0.71
Measured Value	55	7.2	0.82
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 2 (2/18/04) – hardness = 21.1

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	21.23, 31.49	3.1, 2.37	11.46, 0.44
Measured Value	71	12	1
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 3 (2/22/04) – hardness = 17.1

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	26.24, 26.46	2.5, 1.98	9.04, 0.35
Measured Value	52	5	0.48J
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 4 (2/26/04) – hardness = 12.1

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	19.57, 19.74	1.8, 1.47	6.1, 0.24
Measured Value	37	4.4	0.61
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Year 2004-2005

Event 1 (10/17/04) – hardness = 100

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	117.18, 118.14	13.4, 8.96	64.58, 2.5
Measured Value	130	12	3.3
Exceeds?	***Yes, both***	***Yes, CCC only***	***Yes, CCC only***

Event 2 (10/20/04) – hardness = 21

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	31.23, 31.49	3.1, 2.3	11.4, 0.44
Measured Value	240	5.7	0.65
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 3 (10/27/04) – hardness = 16

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	24.8, 25.01	2.4, 1.87	8.38, 0.33
Measured Value	11	3.5	0.4J
Exceeds?	No	***Yes, both***	***Yes, CCC only***

Event 4 (12/29/04) – hardness = 29

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	41.05, 41.39	4.2, 3.11	16.4, 0.64
Measured Value	9.8	3.9	0.32J
Exceeds?	No	***Yes, CCC only***	No

Year 2005-2006

Event 1 (10/18/05) – hardness = 59

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	74.94, 75.55	8.2, 5.71	36.2, 1.4
Measured Value	120J	12	1.7
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 2 (1/2/06) – hardness = 25

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	36.2, 36.5	3.6, 2.74	13.88, 0.54
Measured Value	49	5.7	0.66
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 3 (2/28/06) – hardness = 18

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	27.41, 27.63	2.7, 2.07	9.58, 0.37
Measured Value	53	6.9	0.92
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 4 (3/3/06) – hardness = 23

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	33.73, 34.01	3.4, 2.55	12.64, 0.49
Measured Value	20	4.8	0.5
Exceeds?	No	***Yes, both***	***Yes, CCC only***

Year 2006-2007

Event 1 (2/11/07) – hardness = 49

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	64.03, 64.55	6.9, 4.87	29.47, 1.14
Measured Value	78	10	0.86
Exceeds?	***Yes, both***	***Yes, both***	No

Event 2 (4/20/07) – hardness = 42

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	56.19, 56.65	5.9, 4.27	24.82, 0.96
Measured Value	91	12	1.5
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Year 2007-2008

Event 1 (9/22/07) – hardness = 260

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	263.31, 265.46	33.10, 20.26	179.59, 6.93
Measured Value	130	17	3
Exceeds?	No	No	No

Event 2 (12/7/07) – hardness = 27

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	38.64, 38.96	3.9, 2.93	15.14, 0.59
Measured Value	74	11	0.92
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 3 (12/19/07) – hardness = 33

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	45.8, 46.18	4.7, 3.47	18.96, 0.73
Measured Value	49	9.1	0.76
Exceeds?	***Yes, both***	***Yes, both***	***Yes, CCC only***

Event 4 (1/6/08) – hardness = 31

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	43.44, 43.79	4.5, 3.29	17.68, 0.68
Measured Value	42	6.8	0.44
Exceeds?	No	***Yes, both***	No

Year 2008-2009

Event 2 (12/15/08) – hardness = 18

	Zinc (Zn)	Copper (Cu)	Lead (Pb)
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	27.41, 27.63	2.67, 2.07	9.58, 0.37
Measured Value	26	7.4	0.34
Exceeds?	***Yes, both***	***Yes, both***	No

Event 3 (2/6/09) – hardness = 22

	Zinc (Zn)	**Copper (Cu)**	**Lead (Pb)**
	CMC, CCC	**CMC, CCC**	**CMC, CCC**
Standard	32.49, 32.75	3.23, 2.46	12.02, 0.47
Measured Value	46	8.1	1.1
Exceeds?	***Yes, both***	***Yes, both***	No

J = value is considered an estimate.
U = not detected at the detection limit.

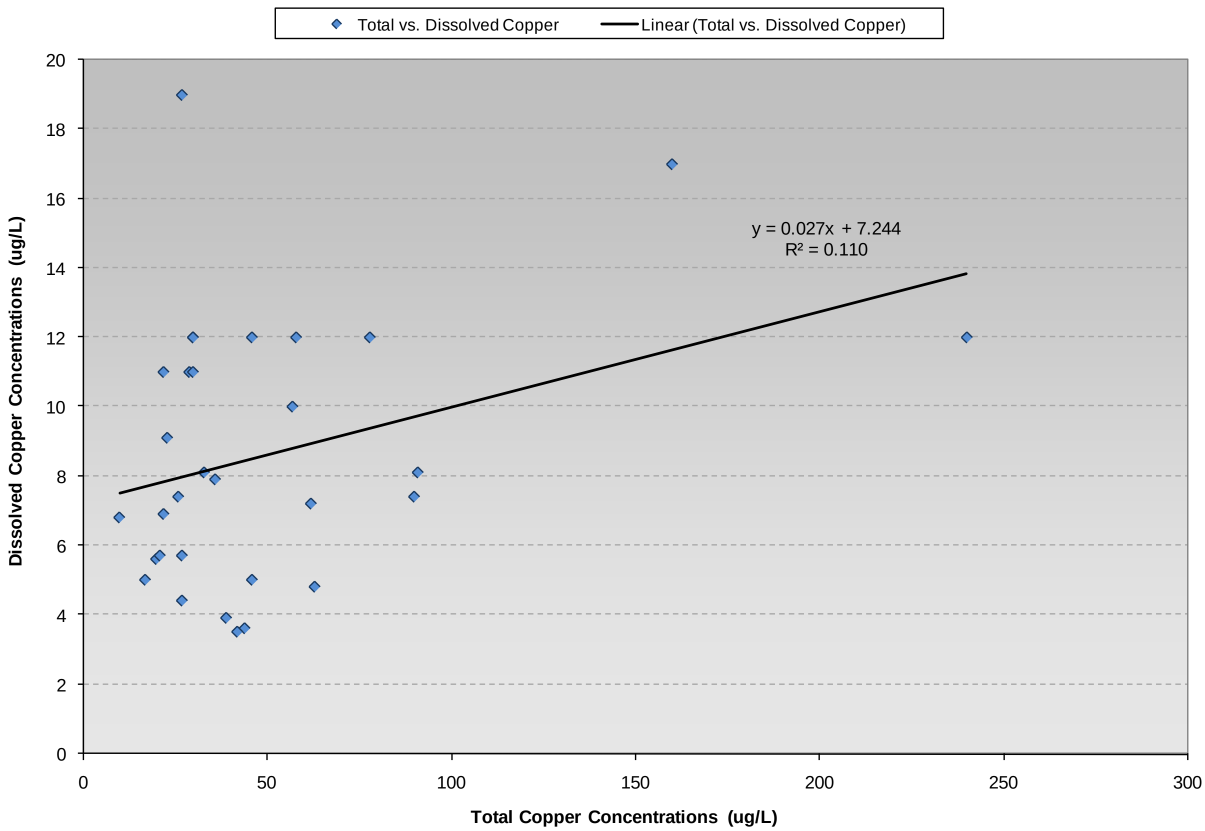
Source 1. Excel spreadsheet "Long Beach – Los Cerritos summary 20-Mar-08.xls" provided by Tom Leary, City of Long Beach, to Peter Kozelka, USEPA, 3/22/08.

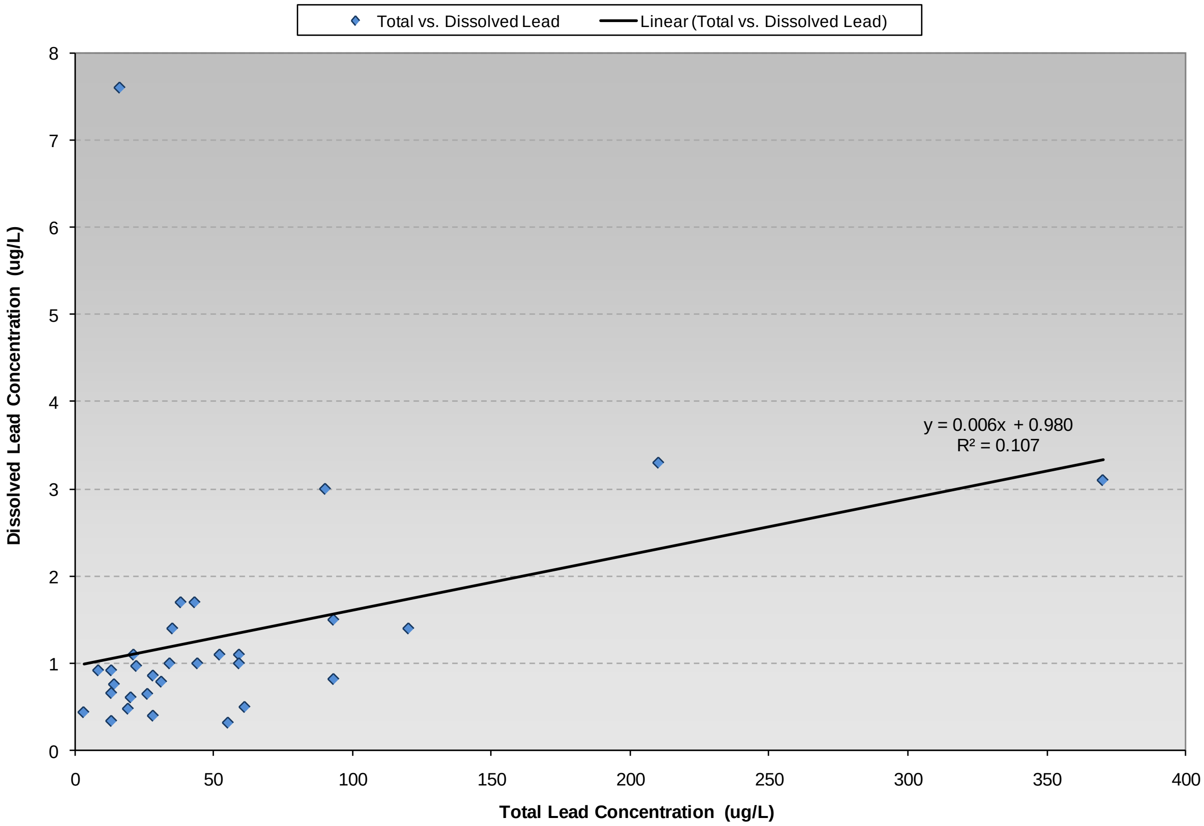
Source 2. City of Long Beach Stormwater Monitoring Reports from 2002 to 2007.

Source 3. Excel spreadsheet submitted via email from M. Stevenson, Kinnetics Laboratories, Inc., to K. Graves, USEPA Region 9, 10/21/09.

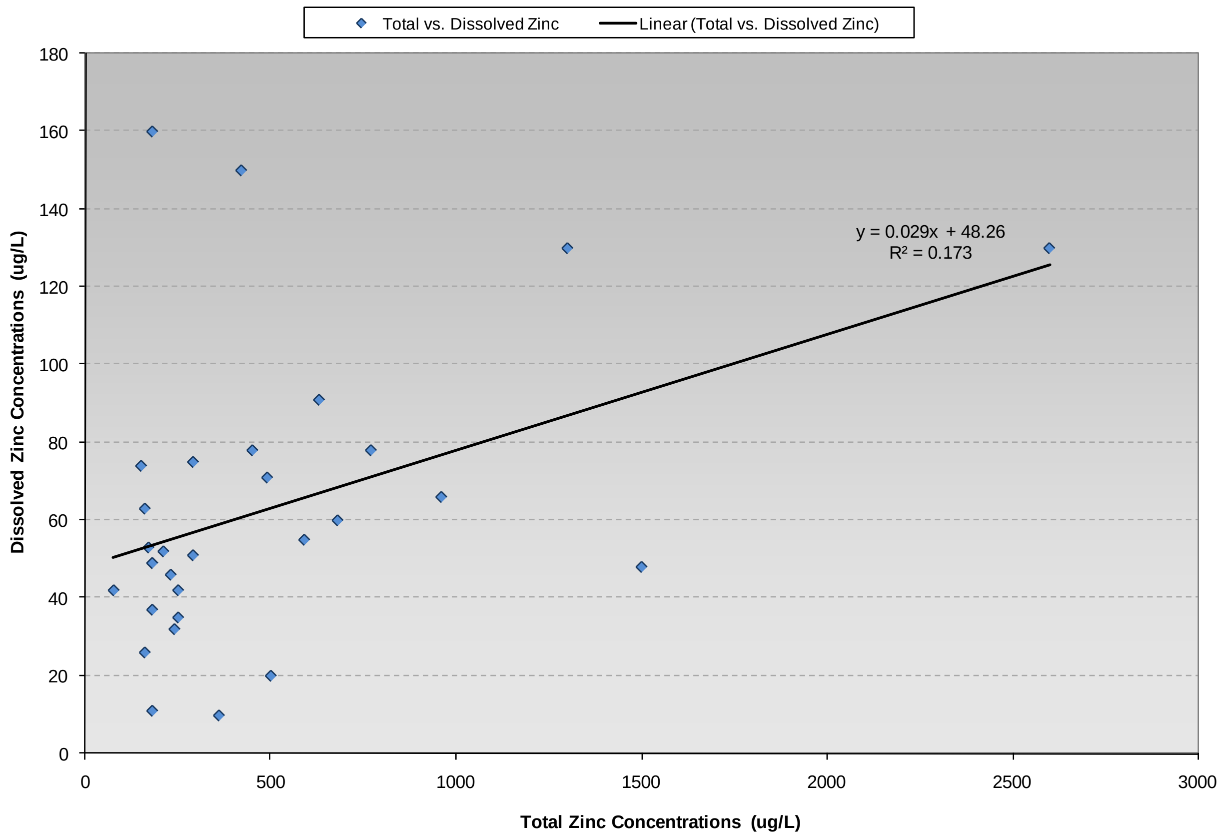
APPENDIX C

Wet-Weather Regression Analysis Comparing Dissolved to Total Recoverable Concentrations – Los Cerritos Channel Monitoring Station





Total vs. Dissolved Lead
Linear (Total vs. Dissolved Lead)
y = 0.006x + 0.980
R² = 0.107
Dissolved Lead Concentration (ug/L)
Total Lead Concentration (ug/L)
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
300
350
400


Total vs. Dissolved Zinc
Linear (Total vs. Dissolved Zinc)
y = 0.029x + 48.26
R² = 0.173
Dissolved Zinc Concentrations (ug/L)
Total Zinc Concentrations (ug/L)
0
20
40
60
80
100
120
140
160
180
0
500
1000
1500
2000
2500
3000

TETRA TECH, INC.
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MEMORANDUM

DATE: February 9, 2010

TO: Karin Graves and Peter Kozelka (USEPA, Region IX)

FROM: Stephen Carter, Amy King, and Mark Sievers

SUBJECT: Dry Weather Existing Metals Loads in Los Cerritos Channel

The freshwater portion of the Los Cerritos Channel (LCC) watershed is a 27.7 square mile (71.7 square kilometer) area located between the Los Angeles River and San Gabriel River watersheds (Figure 1). This watershed initially drains to a tidally-influenced wetlands system before discharging to Alamitos Bay. Copper, lead, and zinc TMDLs are required for Los Cerritos Channel.

Because the pollutant sources and their means of transport to receiving waters vary between wet and dry conditions (McPherson et al., 2005; LARWQCB, 2005a, 2005b, 2005c, Stein et al., 2003), Tetra Tech developed technical approaches that are consistent with our understanding of the processes for each weather condition—this assumption is consistent with most other TMDLs adopted in the Los Angeles Region. The remainder of this memorandum describes our technical approach and estimated metal loads for dry weather conditions. The wet weather technical approach and resulting metals loads are described in a separate document entitled "Wet Weather Watershed Model Development for Simulation of Metals Loadings to Los Cerritos Channel" (dated February 9, 2010).

During dry weather, watershed flows in LCC are dominated by groundwater inflow and discharges to the stormwater conveyance system from illicit connections, excess irrigation, and other residential and commercial practices (McPherson et al., 2005; Stein and Ackerman, 2007). Although dry-weather flows are substantially less than stormflows in the region, their long-term contribution of pollutants can be substantial (McPherson et al., 2005; Stein et al., 2003). Dry weather monitoring data for LCC were analyzed to evaluate impairments and estimate existing dry weather metals loading in the freshwater portion of the watershed.

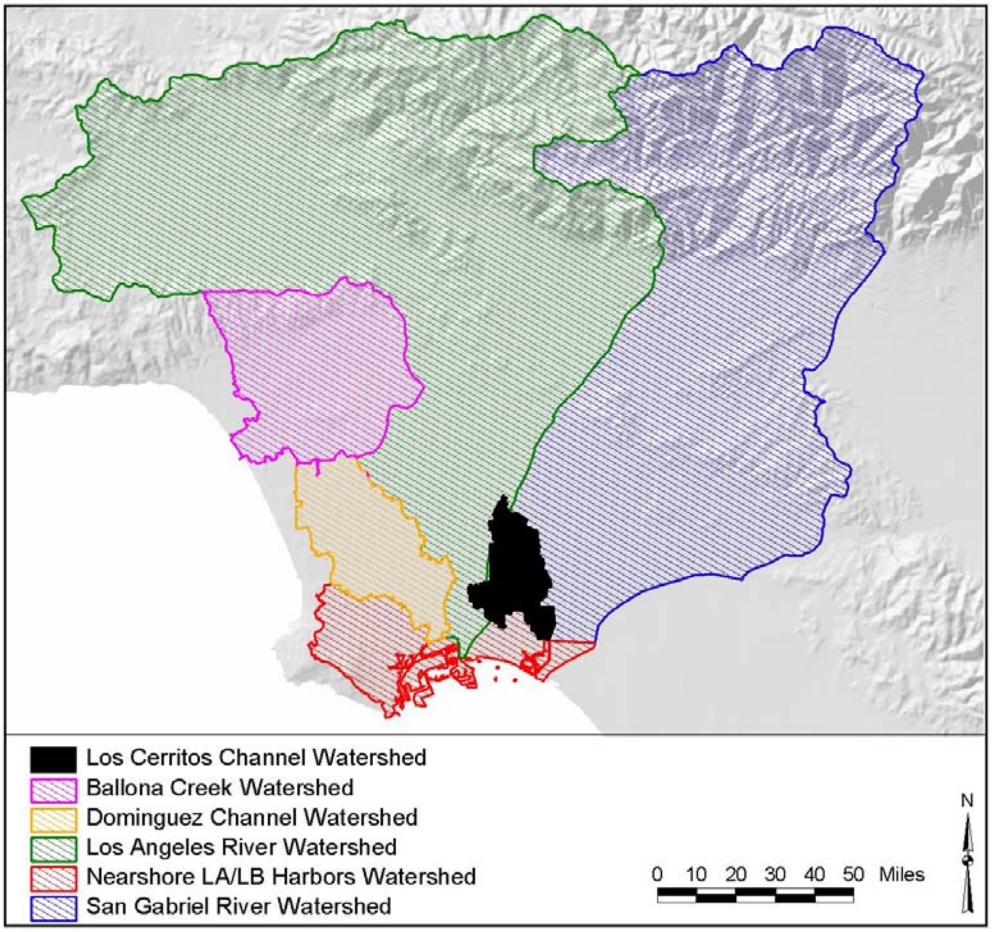

Figure 1. Los Cerritos Channel Watershed (*freshwater*)

USEPA Region IX evaluated the City of Long Beach dissolved metals dry weather monitoring data for LCC at Stearns Street (collected from 2001 to 2009) and several other stations within the listed segment to confirm impairments. Specifically, freshwater Criterion Maximum Concentrations (CMC) and Criterion Continuous Concentrations (CCC) were calculated using the hardness values collected during each dry weather monitoring event (USEPA, 2006). The dissolved copper, lead, and zinc monitoring data were then compared with the applicable hardness-specific criteria. The results of these analyses are presented in Table 1, where red font indicates an exceedence of the numeric water quality criteria. There were 21 dry-weather monitoring events evaluated (note: lead and zinc data were only available for sixteen events). Copper was the only metal to exceed the numeric water quality criteria (two exceedences of the acute criteria and nine exceedences of the chronic criteria).

Table 1. Dry Weather Dissolved Metal Comparisons to Water Quality Targets

Date	Station	Hardness (mg/L)		Dissolved Copper (µg/L)		Dissolved Lead (µg/L)		Dissolved Zinc (µg/L)	
				CMC	CCC	CMC	CCC	CMC	CCC
6/5/01	Stearns St.	160	Measured result	14		2.4		13	
			Standard	20.9	13.38	107.31	4.18	174.5	175.93
			Exceedence	No	***Yes***	No	No	No	No
8/16/01	Stearns St.	170	Measured result	16		3.2		39	
			Standard	22.2	14.09	114.5	4.46	183.7	185.2
			Exceedence	No	***Yes***	No	No	No	No
5/9/02	Stearns St.	130	Measured result	16		0.5U		9.3	
			Standard	17.2	11.21	85.83	3.34	146.35	147.55
			Exceedence	No	***Yes***	No	No	No	No
9/5/02	Stearns St.	180	Measured result	6.7		0.58		9	
			Standard	23.4	14.8	121.7	4.7	192.82	194.4
			Exceedence	No	No	No	No	No	No
5/20/03	Stearns St.	154	Measured result	14		1.2		19	
			Standard	20.2	12.95	103	4.01	168.94	170.33
			Exceedence	No	***Yes***	No	No	No	No
9/10/03	Stearns St.	202	Measured result	3.4		0.57		17	
			Standard	26.1	16.33	137.59	5.36	212.61	214.35
			Exceedence	No	No	No	No	No	No
5/4/04	Stearns St.	176	Measured result	7.7		0.6		8.8	
			Standard	22.9	14.52	118.82	4.63	189.18	190.73
			Exceedence	No	No	No	No	No	No
8/31/04	Stearns St.	180	Measured result	9.8		0.71		8.2	
			Standard	23.4	14.8	121.7	4.7	192.82	194.4
			Exceedence	No	No	No	No	No	No
5/25/05	Stearns St.	180	Measured result	8.4		0.7		14	
			Standard	23.4	14.8	121.7	4.7	192.82	194.4
			Exceedence	No	No	No	No	No	No
8/18/05	Stearns St.	270	Measured result	12		0.6		R	
			Standard	34.3	20.93	186.84	7.28	271.86	274.09
			Exceedence	No	No	No	No	---	
5/11/06	Stearns St.	140	Measured result	15		1.1		19	
			Standard	18.5	11.94	92.97	3.62	155.84	157.11
			Exceedence	No	***Yes***	No	No	No	No
9/7/06	Stearns St.	130	Measured result	7.5		0.74J		6.7J	
			Standard	17.2	11.21	85.83	3.34	146.35	147.55
			Exceedence	No	No	No	No	No	No
5/17/07	Stearns St.	180	Measured result	12		0.8		13	
			Standard	23.4	14.8	121.7	4.7	192.82	194.4
			Exceedence	No	No	No	No	No	No
9/26/07	Stearns St.	140	Measured result	27		0.78		17	
			Standard	18.5	11.94	92.97	3.62	155.84	157.11
			Exceedence	***Yes***	***Yes***	No	No	No	No
5/7/08	Stearns St.	150	Measured result	11		0.64		8.3	
			Standard	19.69	12.66	100.13	3.90	165.22	166.57
			Exceedence	No	No	No	No	No	No
5/7/09	Stearns St.	120	Measured result	13		1.1		13	
			Standard	15.96	10.47	78.72	3.07	136.76	137.87
			Exceedence	No	***Yes***	No	No	No	No
3/3/09	CC-01-A	120	Measured result	11		NR		NR	
			Standard	15.96	10.47	78.72	3.07	136.76	137.87
			Exceedence	No	***Yes***	N/A	N/A	N/A	N/A
4/9/09	LB9-CU2-CC-A	110	Measured result	15		NR		NR	
			Standard	14.70	9.72	71.63	2.79	127.04	128.08
			Exceedence	***Yes***	***Yes***	N/A	N/A	N/A	N/A

Date	Station	Hardness (mg/L)		Dissolved Copper (µg/L)		Dissolved Lead (µg/L)		Dissolved Zinc (µg/L)	
				CMC	CCC	CMC	CCC	CMC	CCC
5/11/09	**CC-A**	**300**	**Measured result**	5.7		NR		NR	
			Standard	37.84	22.90	208.58	8.13	297.25	299.68
			Exceedence	No	No	N/A	N/A	N/A	N/A
5/11/09	**CC-H**	**300**	**Measured result**	6.6		NR		NR	
			Standard	37.84	22.90	208.58	8.13	297.25	299.68
			Exceedence	No	No	N/A	N/A	N/A	N/A
5/11/09	**PV-A**	**250**	**Measured result**	16		NR		NR	
			Standard	31.86	19.59	172.34	6.72	254.70	256.78
			Exceedence	No	No	N/A	N/A	N/A	N/A

NR = measurement not reported
N/A = exceedance not determined because observed concentration was not reported
U qualifier = reported value was below the detection limit
J qualifier = reported value was above the detection limit, but below the reporting limit

Additional analyses were performed to calculate existing dry weather metals loadings in LCC. The available raw monitoring data are presented in Table 2. These data consist of total and dissolved metals measurements for the 21 dry weather monitoring samples collected in LCC at Stearns Street and other stations, as well as their associated flow values (in cubic feet per second [cfs]), where reported. Summary statistics for these data, including minimum, maximum, and average values, are presented in Table 3.

Table 2. Los Cerritos Channel Dry Weather Raw Data

Sample date	Location	Hardness (mg/L)	TSS (mg/L)	Diss. copper (µg/L)	Total copper (µg/L)	Diss. lead (µg/L)	Total lead (µg/L)	Diss. zinc (µg/L)	Total zinc (µg/L)	Inst. flow (cfs)
6/5/2001	Stearns St.	160	14	14	19	2.4	3.1	13	23	5.2
8/16/01	Stearns St.	170	58	16	17	3.2	3.5	39	43	3.55
5/9/02	Stearns St.	130	2	16	22	0.5U	0.78	9.3	17	2.75
9/5/02	Stearns St.	180	18	6.7	10	0.58	1.2	9	12	0.625
5/20/03	Stearns St.	154	4	14	16	1.2	1.3	19	13	7.1
9/10/03	Stearns St.	202	56	3.4	15	0.57	6.5	17	92	2.1
5/5/04	Stearns St.	176	128	7.7	26	0.6	17	8.8	190	2.4
8/31/04	Stearns St.	180	41	9.8	16	0.71	6.8	8.2	33	2.5
5/25/05	Stearns St.	180	11	8.4	11	0.7	1.2	14	22	1.61
8/18/05	Stearns St.	270	44	12	17	0.6	2.8	43	40	3.13
5/11/06	Stearns St.	140	72	15	22	1.1	3.6	19	68	0.73
9/7/06	Stearns St.	130	38	7.5	14	0.74J	1.5	6.7J	22	4.97
5/17/07	Stearns St.	180	20	12	19	0.8	1.8	13	24	2.38
9/26/07	Stearns St.	140	2.2	27	29	0.78	1.1	17	21	2.73
5/7/08	Stearns St.	150	11	11	12	0.64	0.94	8.3	12	NR
5/7/09	Stearns St.	120	6.8	13	14	1.1	1.4	13	16	NR
3/3/09	CC-01-A	120	NR	11	12	NR	NR	NR	NR	1.32
4/9/09	LB9-CU2-CC-A	110	NR	15	19	NR	NR	NR	NR	0.67
5/11/09	CC-A	300	NR	5.7	7.7	NR	NR	NR	NR	0.37
5/11/09	CC-H	300	NR	6.6	10	NR	NR	NR	NR	0.37
5/11/09	PV-A	250	NR	16	18	NR	NR	NR	NR	0.06

NR = measurement not reported
U qualifier = reported value was below the detection limit
J qualifier = reported value was above the detection limit, but below the reporting limit

Table 3. Dry Weather Summary Statistics

Parameter	Minimum	Average	Maximum	Count
Dissolved copper (μg/L)	3.40	11.80	27.00	21
Dissolved lead (μg/L)	0.50	1.01	3.20	16
Dissolved zinc (μg/L)	6.70	16.08	43.00	16
Total copper (μg/L)	7.70	16.46	29.00	21
Total lead (μg/L)	0.78	3.41	17.00	16
Total zinc (μg/L)	12.00	40.50	190.00	16
Flow (cfs)	0.06	2.35	7.10	19

These monitoring results represent concentrations near the bottom of the watershed and were used to estimate existing conditions for dry-weather loadings. Specifically, the metals and instantaneous flow data presented above were used to calculate flow-weighted average concentrations for total and dissolved copper, lead, and zinc (Table 4) (note: flow-weighted average concentrations could only be calculated when both concentration and flow data were available; therefore, the copper flow-weighted average concentrations are based on 19 samples and the lead and zinc flow-weighted average concentrations are based on 14 samples as shown in Table 2). The metals concentrations were multiplied by their respective dry weather flows to determine the average daily loadings. These values were summed and then divided by the total dry weather flow. To calculate existing dry weather loads, the flow-weighted average concentrations were multiplied by the average dry weather flow (2.35 cfs) and necessary conversion factors (Table 4). The average observed dry weather flow based on 2001-2009 data (2.35 cfs) is just below the 90^{th} percentile of historic flow data (1955 – 1991, with a data gap from 1974 – 1988) at Stearns Street (3.0 cfs).

Table 4. Dry Weather Flow-weighted Mean Concentrations and Loads

Parameter	Flow weighted mean (μg/L)	Existing Dry Weather Load (pounds per day)
Dissolved copper	12.54	0.159
Dissolved lead	1.20	0.015
Dissolved zinc	17.50	0.222
Total copper	17.74	0.225
Total lead	3.36	0.043
Total zinc	37.93	0.481

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MEMORANDUM

DATE: February 9, 2010

TO: Karin Graves and Peter Kozelka (USEPA, Region IX)

FROM: Stephen Carter, Amy King, and Mark Sievers

SUBJECT: Watershed Model Development for Simulation of Wet-Weather Metals Loadings to Los Cerritos Channel

1. Introduction

The freshwater portion of the Los Cerritos Channel (LCC) watershed is a 27.7 square mile (71.7 square kilometer) area located between the Los Angeles River and San Gabriel River watersheds (Figure 1). This watershed initially drains to a tidally-influenced wetlands system before discharging to Alamitos Bay. Copper, lead, and zinc Total Maximum Daily Loads (TMDLs) are required for Los Cerritos Channel.

Because the pollutant sources and their means of transport to receiving waters vary between wet and dry conditions (McPherson et al., 2005; LARWQCB, 2005a, 2005b, 2005c, Stein et al., 2003), Tetra Tech developed technical approaches that are consistent with our understanding of the processes for each weather condition—this assumption is consistent with most other TMDLs adopted in the Los Angeles Region. This report provides a summary of the approach Tetra Tech used for estimation of copper, lead, and zinc in wet weather conditions. Estimation of metals loads during dry weather conditions were addressed in a separate technical memo ("Dry Weather Existing Metals Loads in Los Cerritos Channel" dated February 9, 2010).

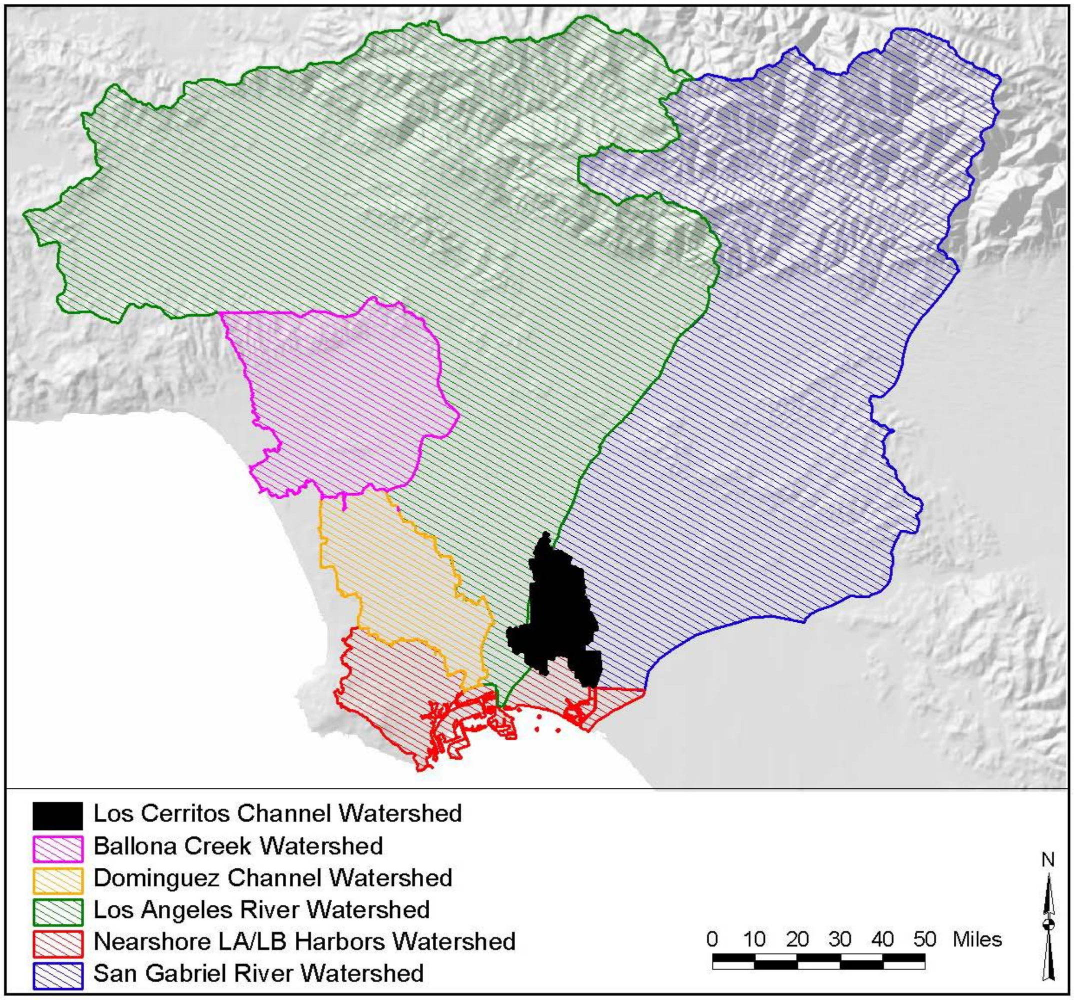

Figure 1. Location of Los Cerritos Channel Watershed (*Freshwater*)

2. Wet Weather Modeling Approach

The transport of metals during wet-weather events is generally believed to be associated with the detachment and transport of sediment (Buffleben et al., 2002; CALTRANS, 2003; Hoffman et al., 1982; Lau and Stenstrom, 2005; Logonathan et al., 1997; Stein et al., 2005; Yunker et al., 2002). Specifically, during rainy periods, these pollutant loads are delivered to the waterbody through creeks and stormwater collection systems.

Specific sources of metals vary based on location and pollutant and, occasionally, concentration "hot spots" are present. These "hot spots" are typically associated with spills or other events that lead to higher pollutant concentrations and their presence and impact to receiving waters are difficult to identify/characterize. Additionally, available data to characterize the pollutant sources is often limited. Metals can also be linked to specific land use types that have higher relative accumulation rates of the pollutant(s), higher relative loads of sediment from the land surface, or are more likely to deliver sediment and associated pollutants to waterbodies due to delivery through stormwater collection systems.

To assess the link between sources of sediment, metals, and the impaired waters, a modeling system was utilized that simulates land-use based sources of sediment and associated metals loads and the hydrologic and hydraulic processes that affect delivery.

The U.S. Environmental Protection Agency's (EPA) Loading Simulation Program C++ (LSPC) (Shen et al., 2004; USEPA, 2003a) was used to represent the hydrologic and water quality conditions in the Los Cerritos Channel watershed. LSPC is a component of the EPA's TMDL Modeling Toolbox (USEPA, 2003b), which has been developed through a joint effort between EPA and Tetra Tech, Inc. It integrates a comprehensive data storage and management capability, a dynamic watershed model (a re-coded version of EPA's Hydrological Simulation Program – FORTRAN [HSPF] [Bicknell et al., 2001]), and a data analysis/post-processing system into a convenient PC-based windows interface that dictates no software requirements.

LSPC is capable of representing loading and both flow and water quality from non-point and point sources as well as simulating in-stream processes. LSPC can simulate flow, sediment, metals, nutrients, pesticides, and other conventional pollutants for pervious and impervious lands and waterbodies. The model has been successfully applied and calibrated in Southern California for the Los Angeles River (LAR), the San Gabriel River (SGR), Dominguez Creek (DC) (original model by the Southern California Coastal Water Research Project [SCCWRP]), the nearshore watersheds draining to Los Angeles/Long Beach Harbors (LAH), the San Jacinto River, and multiple watersheds draining to impaired beaches of the San Diego Region. For Los Cerritos Channel, LSPC was used to simulate metals (copper, lead, and zinc) for determining loads.

Previous wet-weather watershed modeling and TMDL efforts by Tetra Tech and SCCWRP have led to the development of a regional watershed modeling approach to simulate hydrology, sediment, and metals transport in the Los Angeles Region. The regional modeling approach assumes that metals loadings can be dynamically simulated based on hydrology and sediment transported from land uses in a watershed. Development of the approach resulted from application and testing of models for multiple small-scale land use sites and larger watersheds in the Los Angeles Region. SCCWRP developed watershed models, based on HSPF (Bicknell et al., 2001), of multiple homogeneous land use sites in the region. Sufficient stormflow and water quality data were available at these locations to facilitate calibration of land-use-specific HSPF modeling parameters. These parameters were validated in an additional HSPF model of Ballona Creek (Ackerman et al., 2005; SCCWRP, 2004), and similar models of LAR (Tetra Tech, Inc., 2004), SGR (Tetra Tech, Inc, 2005), and LAH (Tetra Tech, Inc, 2006) using LSPC. These models were used to calculate TMDLs for each of these waterbodies (LARWQCB, 2005a, 2005c, 2006; draft LAH TMDL currently under development).

The methods used for previous modeling studies of LAR, SGR, DC, and LAH were applied for freshwater portion of the Los Cerritos Channel watershed, with a few modifications as discussed below. The following sections describe the wet-weather model configuration, validation, and application.

2.1. Model Configuration

The watershed model represented the variability of wet-weather runoff source contributions through dynamic representation of hydrology and land practices. It included all point and non-point source contributions. Key components of the watershed modeling that are discussed below are:

- Watershed segmentation
- Meteorological data
- Land use representation
- Soils
- Reach characteristics
- Point source discharges
- Hydrology representation
- Pollutant representation
- Flow data

2.1.1. Watershed Segmentation

To evaluate sources contributing to an impaired waterbody and to represent the spatial variability of these sources, the contributing drainage area was represented by a series of subbasins. Tetra Tech obtained a Geographic Information System (GIS) coverage of the freshwater portion of the LCC watershed from the Los Angeles Regional Water Quality Control Board (LARWQCB) (modified from the Los Angeles County Department of Public Works layer). The original subwatersheds in this coverage were grouped into model subbasins based on sewersheds (obtained from the Los Angeles County Spatial Information Website [LACDPW, 2008]), monitoring locations, and field reconnaissance by the City of Downey (Figure 2). There is a 5.05 acre area in the northern-most subwatershed located in the City of Downey that is part of a Caltrans right-of-way and drains into the Los Angeles River watershed. Confirmation of this drainage pattern was not received until the modeling was completed; therefore, this area is included in the modeling (and subsequent modeling results), but is excluded from TMDL calculations and allocations. Considering this is a very small area (less than 0.02 percent of the watershed area), it is assumed to have a negligible impact on the wet weather modeling results. The watershed was divided into ten subbasins for appropriate hydrologic connectivity and representation. Figure 2 presents the model domain.

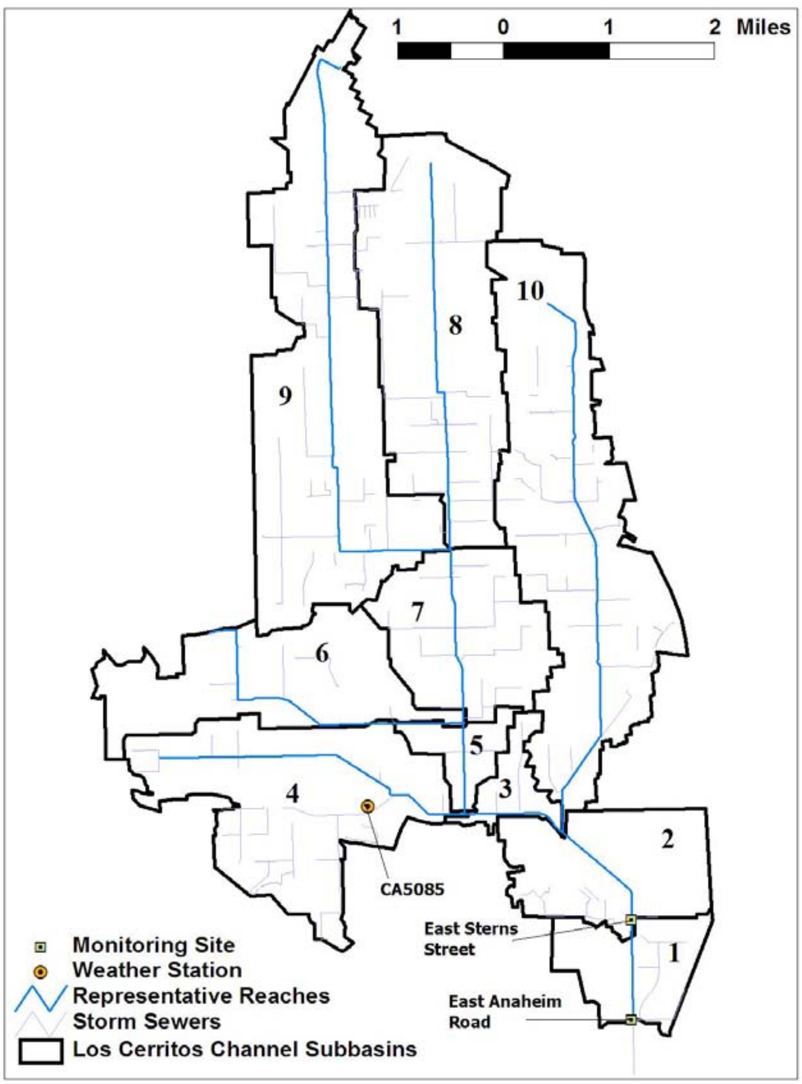

Figure 2. Model Subbasins and Monitoring Stations

2.1.2. *Meteorological Data*

Meteorological data are a critical component of the watershed model. LSPC requires appropriate representation of precipitation and potential evapotranspiration (ET). In general, hourly precipitation (or finer resolution) data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly-recorded data were considered in the precipitation data selection process. Rainfall-runoff processes for each subbasin were driven by precipitation data from the most representative station. These data provide necessary input to LSPC algorithms for hydrologic and water quality representation.

National Climatic Data Center (NCDC) precipitation data were reviewed based on geographic location, period of record, and missing data to determine the most appropriate meteorological stations to represent the LCC model domain. Hourly rainfall data were obtained from the Long Beach weather station (CA5085) located in the Los Cerritos Channel watershed (Figure 2). Precipitation data were obtained for January 1, 1980 through January 28, 2008.

Because rainfall gages are not always in operation and accurately recording data, the resulting dataset may contain various intervals of accumulated, missing, or deleted data. Missing or deleted intervals are periods over which either the rainfall gage malfunctioned or the data records were somehow lost. Accumulated intervals represent cumulative precipitation over several hours, but the exact hourly distribution of the data is unknown. To address the incomplete portions of CA5085 data, it was necessary to patch the rainfall data with information from nearby gages using normal-weighted hourly distributions. Because the normal ratio considers the long-term average rainfall as the weighting factor, this method is adaptable to regions where there is large orographic precipitation variation since elevation differences will not bias the predictive capability of the method (Dunne & Leopold, 1978).

Specifically, the normal-ratio method (Dunne & Leopold, 1978) was used to patch missing data with hourly rainfall distributions at nearby gages. To apply this normal-ratio method, a composite hourly distribution was first estimated for CA5085 (where accumulated, missing, or deleted data exist). This distribution was determined by using a weighted average from surrounding *n* stations with similar rainfall patterns and where unimpaired data were measured for the same time period.

Potential evapotranspiration, which is also required by the LSPC model, was calculated from data obtained from NCDC. Specifically, long-term hourly wind speed, cloud cover, temperature, and dew point data available for the Los Angeles International Airport (WBAN #23174) were used to calculate potential evapotranspiration for the weather station representing watershed.

2.1.3. *Land Use Representation*

The watershed model requires a basis for distributing hydrologic and pollutant loading parameters. This is necessary to appropriately represent hydrologic variability throughout the basin, which is influenced by land surface and subsurface characteristics. It is also necessary to represent variability in pollutant loading, which is highly correlated with land practices. The basis for this distribution was provided by the land use coverage of the entire watershed. The land use data used to represent watershed was the Southern California Association of Governments (SCAG) 2005 land use dataset that covers Los Angeles County.

Although the multiple categories in the land use coverage provide much detail regarding spatial representation of land practices in the watershed, such resolution is unnecessary for watershed modeling if many of the categories share hydrologic or pollutant loading characteristics. Therefore, many land use categories were grouped into similar classifications, resulting in a subset of seven categories for modeling: agriculture, commercial, high-density residential, industrial, low-density residential, mixed urban, and open. Selection of these land use categories was based on the availability of monitoring data and literature values that could be used to characterize individual land use contributions and critical metal-contributing practices associated with different land uses as well as comments received from local stakeholders. The distributions of the seven land uses (urban land uses were further separated into pervious and impervious areas, as described below) in the ten subbasins are presented in Table 1 and Figure 3.

LSPC algorithms require that urban land use categories be divided into separate pervious and impervious land units for modeling. The division of the seven land use categories identified above to represent impervious and pervious areas in the model was based on the 2001 Impervious Surface layer of the National Land Cover Dataset (NLCD) (downloaded from the USGS National Map Seamless server (http://seamless.usgs.gov/website/seamless/viewer.htm). Specifically, this data layer provided variable impervious percentages throughout the Los Cerritos Channel watershed. This variable coverage was applied to the modeled area, resulting in different percent impervious values for each urban land use-subbasin combination (Table 2). This approach to represent imperviousness is different from the regional modeling approach; however, it uses more local data and provides for a more accurate representation of the watershed conditions. This division resulted in 12 unique pervious or impervious land uses (Table 1).

Table 1. Land Use Areas (acres) of each Subbasin

Land Cover Type	Subbasin Number										Grand Total
	1	2	3	4	5	6	7	8	9	10	
Agriculture	7.2	0.1	0.0	0.0	0.0	0.0	0.0	37.3	42.4	50.0	137.1
Commercial	18.8	42.0	17.0	72.0	1.9	54.2	50.4	98.5	169.4	99.0	623.1
Commercial (Imp.)	29.3	115.7	50.3	280.5	2.6	236.0	109.5	408.3	540.5	272.9	2,045.5
High Density Residential	0.6	1.5	0.0	17.9	0.0	10.2	18.3	95.6	129.5	48.4	322.1
High Density Res. (Imp.)	1.7	3.3	0.0	22.1	0.0	37.6	40.9	275.7	361.0	164.3	906.6
Industrial	6.3	14.6	0.0	155.0	0.0	16.3	1.0	28.8	88.8	15.1	325.7
Industrial (Imp.)	16.5	32.9	0.0	550.8	0.0	124.2	18.8	96.1	411.0	43.9	1,294.2
Low Density Residential	249.7	281.5	94.9	128.0	104.3	305.2	418.5	662.1	690.8	1,002.3	3,937.2
Low Density Res. (Imp.)	320.5	390.4	128.0	148.1	133.6	336.4	443.9	935.4	1,092.0	1,413.3	5,341.7
Mixed Urban	30.2	49.5	4.7	288.0	1.0	88.7	74.7	4.8	64.5	77.8	683.8
Mixed Urban (Imp.)	37.6	29.7	10.2	464.8	1.6	238.6	70.2	8.8	55.7	64.6	981.9
Open	0.0	276.2	0.0	143.5	86.7	203.4	112.3	60.4	63.9	151.5	1,097.9
Water	1.1	3.6	0.0	0.0	0.0	12.9	1.3	0.0	0.0	0.0	18.9
Grand Total	719.6	1,241.1	305.0	2,270.6	331.6	1,663.7	1,359.7	2,711.8	3,709.5	3,403.1	17,715.8

Note: The land use and watershed areas presented in this table are based on the modeled area, which contains the 5.05 acres in subwatershed 9 that actually drain to the Los Angeles River watershed (these areas are in the high density residential and industrial land uses). Inclusion of this small area in the modeling is expected to have a negligible impact on the results.

Table 2. Percent impervious of each Urban Land Use Type and Subbasin

Urban Land Cover Type	Subbasin Number									
	1	2	3	4	5	6	7	8	9	10
Commercial	60.9	73.4	74.8	79.6	57.7	81.3	68.5	80.6	76.1	73.4
High Density Residential	73.2	68.2		55.2		78.6	69.1	74.3	73.6	77.2
Industrial	72.5	69.3		78.0		88.4	95.2	77.0	82.2	74.4
Low Density Residential	56.2	58.1	57.4	53.6	56.2	52.4	51.5	58.6	61.3	58.5
Mixed Urban	55.5	37.5	68.5	61.7	62.4	72.9	48.5	64.5	46.3	45.4

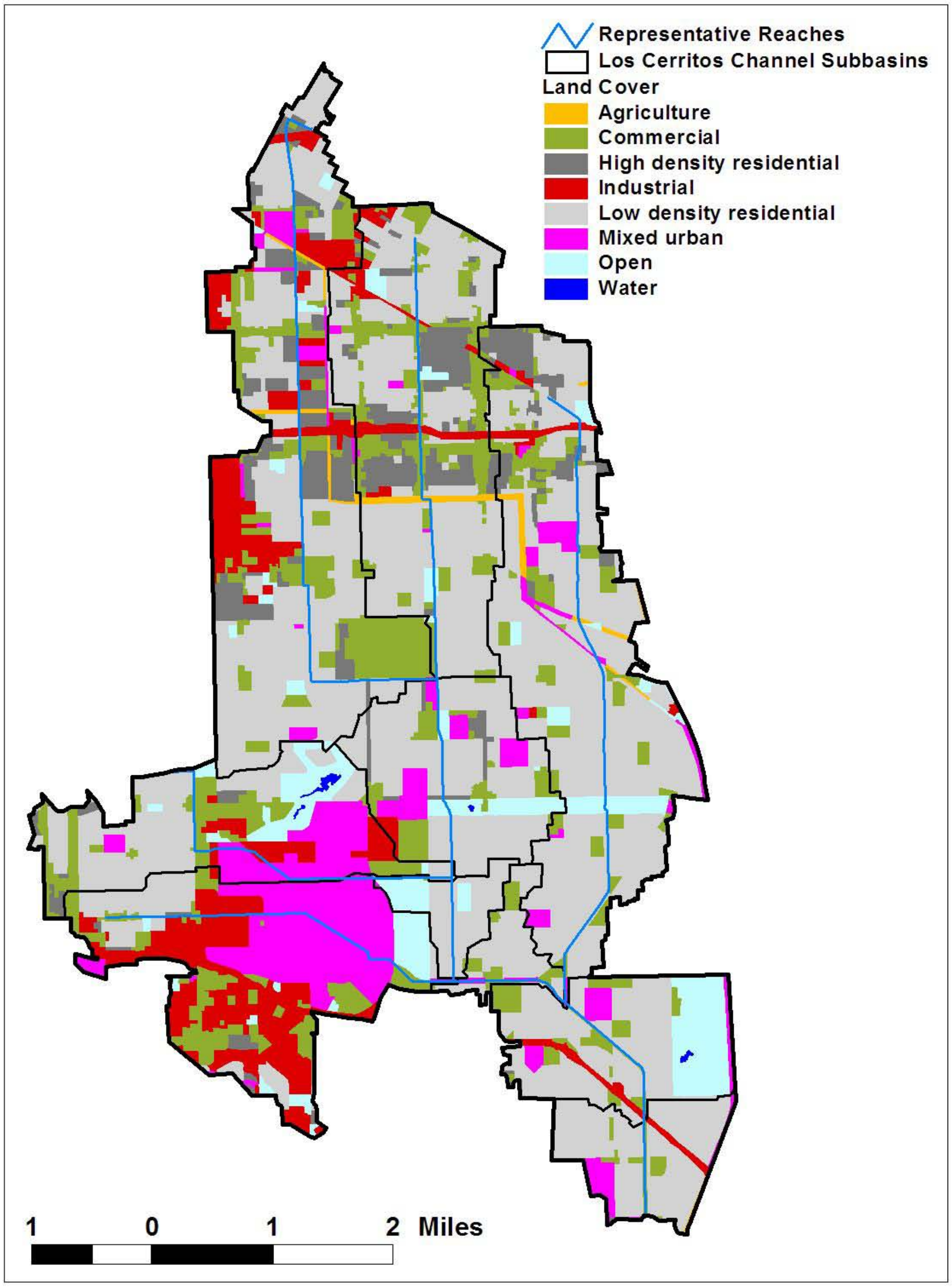

Figure 3. Land Use Cover in the Los Cerritos Channel Watershed

2.1.4. Soils

There are four main Hydrologic Soil Groups (Groups A, B, C, and D). These groups range from soils with low runoff potential to soils with high runoff potential (USDA, 1986). Due to large amounts of disturbed soils in urbanized areas and the high percentage of urban land uses in the watershed, only one generic soil grouping was used in the model, which is consistent with previous studies (Tetra Tech, Inc, 2006). In addition, the model domain is represented by a single soil mapping unit identification number (CA638) and the State Soil Geographic (STATSGO) Database soil layer includes a single category for urban areas (USDA, 2006). The STATSGO database is a national soil GIS layer distributed by the Natural Resources

Conservation Service (NRCS) - National Cartography and Geospatial Center (NCGC). More recent data layers are available, such as the more detailed Soil Survey Geographic (SSURGO) soil layer (also distributed by the NRCS-NCGC) and a layer distributed by the County of Los Angeles. The SSURGO data layer does not cover highly urban areas, such as the Los Cerritos Channel watershed, while the County of Los Angeles layer, which has more detail than the other national data layers, does not provide a direct linkage to the hydrologic soil groups required for modeling. Because of the limitations associated with these other, more recent data, the STATSGO data is the only available dataset with adequate information on hydrologic soil groups for application of the regional modeling approach.

2.1.5. Reach Characteristics

Each delineated subbasin was represented with a single reach assumed to be a completely mixed, one-dimensional segment with a trapezoidal cross-section. The reaches are based on storm sewer systems, since much of the flow in the watershed drains through storm sewers. Once the representative reach was identified for each subbasin, slopes were calculated based on Digital Elevation Model (DEM) data, and stream lengths measured from the GIS reach coverage.

In addition to stream slope and length, mean depths and channel widths are required to route flow and pollutants through the hydrologically connected subbasins. Mean stream depth and channel width were estimated using regression curves that relate upstream drainage area to stream/sewer dimensions. An estimated Manning's roughness coefficient of 0.02 was also applied to each representative stream reach.

2.1.6. Point Source Discharges

During watershed model configuration, National Pollutant Discharge Elimination System (NPDES) discharges can be incorporated into the model as point sources of flow and pollutants. There were no major point sources of flow located in the watershed, so this step was excluded during model development.

2.1.7. Hydrology Representation

Watershed hydrology plays an important role in the determination of nonpoint source flow and ultimately nonpoint source loadings to a waterbody. The watershed model must appropriately represent the spatial and temporal variability of hydrologic characteristics within a watershed. Key hydrologic characteristics include interception storage capacities, infiltration properties, evaporation and transpiration rates, and watershed slope and roughness. LSPC's algorithms are identical to those in HSPF. The LSPC/HSPF modules used to represent watershed hydrology for TMDL development included PWATER (water budget simulation for pervious land units) and IWATER (water budget simulation for impervious land units). A detailed description of relevant hydrological algorithms is presented in the HSPF User's Manual (Bicknell et al., 2001).

Key hydrologic parameters in the PWATER and IWATER modules are infiltration, groundwater flow, and overland flow. The model was populated using hydrologic parameters for the LAH model (Tetra Tech, Inc., 2006).

2.1.8. Watershed Runoff Pollutant Representation

The various pollutants were represented through their association with sediment and/or flow. Therefore, to simulate sediment contributions, the SEDMNT, SOLIDS, and SEDTRN modules were implemented and are discussed below. After using the sediment module to simulate TSS, metals associated with sediment were simulated using the POTFW parameter in the LSPC water quality module. The pollutant-specific approaches and results are discussed in Sections 2.2.2 and 2.2.3.

The SEDMNT module simulates the production and removal of sediment from all pervious land segments in the model. The removal of sediment by water is simulated as washoff of detached sediment and scour of the soil matrix. Both processes are highly dependent on land use. Washoff depends on both the amount of detached sediment available to be carried away by the overland flow and the transport capacity of the overland flow. The amount of detached sediment available to be transported depends primarily on the rainfall intensity. The transport capacity of the overland flow depends on surface water storage and surface water flow.

The SOLIDS module represents the accumulation and removal of sediment/solids from impervious lands. The removal of sediment/solids is simulated by washoff of available sediment. Sediment/solids accumulation represents atmospheric fallout and general land surface accumulation for urban areas.

Once the sediment is transported to the stream channel by overland flow, the SEDTRN module simulates the transport, deposition, and scour of sediment in the stream channels. These processes depend primarily on sediment characteristics, e.g., settling velocity, critical shear stress for deposition, critical shear stress for resuspension, and predicted bottom shear stresses.

2.1.9. Flow Data

The City of Long Beach collects flow data at a station approximately one mile upstream of the tidal boundary on Los Cerritos Channel at East Stearns Street. Recent data (from January 23, 2001 to present) were taken at different frequencies (initial measurements were collected every 5 to 30 minutes and more recent measurements were hourly). This dataset contained some missing data points, which indicates that the monitoring station was occasionally inoperable. In addition, 18.8 cubic feet per second (cfs) was the minimum detected flow for these data. The Los Angeles County Department of Public Works (LACDPW) has daily average flow from 1949 through 1955 for Los Cerritos Channel at East Anaheim Road and from 1955 through 1991 (there was a data gap from 1974 to 1988) for Los Cerritos Channel at East Stearns Street. Table 3 presents the flow data statistics.

Table 3. Flow Data

Data Source	Location	Date Range	Count	Minimum	Maximum	Mean	Median
LACDPW	E. Anaheim Road	10/1/49 – 9/30/55	2,191	0.0	836.0	6.2	0.0
LACDPW	E. Stearns Street	10/1/55 – 9/30/74	6,940	0.0	1,460.0	7.8	1.0
LACDPW	E. Stearns Street	10/1/88 – 4/30/91	942	0.1	489.0	7.3	1.3
City of Long Beach	E. Stearns Street	1/23/01 – 3/19/08	113,398	0.0[a]	4,647.0	43.0[a]	0.0[a]

[a] The minimum detectable flow in this dataset was 18.8 cfs; therefore, flows less than 18.8 cfs were recorded as 0.0 cfs, thus skewing the summary statistics.

2.2. Model Validation

After the model was configured, model validation was performed. Model calibration and validation is generally a multi-phase process, with hydrology calibration and validation completed before repeating the process for water quality. Model calibration was not performed since the hydrologic, sediment, and water quality parameters from the LAH model were applied to the LCC model without further calibration (Tetra Tech, Inc, 2006). Therefore, the Los Cerritos Channel model was used to further validate the previously calibrated parameters. Model validation essentially confirmed the applicability of the watershed-based parameters derived during the calibration process. Upon completion of the validation at selected locations, a validated dataset containing parameter values for each modeled land use and pollutant was developed. It is important to note that while the hydrologic, sediment, and water quality parameters were identical to the LAH model (i.e., use of the regional approach), some of the model configuration differed from the regional approach. For example, the land use classifications were modified based on comments received from watershed stakeholders and revised potency factors for copper were utilized. In addition, the use of variable percent impervious values throughout the watershed (Table 2) is a departure from the regional modeling approach; however, this step more accurately simulates hydrology and is considered an improvement to the model because it uses more local data than the regional approach.

Wet-weather events for LCC were simulated using the configured LSPC model (Figure 2). Simulations were performed using the validated parameters to obtain flow, total suspended solid (TSS), and total metals model output. Data from the City of Long Beach were used for comparison with model output. Model results were used to determine existing conditions for TMDL development for the freshwater portion of the Los Cerritos Channel watershed (see Section 4.0).

2.2.1. Hydrology Validation

Hydrology is the first model component validated because estimation of sediment loading relies heavily on flow prediction. The hydrology validation involved a comparison of model results to long-term in-channel flow observations at East Stearns Street. The model was populated using hydrologic parameters from the LAH model (Tetra Tech, Inc, 2006). The LAH model had very similar land uses and topography to the Los Cerritos Channel watershed, so the parameters were easily transferred.

The model's accuracy was primarily assessed through interpretation of the time-variable plots (Figure 4). Time-variable plots of observed versus modeled flow provided insight into the model's representation of storm hydrographs, baseflow recession, and time distribution. Wet weather flow was characterized as flow greater than 22.86 cfs. This value is the 90^{th} percentile flow at the East Stearns Street flow gage, which was calculated after replacing flow in the dataset less than 18.8 cfs (which was the minimum detectable flow at this station) with the average observed dry weather flow (2.35 cfs). The minimum wet weather flow (22.86 cfs) is illustrated in Figure 4 by a red horizontal line.

As indicated in the figures, the model generally captures the observed flow data well. The most significant discrepancies occurred in 2005. Specifically, several storm events in 2005 were not predicted by the model and one event that was predicted in 2005 was not observed. These discrepancies are most likely due to missing or patched data in the weather file. Figure 5 presents a comparison of the observed and modeled mean monthly flows. Results match up fairly well, with a few noticeable exceptions, such as February 2005 (most likely due to the weather data) and late 2002, which had significant low level flows (also shown in Figure 4) that were not predicted by the model. Figure 6 illustrates a seasonal regression (R^2 = 0.8982) and temporal aggregate. Deviations from the observed data are likely caused by localized conditions that are not captured as input to the model. The discrepancies between modeled and observed flow are considered well within the acceptable modeling ranges; therefore, the hydrology parameters previously calibrated for LAH remained unchanged (Tetra Tech, Inc, 2006).

During low flow conditions, the model is unable to predict dry urban runoff associated with human activities (e.g., lawn irrigation, car washing) without data quantifying the spatial distribution, flow, and loadings associated with these sources. As a result, the LSPC watershed model is not used for dry-weather load estimates and a separate methodology was used to calculate dry weather loadings (see "Dry Weather Existing Metal Loads in Los Cerritos Channel" dated November 18, 2009).

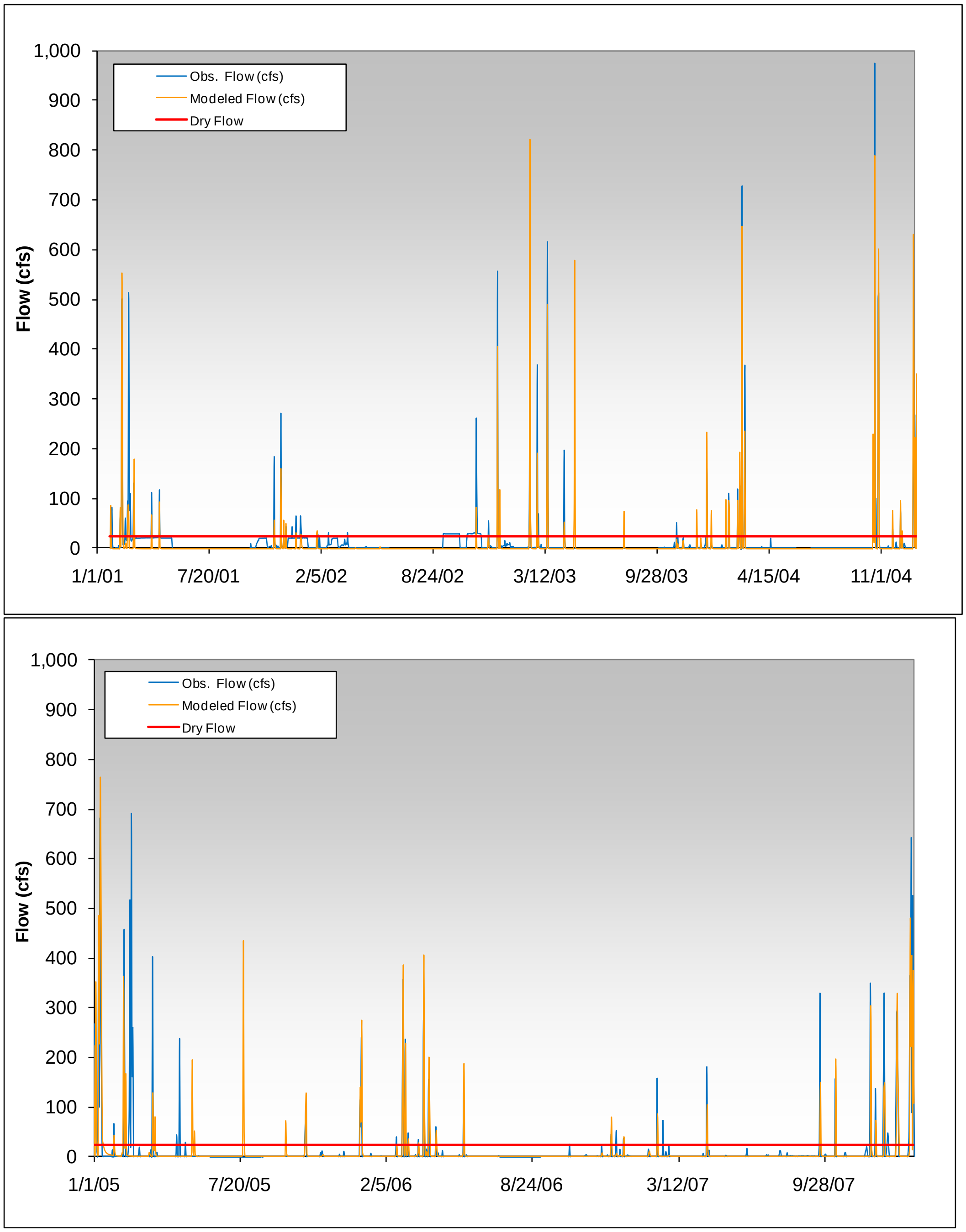

Figure 4. Average Daily Modeled and Observed Flow

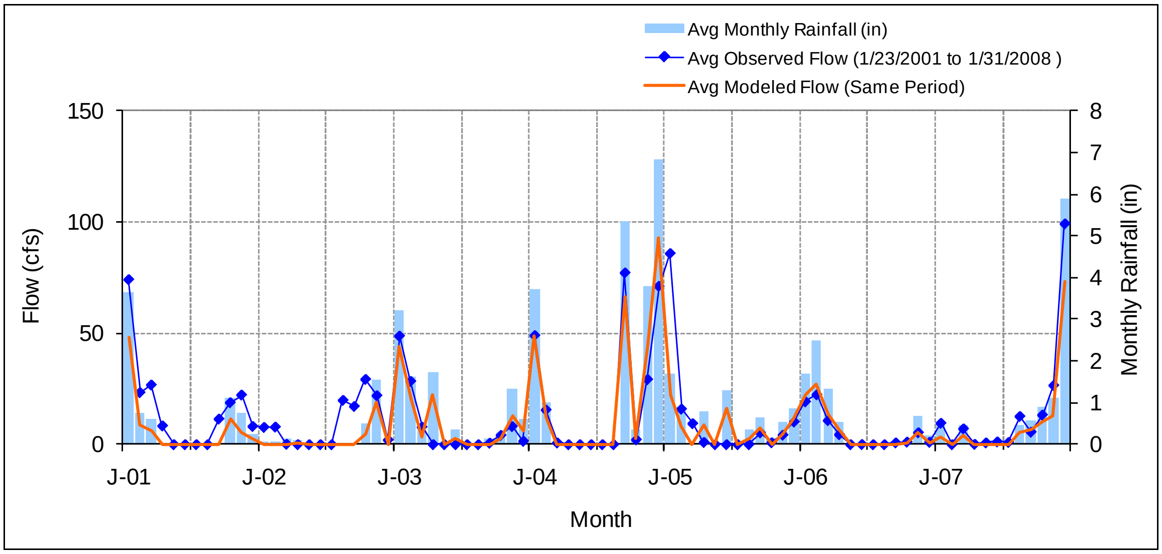

Figure 5. Mean Monthly Flow: Average Daily Modeled vs. Average Daily Observed

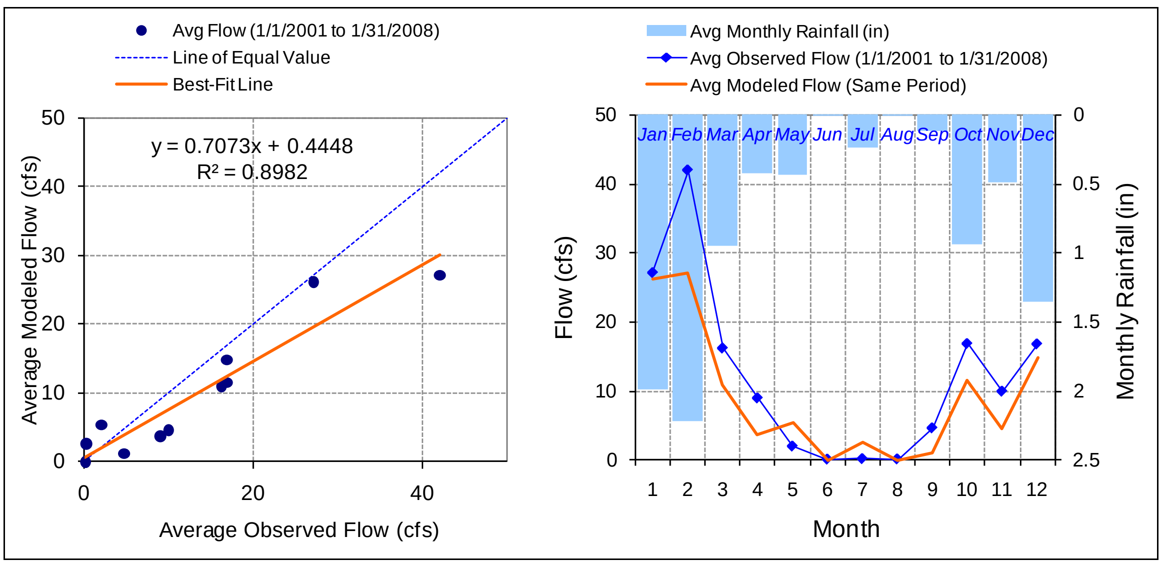

Figure 6. Seasonal Regression and Temporal Aggregate: Average Daily Modeled vs. Average Daily Observed

2.2.2. Sediment Validation

Once the model was validated for hydrology, the regional modeling approach was applied to predict sediment in the freshwater portion of the Los Cerritos Channel watershed. To simulate sediment contributions, the SEDMNT, SOLIDS, and SEDTRN modules were implemented (see section 2.1.8). For this study, the sediment parameters from the regional modeling approach (SCCWRP, 2004; Tetra Tech, Inc, 2004 & 2005) were applied to the appropriate land uses in the LCC model domain. The robust calibration and validation process previously performed for land use sites, Ballona Creek, LAR, LAH, and SGR are considered sufficient for documenting the performance of modeling parameters and verifying the transferability of the parameters among models of adjacent watersheds in the region. The application of the regional modeling approach provides increased opportunity for verification as additional datasets become available for comparison with model predictions. Final model parameter values for sediment simulation processes are presented in Table 4.

Table 4. Sediment Parameters in the Los Cerritos Channel Watershed Model

Parameter	Agri-culture	Commer-cial	High density residential	Industrial	Low density residential	Mixed urban	Open	Port activities
PERVIOUS LAND USE								
Splash detachment								
SMPF	1	1	1	1	1	1	1	1
KRER	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
JRER	2	2	2	2	2	2	2	2
AFFIX	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COVER	0	0	0	0	0	0	0	0
NVSI	20	20	20	20	20	20	20	20
Soil matrix scouring								
KSER	8	8	8	8	8	8	8	8
JSER	2	2	2	2	2	2	2	2
KGER	0	0	0	0	0	0	0	0
JGER	2	2	2	2	2	2	2	2
IMPERVIOUS LAND USE								

Parameter	Commercial	High density residential	Industrial	Low density residential	Mixed urban	Port activities
KEIM	0.05	0.1	0.35	0.15	0.05	0.35
JEIM	2	2	2	2	2	1.75
ACCSDP	0.004	0.004	0.004	0.004	0.004	0.004
REMSDP	0.025	0.025	0.025	0.025	0.025	0.025

Parameter Descriptions:

- *SMPF* is the supporting management practice factor.
- *KRER* is the coefficient in the soil detachment equation.
- *JRER* is the exponent in the soil detachment equation.
- *AFFIX* is the fraction by which detached sediment storage decreases each day as a result of soil compaction.
- *COVER* is the fraction of land surface which is shielded from rainfall erosion.
- *NVSI* is the rate at which sediment enters detached storage from the atmosphere negative value may be used to simulate removal by human activity or wind.
- *KSER* is the coefficient in the detached sediment washoff equation.
- *JSER* is the exponent in the detached sediment washoff equation.
- *KGER* is the coefficient in the matrix soil scour equation, which simulates gully erosion.
- *JGER* is the exponent in the matrix soil scour equation, which simulates gully erosion.
- *KEIM* is the coefficient in the solids washoff equation.
- *JEIM* is the exponent in the solids washoff equation.
- *ACCSDP* is the rate at which solids accumulate on the land surface.
- *REMSDP* is the fraction of solids storage which is removed each day when there is no runoff.

To assess the predictive capability of the model, the output was graphically compared to observed data. Similar to the hydrology simulations, predicted TSS was compared to observed TSS from sampling events at East Stearns Street.

The sediment validation results over time are presented in Figure 7 and Figure 8 shows the comparison of modeled and observed TSS concentrations by flow. Overall, the model appears to reproduce the magnitude of observed data reasonably well. Similar to the hydrology results, these discrepancies are well within acceptable modeling ranges. Deviations from the observed data may be caused by localized conditions that are not captured as input to the model.

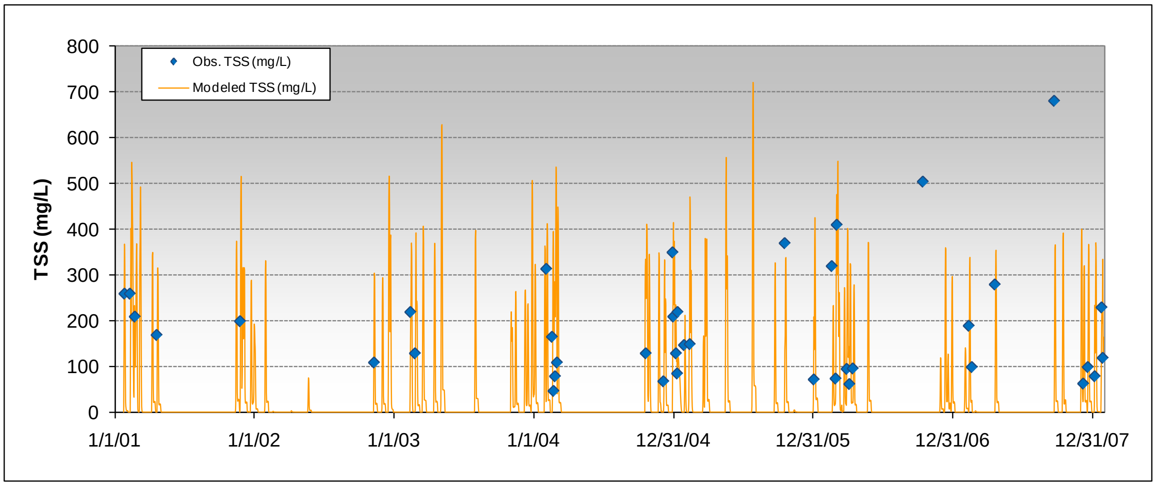

Figure 7. Modeled and Observed TSS Time-series

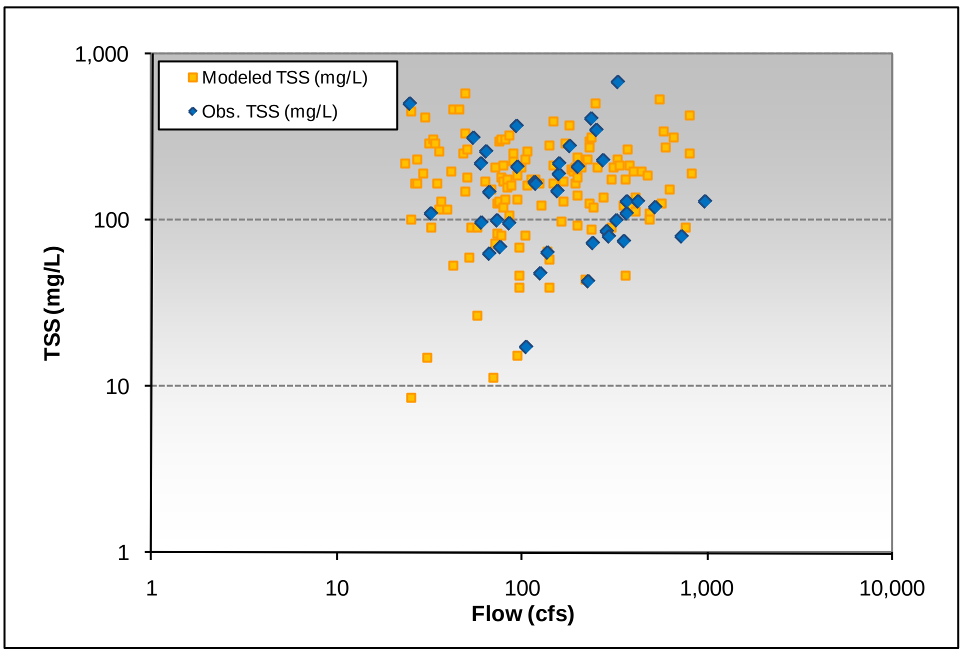

Figure 8. Modeled and Observed Wet Weather TSS Concentrations by Flow

2.2.3. Metals Validation

The regional modeling approach described above for sediment (SCCWRP, 2004; Tetra Tech, Inc, 2004 & 2005) was also applied to simulate metals in the freshwater portion of the Los Cerritos Channel watershed (with minor modifications to model configuration, as previously discussed). Copper, lead, and zinc were represented in the model through their association with sediment. After using the sediment module to simulate TSS, metals associated with sediment were simulated using the LSPC water quality module. The relationships between sediment and copper, lead, and zinc were simulated using the POTFW parameter. POTFW is the washoff potency factor or the ratio of constituent yield to sediment outflow. A unique value for POTFW can be assigned for each constituent and these values can vary by land use. The regionally calibrated POTFW parameter values applied to the LCC model domain are presented in Table 5. The lead and zinc values (Ackerman et al., 2005; SCCWRP, 2004) have been validated as part of several other modeling studies (Tetra Tech, Inc., 2004, 2005, and 2006), while the copper potency factors are revised values (Ackerman and Weisberg, 2006) and this application is the first known validation (other than the original study) .

Table 5. Metals Washoff Potency Factors

Land Use	Copper	Lead	Zinc
Agriculture	0.6	0.1	2.5
Commercial	1	1	10.2
High density residential	0.6	0.8	7.5
Industrial	0.3	0.15	4
Low density residential	0.3	0.2	1.2
Mixed urban	0.8	0.25	5
Open	0.15	0.1	2.5

To assess the predictive capability of the model, the output was graphically compared to observed data. Similar to the previous simulations, predicted copper, lead, and zinc were compared to observed concentrations at East Stearns Street. Model results for metals concentrations are presented in Figure 9 through Figure 14. Specifically, Figure 9, Figure 11, and Figure 13 illustrate the time-series results for copper, lead, and zinc, respectively. Figure 10, Figure 12, and Figure 14 show comparisons between modeled and observed copper, lead, and zinc concentrations, respectively, by wet weather flow (greater than 22.86 cfs). The time-series graphs illustrate that, for copper, lead, and zinc, the predicted concentrations are slightly lower than the observed concentrations for the measured storms; however, other, unmonitored storms show higher predicted concentrations (except zinc in which the simulated values do not reach the magnitude of observed concentrations [Figure 13]). The figures representing the concentrations by flow indicate that the model is capturing the magnitude of observed data reasonably well. These model results are within acceptable modeling ranges. Deviations from the observed data may be caused by localized conditions that are not captured as inputs to the model.

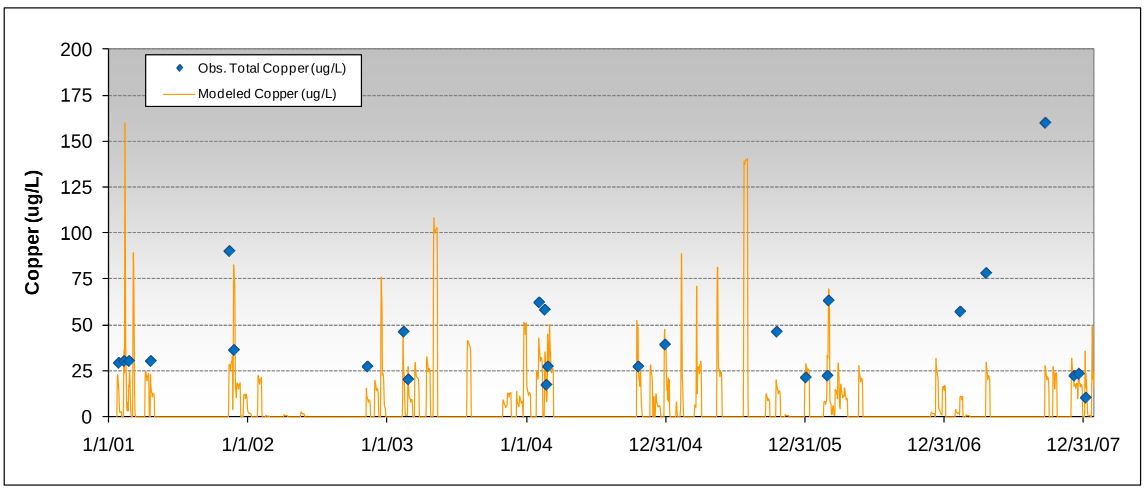

Figure 9. Modeled and Observed Copper Time-series

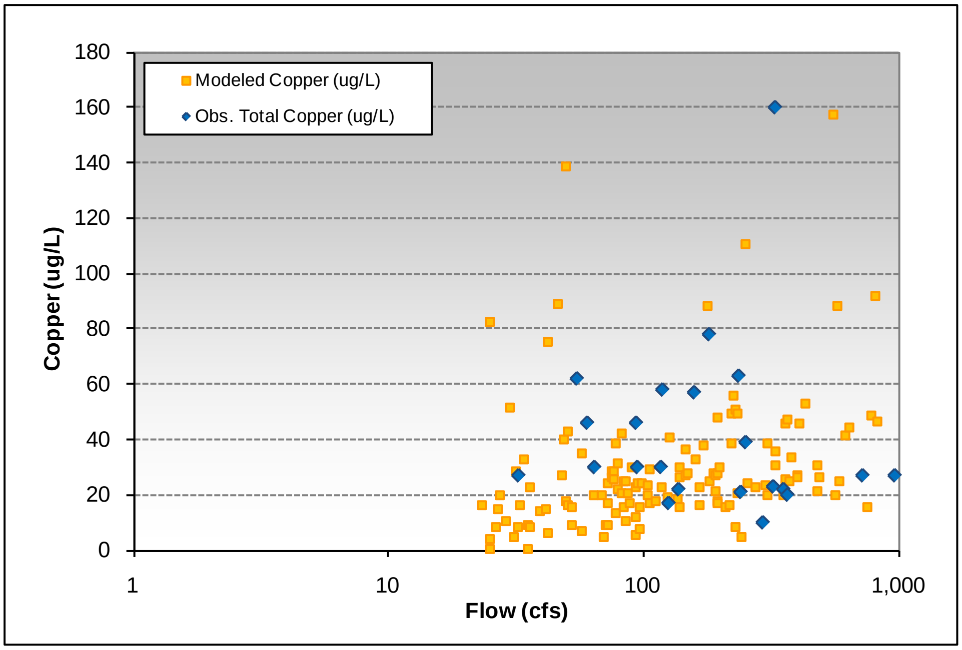

Figure 10. Modeled and Observed Wet Weather Copper Concentrations by Flow

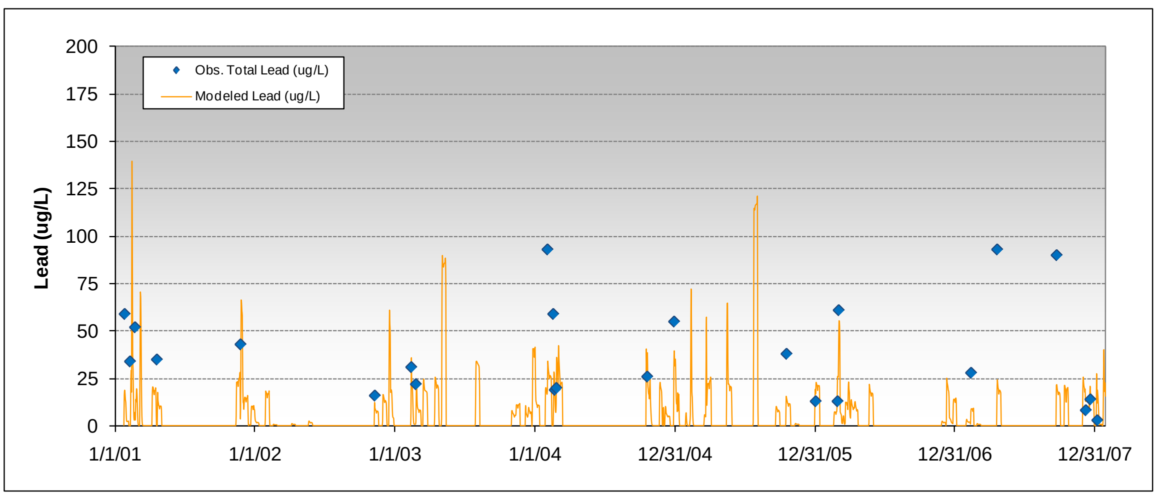

Figure 11. Modeled and Observed Lead Time-series

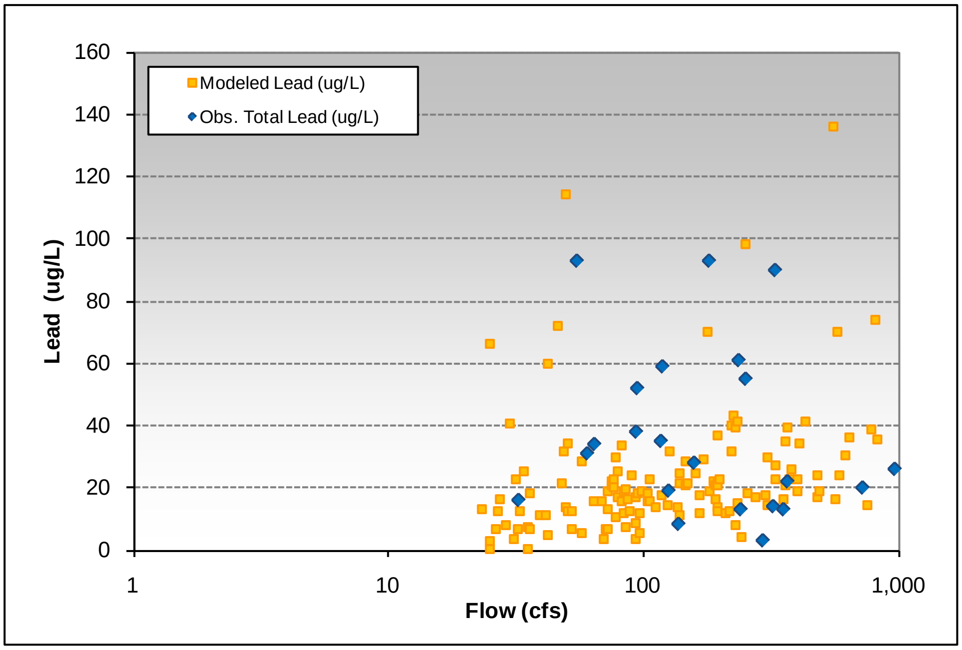

Figure 12. Modeled and Observed Wet Weather Lead Concentrations by Flow

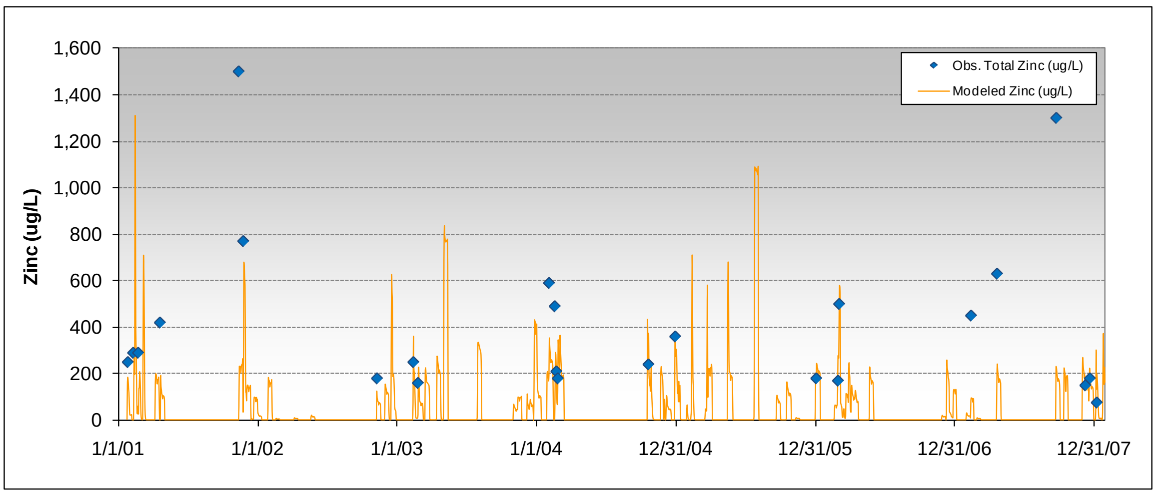

Figure 13. Modeled and Observed Zinc Time-series

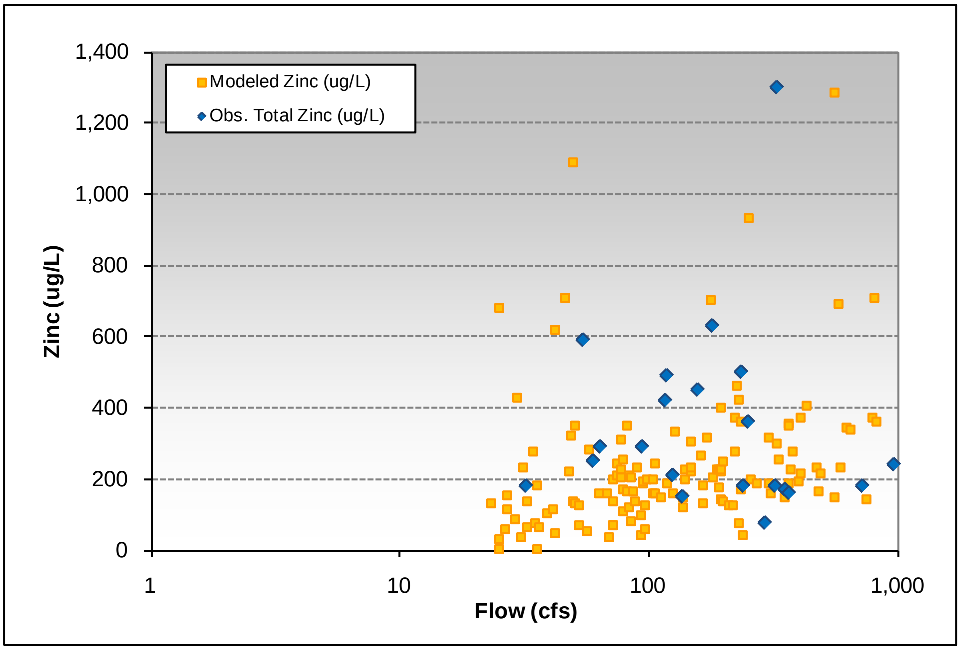

Figure 14. Modeled and Observed Wet Weather Zinc Concentrations by Flow

In addition to the graphical comparisons, summary statistics were calculated for comparison of both event mean concentrations (EMC) and loads for all monitoring dates during the simulation period. These results are presented in Table 6 and Table 7, respectively. Specifically, these tables present the units, number of paired data, simulated and observed mean and median, and percent difference for the mean and median for TSS, copper, lead, and zinc. These summary statistics indicate that the modeled and observed mean EMCs differed by 20 to 49 percent; all mean EMC values were underpredicted (Table 6). The percent difference for mean modeled and observed loads ranged from 10 to 37percent, while the percent difference for median modeled and observed loads ranged from 33 to 51 percent (Table 7).

Table 6. Modeled and Observed Event Mean Concentration Summary Statistics (2001-2008)

	Total Suspended Solids	**Total Copper**	**Total Lead**	**Total Zinc**
Units	mg/L	ug/L	ug/L	ug/L
Number of Paired Data (2001 – 2008)	40	29	29	28
Simulated Mean	149	40	30	333
Observed Mean	266	51	59	508
Percent Difference (%) [a]	-43.8%	-20.1%	-48.5%	-34.6%
Simulated Median	135	34	25	284
Observed Median	180	30	35	290
Percent Difference (%) [a]	-25.2%	12.1%	-29.2%	-2.0%

[a] Percent Difference = (Simulated – Observed)/(Observed)

Table 7. Modeled and Observed Load Summary Statistics

	Total Suspended Solids	Total Copper	Total Lead	Total Zinc
Units	lb/day	lb/day	lb/day	lb/day
Number of Paired Data (2001 – 2008)	40	29	29	28
Simulated Mean	229,382	65	49	528
Observed Mean	334,593	72	78	705
Percent Difference (%) [a]	-31.4%	-10.4%	-36.9%	-25.1%
Simulated Median	138,804	29	21	248
Observed Median	208,030	51	43	469
Percent Difference (%) [a]	-33.3%	-43.7%	-50.7%	-47.1%

[a] Percent Difference = (Simulated – Observed)/(Observed)

3. Model Assumptions

Assumptions are inherent to the modeling process as the model user attempts to represent the actual system as accurately as possible. The assumptions associated with the LSPC model and its algorithms are described in the HSPF User's Manual (Bicknell et al., 2001). There were several additional modeling assumptions used in the model, which are described below.

- Land use practices are consistent for all that fall within a given category and associated modeling parameters are transferable between subbasins.
- Sediment wash off from pervious areas occurred via detachment of the soil matrix for the wet-weather model. This process was considered uniform regardless of the land use type or season.
- Sediment in the watershed consisted of 5% sand, 65% clay, and 30% silt.
- For the wet-weather model, trace metals were linearly related to total suspended solids. As described in SCCWRP (2004), analysis of stormwater data supports this assumption.
- Trace metals were bound to a particle during wet-weather wash off until they dissociated upon reaching the receiving waterbody.
- No further calibration was required for flow, sediment, or water quality parameters in the model.

4. Model Application and Conclusions

The model of the freshwater portion of the LCC watershed was based on previously calibrated and validated modeling parameters and is considered an additional validation of these parameters; however, several changes were made during model configuration to more accurately represent local conditions. As indicated above, the model predicted observed flow, sediment, copper, lead, and zinc within acceptable modeling ranges. Differences were likely due to localized conditions that were not accurately represented as model input (i.e., either storms recorded at the weather station did not occur in the LCC watershed [or did not occur at the same intensity] or localized storms observed in the LCC watershed were not recorded at the weather station).

The wet weather model output can be used in various ways to support TMDL development and implementation. For instance, the results were summarized to evaluate the spatial distribution of metals loadings. Figure 15 illustrates the copper, lead, and zinc loading rates by model subbasin in pounds per acre per year (lb/acre/year). This figure indicates that the highest loading rates are generally located near the top of the watershed for all three metals (with additional high loadings for zinc in the southwest corner). Table 8 presents the average annual loading rates by land use for copper, lead, and zinc. The high density residential land use has the highest loadings for lead, while the industrial land use has the highest loading for copper and zinc.

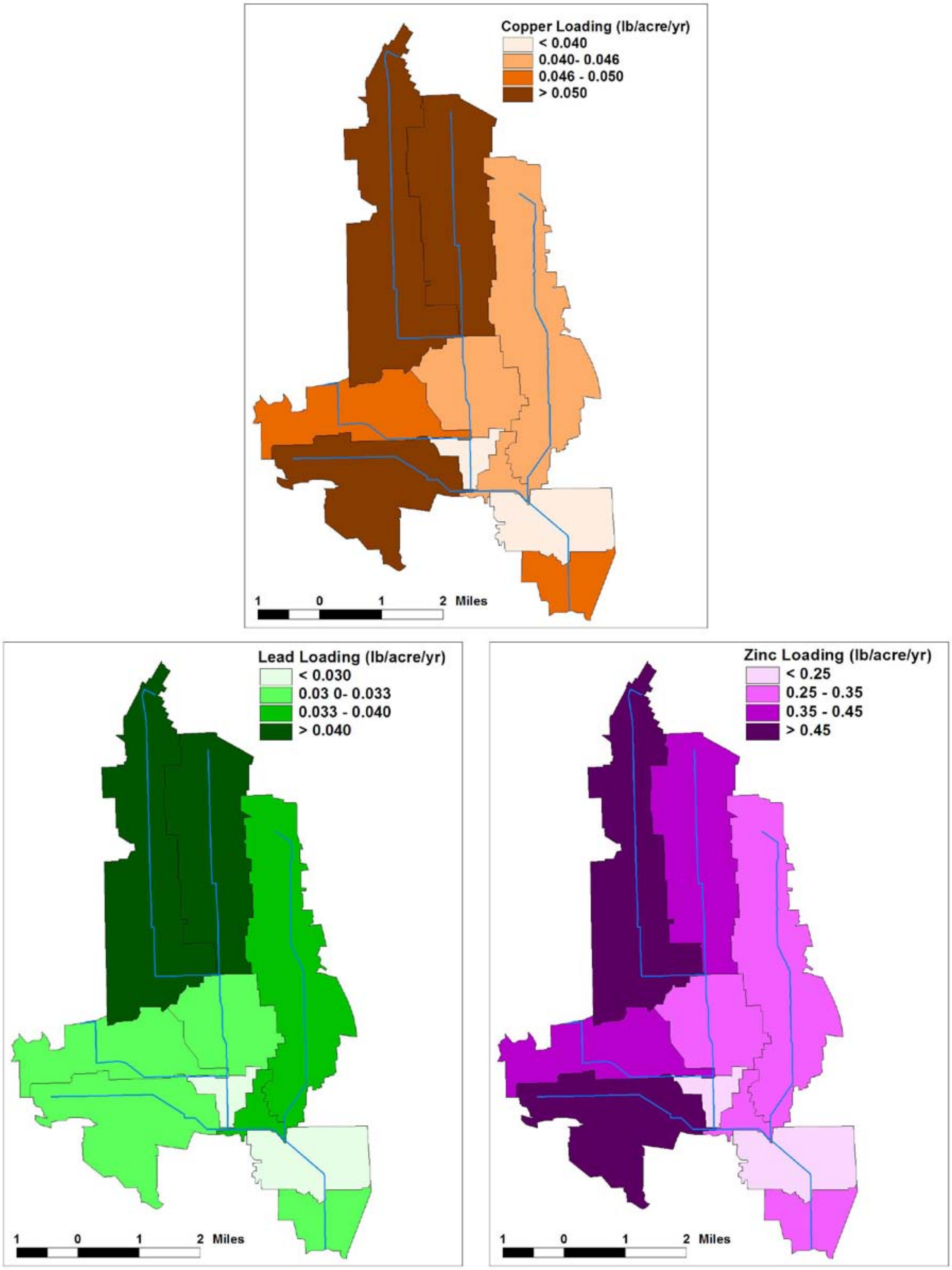

Figure 15. Metal Loadings by Subbasin (lb/acre/year)

Table 8. Average Annual Modeled Loading Rates by Land Use

Land Cover Category	Copper (lb/ac/yr)	Lead (lb/ac/yr)	Zinc (lb/ac/yr)
Agriculture	3.170E-08	5.283E-09	1.321E-07
Commercial	7.094E-02	7.094E-02	7.236E-01
High Density Residential	7.970E-02	1.063E-01	9.963E-01
Industrial	8.182E-02	4.091E-02	1.091E+00
Low Density Residential	4.250E-02	2.834E-02	1.700E-01
Mixed Urban	4.081E-02	1.275E-02	2.551E-01
Open	8.031E-08	5.354E-08	1.338E-06

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APPENDIX F

Los Cerritos Flow Summary

Key	Date			Flow (cfs)								
	From	To	Count	Min	Avg	Max	50th	60th	70th	80th	90th	95th
1	10/1/1949	9/30/1955	2,191	0.00	6.21	836.00	0.00	0.00	0.20	0.40	2.50	17.85
2	10/1/1955	4/30/1991	7,882	0.00	7.74	1,460.00	1.00	1.20	1.43	1.70	3.00	14.70
3	***1/23/2001***	***3/19/2008***	***2,052***	***0.00***	***15.70***	***975.11***	***0.00***	***0.00***	***0.00***	***6.93***	***21.39***	***60.06***
4	***1/23/2001***	***3/19/2008***	***2,052***	***2.35***	***17.75***	***975.20***	***2.35***	***2.35***	***2.35***	***9.11***	***22.86***	***60.37***
5	***1/23/2001***	***3/19/2008***	***2,052***	***18.70***	***31.33***	***975.66***	***18.70***	***18.70***	***18.70***	***19.76***	***28.30***	***63.15***

1. Historic gage at Anaheim (bottom of freshwater portion of the Channel). USGS Station F279B.

2. Historic gage at Stearns (approx. 1 mile upstream from the historic Anaheim station). USGS Station F279C.

3. City of Long Beach gage at Stearns. Sampler only records flows of 18.8 cfs or higher. Data reflects average daily flows with zeros to represent flows < 18.8 cfs. This scenario shows minimum possible flow.

4. City of Long Beach gage at Stearns. Sampler only records flows of 18.8 cfs or higher. Data reflects average daily flows with 2.35 cfs to represent flows < 18.8 cfs.

5. City of Long Beach gage at Stearns. Sampler only records flows of 18.8 cfs or higher. Data reflects average daily flows with 18.7 cfs to represent flows < 18.8 cfs. This scenario shows maximum possible flow.