APPENDIX E
QUAL2K INPUT, DATA PREPARATION, AND MODEL ASSUMPTIONS FOR THE LA PLATA DISSOLVED OXYGEN TMDL

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Dissolved Oxygen TMDL Development

This section provides a description of the technical approach used to develop the dissolved oxygen TMDL for the La Plata River (McDermott Arroyo to Colorado border). The methodology is developed based on project objectives, data availability, model applicability, and consideration of critical condition and seasonal variation.

In order to ensure that the dissolved oxygen standards for the La Plata River are met under the critical environmental conditions, the QUAL2K (Q2K) model runs concentrated on dissolved oxygen simulations. Excessive algal growth impacts diurnal dissolved oxygen fluctuations, with higher dissolved oxygen in stream during the daylight hours due to algal photosynthesis process and lower dissolved oxygen concentrations during the nighttime due to plant respiration. These diurnal swings in dissolved oxygen could cause the in-stream dissolved oxygen to fall below the minimum dissolved oxygen allowed by the water quality standards (i.e. 6.0 mg/L). The magnitude of the diurnal swing could have a stressing effect on aquatic life if it is too large. Q2K links plant respiration and photosynthesis as well as other oxygen demanding substances such as carbonaceous biological oxygen demand (CBOD), the nitrification process (which uses oxygen to reduce organic nitrogen to ammonia and then to nitrite/nitrate) and sediment demands of organic substances to in-stream oxygen levels.

During the 2002 water quality survey of the La Plata River, diurnal data was collected at Surface Water Quality Bureau (SWQB) station 14 (Figure 1). This data showed diurnal swings of dissolved oxygen and these daily swings ranged from about 3.27 mg/L dissolved oxygen to as much as 8.91 mg/L.

Data collection efforts for the Q2K model should include measurements and observations to collect local data necessary to modify the model to local conditions. The measurements required for Q2K include meteorological data, flow data, field water quality measurements (temperature, dissolved oxygen, pH, etc.) as well as eutrophication impairment-related parameters such as nutrients, oxygen-demanding substances, and Total Suspended Solids (TSS). Biological data, such as local periphyton algae biomass distribution and density, are also important inputs for the model.

The Q2K model configuration involves setting up model reaches and setting initial conditions, boundary conditions, and hydraulic and kinetic parameters for the hydrodynamic and water quality simulations. The model was run for the assessment unit La Plata River (McDermott Arroyo to Colorado Border) and was divided into two reaches (i.e. above Cunningham Ditch to the Colorado Border and below Cunningham Ditch to McDermott Arroyo) (see Figure 1). Each reach had one sampling station and two irrigation ditches that were active during the modeling period. Ideally the assessment unit would have been further divided into smaller reaches approximately 1 kilometer (km) long, but because only limited data at two stations was available additional splitting was not practical.

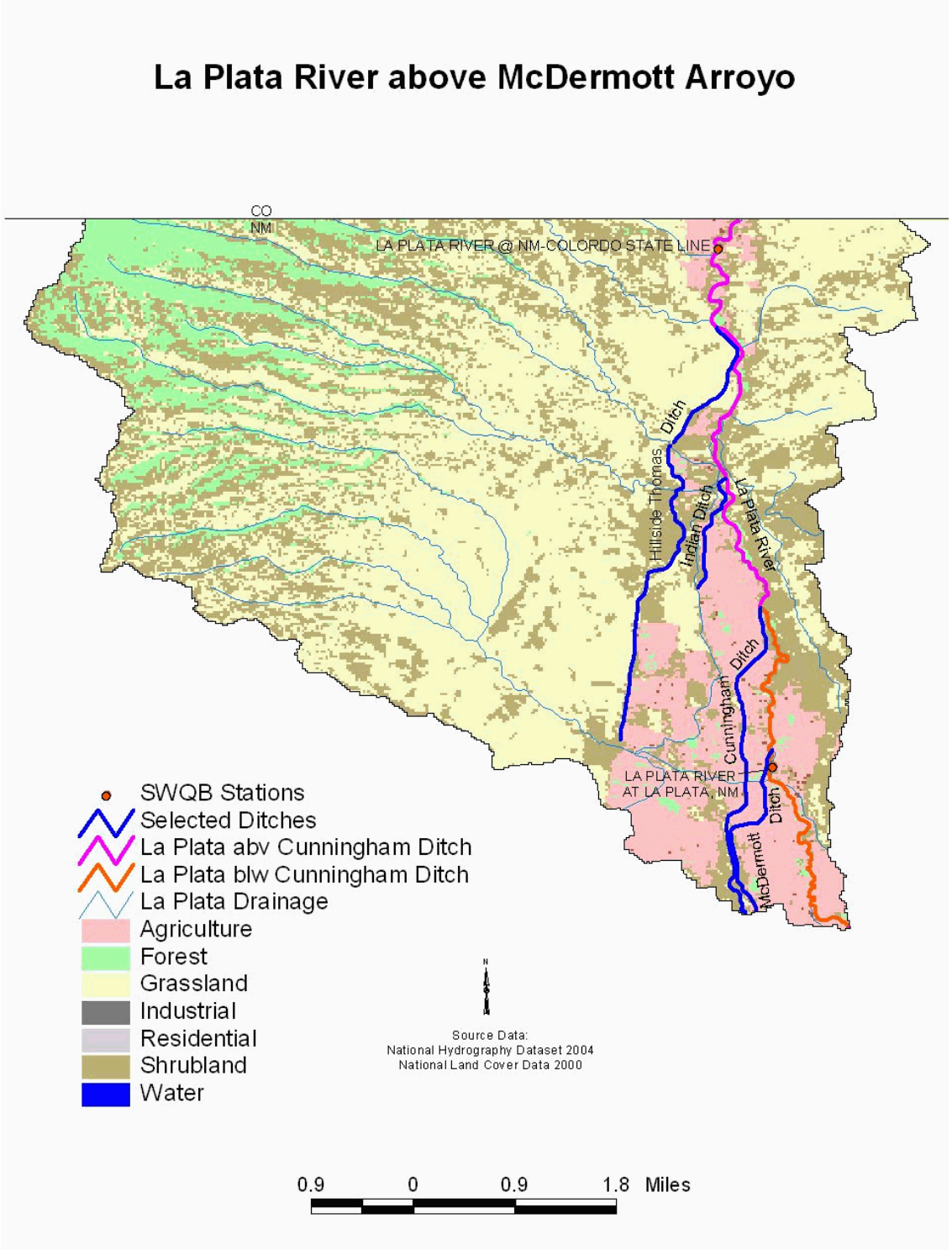

Figure 1: Q2K Model Segmentation for La Plata River Dissolved Oxygen TMDL Development

Data/Parameter Input

Whenever possible, input data for the Q2K model were based on field observed flow and water quality data, but the data collection performed on the La Plata River in 2002 was not specifically designed to meet the data requirements for Q2K. Therefore, additional data collected by the U.S. Geological Survey (USGS) had to be used to supplement the SWQB data. Additionally, some default values in the Q2K model were not modified because sufficient information was not available to determine the correct values for the La Plata River.

The following sections list the input parameters for Q2K based on the worksheets within the Q2K model.

Headwaters Worksheet

The USGS gage at the NM-Colorado border (09366500) was considered the headwaters of the La Plata River for the Q2K model. The model was run for June 20, 2002 because this date was within the critical period for dissolved oxygen and diurnal sonde data at SWQB station 14 was available for this date. Water quality grab sample data collected at SWQB station 13 located approximately 0.3 miles downstream from the USGS gage was used as the headwaters data. Table 1 lists the Q2K model headwaters worksheet input data and where this data was obtained. The headwaters worksheet asks for hourly water quality data, but this data was not available at SWQB station 13 therefore it was assumed for the model input that the data remained constant throughout the day.

Reach Worksheet

The majority of information used for the Reach worksheet was obtained using Geographic Information Systems (GIS) data. The depth and velocity information needed for the rating curves was obtained from the USGS for the NM-Colorado gage (09366500) and field measurements collected by SWQB staff were used for the La Plata gage (09367000). The equations for the rating curves are described in Section 3.2.2 of the Q2K Documentation and Users Manual (Chapra and Pelletier, 2003). The input parameters for the Reach worksheets are presented in Table 2.

Table 1. Headwaters Data Input

Headwater Parameters	Input Value	Data Obtained From
Headwater Flow	0.0569 m^3/s	USGS gage 09366500 for 6/20/02
Temperature	25.80°C	SWQB sonde data from 6/17/02
Conductivity	964 umhos	SWQB sonde data from 6/17/02
Inorganic Solids	7.00 mg/L	No ISS data available, so SWQB TSS data from 6/17/02 was used
Dissolved Oxygen	9.07 mg/L	SWQB sonde data from 6/17/02
CBODslow	11.00 mg/L	Based on calibration of the model
CBODfast	11.00 mg/L	Based on calibration of the model
Dissolved Organic Nitrogen	218.00 ug/L	SWQB 6/17/02 data (Total Kjehldal Nitrogen - 1/2 Ammonia [detection limit])
NH4-Nitrogen	50.00 ug/L	SWQB 6/17/02 data (Reported as Nitrate + Nitrate, 1/2 detection limit was used)
NO3-Nitrogen	50.00 ug/L	SWQB 6/17/02 data (Reported as Nitrate + Nitrate = <100 ug/L, 1/2 detection limit was used)
Dissolved Organic Phosphorus	10.00 ug/L	SWQB 6/17/02 data (TP = <30 ug/L, Inorganic P was likely to be higher in this system)
Inorganic Phosphorus	20.00 ug/L	SWQB 6/17/02 data (TP = <30 ug/L, Inorganic P was likely to be higher in this system)
Phytoplankton	NA	No data available, left blank
Detritus	NA	No data available, left blank
Pathogen	18.5 cfu/100mL	SWQB 8/20/02 data
Alkalinity	178.67 mg/L	Average of SWQB 4/17/02, 8/20/02 and 9/16/02 data
pH	7.91 s.u.	SWQB sonde data from 6/17/02

NA = Not available.

Table 2. Reach Data Input

Reach	Headwater	La Plata 1	La Plata 2	Data Obtained From
Downstream end of Reach		**Cunningham Ditch**	**McDermott Arroyo**	
Downstream Location (km from CO-NM Border)	0	7.6	13.8	GIS coverage
Elevation				
Upstream (m)	NA	1823	1769	GIS coverage
Downstream (m)	1823	1769	1725	GIS coverage
Downstream				
Latitude	36°59'56"	36°56'58"	36°54'30"	GIS coverage
Longitude	108°11'21"	108°11'11"	108°10'30"	GIS coverage
Rating Curves				
Velocity				
Coefficient	1.276	1.276	19.16	Calculated[(a)]
Exponent	0.43	0.43	0.43	Q2K Manual (Typical Value)
Depth				
Coefficient	3.7196	3.7196	6.0196	Calculated[(a)]
Exponent	0.45	0.45	0.45	Q2K Manual (Typical Value)
Prescribed Dispersion (m2/s)	NA	NA	NA	No data available, left blank
Weir Height (m)	NA	NA	NA	No data available, left blank
Prescribed Reaeration (/d)	NA	0.10	0.10	Based on best professional judgment
Bottom Algae Coverage (%)	NA	10	75	SWQB Habitat assessment
Bottom SOD Coverage (%)	NA	3	25	SWQB field measurement (percent fines)
Prescribed SOD (gO2/m2/d)	NA	NA	NA	No data available, left blank
Prescribed CH4 flux (gO2/m2/d)	NA	NA	NA	No data available, left blank
Prescribed NH4 flux (mgN/m2/d)	NA	NA	NA	No data available, left blank
Prescribed Inorg P flux (mgP/m2/d)	NA	NA	NA	No data available, left blank

NA = Not available.

(a) Velocity and depth coefficients were calculated using the following equations from Section 3.2.2 (Chapra and Pelletier 2003):

$U = aQ^b$

$H = \alpha Q^\beta$

Where;

$b = 0.43$

$\beta = 0.45$

U = velocity (m/s)

H = depth (m)

Q = flow (m^3/s).

Meteorological Data Worksheets

The meteorological data needed for the air temperature, dew point temperature, wind speed, and cloud cover worksheets were collected at the Farmington, NM weather station. All of this information was available for June 20, 2002 at Weather Underground (www.wunderground.com). This website also provided all of the hourly information required for the Q2K model. Using data from the Farmington weather station was not ideal, but the required data was not available for the town of La Plata, NM. Farmington and La Plata are only about 16 miles apart and weather patterns for the two areas are very similar. The same meteorological data was used for both the La Plata 1 and La Plata 2 reaches in the model.

The cloud cover data was provided at Weather Underground as conditions (i.e. clear, smoke, partly cloudy, or mostly cloudy). Since the Q2K model requires percents for the input data percent values were assigned to each of these conditions (i.e. clear = 0%, smoke = 10%, partly cloudy = 25%, and mostly cloudy = 50%).

The shade data used for the shade worksheet was based on estimates obtained from aerial photography digitized on a topographic map of the La Plata watershed. Estimates were then compared to notes taken in the field and the resulting percents were discussed with the field crew that performed the sampling survey in 2002. The Q2K asks for hourly input of shade values but this information was not available so the same percents were used for daylight hours and 100% shade was used for the period from one hour before sundown to one hour after sunrise. The percent shade for each of the reaches (i.e. La Plata 1 and La Plata 2) is based on the average shade amounts for that particular reach.

Table 3 presents the meteorological data used for the air temperature, dew point temperature, wind speed, cloud cover, and shade worksheets.

Table 3. Meteorological Data Input

Time	Air Temp (^oC)	Dew Point Temp (^oC)	Wind Speed (m/s)	Cloud Cover (%)	Shade (%)	
					La Plata 1	La Plata 2
12:00 AM	15.60	11.70	4.11	0.0%	100.0%	100.0%
1:00 AM	15.60	11.70	2.06	0.0%	100.0%	100.0%
2:00 AM	13.90	12.80	2.58	0.0%	100.0%	100.0%
3:00 AM	13.30	12.80	2.58	0.0%	100.0%	100.0%
4:00 AM	11.70	11.10	2.58	0.0%	100.0%	100.0%
5:00 AM	13.90	8.90	4.64	0.0%	100.0%	100.0%
6:00 AM	14.00	7.00	5.67	0.0%	100.0%	100.0%
7:00 AM	13.90	7.20	4.64	0.0%	100.0%	100.0%
8:00 AM	16.70	6.10	4.64	0.0%	100.0%	100.0%
9:00 AM	18.30	3.30	3.61	0.0%	50.0%	25.0%
10:00 AM	22.20	1.10	2.06	0.0%	50.0%	25.0%
11:00 AM	26.70	0.60	3.08	0.0%	50.0%	25.0%
12:00 PM	28.90	1.70	2.58	10.0%	50.0%	25.0%
1:00 PM	31.10	3.30	1.56	10.0%	50.0%	25.0%
2:00 PM	32.20	5.00	7.20	10.0%	50.0%	25.0%
3:00 PM	35.00	6.70	6.17	10.0%	50.0%	25.0%
4:00 PM	36.70	6.10	6.69	0.0%	50.0%	25.0%
5:00 PM	36.10	6.10	8.75	0.0%	50.0%	25.0%
6:00 PM	36.10	6.70	6.69	0.0%	50.0%	25.0%
7:00 PM	34.40	5.60	10.28	0.0%	50.0%	25.0%
8:00 PM	30.60	3.30	2.06	0.0%	100.0%	100.0%
9:00 PM	30.00	2.20	1.56	25.0%	100.0%	100.0%
10:00 PM	28.90	1.70	1.56	25.0%	100.0%	100.0%
11:00 PM	26.00	7.00	14.42	50.0%	100.0%	100.0%

Rate/Light and Heat Worksheets

The default/recommended water column rates within the Q2K model were used for the La Plata River dissolved oxygen model. Table 4 lists the water column rate values. The default Q2K values were also used for the light and heat worksheet (Table 5).

Table 4. Water Column Rate Input

Parameter	Value	Units	Symbol
Stoichiometry:			
Carbon	40	mgC	gC
Nitrogen	7.2	mgN	gN
Phosphorus	1	mgP	gP
Dry weight	100	mgD	gD
Chlorophyll	1	mgA	gA
Inorganic suspended solids:			
Settling velocity	1	m/d	v_i
Oxygen:			
Reaeration model	Internal		
Temp correction	1.024		θ_a
O2 for carbon oxidation	2.69	gO2/gC	r_{oc}
O2 for NH4 nitrification	4.57	gO2/gN	r_{on}
Oxygen inhib CBOD oxidation model	Exponential		
Oxygen inhib CBOD oxidation parameter	0.60	L/mgO2	K_{socf}
Oxygen inhib nitrification model	Exponential		
Oxygen inhib nitrification parameter	0.60	L/mgO2	K_{sona}
Oxygen enhance denitrification model	Exponential		
Oxygen enhance denitrification parameter	0.60	L/mgO2	K_{sodn}
Slow CBOD:			
Hydrolysis rate	2	/d	k_{hc}
Temp correction	1.047		θ_{hc}
Fast CBOD:			
Oxidation rate	4	/d	k_{dc}
Temp correction	1.047		θ_{dc}
Organic N:			
Hydrolysis	0.05	/d	k_{hn}
Temp correction	1.07		θ_{hn}
Ammonium:			
Nitrification	4	/d	k_{na}
Temp correction	1.07		θ_{na}
Nitrate:			
Denitrification	1	/d	k_{dn}
Temp correction	1.07		θ_{dn}
Sed denitrification transfer coeff	0	m/d	v_{di}
Temp correction	1.07		θ_{di}
Organic P:			
Hydrolysis	2	/d	k_{hp}
Temp correction	1.07		θ_{hp}

Phytoplankton:			
Max Growth	2.5	/d	k_{qp}
Temp correction	1.07		θ_{qp}
Respiration	0.1	/d	k_{rp}
Temp correction	1.07		θ_{rp}
Death	0	/d	k_{dp}
Temp correction	1		θ_{dp}
Nitrogen half sat constant	15	ugN/L	k_{sPp}
Phosphorus half sat constant	2	ugP/L	k_{sNp}
Light model	Half saturation		
Light constant	57.6	langleys/d	K_{Lp}
Ammonia preference	25	ugN/L	k_{hnxp}
Settling velocity	0.15	m/d	v_a
Bottom Algae:			
Max Growth	60	gD/m^2/d	C_{qb}
Temp correction	1.07		θ_{qb}
Respiration	1	/d	k_{rb}
Temp correction	1.07		θ_{rb}
Death	0.25	/d	k_{db}
Temp correction	1.07		θ_{db}
Nitrogen half sat constant	300	ugN/L	k_{sPb}
Phosphorus half sat constant	100	ugP/L	k_{sNb}
Light model	Half saturation		
Light constant	50	langleys/d	K_{Lb}
Ammonia preference	25	ugN/L	k_{hnxb}
Detritus (POM):			
Dissolution	5	/d	k_{dt}
Temp correction	1.07		θ_{dt}
Settling velocity	1	m/d	v_{dt}
Pathogens:			
Decay	0.8	/d	k_{dx}
Temp correction	1.07		θ_{dx}
Settling velocity	1	m/d	v_x
pH:			
Partial pressure of carbon dioxide	347	ppm	p_{CO2}

Table 5. Light and Heat Input

Parameter	Value	Unit	Symbol
Photosynthetically Available Radiation	0.47		
Background light extinction	0.2	*/m*	k_{eb}
Linear chlorophyll light extinction	0.0088	*1/m-(ugA/L)*	α_p
Nonlinear chlorophyll light extinction	0.054	*1/m-(ugA/L)2/3*	α_{pn}
ISS light extinction	0.052	*1/m-(mgD/L)*	α_t
Detritus light extinction	0.174	*1/m-(mgD/L)*	α_o
Solar shortwave radiation model			
Atmospheric attenuation model for solar	Bras		
Bras solar parameter			
atmospheric turbidity coefficient (2=clear, 5=smoggy, default=2)	2		n_{fac}
Downwelling atmospheric longwave IR radiation			
atmospheric longwave emissivity model	Brunt		
Evaporation and air convection/conduction			
wind speed function for evaporation and air convection/conduction	Brady-Graves-Geyer		

Point Sources/Abstractions Worksheets

There are no permitted point source facilities located on the La Plata River (McDermott Arroyo to Colorado Border). There are several irrigation diversion and return flow ditches located along the La Plata River. Approximate with irrigation withdrawal values were determined based by contacting the NM Office of the State Engineer's Water Master for the La Plata, but no information was available for the amount of irrigation water being returned to the river through the return flow ditches. Therefore the values had to be modified in order to keep the river channel from going dry. The flow at the SWQB station 14 was subtracted from the flow at the NM-Colorado border to determine the net loss in the river channel for June 20, 2002. A percentage of this net loss was assigned to four of the irrigation diversion ditches based on water rights (Table 6).

Table 6. Point Abstractions Input

Name	*Location (km)*	*Point Abstraction (m^3/s)*
Hillside-Thomas Ditch	2.30	0.0035
Indian Ditch	5.00	0.0310
Cunningham Ditch	7.10	0.0155
McDermott Ditch	9.70	0.0057

Diffuse Sources Worksheets

No data for diffuse sources (i.e. Nonpoint sources) was collected; therefore this sheet was left blank.

Hydraulics, Temperature, Water Quality, Diel Data Worksheets
All hydraulics data for the headwaters/SWQB station 13 was obtained from the USGS NM-Colorado gage (09366500) and hydraulics data for SWQB station 14 was provided by SWQB field studies. Hydraulic, temperature, and water quality data are presented in Table 7.

Diel data was available for SWQB station 14, but only for the parameters collected using a YSI sonde (i.e. conductivity, pH, dissolved oxygen, and temperature (Table 8).

Table 7. Hydraulics, Temperature, and Water Quality Data Input

Parameter	(SWQB station 13)	(SWQB station 14)	Data Obtained From
Distance from Headwaters (km)	0.60	9.96	GIS Coverage
Flow (m^3/s)	0.057	0.00014	Field data/USGS
Depth (m)	1.024	0.111	Field data/USGS
Velocity (m/s)	0.372	0.422	Field data/USGS
Travel time (/d)	0.002	0.2090	Field data/USGS
Mean Temp (C)	25.80	19.00	SWQB sonde data from 6/17/02
Min Temp (C)	NA	13.91	SWQB sonde data from 6/17/02
Max Temp (C)	NA	26.38	SWQB sonde data from 6/17/02
Conductivity (umhos)	964	1349.59	SWQB sonde data from 6/17/02
ISS (mg/L)	7.00	3.00	Field data
DO (mg/L)	9.07	5.91	SWQB sonde data from 6/17/02
Norg (ug/L)	218.00	226.00	SWQB 6/17/02 data (Total Kjehldal Nitrogen - 1/2 Ammonia [detection limit])
NH4 (ug/L)	50.00	50.00	SWQB 6/17/02 data (Reported as Nitrate + Nitrate, 1/2 detection limit was used)
NO3 (ug/L)	50.00	50.00	SWQB 6/17/02 data (Reported as Nitrate + Nitrate = <100 ug/L, 1/2 detection limit was used)
Porg (ug/L)	10.00	10.00	SWQB 6/17/02 data (TP = <30 ug/L, Inorganic P was likely to be higher in this system)
Inorg P (ug/L)	20.00	20.00	SWQB 6/17/02 data (TP = <30 ug/L, Inorganic P was likely to be higher in this system)
Pathogens (cfu/100 mL)	18.50	461.10	SWQB 13 = 8/20/02 data and SWQB 14 = 6/17/02 data
Alkalinity ($mgCaCO_3/L$)	178.67	191.00	SWQB 13 = Average of SWQB 4/17/02, 8/20/02 and 9/16/02 data; SWQB 14 = 6/17/02 data
pH	7.91	7.97	SWQB sonde data from 6/17/02
TN (ug/L)	268.00	276.00	SWQB 6/17/02 data (Total Kjehldal Nitrogen)

TP (ug/L)	30.00	30.00	SWQB 6/17/02 (TP = <30 ug/L, used detection limit)
TSS (mg/L)	7.00	3.00	SWQB 6/17/02 data
TOC	3.22	3.60	SWQB 6/17/02 data

Table 8. Diel Data Input

Time (hr)	*Temp Water (^oC)*	*cond (umhos)*	*DO (mg/L)*	*pH*
1.00	19.00	1349.00	3.68	7.73
2.00	17.98	1354.00	3.77	7.73
3.00	17.23	1355.00	3.68	7.72
4.00	16.57	1358.00	3.70	7.71
5.00	15.80	1365.00	3.73	7.71
6.00	15.26	1365.00	3.80	7.70
7.00	14.67	1366.00	4.00	7.71
8.00	14.13	1365.00	4.23	7.72
9.00	14.00	1363.00	4.65	7.74
10.00	14.13	1360.00	5.59	7.83
11.00	15.28	1355.00	7.04*	8.01
12.00	17.75	1352.00	8.27*	8.19
13.00	20.33	1347.00	8.91*	8.30
14.00	22.96	1341.00	9.03*	8.33
15.00	25.06	1333.00	9.07*	8.33
16.00	26.04	1325.00	9.05*	8.33
17.00	26.05	1322.00	8.63*	8.30
18.00	24.64	1328.00	7.68*	8.24
19.00	23.50	1334.00	7.00*	8.19
20.00	22.44	1340.00	6.59*	8.08
21.00	21.23	1345.00	5.99	8.04
22.00	20.94	1349.00	5.34	7.95
23.00	20.48	1354.00	4.69	7.88
24.00	19.85	1361.00	4.19	7.80

* Values exceeded the dissolved oxygen criteria of 6.0 mg/L

Model Calibration and Validation

Calibration data for ambient water quality were based on the SWQB field sampling effort in 2002. Channel dimensions and cross sections are based on field physical measurement taken by USGS. Rating curve coefficients and exponents were developed using the equations in Chapra and Pelletier (2003). Air temperature, dew point temperature, and wind speed were based on meteorological data from the Farmington weather station (available at http://www.wunderground.com/).

For water quality calibration, the modeled concentrations for the following parameters were compared with observed data in order to provide guidance on parameter adjustment: Temperature, pH, alkalinity, dissolved oxygen, Total Nitrogen (TN), and Total Phosphorus (TP) (see Figures 2-7). Overall, the model is considered reasonably calibrated because the model simulated pollutants of interest within the range shown by the observed data and the model reproduced the general water quality trends reasonably well throughout the system.

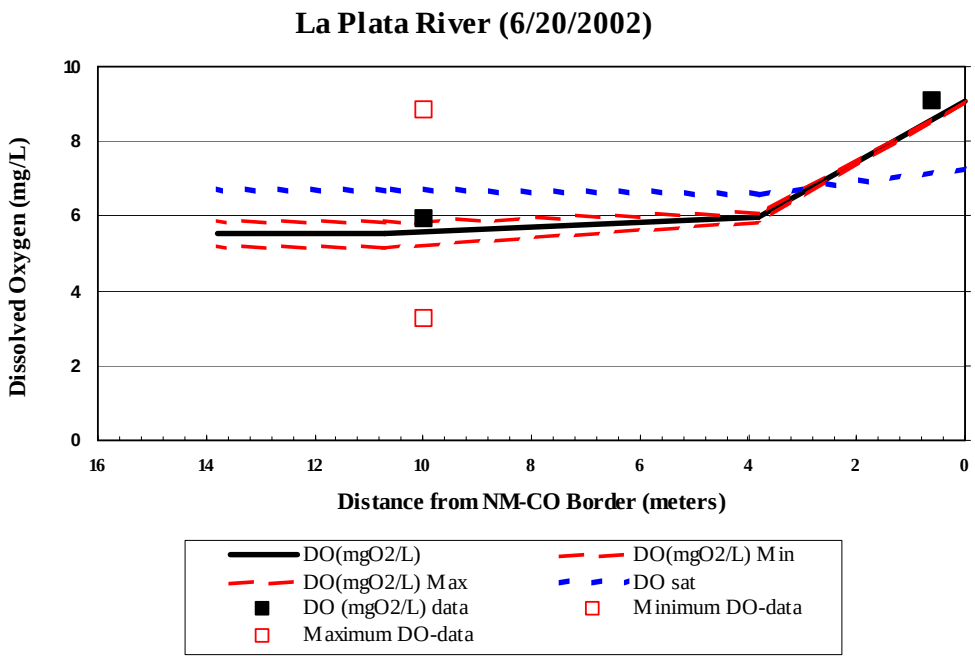

Figure 2. Model-Predicted Dissolved Oxygen Based on Existing Conditions for the La Plata River

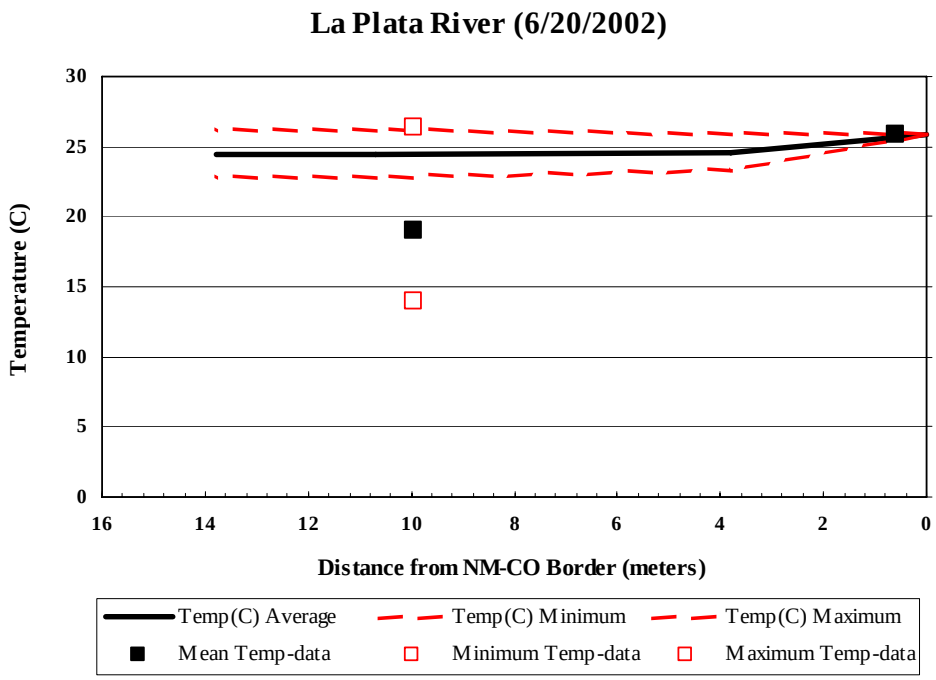

Figure 3. Model-Predicted Temperature Based on Existing Conditions for the La Plata River

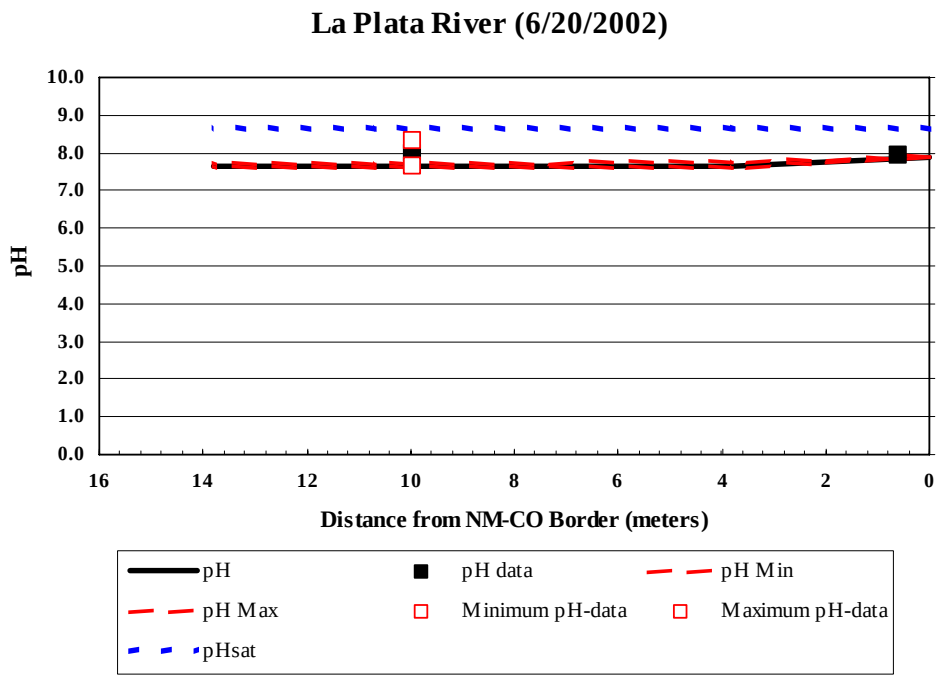

Figure 4. Model-Predicted pH Based on Existing Conditions for the La Plata River

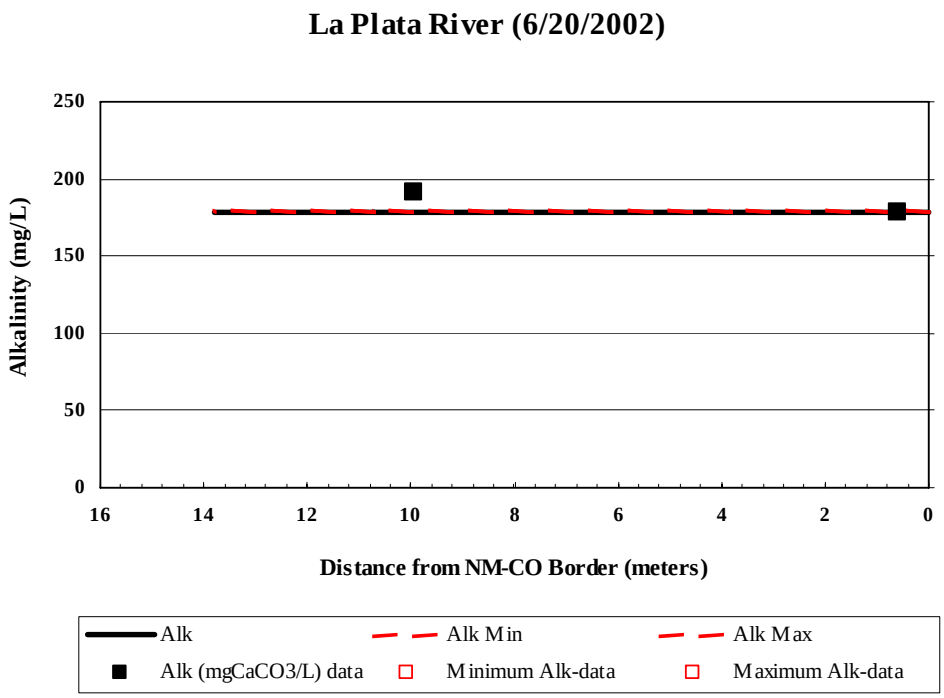

Figure 5. Model-Predicted Alkalinity Based on Existing Conditions for the La Plata River

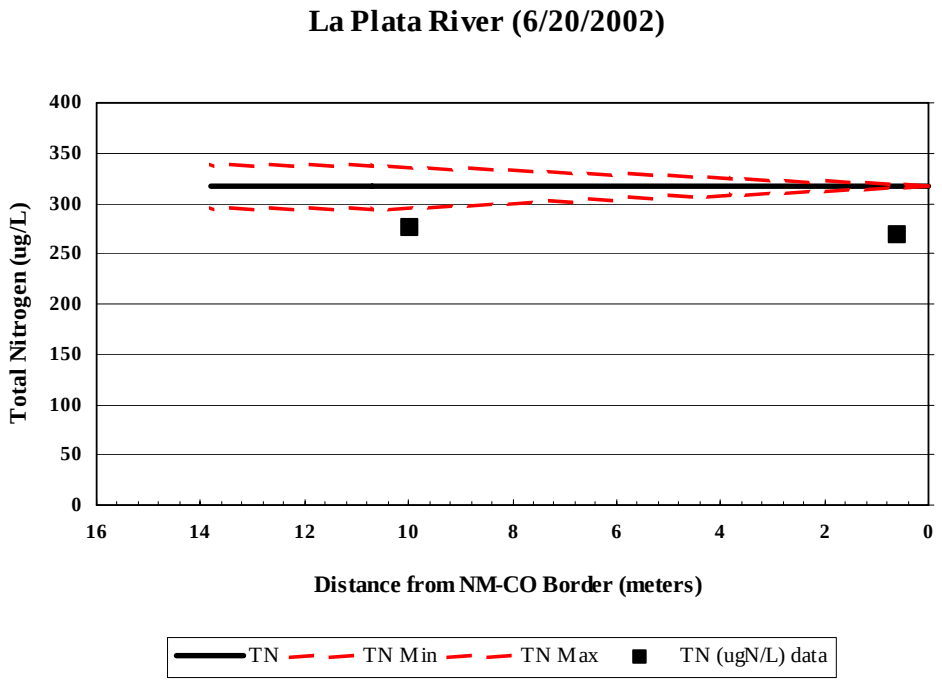

Figure 6. Model-Predicted Total Nitrogen Based on Existing Conditions for the La Plata

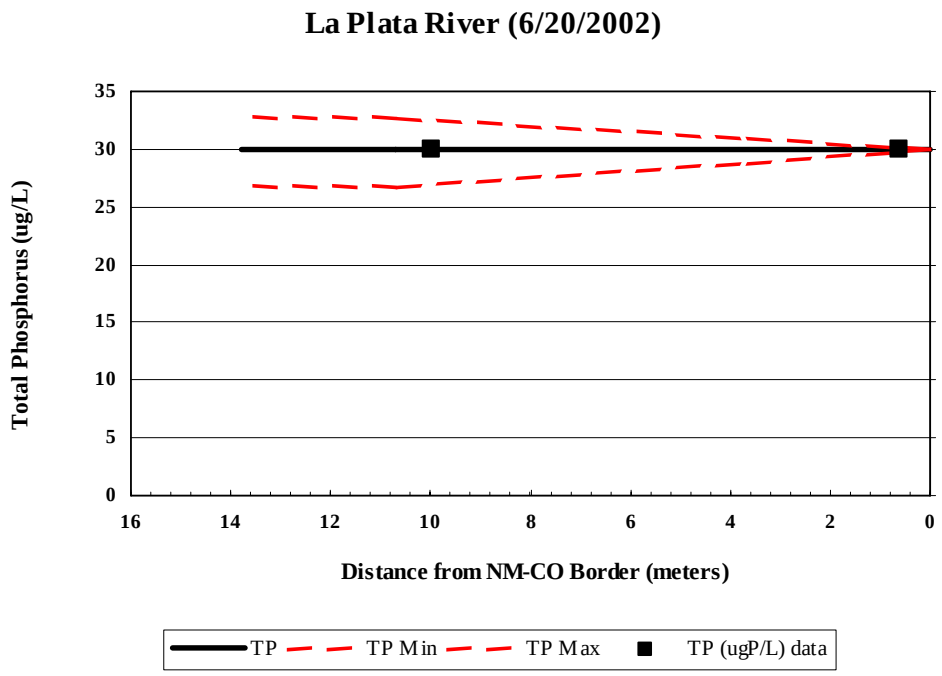

Figure 7. Model-Predicted Total Phosphorus Based on Existing Conditions for the La Plata River

TMDL Endpoint

The calibration or baseline model run for dissolved oxygen is shown in Figure 2. This corresponds to a CBODu value of 18.28 mg/L. The baseline condition model was then run adjusting the CBOD (while keeping the rest of the calibrated parameters the same), to bring the in-stream dissolved oxygen concentration up to or above 6.0 mg/L (representing the state water quality criterion). This involved an iterative process to determine the CBOD value that would not violate water quality standards for dissolved oxygen (Figure 8). This value was determined to be 10.83 mg/L CBODu or 12.09 mg/L of total ultimate biochemical oxygen demand (TBODu) (see TMDL calculations in Section 5.3 of the main document). Table 9 provides a summary of selected parameters related to dissolved oxygen concentrations from the output tables in Q2K.

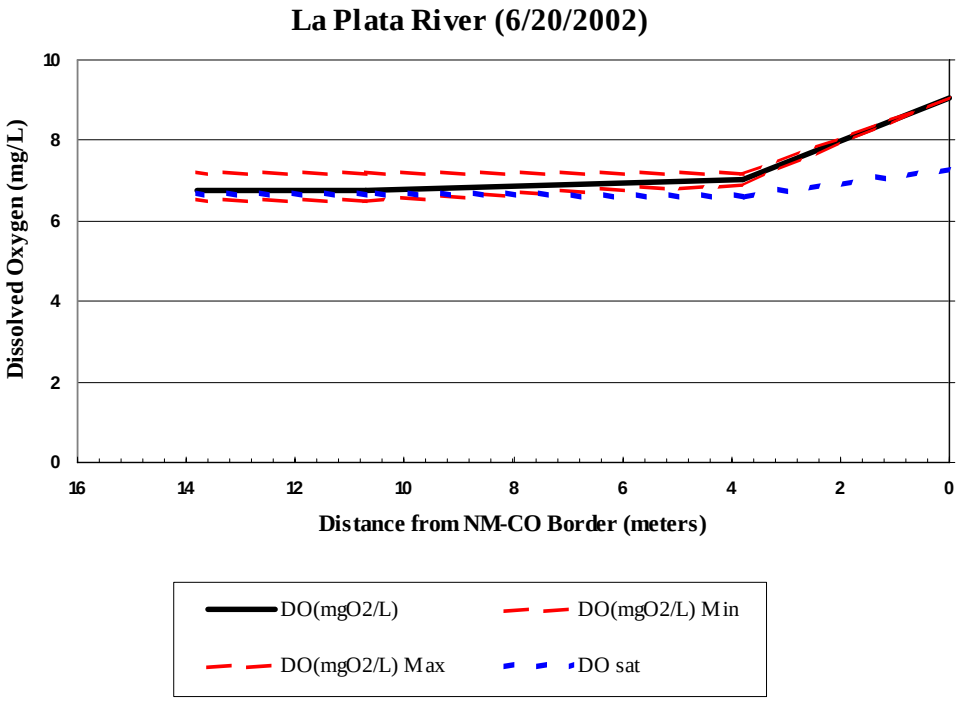

Figure 8. Model-predicted Dissolved Oxygen Concentrations in the La Plata River for the TMDL Scenario

Table 9. Output values for Selected Parameters in the La Plata River for the TMDL Scenario

Reach Label	Headwater	La Plata 1	La Plata 2
Distance (km from the top of the reach)	0.00	3.80	10.70
Average Temp (C)	25.80	24.60	24.40
DO (mgO2/L)	9.07	7.03	6.77
Alkalinity	178.67	178.58	178.60
pH	7.91	7.76	7.74
Total Nitrogen	318.00	317.77	317.44
Total Phosphorus	30.00	29.98	29.94
TKN	268.00	256.53	259.56
CBODu	13.00	11.10	10.83
NH3	2.31	1.16	1.13
DO saturation	7.29	6.61	6.68
pH saturation	8.68	8.67	8.67

References

Chapra, Steve and Greg Pelletier. 2003. *QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality. Documentation and Users Manual.* Civil and Environmental Engineering Dept., Tufts University, Medford, MA.