APPENDIX D
HYDROLOGY, GEOMETRY, AND METEROLOGICAL INPUT DATA FOR SSTEMP

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4Q3	Four-consecutive day discharge that has a recurrence interval of three years
cfs	Cubic Feet per Second
GIS	Geographic Information Systems
GPS	Global Positioning System
IOWDM	Input and Output for Watershed Data Management
mi^2	Square Miles
^oC	Degrees Celcius
SEE	Standard Error of Estimate
SSTEMP	Stream Segment Temperature
SWSTAT	Surface-Water Statistics
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WinXSPRO	Windows-Based Stream Channel Cross-Section Analysis

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D 1.0 INTRODUCTION

This appendix provides site-specific hydrology, geometry, and meteorological data for input into the Stream Segment Temperature (SSTEMP) Model (Bartholow 2002). Hydrology variables include segment inflow, inflow temperature, segment outflow, and accretion temperature. Geometry variables are latitude, segment length, upstream and downstream elevation, Width's A-term, Width's B-term, and Manning's n. Meterological inputs to SSTEMP Model include air temperature, relative humidity, windspeed, ground temperature, thermal gradient, possible sun, dust coefficient, ground reflectivity, and solar radiation. In the following sections, these parameters are discussed in detail for each assessment unit to be modeled using SSTEMP Model. The assessment units were modeled on the day of the maximum recorded thermograph measurement. The assessment units and modeled dates are defined as follows:

Table D.1 Assessment Units and Modeled Dates

Assessment Unit ID	Assessment Unit Description	Modeled Date
NM-2306.A_065	Cienguilla Creek (Eagle Nest to headwaters)	7/20/2006
NM-2306.A_040	Cimarron River (Cimarron Village to Turkey Creek)	7/16/2006
NM-2305.A_060	Moreno Creek (Eagle Nest Lake to headwaters)	8/10/2006
NM-2306.A_051	Rayado Creek (Miami Lake Diversion to headwaters)	7/16/2006
NM-2306.A_064	Sixmile Creek (Eagle Nest Lake to headwaters)	7/15/2006
NM-2306.A_120	South Ponil Creek (Ponil Creek to Middle Ponil)	6/2/2006
NM-2306.A_068	Ute Creek (Cimarron River to headwaters)	7/16/2006

D 2.0 HYDROLOGY

D2.1 Segment Inflow

This parameter is the *mean daily* flow at the top of the stream segment. If the segment begins at an effective headwater, the flow is entered into SSTEMP Model as zero. Flow data from USGS gages were used when available. To be conservative, the lowest four-consecutive-day discharge that has a recurrence interval of three years but that does not necessarily occur every three years (4Q3) was used as the inflow instead of the mean daily flow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. The 4Q3 would be determined for gaged sites using a log Pearson Type III distribution through "*Input and Output for Watershed Data Management*" (IOWDM) software, Version 4.1 (USGS 2002a) and "*Surface-Water Statistics*" (SWSTAT) software, Version 4.1 (USGS 2002b).

Discharges for ungaged sites on gaged streams were estimated based on methods published by Thomas *et al.* (1997). If the drainage area of the ungaged site is between 50 and 150 percent of the drainage area of the gaged site, the following equation is used:

$$Q_u = Q_g \left(\frac{A_u}{A_g} \right)^{0.5}$$

where,

Q_u = Area weighted 4Q3 at the ungaged site (cubic feet per second [cfs])
Q_g = 4Q3 at the gaged site (cfs)
A_u = Drainage area at the ungaged site (square miles [mi^2])
A_g = Drainage area at the gaged site (mi^2)

Drainage areas for assessment units to which this method was applied are summarized in the following table:

Table D.2 Drainage Areas for Estimating Flow by Drainage Area Ratios

Assessment Unit	USGS Gage	Drainage Area from Gage (mi^2)	Drainage Area from Top of AU (mi^2)	Drainage Area from Bottom of AU (mi^2)	Ratio of DA of Ungaged (upstream) to Gaged Site	Ratio of DA of Ungaged (downstream) to Gaged Site
NM-2306.A_065	07204500	56	— [b]	74.74	— [b]	133%
NM-2306.A_040	07207000	294	87.15	97.25	**29.6% [c]**	**33% [c]**
NM-2305.A_060	07204000	73.8	27.12	79.53	**37% [c]**	108%
NM-2306.A_051	07208500	65	— [b]	69.75	— [b]	107%
NM-2306.A_064	07205000	10.5	— [b]	13.88	— [b]	132%
NM-2306.A_120	— [a]	—	87.33	95.64	—	—
NM-2306.A_068	— [a]	—	— [b]	15.86	—	—

Notes:
(a) Regression method developed by Waltemeyer (2002) was used to estimate flows since this is an ungaged stream.
(b) Assessment unit begins at headwaters.
(c) The method developed by Thomas et al. (1997) is not applicable because the drainage area of the ungaged site is less than 50 percent of the drainage area of the gaged site. Therefore, the method developed by Waltemeyer (2002) was used to estimate flows for this assessment unit.

mi^2 = Square miles
USGS = U.S. Geological Survey
AU = Assessment Unit

4Q3 derivations for ungaged streams were based on analysis methods described by Waltemeyer (2002). Two regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico (i.e., statewide and mountainous regions above 7,500 feet in elevation). The following statewide regression equation is based on data from 50 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 = 1.2856 \times 10^{-4}\ DA^{0.42}\ P_w^{3.16}$$

where,

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = Drainage area (mi^2)
P_w = Average basin mean winter precipitation (inches)

The average standard error of estimate (SEE) and coefficient of determination are 126 and 48 percent, respectively, for this regression equation (Waltemeyer 2002). The following regression equation for mountainous regions above 7,500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 7.3287 \times 10^{-5} \; DA^{0.70} \; P_w^{\;3.58} \; S^{1.35}$$

where,

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = Drainage area (mi^2)
P_w = Average basin mean winter precipitation (inches)
S = Average basin slope (percent)

The average SEE and coefficient of determination are 94 and 66 percent, respectively, for this regression equation (Waltemeyer 2002). The drainage areas, average basin mean winter precipitation, and average basin slope for assessment units where this regression method was used are presented in the following table:

Table D.3 Parameters for Estimating Flow using USGS Regression Model

Assessment Unit	Regression Model[(a)]	Average Elevation for Assessment Unit (feet)	Mean Basin Winter Precipitation (inches)	Average Basin Slope (unitless)
NM-2306.A_065	Mountainous	8997	8.65	0.174
NM-2306.A_040	Statewide	6525	8.22	0.248
NM-2305.A_060	Mountainous	8394	9.43	0.244
NM-2306.A_051	Mountainous	8368	9.11	0.219
NM-2306.A_064	Mountainous	9024	8.00	0.272
NM-2306.A_120	Statewide	6914	8.79	0.303
NM-2306.A_068	Mountainous	9143	10.01	0.299

Notes:
mi^2 = Square miles
[(a)] Waltemeyer (2002)

Based on the methods described above, the following values were estimated for inflow:

Table D.4 Inflow

Assessment Unit	Ref.	4Q3 (cfs)	DAt (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Inflow (cfs)
NM-2306.A_065	N/A	–	–	56	8.65	0.174	0.00[(3)]
NM-2306.A_040	(a)	3.30 [(1)]	87.15	294	8.22	0.248	0.65
NM-2305.A_060	(b)	0.18 [(2)]	27.12	73.8	9.43	0.244	0.34

Assessment Unit	Ref.	4Q3 (cfs)	DAt (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Inflow (cfs)
NM-2306.A_051	N/A	–	–	65	9.11	0.219	0.00[(3)]
NM-2306.A_064	N/A	–	–	10.5	8.00	0.272	0.00[(3)]
NM-2306.A_120	(a)	–	87.33	–	8.79	0.303	0.81
NM-2306.A_068	N/A	–	–	–	10.01	0.299	0.00[(3)]

Notes:
N/A = Not applicable, assessment unit begins at headwaters.
Ref. = Reference
(a) Waltemeyer (2002), statewide
(b) Waltemeyer (2002), mountainous

cfs = cubic feet per second
mi^2 = Square miles
in = Inches
Pw = Mean winter precipitation
DAt = Drainage area from top of segment
DAb = Drainage area from bottom of segment
DAg = Drainage area from USGS gage
S = Average basin slope
(1) Based on period of record for USGS gage-Cimarron River near Cimarron, NM (07207000)
(2) Based on period of record for USGS gage-Moreno Creek at Eagle Nest, NM (07204000)
(3) Inflow is zero because assessment unit begins at headwaters.

D2.2 Inflow Temperature

This parameter represents the *mean daily* water temperature at the top of the segment. 2006 data from thermographs positioned at the top of the assessment unit were used when possible. If the segment began at a true headwater, the temperature entered was zero degrees Celcius (°C) (zero flow has zero heat). The following inflow temperatures for impaired assessment units were modeled in SSTEMP:

Table D.5 Mean Daily Water Temperature

Assessment Unit	Upstream Thermograph Location	Inflow Temp. [1] (°C)	Inflow Temp. (°F)
NM-2306.A_065	None (headwaters)	0	32.0
NM-2306.A_040	Cimarron River above Cimarron Village- 05Cimarr050.8	16.98	62.56
NM-2305.A_060	Moreno Creek on NM 64 at USGS gage- 05Moreno003.7	16.36	61.45
NM-2306.A_051	None (headwaters)	0	32.0
NM-2306.A_064	None (headwaters)	0	32.0
NM-2306.A_120	South Ponil above North Ponil- 05SPonil000.1	16.21	61.18
NM-2306.A_068	None (headwaters)	0	32.0

Notes:
°C = Degrees Celcius
°F = Degrees Farenheit
[1] Mean daily average for May 16-September 13, 2006, except South Ponil which was May 16-June 14.

D2.3 Segment Outflow

Flow data from USGS gages were used when available. To be conservative, the 4Q3 was used as the segment outflow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. Outflow was estimated using the methods described in Section D2.1. The following table summarizes 4Q3s used in the SSTEMP Model:

Table D.6 Segment Outflow

Assessment Unit	Ref.	4Q3 (cfs)	DAb (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Outflow (cfs)
NM-2306.A_065	(a)	0.31 [(1)]	74.74	56	8.65	0.174	0.36
NM-2306.A_040	(b)	3.30 [(2)]	281.52	294	8.22	0.248	1.07
NM-2305.A_060	(a)	0.18 [(3)]	79.53	73.8	9.43	0.244	0.19
NM-2306.A_051	(a)	1.88 [(4)]	69.75	65	9.11	0.219	1.95
NM-2306.A_064	(a)	0.17 [(5)]	13.88	10.5	8.00	0.272	0.20
NM-2306.A_120	(b)	–	95.64	–	8.79	0.303	0.84
NM-2306.A_068	(c)	–	15.86	–	10.01	0.299	0.38

Notes:
Ref. = Reference
(a) Thomas et al. (1997)
(b) Waltemeyer (2002), statewide
(c) Waltemeyer (2002), mountainous

cfs = cubic feet per second
mi^2 = Square miles
in = Inches
Pw = Mean winter precipitation
DAb = Drainage area from bottom of segment
DAg = Drainage area from USGS gage
S = Average basin slope
[(1)] Based on period of record for USGS gage-Cieneguilla Creek near Eagle Nest, NM (07204500)
[(2)] Based on period of record for USGS gage-Cimarron River near Cimarron, NM (07207000)
[(3)] Based on period of record for USGS gage-Moreno Creek at Eagle Nest, NM (07204000)
[(4)] Based on period of record for USGS gage-Rayado Creek near Cimarron, NM (07208500)
[(5)] Based on period of record for USGS gage-Sixmile Creek near Eagle Nest, NM (07205000)

D2.4 Accretion Temperature

The temperature of the lateral inflow, barring tributaries, generally should be the same as groundwater temperature. In turn, groundwater temperature may be approximated by the mean annual air temperature. Mean annual air temperature for 2006 was used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table D.7 Mean Annual Air Temperature as an Estimate for Accretion Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature (ºC)	Mean Annual Air Temperature (ºF)
NM-2306.A_065	(a)	6.55	43.783
NM-2306.A_040	(a)	6.55	43.783
NM-2305.A_060	(a)	6.55	43.783
NM-2306.A_051	(a)	6.55	43.783
NM-2306.A_064	(a)	6.55	43.783
NM-2306.A_120	(a)	6.55	43.783
NM-2306.A_068	(a)	6.55	43.783

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Cimarron RAWS, Elevation 2,665 meters; Latitude 36.606100 N, Longitude 105.120300 W),* ***2006***
ºF = Degrees Farenheit
ºC = Degrees Celciu

D 3.0 GEOMETRY

D3.1 Latitude

Latitude refers to the position of the stream segment on the earth's surface. Latitude is generally determined in the field with a global positioning system (GPS) unit. Latitude for each assessment unit is summarized below:

Table D.8 Assessment Unit Latitude

Assessment Unit	Latitude (decimal degrees)
NM-2306.A_065	36.42
NM-2306.A_040	36.52
NM-2305.A_060	36.60
NM-2306.A_051	36.42
NM-2306.A_064	36.54
NM-2306.A_120	36.63
NM-2306.A_068	36.59

D3.2 Dam at Head of Segment

The following assessment units have a dam at the upstream end of the segment with a constant, or nearly constant diel release temperature:

Table D.9 Presence of Dam at Head of Segment

Assessment Unit	Dam?
NM-2306.A_065	No
NM-2306.A_040	No[1]
NM-2305.A_060	No
NM-2306.A_051	No
NM-2306.A_064	No
NM-2306.A_120	No
NM-2306.A_068	No

[1] Eagle Nest Lake is upstream but not at the head of the segment.

D3.3 Segment Length

Segment length was determined with National Hydrographic Dataset Reach Indexing GIS tool. The segment lengths are as follows:

Table D.10 Segment Length

Assessment Unit	Length (miles)
NM-2306.A_065	12.63
NM-2306.A_040	4.25
NM-2305.A_060	9.0
NM-2306.A_051	24.26
NM-2306.A_064	4.6
NM-2306.A_120	5.3
NM-2306.A_068	8.04

D3.4 Upstream Elevation

The following upstream elevations were determined with National Hydrographic Dataset Reach Indexing GIS tool.

Table D.11 Upstream Elevations

Assessment Unit	Upstream Elevation (feet)
NM-2306.A_065	9,800
NM-2306.A_040	6,629
NM-2305.A_060	8,620
NM-2306.A_051	10,320
NM-2306.A_064	9,880
NM-2306.A_120	7,128
NM-2306.A_068	10,960

D3.5 Downstream Elevation

The following downstream elevations were determined with National Hydrographic Dataset Reach Indexing GIS tool.

Table D.12 Downstream Elevations

Assessment Unit	Downstream Elevation (feet)
NM-2306.A_065	8,194
NM-2306.A_040	6,420
NM-2305.A_060	8,167
NM-2306.A_051	6,415
NM-2306.A_064	8,167
NM-2306.A_120	6,700
NM-2306.A_068	7,325

D3.6 Width's A and Width's B Term

Width's B Term was calculated as the slope of the regression of the natural log of width and the natural log of flow. Width-versus-flow regression analyses were prepared by entering cross-section field data into a Windows-Based Stream Channel Cross-Section Analysis (WINXSPRO 3.0) Program (U.S. Department of Agriculture [USDA] 2005). Theoretically, the Width's A Term is the untransformed Y-intercept. However, because the width versus discharge relationship tends to break down at very low flows, the Width's B-Term was first calculated as the slope and Width's A-Term was estimated by solving for the following equation:

$$W = A \times Q^B$$

where,

W = Known width (feet)
A = Width's A-Term (seconds per square foot)
Q = Known discharge (cfs)
B = Width's B-Term (unitless)

The following table summarizes Width's A- and B-Terms for assessment units requiring temperature TMDLs:

Table D.13 Width's A and Width's B Terms

Assessment Unit	Width's B-Term	Width's A-Term (1)
NM-2306.A_065	0.349	2.33
NM-2306.A_040	0.356	5.78
NM-2305.A_060	0.361	2.18
NM-2306.A_051	0.450	3.95
NM-2306.A_064	0.505	0.735
NM-2306.A_120	0.327	6.98
NM-2306.A_068	0.484	0.748

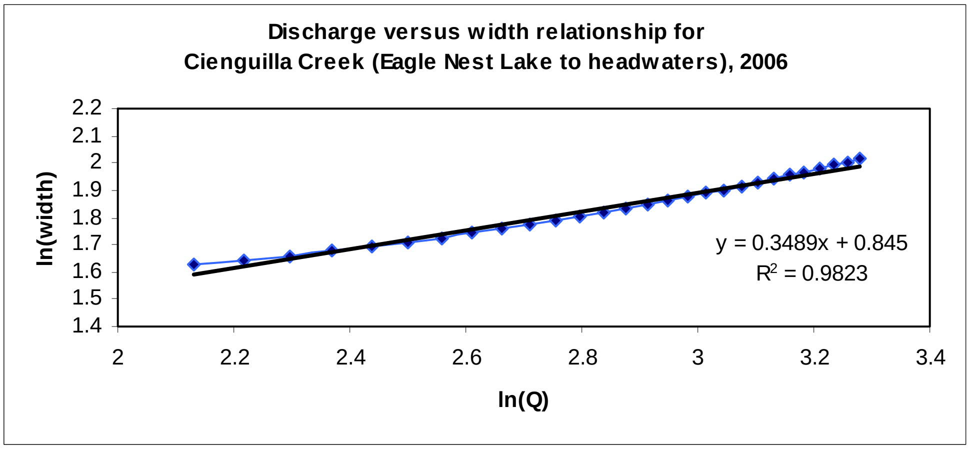
(1) A=e^constant from regression

The following figures present the detailed calculations for the Width's B-Term.

Measurements were collected at one site within these assessment units. The regression of natural log of width and natural log of flow for each location is as follows:

Figure D.1 Wetted Width versus Flow for Assessment Unit NM-2306.A_065*

**Cross-section E from 8/30/2006 data collection*



SUMMARY OUTPUT

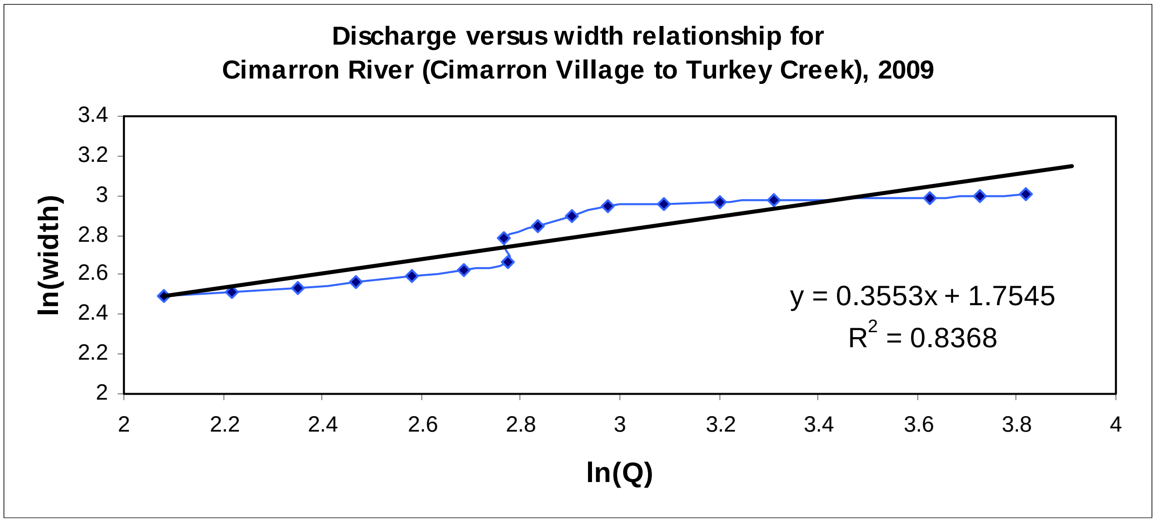
Regression Statistics	
Multiple R	0.991088109
R Square	0.982255641
Adjusted R Square	0.981573165
Standard Error	0.016116291
Observations	28

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.373824506	0.373825	1439.254	2.70191E-24
Residual	26	0.006753106	0.00026		
Total	27	0.380577612			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.844989479	0.026220739	32.226	1.73E-22	0.791091979	0.898887	0.791091979	0.898886979
X Variable 1	0.34891012	0.00919697	37.93751	2.7E-24	0.330005476	0.367815	0.330005476	0.367814763

Figure D.2 Wetted Width versus Flow for Assessment Unit NM-2306.A_040



SUMMARY OUTPUT

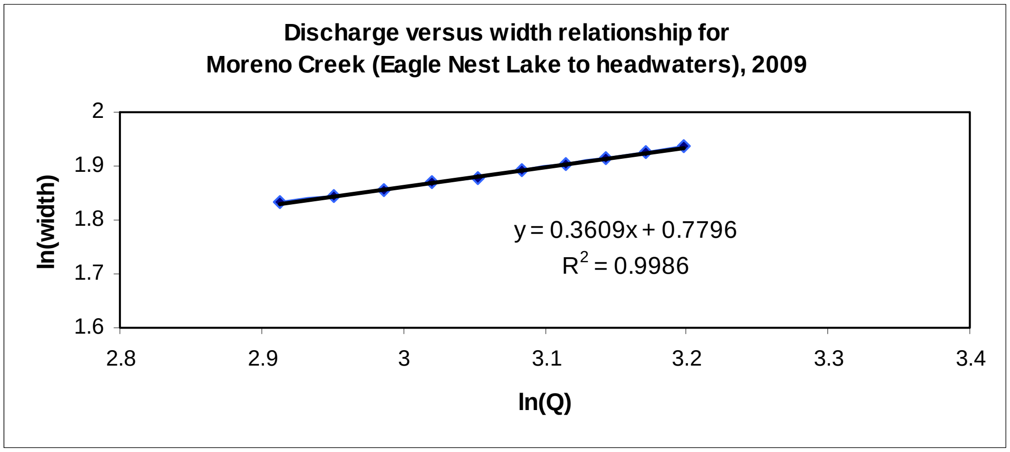
Regression Statistics	
Multiple R	0.91245644
R Square	0.83257675
Adjusted R	0.82211279
Standard E	0.0843572
Observatio	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	1	0.566203855	0.566204	79.56618	1.31424E-07
Residual	16	0.113858202	0.007116		
Total	17	0.680062058			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.8147014	0.112269493	16.1638	2.48E-11	1.57670071	2.052702	1.57670071	2.052702092
X Variable	0.33270732	0.03729908	8.919987	1.31E-07	0.253636805	0.411778	0.253636805	0.411777838

Figure D.3 Wetted Width versus Flow for Assessment Unit NM-2306.A_060



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999305274
R Square	0.998611031
Adjusted R Square	0.99843741
Standard Error	0.001365942
Observations	10

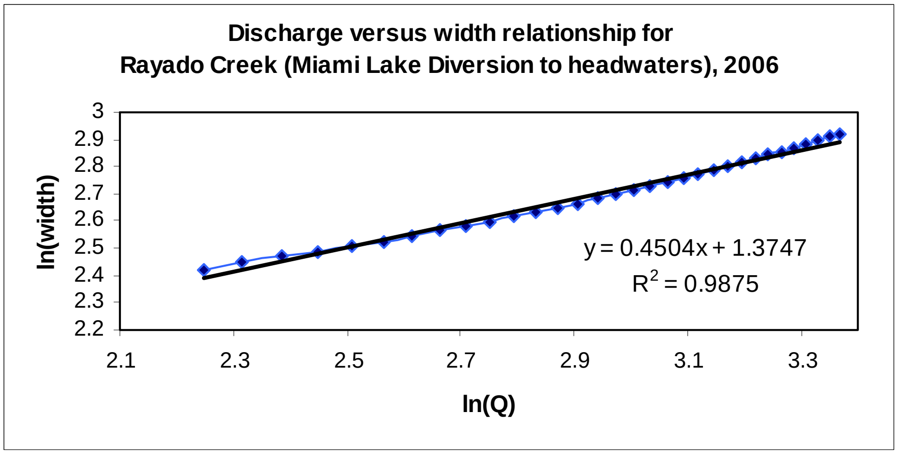
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.010731449	0.010731	5751.669	1.01828E-12
Residual	8	1.49264E-05	1.87E-06		
Total	9	0.010746375			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.779552422	0.014582709	53.45731	1.66E-11	0.745924634	0.813180209	0.745924634	0.813180209
X Variable 1	0.360856981	0.00475815	75.83976	1.02E-12	0.349884666	0.371829295	0.349884666	0.371829295

Figure D.4 Wetted Width versus Flow for Assessment Unit NM-2306.A_051*

**Cross-section E from 8/30/2006 data collection*



SUMMARY OUTPUT

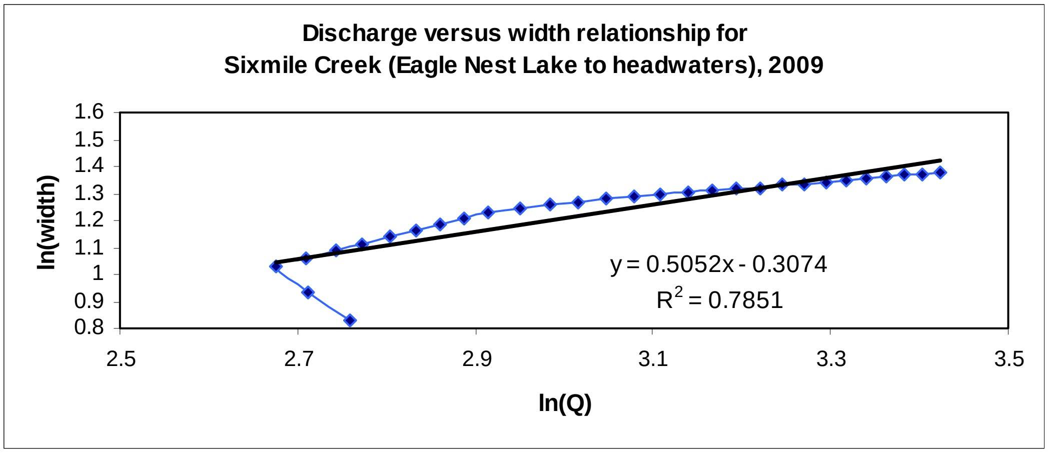
Regression Statistics	
Multiple R	0.993725024
R Square	0.987489423
Adjusted R Square	0.987072403
Standard Error	0.016891255
Observations	32

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.6756164	0.675616	2367.971	4.18296E-30
Residual	30	0.008559435	0.000285		
Total	31	0.684175835			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.374697383	0.027279292	50.39344	1.48E-30	1.318985636	1.430409	1.318985636	1.430409129
X Variable 1	0.450430134	0.009256339	48.6618	4.18E-30	0.431526168	0.469334	0.431526168	0.469334101

Figure D.5 Wetted Width versus Flow for Assessment Unit NM-2306.A_064



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.88603531
R Square	0.78505857
Adjusted R Square	0.77738209
Standard Error	0.064739671
Observations	30

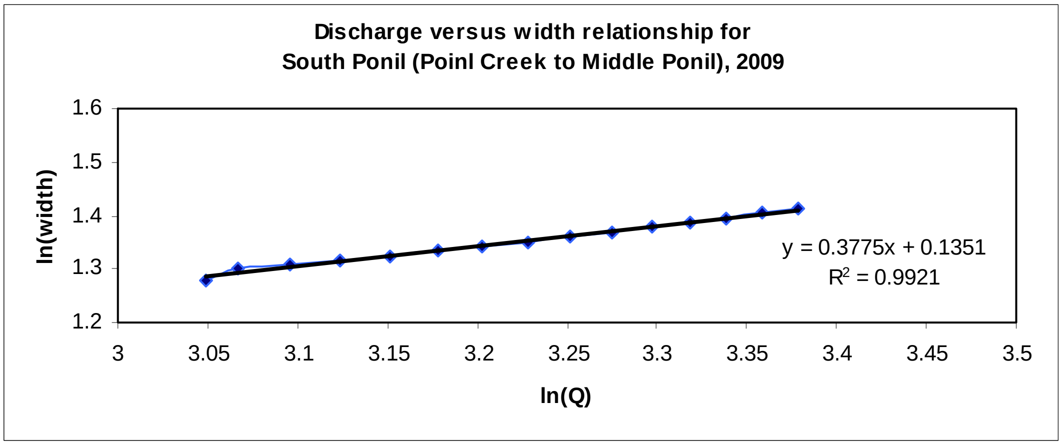
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.428628384	0.428628	102.268	7.50986E-11
Residual	28	0.117354299	0.004191		
Total	29	0.545982682			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.307435809	0.153027609	-2.009022	0.054264	-0.620898651	0.006027	-0.620898651	0.006027034
X Variable 1	0.505215031	0.049958143	10.11277	7.51E-11	0.402880416	0.60755	0.402880416	0.607549646

Figure D.6 Wetted Width versus Flow for Assessment Unit NM-2306.A_120*

**data collections from 05SPonil008.5*



SUMMARY OUTPUT

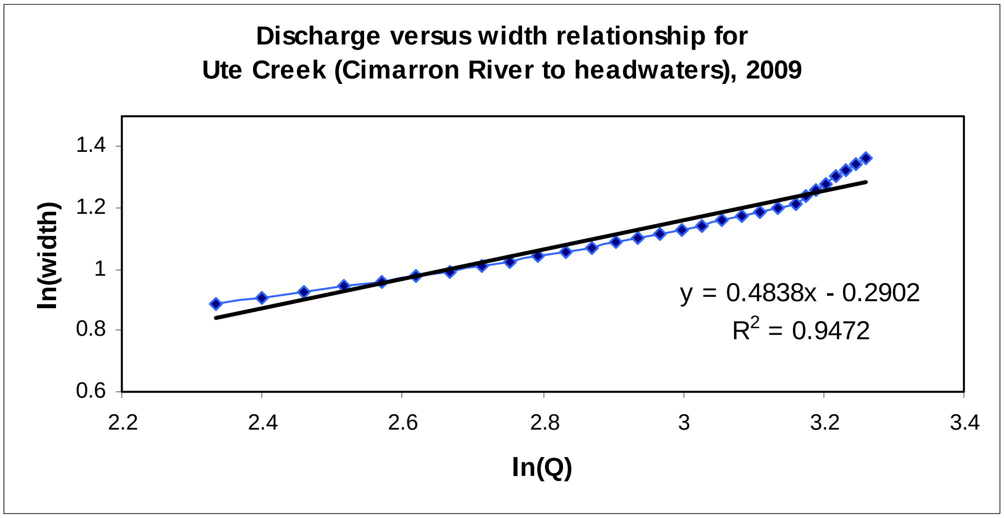
Regression Statistics	
Multiple R	0.996048114
R Square	0.992111845
Adjusted R Square	0.991505064
Standard Error	0.00376334
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.02315664	0.023157	1635.041	4.66074E-15
Residual	13	0.000184115	1.42E-05		
Total	14	0.023340755			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.13508656	0.030088474	4.489645	0.000609	0.070084364	0.200088755	0.070084364	0.200088755
X Variable 1	0.377528127	0.00933652	40.43564	4.66E-15	0.357357802	0.397698452	0.357357802	0.397698452

Figure D.7 Wetted Width versus Flow for Assessment Unit NM-2306.A_068



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.973233872
R Square	0.947184169
Adjusted R	0.945228028
Standard E	0.032513581
Observatio	29

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	1	0.511874716	0.511875	484.2104	8.92287E-19
Residual	27	0.028542589	0.001057		
Total	28	0.540417305			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.290161845	0.064290113	-4.51332	0.000113	-0.422074258	-0.158249432	-0.422074258	-0.158249432
X Variable	0.483756271	0.021984144	22.00478	8.92E-19	0.438648534	0.528864009	0.438648534	0.528864009

D3.7 Manning's n or Travel Time

Site-specific values were calculated using Strickler's equation to estimate Manning's roughness based on prevailing sediment sizes in the streambed:

$$n = \frac{(d_{50})^{1/6}}{21.0}$$

where d_{50} is the median sediment size in meters.

The following table summarizes the Manning’s n input values for each assessment unit:

Table D.14 Manning’s n

Assessment Unit	d_{50} (in meters)	Manning’s n
NM-2306.A_065	46	0.090
NM-2306.A_040	19	0.078
NM-2305.A_060	20.5	0.079
NM-2306.A_051	75.5	.098
NM-2306.A_064	5.5	0.063
NM-2306.A_120	45.5	0.090
NM-2306.A_068	4.5	0.061

D 4.0 METEOROLOGICAL PARAMETERS

D4.1 Air Temperature

This parameter is the mean daily air temperature for the assessment unit (or average daily temperature at the mean elevation of the assessment unit). Air temperature will usually be the single most important factor in determining mean daily water temperature. Air temperatures are usually measured directly (in the shade) using air thermographs and adjusted to what the temperature would be at the mean elevation of the assessment unit. The following table summarizes mean daily air temperatures for each assessment unit (for its modeled date) requiring a temperature TMDL:

Table D.15 Mean Daily Air Temperature

Assessment Unit	Elevation at Air Thermograph Location (meters)	Measured Mean Daily Air Temperature (°C)	Mean Elevation for Assessment Unit (meters)	Adjusted Mean Daily Air Temperature (°C)	Adjusted Mean Daily Air Temperature (°F)
NM-2306.A_065	2510	19.43	2742	17.91	64.24
NM-2306.A_040	2018	23.64	1989	23.83	74.89
NM-2305.A_060	2510 [b]	16.36	2558	16.05	60.89
NM-2306.A_051	2018 [a]	23.64	2551	20.14	68.25
NM-2306.A_064	2510 [b]	18.34	2751	16.76	62.17
NM-2306.A_120	2192	17.00	2787	13.10	55.58
NM-2306.A_068	2192 [c]	20.84	2107	21.40	70.52

Notes:

ºF = Degrees Farenheit

ºC = Degrees Celcius

[a] *No air thermographs deployed. Air thermograph at Cimarron River above Cimarron Village was used.*

[b] *No air thermographs deployed. Air thermograph at Cienguilla Crek above Eagle Nest Lake was used.*

[c] *No air thermographs deployed. Air thermograph at South Ponil above Middle Ponil was used.*

The adiabatic lapse rate was used to correct for elevational differences from the met station:

$$T_a = T_o + C_t \times (Z - Z_o)$$

where,

T_a = air temperature at elevation E (°C)

T_o = air temperature at elevation E_o (°C)

Z = mean elevation of segment (meters)

Z_o = elevation of station (meters)

C_t = moist-air adiabatic lapse rate (-0.00656 °C/meter)

D4.2 Maximum Air Temperature

Unlike the other variables, the maximum daily air temperature overrides only if the check box is checked. If the box is not checked, the SSTEMP Model estimates the maximum daily air temperature from a set of empirical coefficients (Theurer et al., 1984 as cited in Bartholow 2002) and will print the result in the grayed data entry box. A value cannot be entered unless the box is checked.

D4.3 Relative Humidity

Relative humidity data were obtained from the New Mexico State University Climate Network (http://weather.nmsu.edu/data/data.htm). The data were corrected for elevation and temperature using the following equation:

$$R_h = R_o \times \left(1.0640^{(To-Ta)}\right) \times \left(\frac{T_a + 273.16}{T_o + 273.16}\right)$$

where,

R_h = relative humidity for temperature T_a (decimal)
R_o = relative humidity at station (decimal)
T_a = air temperature at segment (°C)
T_o = air temperature at station (°C)

The following table presents the adjusted mean daily relative humidity for each assessment unit:

Table D.16 Mean Daily Relative Humidity

Assessment Unit	Ref.	Mean Daily Air Temp. at Weather Station (°C)	Mean Daily Air Temperature at AU (°C)	Mean Daily Relative Humidity at Weather Station (percent)	Mean Daily Relative Humidity for AU (percent)
NM-2306.A_065	(a)	19.17	17.91	48.88	52.63
NM-2306.A_040	(a)	19.98	23.83	34	27.13
NM-2305.A_060	(a)	14.38	16.05	78.54	71.22
NM-2306.A_051	(a)	19.98	20.14	34	33.68
NM-2306.A_064	(a)	19.07	16.76	66.32	75.93
NM-2306.A_120	(a)	14.11	13.10	57.40	60.90
NM-2306.A_068	(a)	19.98	21.40	34	31.28

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Cimarron RAWS, Elevation 2,665 meters; Latitude 36.606100 N, Longitude 105.120300 W),* ***modeled dates in 2006***
AU = Assessment Unit
ºC = Degrees Celcius

D4.4 Wind Speed

Average daily wind speed data were obtained from the New Mexico State University Climate Network (http://weather.nmsu.edu/data/data.htm). The following table presents the mean daily wind speed for each assessment unit:

Table D.17 Mean Daily Wind Speed

Assessment Unit	Ref.	Mean Daily Wind Speed (miles per hour)	Date
NM-2306.A_065	(a)	3.833	7/20/2006
NM-2306.A_040	(a)	4.273	7/16/2006
NM-2305.A_060	(a)	3.750	8/10/2006
NM-2306.A_051	(a)	4.273	7/16/2006
NM-2306.A_064	(a)	4.773	7/15/2006
NM-2306.A_120	(a)	3.25 [(b)]	6/2/2006
NM-2306.A_068	(a)	4.273	7/16/2006

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Cimarron RAWS, Elevation 2,665 meters; Latitude 36.606100 N, Longitude 105.120300 W)*
(b) No windspeed available for 6/2/2006. The average of the values for June 1 and June 3 was used.

D4.5 Ground Temperature

Mean annual air temperature data for 2006 were used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table D.18 Mean Annual Air Temperature as an Estimate for Ground Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature (°C)	Mean Annual Air Temperature (°F)
NM-2306.A_065	(a)	14.11	43.783
NM-2306.A_040	(a)	14.11	43.783
NM-2305.A_060	(a)	14.11	43.783
NM-2306.A_051	(a)	14.11	43.783
NM-2306.A_064	(a)	14.11	43.783
NM-2306.A_120	(a)	14.11	43.783
NM-2306.A_068	(a)	14.11	43.783

Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Cimarron RAWS, Elevation 2,665 meters; Latitude 36.606100 N, Longitude 105.120300 W)*

°F = Degrees Farenheit
°C = Degrees Celcius

D4.6 Thermal Gradient

The default value of 1.65 was used in the absence of measured data.

D4.7 Possible Sun

Percent possible sun for Albuquerque is found at the Western Regional Climate Center web site http://www.wrcc.dri.edu/htmlfiles/westcomp.sun.html#NEW%20MEXICO. The percent possible sun is 83 percent for June, 77 for July, and 73 for August for the Clayton station.

D4.8 Dust Coefficient

If a value is entered for solar radiation, SSTEMP Model will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation. Solar radiation data are available from the New Mexico State University Climate Network (see Section 4.10).

D4.9 Ground Reflectivity

If a value is entered for solar radiation, SSTEMP Model will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation. Solar radiation data are available from the New Mexico State University Climate Network (see Section 4.10).

D4.10 Solar Radiation

Because solar radiation data were obtained from an external source of ground level radiation, it was assumed that about 90% of the ground-level solar radiation actually enters the water. Thus, the recorded solar measurements were multiplied by 0.90 to get the number to be entered into the SSTEMP Model. The following table presents the measured solar radiation at Cimarron for 2006:

Table D.19 Mean Daily Solar Radiation

Assessment Unit	Ref.	Date	Mean Solar Radiation (L/hour)	Mean Solar Radiation x 0.90 (L/day)
NM-2306.A_065	(a)	7/20/2006	22.579	487.71
NM-2306.A_040	(a)	7/16/2006	27.805	600.59
NM-2305.A_060	(a)	8/10/2006	17.526	378.56
NM-2306.A_051	(a)	7/16/2006	27.805	600.59
NM-2306.A_064	(a)	7/15/2006	32.525	702.54
NM-2306.A_120	(a)	6/2/2006	15.432 [(b)]	360.805
NM-2306.A_068	(a)	7/16/2006	27.805	600.59

Ref. = References for Weather Station Data are as follows:

(a) *New Mexico State University Climate Network (Cimarron RAWS, Elevation 2,665 meters; Latitude 36.606100 N, Longitude 105.120300 W)*

(b) No solar radiation values available for 6/2/2006. The averaged value for 5/26-6/9 was used.

D 5.0 SHADE

Percent shade was estimated for the assessment units using field estimations per geomorphological survey field notes from 2006 and 2009. The value in Table D.20 reflects the average of 6 measurements taken at the cross-section of the primary site in the AU, unless otherwise noted. The measurements may have also been averaged along with visual estimates using USGS digital orthophoto quarter quadrangles downloaded from New Mexico Resource Geographic Information System Program (RGIS), online at http://rgis.unm.edu/. This parameter refers to how much of the segment is shaded by vegetation, cliffs, etc. The following table summarizes percent shade for each assessment unit:

Table D.20 Percent Shade

Assessment Unit	Percent Shade
NM-2306.A_065	12%
NM-2306.A_040	46%
NM-2305.A_060	7%
NM-2306.A_051	22% [a]
NM-2306.A_064	22%
NM-2306.A_120	11%
NM-2306.A_068	86%

[a] Rayado Creek 3 miles above NM 21 – 05Rayado38.4

D 6.0 REFERENCES

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