California Regional Water Quality Control Board
North Coast Region

Navarro River Watershed

Addenda to

Technical Support Document
for the
Total Maximum Daily Load
for Sediment

and

Technical Support Document
for the
Total Maximum Daily Load
for Temperature

December 21, 2000

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CHAPTER A-1
TEMPERATURE

1.0 SUMMARY OF COMMENTS ON THE DRAFT TECHNICAL SUPPORT DOCUMENT ADDRESSED IN THIS CHAPTER

1.1 Gaining vs. Losing Reaches.

Several commentors pointed out that the reach used in the SSTEMP analysis is a gaining reach (outflow from the reach is greater than inflow to the reach for a given point in time, meaning that the stream is gaining flow on the reach), and that the analysis was flawed for not also having considered a losing reach (outflow from the reach is less than inflow to the reach for a given point in time). We agree that the stream network has both gaining and losing reaches.

We disagree as to the characterization that all or half of stream reaches are losing, as suggested by several commentors. Figures A-1 and A-2 present graphs for 1995 and 1996 showing the relationship of drainage area to flow for different dry season dates. These graphs illustrate a general trend of increasing flow with increasing drainage area for any given date, implying that the watershed overall is gaining. There are not data available to sort out the relative lengths of gaining and losing reaches in the watershed. Available data show that both gaining and losing reaches occur in the watershed in the dry season. The existence of both gaining and losing reaches in the watershed suggests that both types of reaches should be considered.

1.2 Inflow Temperature as Part of Sensitivity Analysis

One commentor presented results showing a high degree of correlation between inflow and outflow temperatures on the reach of the Navarro modeled in the TSD. The commentor suggests that the inflow temperature explains most of the variation in the outflow temperature, and further suggests that not including inflow temperature in the sensitivity analysis ignores the most important variable affecting outflow temperature. This section responds to these comments.

While there may be a relationship between inflow temperature and outflow temperature, this does not imply a cause and effect relationship. Knowing the temperature at one location may allow prediction of temperatures at many other locations with a high level of accuracy and confidence, even though there may be no direct causal link among these different locations. . For example, it would be possible to compare temperatures collected at a location on Indian Creek with temperatures collected at a location on Rancheria Creek, and show a very close relationship, as has been shown in the comment letters for two points on the Navarro. This does not mean that stream temperatures on Indian Creek are controlled by stream temperatures on Rancheria Creek, or vice versa. Stream temperatures at all of these locations respond to a variety of factors, including solar radiation inputs, climatic conditions, the time of year, conditions along the streams, and other factors outside of the streams. In some cases, different locations may be similar in terms of stream geometry, aspect, and other factors. Stream temperatures at these locations may show similar responses to the same climatic and other external factors. Temperatures measured in these streams would be highly correlated. Temperatures at two nearby locations that respond to the same outside forces are not independent measurements. The fact that knowing a temperature at one location allows a good prediction of the temperature at another location does not imply a cause and effect relationship between the temperature at one point and that at another.

Results in one comment letter are based on a default sensitivity analysis provided with SSTEMP. This default varies every parameter by 10% above and 10% below whatever the assigned starting value is. Using a 20% range (2 x 10%) is arbitrary and may not reflect the actual variation of these parameters that could be expected in any particular watershed. The actual variation may be more or less than 20%. Specifically, results based on a 20% variation are not representative of conditions in the Navarro watershed. For example, a 20% range of segment inflow would be about 3.73 cfs. The actual range in segment inflows is much larger than this. For example, lowest flows during the critical temperature period (June 22 to August 31) have varied from 0.23 cfs to 140 cfs at the USGS gage, a much larger range than 3.73 cfs. The situation is similar for a number of other parameters. For inflow temperature on the other hand, varying the starting value by 10% above the starting value gives a value of 80°F. Since the starting value of 72.72°F is one of the highest MWAT readings recorded in the watershed, adding 10% to this produces a value much higher (by more than 7°F) than anything measured in the watershed.

1.3. SSTEMP Sensitivity Analysis and Its Uses

Several commentors stated their concern that the SSTEMP approach reflects conditions at one location on one date and does not adequately represent conditions in the watershed. It was specifically stated that looking at a gaining reach only, and not a losing reach, represented a significant deficiency in the TSD.

With regard to the limited applicability of the model, note that a specific reach is used to calibrate the model, in other words to test the model against data collected in the field to make sure that the model is adequately representing real-world conditions. Once the model is calibrated, it can be used to look at many variables and conditions reflective of other reaches. The fact that a particular set of conditions was selected for calibration does not mean that the model applies only to the reach and date used in the calibration.

2.0. BASIS FOR PARAMETER SELECTION FOR SSTEMP NAVARRO RIVER SENSITIVITY ANALYSES

As part of the development of the basis for the Technical Support Document (TSD) prepared by staff of the North Coast Regional Water Quality Control Board and submitted to the US Environmental Protection Agency, the U. S. Geological Survey (USGS) temperature model SSTEMP (Bartholow, 1999) was used to identify those parameters with the most influence on stream temperatures. This section summarizes the basis for the selection of parameter ranges and reference values used in the sensitivity analyses.

The following paragraphs address each model parameter in the order presented in Table A-1. Two reaches were selected for the sensitivity analysis. The first extends from the confluence of Rancheria Creek and Indian Creek (the start of the Navarro River) to Hendy Woods State Park. The second extends along the Navarro River from Hendy Woods State Park (SWRCB-11) to the confluence of the Navarro River with Mill Creek, near Husch Vineyards (SWRCB-12). These reaches were selected based on the availability of flow and temperature data in the same year at locations that could be used to define a reach. These locations constituted suitable pairs of datasets meeting the data availability criteria. The dates selected for modeling were generally near the maximum seasonal value of the 7-day running average of stream temperatures (MWAT) at the monitoring stations. For the upstream reach, July 25 was selected as the date for model calibration. The 1996 MWAT occurred at the downstream end of the reach and on Rancheria Creek the week of July 25 (week of July 25-31). Stream temperatures from July 22 (representing the week surrounding dates when flow was measured on this reach) were used. For the downstream reach, the date of the 1995 MWAT, which occurred July 31 (week of July 31-August 6), was selected for model calibration.

The model was calibrated to interpolated and actual flow or temperature values. Interpolated values were calculated from measured flows and temperatures. Parameters varied in the calibrations included mean air temperature, wind speed, relative humidity, and possible sun. The calibrated model of the downstream reach used as the starting point for the sensitivity analysis reproduced mean and estimated maximum temperatures at the downstream end of the reach within 0.02 °F and 0.17 °F respectively.

Air Temperature. The model calls for weekly average air temperature. The initial range of values was set using Period of Record General Climate Summaries for Ukiah and Point Arena obtained from the Western Regional Climate Center website at www.wrcc.dri.edu. Ukiah is inland from the Navarro watershed. Point Arena is a coastal location west of the reach of interest. These locations bracket the location of interest both physically and meteorologically. Ukiah was used to estimate an upper end value using 1) the highest monthly mean value for the period of record (1906-1998), which is 78.6 °F for July, and 2) the long-term daily average (approximately 75 °F) for July 31-August 6 plus one standard deviation on the maximum temperature for the date (7.6 °F) for an estimated value of 82.6 °F. For Point Arena, the highest monthly mean value is 61.2 °F for August. The long-term daily average for July 31-August 6 is approximately 58 °F. The two values for each site were averaged and rounded to get a range of 60 to 80 °F. These values were confirmed by calculating 7-day running average air temperatures from measured hourly values recorded at the California Department of Forestry and Fire Protection (CDF) facility just east of Boonville. These values showed the range of 60°F to 80°F to be representative of 5 years of summer month (June 22-August 31) air temperatures from 1995-1999 at the CDF Boonville facility. . This date range was selected because it includes all but one of the measured MWAT dates for all of the sites monitored in the watershed except those in the estuary.

The CDF data were also used to estimate the 7-day running average value for the MWAT weeks in 1995 and 1996. Data from CDF were very spotty for the week of interest in 1995 with many missing values, including daily highs and lows. Highs and lows reported in the Santa Rosa Press-Democrat for Boonville were used to estimate the average temperature for the 1995 week of interest in Boonville, by averaging the available highs and lows. Final reference values were selected through the model calibration process. ,

Total Shade. Effective shade measured at SWRCB Sites 8, 9, 10, 11, and 12 were used to estimate reference values and parameter ranges for the modeled reaches. The average of 6 measurements upstream of the Navarro-Mill Creek confluence was used as the reference value (32%) for the downstream reach. The average of 6 measurements on Rancheria Creek upstream of Anderson Creek was used as the initial value for the upstream reach. The lowest individual observation from the reach above Hendy Woods was used as the low value for both reaches of 5%. Effective shade curves developed for the vegetation types occurring in the watershed were used to estimate a potential effective shade value of 70% for the aspect, vegetation type and active channel width typical of the reaches.

Wind Speed. Hourly data on wind speed recorded at the CDF facility were processed into 7-day running average values for the summer months in 1995-1999. These results showed a range of 7-day running average wind speeds of 3-7 mph. Parameters were initialized with values for the weeks of interest. A reference value of 5 miles per hour (mph) was developed through the calibration process.

Relative Humidity. Hourly data on relative humidity recorded at the CDF facility were processed into 7-day running average values for the summer months in 1995-1999. These results showed a range of 7-day running average relative humidity values of 40-80%. The reference values are intermediate, were initialized with values for the weeks of interest, and were adjusted through the calibration process.

Possible Sun. Bartholow (1989) presents US Department of Commerce (1968) data showing mean July percentage of possible sunshine values. The range values (50 to 90%) were estimated from this map (Figure E-3). The reference value was selected through the calibration process.

Inflow and Outflow. The reference values were developed from measured flow data at Sites 8, 9, 10, 11 and 12. Values for the MWAT weeks were developed by interpolation between nearest available measured values. For the downstream reach, ranges of values were developed by first plotting dry season flow values from similar dates collected at the two sites. The regression indicated that flows at Site 12 are consistently higher than flows at Site 11, with a mean difference of 2.2 cfs (Figure A-3). This difference represents accretion along the reach, and probably reflects subsurface inflows from groundwater seepage and intergravel flow. The low end of the inflow range was set as 0.13 cfs, a value prorated to the drainage area above Site 11 with reference to the low flow of record (0.23 cfs) at the USGS gage. The period of record at the USGS gage is 1951-1999. The upper end of the range was set at approximately the highest flow measured for the summer period, again prorated by drainage area. The highest value of low flow observed at the USGS gage for the period of record is 140 cfs, on June 22, 1998. This was again scaled by relative watershed area to get a flow of 85 cfs at the inflow for the reach. Site 12 flows were set at 2.2 cfs more than these values.

For the upstream reach, a similar plot of total flows at Sites 8, 9, and 10 against flow at Site 11 showed a losing reach (Figure A-4). Inflows were calculated by adding flows at Anderson Creek's confluence with the Rancheria (Site 9), Rancheria above Anderson (Site 8), and Indian Creek at its confluence with Rancheria (Site 10) for a given measurement event. The figure indicates that for the measurement events, from 1995-1997, flows at the downstream end of the reach average about 1.7 cfs less than flows at the upstream end of the reach. For the range, since the downstream end of this reach is the same location as the upstream end of the lower reach, flows were set to the same values. Inflows were set 2 cfs higher.

Width's A Term. Summer flow values at Site 11 were used to develop a relationship between flow and wetted channel width for the upstream reach. This relationship, width = 8.24*Q**.38, was used for the reference A-term value, where Q = flow in cfs. For the downstream reach, the relationship was based on flow and wetted channel width data from Site 12, yielding width = 11.76*Q**.207. These values were varied to simulate width:depth ratios ranging from 4 to about 80. This range exceeds width:depth ratios developed from flow measurements made at Sites 11 and 12 during the dry season.

Ground Temperature. Groundwater monitoring well measurements of water temperature were used to estimate the reference value of ground and accretion temperatures. Dry season monitoring rounds from 1998 and 1999 at three locations, 2 in Boonville and one in Philo, showed mean site values of 64 to 66 °F. A deep well at a site in Boonville showed a stabilized water temperature of 62.7 °F. A reference value of 62 °F was used in the analysis. Some reports in the literature (e.g., Bartholow, 1999) suggest setting this value at the long-term average air temperature for the location of interest. Long-term average air temperature at Ukiah is 58.8 °F and is 53.3 °F at Point Arena. The lower end of the range was set at 55 °F. These values are low when compared to water temperatures measured in monitoring wells. The upper end of the range was set at 67 °F, above the highest mean site value observed in the monitoring well data reviewed.

Thermal Gradient. No data on this parameter are available for the watershed. The range was set at the extreme values suggested by Bartholow (1989). The reference was set at the midpoint of the range.

Dust Coefficient. No data on this parameter are available for the watershed. The range was set at the extreme values suggested by Bartholow (1999). The reference was set at the lower end of the range, to reflect lower summer and fall ranges indicated in Bartholow (1999).

Ground Reflectivity. No data on this parameter are available for the watershed. The range of 5 to 30 was set based on information in Bartholow (1989). The reference value of 10 was set within the range of values representative of leaf and needle forest.

3.0 APPLICATION OF SSTEMP TO A LOSING REACH

3.1 Selection of Reach and Model Parameters

To address comments made on the Draft TSD regarding the potential differences in temperature patterns between gaining and neutral or losing reaches, a second reach exhibiting declines in streamflow in a downstream direction was identified and modeled. The selected reach extends from the confluence of Indian Creek and Rancheria Creek to near the picnic area at Hendy Woods State Park (Site 11). Figure A-4 shows the relationship of inflows and outflows on this reach.

SSTEMP was calibrated to reach and watershed conditions on July 25, 1996. Flows were measured on or near this date, which is also near the date on which the maximum value of the 7-day running average temperature was observed at Stations 8 and 11. Inflow temperature was calculated as the weighted average of measured temperatures for July 22, since 7-day running averages for this date were judged to be the most appropriate for comparison to flows measured on July 25, the middle of the week represented by the 7 days beginning July 22.

For information purposes, temperatures at the inflow end of the reach were varied from 66 °F (18.9 °C) to 73.4 °F (23 °C) to investigate the effect of substantially reduced inflow temperatures to the modeled reach.

3.2.Sensitivity Analysis Results for a Losing Reach.

Results for a losing reach showing the effects on outflow temperature of parameter variation over the ranges shown in Table A-1 are shown in Figure A-5. Parameters are ranked by largest effect on the predicted mean temperature at the outflow end of the reach. Results show air temperature, total shade and relative humidity as having the most effect on outflow temperature (more than 1°C), segment inflow, possible sun and wind speed as having moderate effects (between 0.5-1°C), and the remaining parameters as having relatively insignificant effects. Total shade, air temperature and segment inflow have the most effect on estimated maximum (more than 2°C), with possible sun, relative humidity, width's A-term and wind speed having moderate effects (between 1-2°C), and the remaining parameters having relatively insignificant effects.

The four most significant parameters affecting stream temperatures for the modeled losing reach are air temperature, total shade, relative humidity, and segment inflow. Each of these in turn can be affected by management activities. Shade and flow can be directly affected, while air temperature and relative humidity (and wind speed) can be indirectly affected through the management of streamside vegetation conditions.

Varying inflow water temperature over a range from 66°F (18.9°F) to 73.4°F (23°F) resulted in a range of outflow temperatures of 4.48°F (2.49°C).

4.0 REANALYSIS OF THE APPLICATION OF SSTEMP TO A GAINING REACH

During the review of data for the application of SSTEMP to a losing reach, additional information on meteorological conditions was developed, as described above. The ranges of 7-day running average values of air temperature, wind speed, and relative humidity calculated for the years 1995-1999 at the Boonville CDF station differed somewhat from values used in the draft TSD. To reflect this new information, the SSTEMP sensitivity analysis was rerun for a gaining reach, using the ranges of values shown in Table A-1.

Results are presented in Figure A-6. Parameters are ranked by largest effect on the predicted mean temperature at the outflow end of the reach. Results show air temperature, segment inflow, total shade and relative humidity as having the most effect on outflow temperature (more than 1°C), no parameters as having moderate effects (between 0.5-1°C), and the remaining parameters as having relatively insignificant effects. Total shade and air temperature have the most effect on estimated maximum (more than 2°C), relative humidity has a moderate effect (between 1-2°C), and the remaining parameters have relatively insignificant effects.

The four most significant parameters affecting stream temperatures for the modeled losing reach are air temperature, total shade, relative humidity, and segment inflow. Each of these in turn can be affected by management activities. Shade and flow can be directly affected, while air temperature and relative humidity (and wind speed) can be indirectly affected through the management of streamside vegetation conditions.

5.0 SIMULATION OF RESTORATION OF SUMMER DIVERSIONS

The range of flows used in the sensitivity analysis reflects impaired conditions on the losing and gaining reaches. Several comments on the Draft TSD expressed concern that the effect of water withdrawals on stream temperatures was not adequately addressed in the TSD. To address this concern, the model was used to examine the effect on stream temperatures of the full restoration of appropriated flows above the modeled losing reach. Review of Division of Water Rights (DWR) records of diversions permitted in the Navarro watershed in reaches upstream of Hendy Woods and recorded in the DWR database indicates about 4 cfs of permitted diversions in the summer months. This same database indicates permitted summer diversions of over 9 cfs in the watershed and about 8 cfs in the watershed to and including the Mill Creek drainage. To simulate the effect of restoring summer diversions above Hendy Woods, the model was first run for flows in the range from 0.13 cfs to 85 cfs. The model was then rerun for each of these flows by adding 4 cfs to a given flow, calculating the effect on temperature, and plotting the results against the original flow value. This is the model equivalent of assuming that no diversions under permitted summer water rights occur, resulting in an across the board increase in flows for all summer conditions of 4 cfs. Results are shown for a losing reach in Figure A-7. Values of other parameters are set at the values used in the calibration run.

Results indicate that increasing flows by 4 cfs has the least effect on temperature at the high end of the range and has the most effect at the low end of the range. Increasing flows from an adjusted lowest flow value of 0.13 cfs to 4.13 cfs results in a decrease in the predicted outflow temperature of nearly 0.4 °C. The effect over the range of flows is not linear, with very little effect at flows above 20 cfs.

These results were extended to examine the effect of restoration of summer diversions on stream temperature for a range of effective shade values. The flow condition used for this analysis was the low flow of record, representing the most sensitive response of stream temperature to flow. Figure A-8 presents these results for gaining, neutral and losing flow conditions. For gaining conditions, restoring flows increases temperatures for the simulated conditions. This is a result of the addition of surface water at an inflow temperature greater than the groundwater temperature used in the model. Adding water of a higher temperature than groundwater tends to increase stream temperature. Stated another way, the cooling effect of groundwater is less significant as the proportion of groundwater to surface water decreases. If the proportion of groundwater to surface water on a reach were to remain at a constant percentage, increased surface water flow would have no effect on temperature, because it would be accompanied by an exactly balancing increase in groundwater inputs.

For neutral or losing reaches, a very different pattern emerges. For low shade conditions, restoring summer diversions has a cooling effect. This effect is on the order of 1°C for the 1977 low flow condition used. For high shade conditions, restoring summer diversions has a warming effect for the 1977 low flow condition, on the order of 1.5°C. While this may appear to be contradictory, it indicates that higher flows tend to resist tendencies to change. In other words, higher flows have something of a flywheel effect. For reaches where environmental conditions would tend to cool the reach (e.g., high shade conditions), higher flows provide more thermal mass and resist the tendency to cool. For reaches where environmental conditions would tend to warm the reach (e.g., low shade conditions), higher flows provide more thermal mass and resist the tendency to warm. To conclude, for losing or neutral reaches, restoring summer diversions to the stream will lower stream temperatures on reaches that tend to warm. Such reaches could be associated with wide channels, low or absent riparian vegetation, or any other condition that results in relatively low effective shade.

CHAPTER A-2
SEDIMENT

6.0 ADDITIONAL ANALYSIS OF VINEYARD EROSION

Due to substantial public comment, Regional Board Staff revised the analysis of vineyard erosion presented in the Navarro TSD. The revisions are based on a more accurate estimation of current vineyard acreage. The revised vineyard acreage estimates were developed by carefully comparing maps used to develop the original vineyard acreage estimates with David Severn's "Anderson Valley 2000", a videotape of aerial footage of Anderson Valley.

While viewing the videotape, Regional Board Staff found errors in the original estimates of vineyard extent. Some (not all) apple orchards and some vegetable acreage were mistaken for vineyards. Also, Figures 2-4a and 2-4b of the TSD showing the distribution of vegetation in the Navarro watershed were found to be misleading. The polygons described as "new vineyards" were not the only areas of vineyard that were counted in the original analysis. In addition, other areas of vineyards were included based on USGS topographic maps, as well as observations by Regional Board Staff.

The revised estimate of vineyard acreage is 3480 acres, and is reflected in the revised tables below. While the specific numbers have changed, the conclusions remain the same. Road-related sediment delivery is the dominant source of management-related sediment delivery across the Navarro watershed landscape. Vineyards, while only contributing approximately eight percent of the management-related sediment delivery over the Navarro watershed landscape, have the potential to be locally significant. For example, the vineyard density in some smaller watersheds, such as Mill, Lazy, and Floodgate Creeks, has great potential to degrade the habitat in those small streams if conservation practices are not employed.

7.0 LOADING ALLOCATION REVISIONS

Regional Board Staff also received substantial comment from USEPA and the public regarding the sediment load allocations. The original load allocations were developed by applying the required reduction in management-related sediment delivery to meet the TMDL evenly to all sources (i.e., reducing all sources by 62%). The revised load allocations take into account the degree to which individual source processes are controllable to determine an appropriate load allocation.

Table A-2. Sediment Source Allocations

Sediment Source	Current Load	TMDL	Percent Reduction
Shallow Landslides	180	180	
Deep-Seated Landslides	90	90	
Gullies	250	250	
Bank Erosion	60	60	
Inner Gorge/Stream-Side Delivery	590	590	
Road-Stream Crossing Failures	130	65	50%
Road-Related Mass Wasting	120	70	40%
Road-Related Gullying	120	42	65%
Road-Related Surface Erosion	250	50	80%
Skid Trail Erosion	40	20	50%
Vineyard Erosion	55	11	80%
Management Related Mass Wasting	60	36	40%
TOTALS:	1945	1464	

This table revises Table 6-3 of the TSD.

The categories expected to be the most controllable are road surface erosion and vineyard erosion. These categories are allocated twenty percent of their current estimated load.

Reducing the amount of road runoff reaching watercourses (hydrologic connectivity) can effectively limit delivery of sediments generated by road surface erosion. Mitigation measures such as outsloping, installation of rolling dips, and increased frequency of ditch relief culverts can greatly reduce hydrologic connectivity of roads and streams. Where the hydrologic connection of roads and streams can't be eliminated, it can be mitigated by road surfacing and limiting use of those roads.

Vineyard erosion is also an easily controlled source of sediment delivery to streams. Use of conservation measures such as cover crops and contouring, as well as avoidance of areas prone to erosion can reduce the amount of sediment eroded. Delivery of eroded sediments to nearby watercourses can be greatly reduced by utilizing practices such as vegetation filter strips and sediment traps, which intercept sediment before it can reach watercourses. Regional Board staff believe that the potential for significant reductions of sediment delivery from vineyard erosion is great, based on the fact that most vineyards in the Navarro watershed are not incorporating the previously mentioned conservation practices.

Stream crossing failures are allocated fifty percent of their current estimated delivery. Regional Board staff considered the results of Furniss et al's (1998) study that showed that stream crossing failures are difficult to predict, and that increasing hydraulic capacity alone will not prevent failures. Their study also showed that the consequences of stream crossing failures are easy to predict accurately. Minimizing fill volumes and eliminating diversion potential can greatly reduce the volume of sediment delivered to streams. The allocation is based on the premise that eliminating all stream crossing failures is not feasible, but minimizing the consequences of such failures can greatly reduce the loading associated with them.

Mass wasting sources are allocated sixty percent of their current estimated delivery. Regional Board staff considered the controllability and predictability of these features in assigning their allocation.

Road-related gullies are allocated thirty-five percent of their current estimated delivery. Many existing gullies can be easily de-watered by changes in road drainage, however many of these pre-existing gullies will continue to deliver. Options for mitigating road-related gullies on state and county roads are expected to be somewhat limited.

Skid trail erosion is allocated fifty percent of the current estimated load. The allocation is an estimate of what can reasonably be accomplished, based on the best professional judgement (Holly Lundborg, North Coast RWQCB, Timber Harvest Division, personal communication). Note that the allocation is based on a fifty-percent reduction from *today's* standard skidding practices.

Table A-3. Results of Sediment Source Analysis

	Estimated Yield (tons/sq mi/yr)						
Sediment Source	**Anderson**	**Indian**	**Mainstem**	**North Fork**	**Rancheria**	**Entire Watershed**	
Shallow Landslides	180	210	150	160	200	**180**	**Natural: 1170**
Deep-Seated Landslides	0	0	250	0	130	**90**	
Gullies	550	270	60	30	380	**250**	
Bank Erosion	80	60	40	50	70	**60**	
Inner Gorge/Stream-Side Delivery	1180	400	510	280	670	**590**	
Road-Stream Crossing Failures	100	80	140	160	130	**130**	**Human-Caused: 770 (Roads: 620)**
Road-Related Mass Wasting	90	80	140	150	110	**120**	
Road-Related Gullying	90	90	150	150	110	**120**	
Road-Related Surface Erosion	220	210	320	210	250	**250**	
Skid Trail Erosion	10	20	50	70	30	**40**	
Vineyard Erosion	120	0	180	5	5	**60**	
Management Related Mass Wasting	60	70	50	50	60	**40**	
Totals :	2680	1490	2040	1315	2145	**1930**	

This table revises Table 6-2 of the TSD.

8.0 REFERENCES

Bartholow, J.M. 1989. "Stream Temperature Investigations: Field and Analytic Methods." Instream Flow Information Paper No.13, Biological Report 89(17). U.S. Department of the Interior, Fish and Wildlife Service. June 1989.

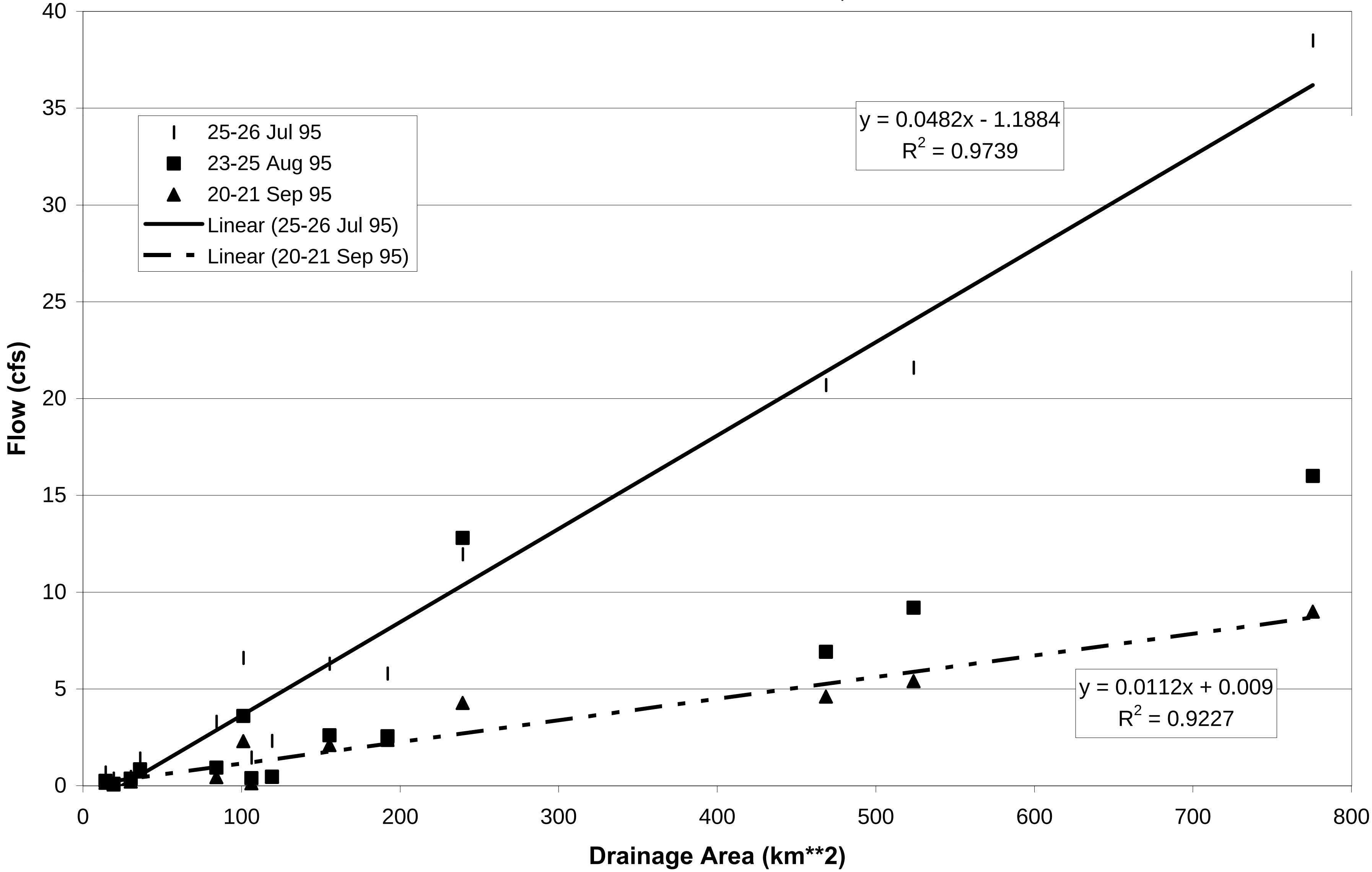
Bartholow, J.M. 1999. "SSTEMP Version 1.1.0." As retrieved from USGS, Midcontinent Ecological Science Center web site at http://www.mesc.usgs.gov/rsm/rsm_software.html.

Table A-1. Ranges of Values Used in SSTEMP Sensitivity Analysis

Parameter	Units	Reference		Range	
		Gaining	Losing	Low	High
Calibration Date		7/31/95	7/25/96		
Inflow Temperature	F/C	72.72/22.62	71.11/21.73	66/18.89	73.4/23
Width's B-Term	dimensionless	0.207	0.38		
Air Temperature	F/C	69/20.56	72.09/22.27	60/15.56	80/26.67
Total Shade	%	32	33	5	70
Wind Speed	mph	5	5	3	7
Relative Humidity	%	70	60	40	80
Possible Sun	%	65	65	50	90
Gaining Reach					
Inflow	cfs	18.65	-	0.13	85
Outflow	cfs	19.8	-	2.33	87.4
Width's A-Term	sec/ft^2	11.76	-	5.39	24.26
Losing Reach					
Inflow	cfs	-	14.09	2.13	87
Outflow	cfs	-	10.95	0.13	85
Width's A-Term	sec/ft^2	-	8.24	4.03	16.11
Ground Temperature	F/C	62/16.67	62/16.67	55/12.78	67/19.44
Thermal Gradient	$joules/m^2/sec/C$	1.65	1.65	0.65	2.65
Dust Coefficient	dimensionless	5	5	3	15
Ground Reflectivity	%	10	10	5	30

Notes:
The range of the A Term is equivalent to a width:depth ratio range from 4.86 to 78.
Stream temperatures, air temperature, wind speed, and relative humidity are based on 7-day running average values from records collected at the California Department of Forestry facility near Boonville.

Figure A-1. Streamflow vs. Drainage Area, Navarro River Watershed, 1995



TSD Addendum Table and Figures.xls A-1
2/12/01

Figure A-2. Streamflow vs. Drainage Area, Navarro River Watershed, 1996

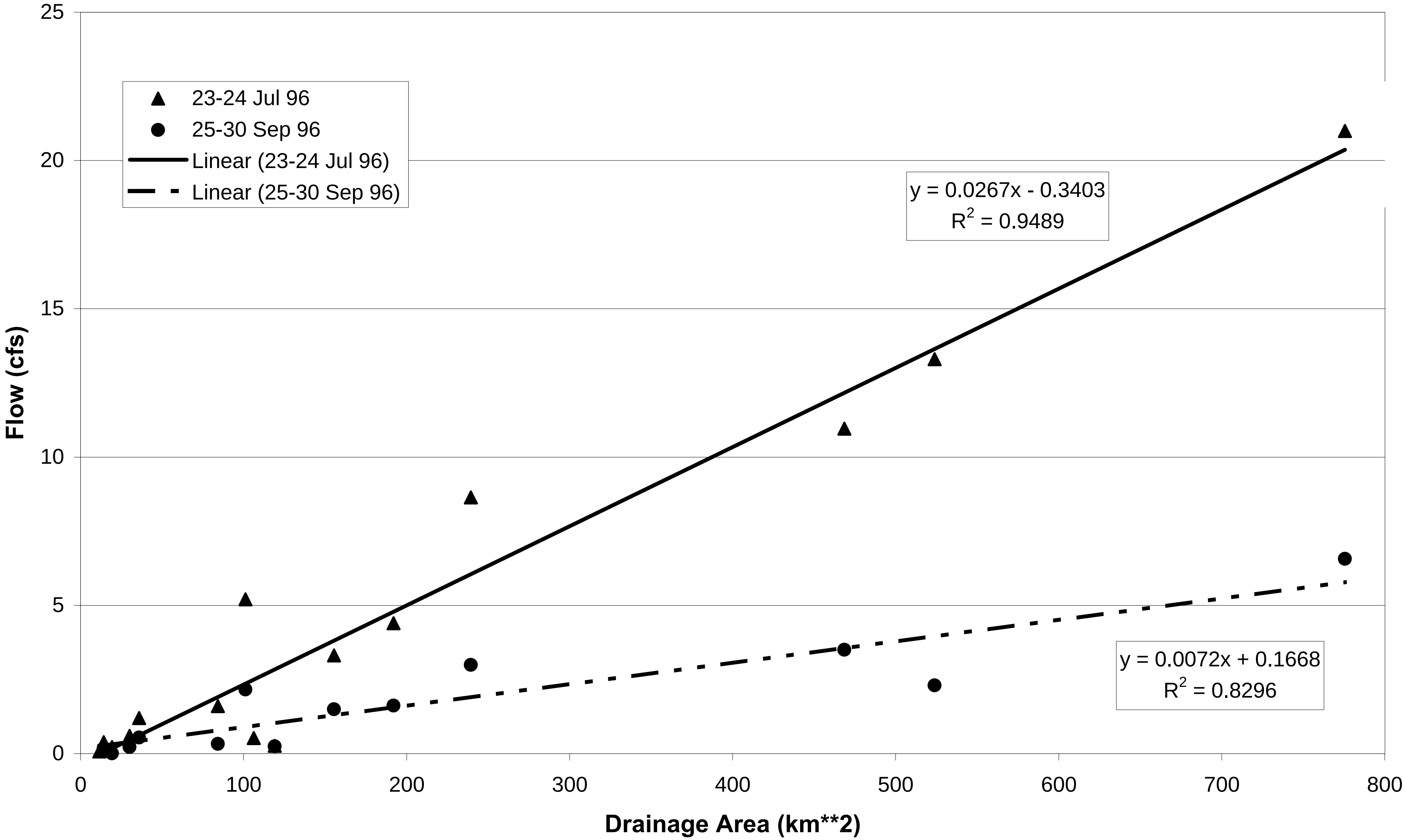


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Figure A-3. Comparison of Dry Season Flows for a Navarro River Losing Reach: SWRCB-11 and SWRCB-12

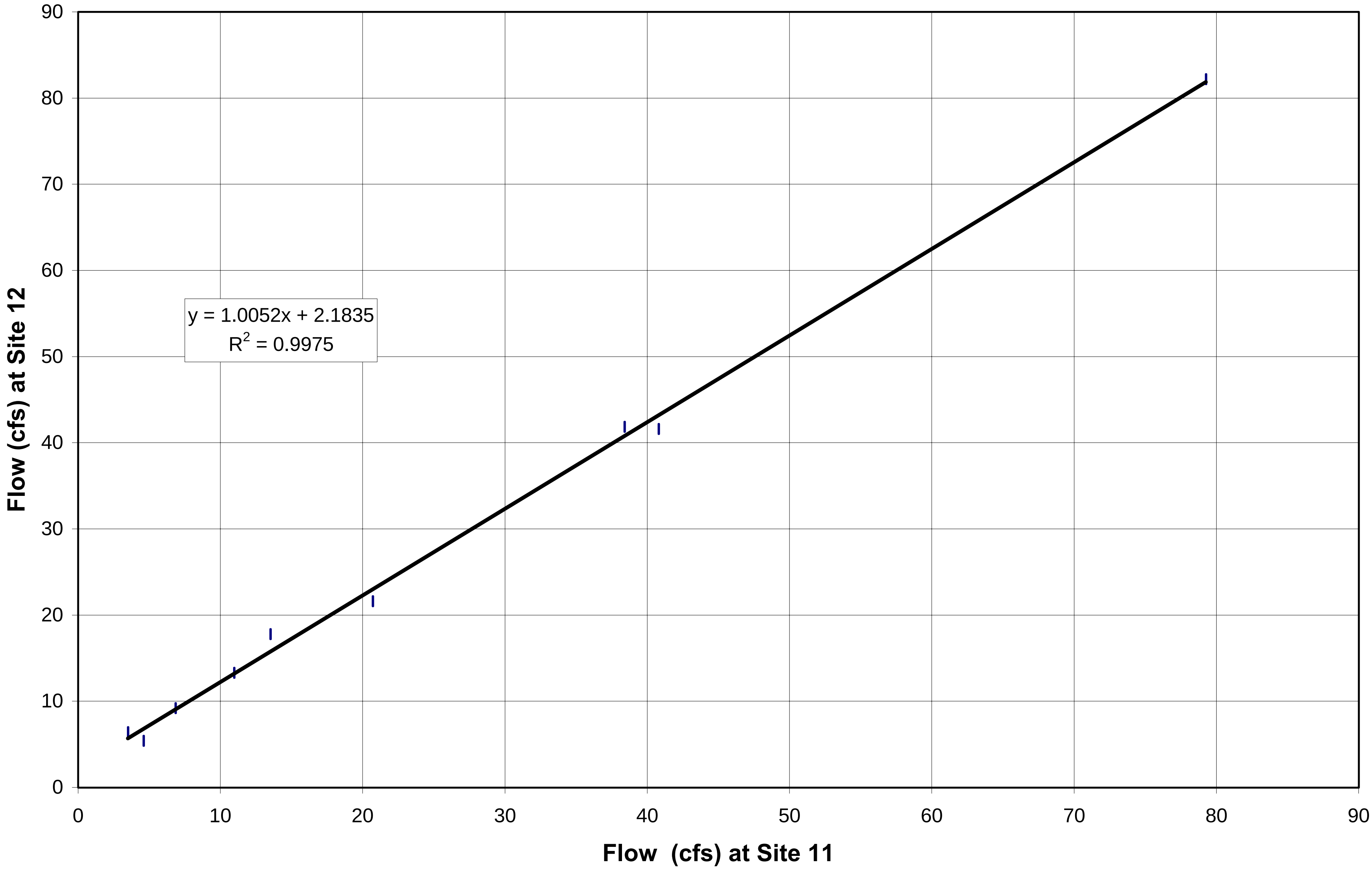
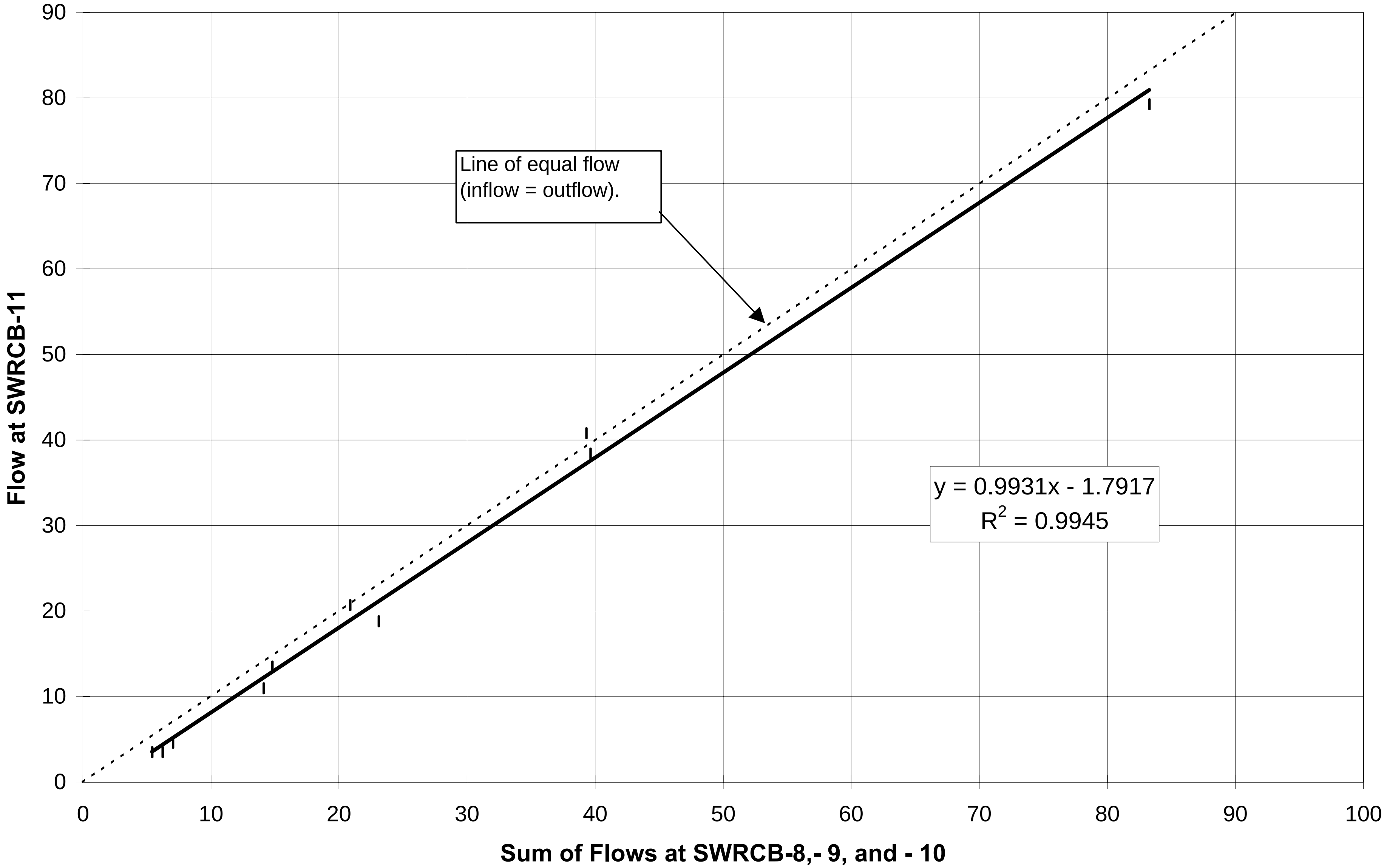


Figure A-4. Comparison of Dry Season Flows for a Navarro River Losing Reach: SWRCB-8, -9, and -10 vs. SWRCB-11



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2/12/01

Figure A-5. Effect on Temperatures at the Downstream End of a *Losing* Reach

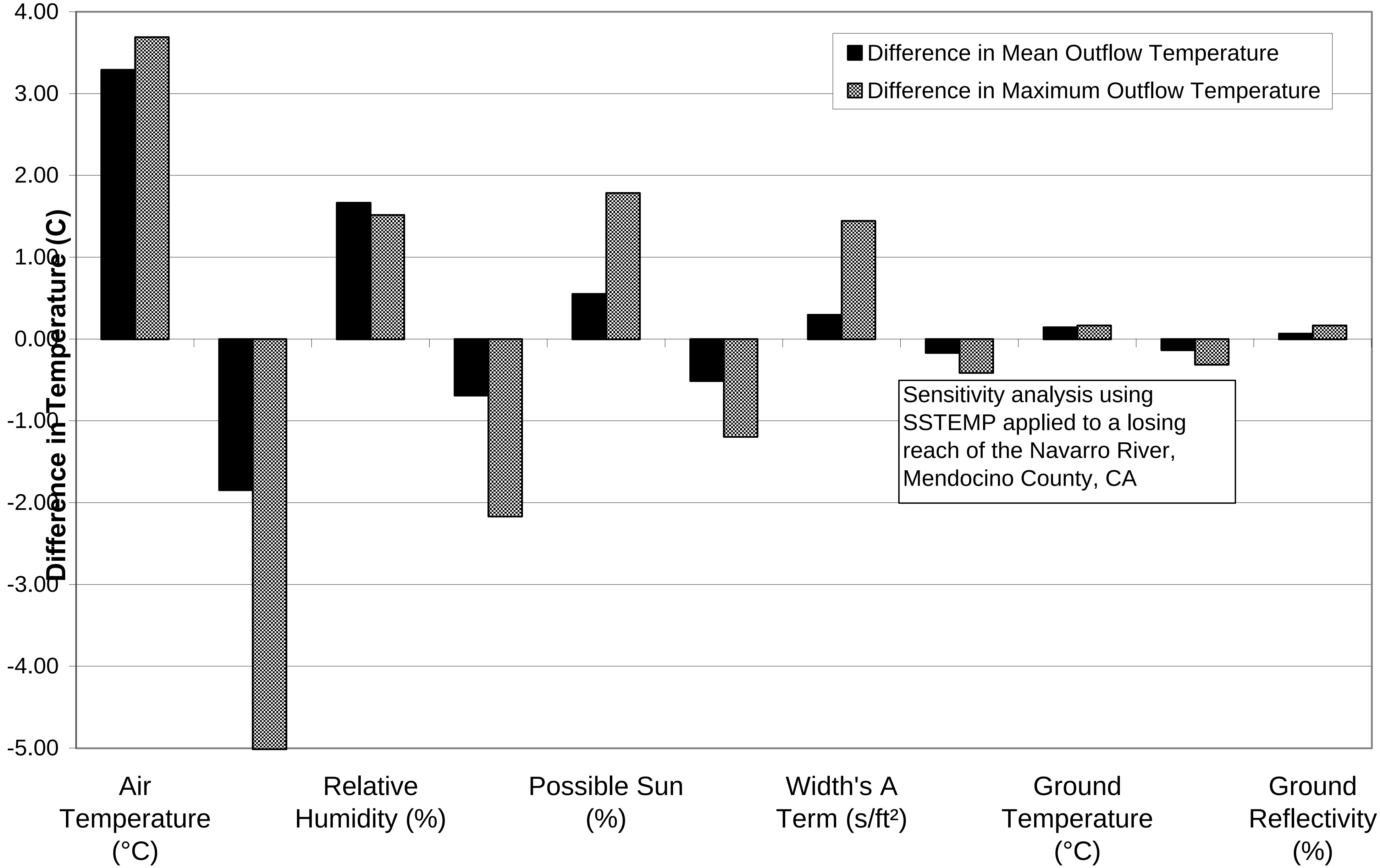

Figure A-6. Effect on Temperatures at the Downstream End of a *Gaining* Reach

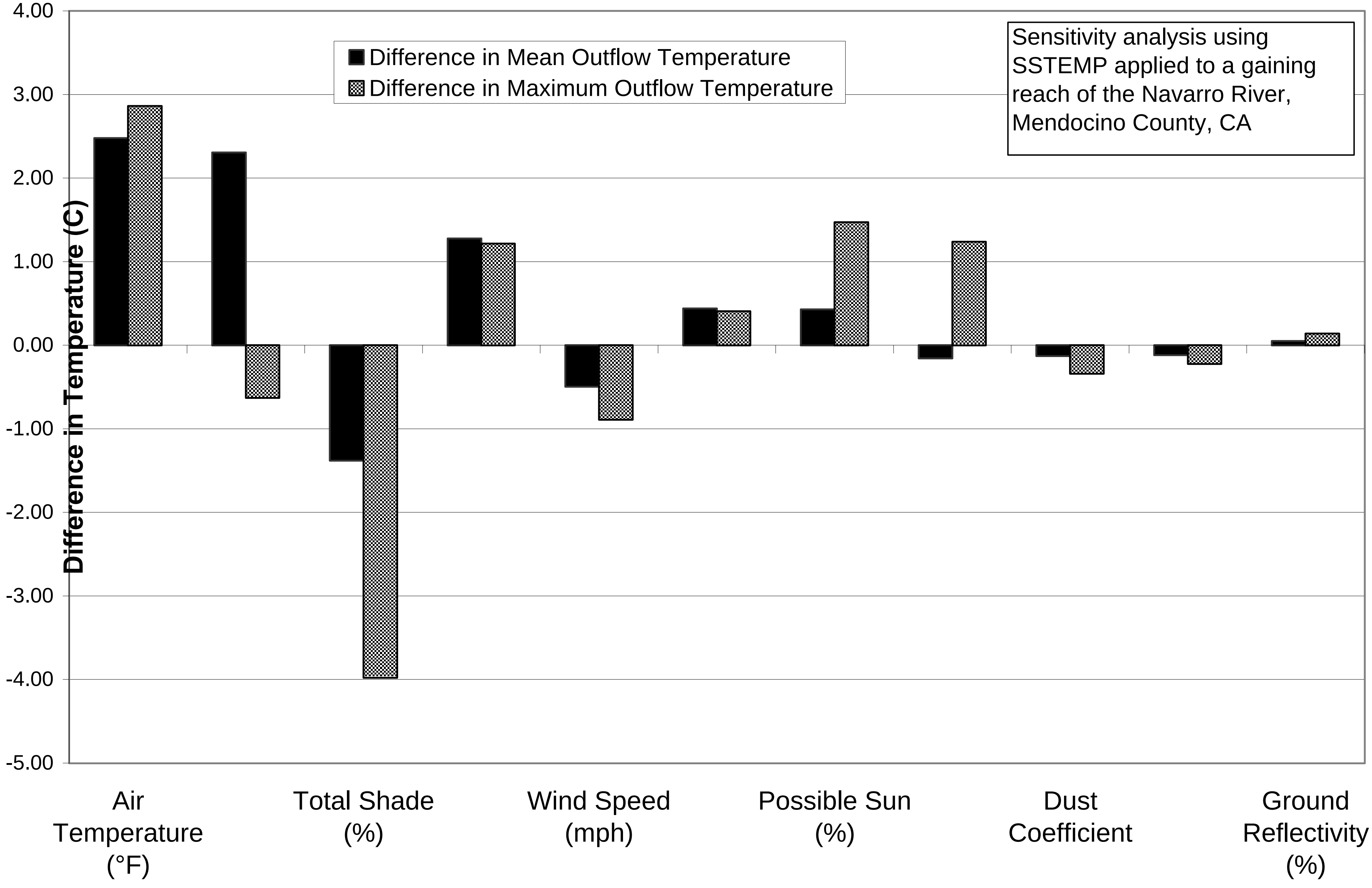

Figure A-7. Predicted Mean Temperature at Downstream End of a Losing Navarro River Reach as a Function of Flow

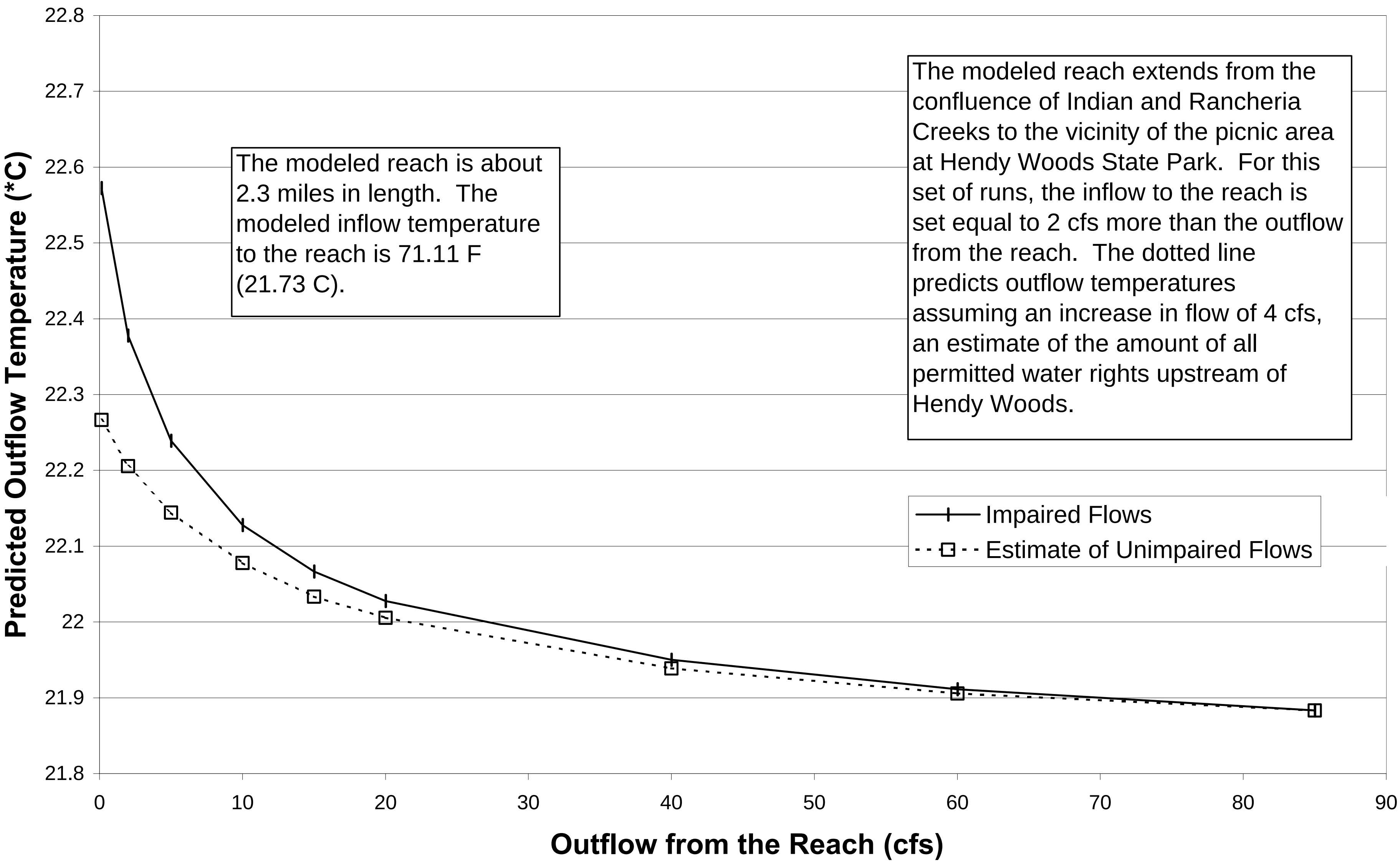

Figure A-8. Effect of Shade and Flow on Stream Temperature: Neutral, Losing, and Gaining Reaches of the Navarro