# Lower Sucker Creek
# Illinois River Subbasin

## TOTAL MAXIMUM DAILY LOAD
## And
## WATER QUALITY MANAGEMENT PLAN

# APPENDICES

April 2002

State of Oregon
Department of Environmental Quality

# APPENDI X A

## ADAPTIV E MANAGEMENT

The goal of the Clean Water Act and associated Oregon Administrative Rules (OARs) is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where nonpoint sources are the main concern. To achieve this goal, implementation must commence as soon as possible.

TMDLs are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met. DEQ recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and techniques are simplifications of these complex processes and, as such, are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is for this reason that the TMDL has been established with a margin of safety.

WQMPs are plans designed to reduce pollutant loads to meet TMDLs. DEQ recognizes that it may take some period of time - from several years to several decades - after full implementation before management practices identified in a WQMP become fully effective in reducing and controlling pollution. In addition, DEQ recognizes that technology for controlling nonpoint source pollution is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated surrogates cannot be achieved as originally established. DEQ also recognizes that, despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated surrogates. Such events could be, but are not limited to, floods, fire, insect infestations, and drought.

Lower Sucker Creek TMDL, pollutant surrogates have been defined as alternative targets for meeting the TMDLs for some parameters. The purpose of the surrogates is not to bar or eliminate human access or activity in the watershed or its riparian areas. It is the expectation, however, that this WQMP and the associated DMA-specific Implementation Plans will address how human activities will be managed to achieve the surrogates. It is also recognized that full attainment of pollutant surrogates (System Potential channel widths and vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, the Implementation Plans should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of System Potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

If a nonpoint source that is covered by the TMDLs complies with its finalized Implementation Plan or applicable forest practice rules, it will be considered in compliance with the TMDL.

DEQ intends to regularly review progress of this WQMP and the associated Implementation Plans to achieve TMDLs. If and when DEQ determines that the WQMP has been fully implemented, that all feasible management practices have reached maximum expected effectiveness and a TMDL or its interim targets have not been achieved, DEQ shall reopen the TMDL and adjust it or its interim targets and the associated water quality standards as necessary.

The implementation of TMDL and associated WQMP is generally enforceable by DEQ, other state agencies and local government. However, it is envisioned that sufficient initiative exists to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the responsible agency (DMA) will work with land managers to overcome impediments to progress through education, technical support, or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. This could occur first through direct intervention from land management agencies (e.g. ODF, ODA, Josephine County), and secondarily through DEQ. The latter may be based on departmental orders to implement management goals leading to water quality standards.

If a source is not given a load allocation, it does not necessarily mean that the source is prohibited from discharging any wastes. A source may be permitted to discharge by DEQ if the holder can adequately demonstrate that the discharge will not have a significant impact on water quality over that achieved by a zero allocation. For instance, a permit applicant may be able to demonstrate that a proposed thermal discharge would not have a measurable detrimental impact on projected stream temperatures when site temperature is achieved. Alternatively, in the case where a TMDL is set based upon attainment of a specific pollutant concentration, a source may be permitted to discharge at that concentration and still be considered as meeting a zero allocation.

In employing an adaptive management approach to the TMDLs and the WQMP, DEQ has the following expectations and intentions:

- Subject to available resources, on a five-year basis, DEQ intends to review the progress of the TMDLs and the WQMP.
- In conducting this review, DEQ will evaluate the progress towards achieving the TMDLs (and water quality standards) and the success of implementing the WQMP.
- DEQ expects that each DMA will also monitor and document its progress in implementing the provisions of its Implementation Plan. This information will be provided to DEQ for its use in reviewing the TMDL.
- As implementation of the WQMP and the associated Implementation Plans proceeds, DEQ expects that DMAs will develop benchmarks for attainment of TMDL surrogates, which can then be used to measure progress.

- Where implementation of the Implementation Plans or effectiveness of management techniques are found to be inadequate, DEQ expects management agencies to revise the components of their Implementation Plan to address these deficiencies.
- When DEQ, in consultation with the DMAs, concludes that all feasible steps have been taken to meet the TMDL and its associated surrogates and attainment of water quality standards, the TMDL, or the associated surrogates is not practicable, it will reopen the TMDL and revise it as appropriate. DEQ would also consider reopening the TMDL should new information become available indicating that the TMDL or its associated surrogates should be modified.

# APPENDI X B

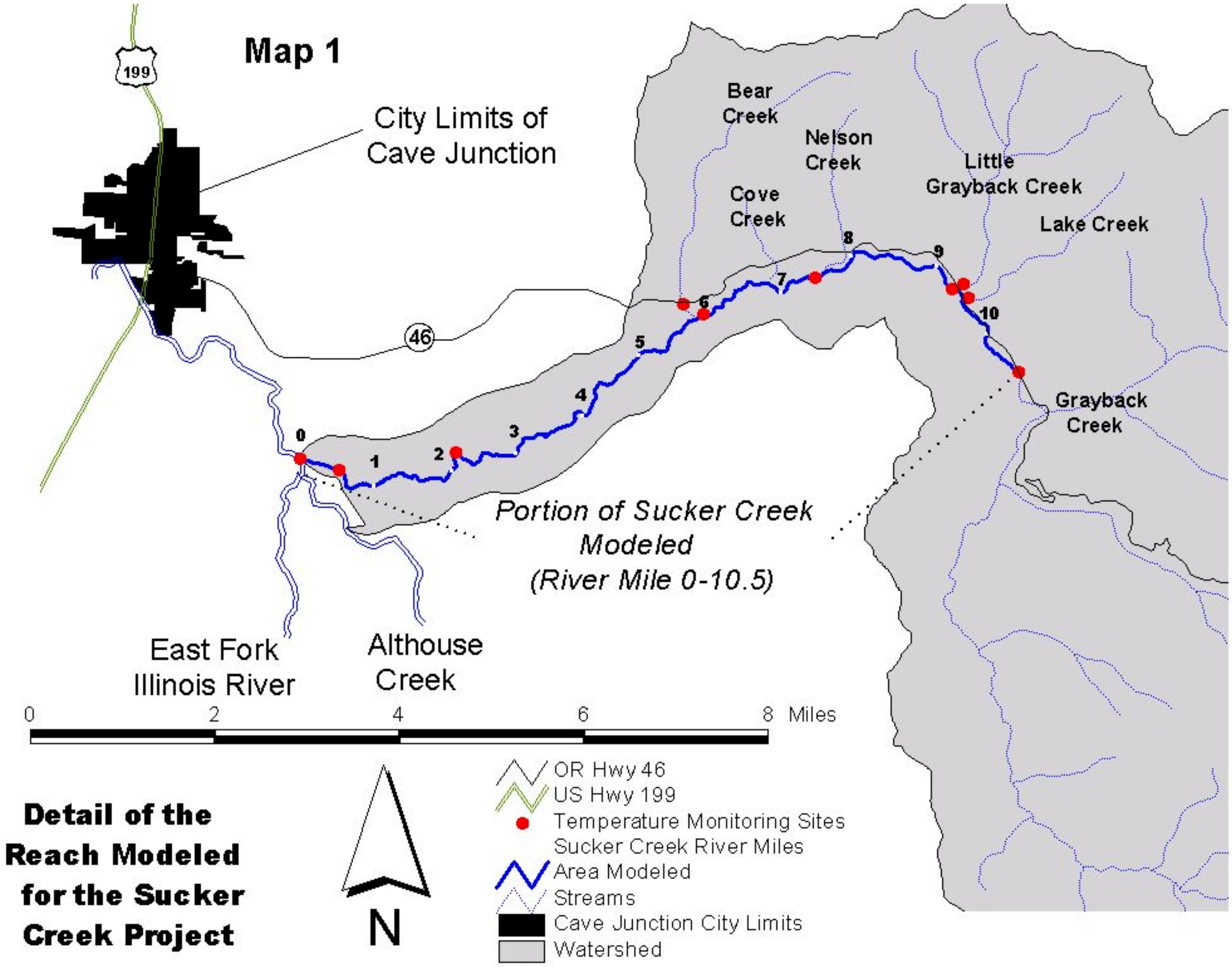
## TEMPERA T URE MODEL

## Lower Sucker Creek

## Stream Temperature Model

DEQ Western Region

April 2002




# TMDL on the Upper Reach of Sucker Creek

In 1999 DEQ of Environmental quality prepared a TMDL for the federal lands in the Sucker Creek watershed above the USFS boundary at Sucker Creek river mile 10.4. The results of this work can be found in the March 1, 1999 Sucker/Grayback TMDL and WQMP. This modeling effort has been undertaken to support the TMDL development for the remaining, lower section of the watershed. The Lower Sucker Creek Watershed includes all lands below the National

Forest boundary at river mile 10.4, a total of 13,770 acres plus all private holdings contained in the upper watershed (2470 acres) for a total of 16,240 acres. Approximately 52% of the land in the study area is under private ownership, the remainder is under BLM, State, and Josephine County management. Information generated during development of this Lower Sucker Creek TMDL and associated WQMP may result in changes or modifications to the existing TMDL for the Upper Section of Sucker Creek.

## SURVEY PURPOSE

Field measured data (collected on 8/3/99) was used to calibrate a stream temperature model, *Heat Source 6.0*. Data from early August was used so that the conditions used to calibrate the model will be as close to a seasonal worst case condition as possible.

The model uses field measurements and model-derived parameters as input to simulate how stream temperatures respond to unique conditions within the watershed. Once the model parameters have been balanced so that the simulation accurately describes the conditions measured in the field (the calibration step), reasonable and obtainable "future conditions" are entered into the model. The model re-summates the amount of energy reaching the stream and re-calculates stream temperatures based on those future condition(s) that are assumed. Equilibrium conditions are calculated for each of the 171 segments that make up the Sucker Creek model (segments are 100 meters long). See Map 1 for the extent of the modeled reach.

Field monitoring, over several summer seasons, has shown that Sucker Creek:

Experiences high summertime temperatures
Lacks streamside shade

- Has excessively wide channel wetted widths and near stream disturbance zone (NSDZ) widths

Two "future" scenarios were examined to show the interplay between these factors. The future simulations presented in this report, and their underlying assumptions are as follows:

- **System Potential Simulation** – Narrows wetted widths and near stream zone of disturbance widths to those expected for a laterally and vertical stable stream of this size and grows riparian vegetation to heights and densities expected for mature stands growing on these soils and in this climate. This results in percent effective shade and Near Stream Disturbance Zone (NSDZ) widths and channel widths to meet the TMDL surrogate targets as defined in Tables 10 and 11 in Section 6 of the TMDL.

- **Channel Improvements versus Shade Improvements Simulation** – Same future conditions as used in the system potential simulation, but with the effect of shade and channel improvements looked at independently. This shows the relative improvements caused by each of these variables.

Like any model that attempts to "look into the future", there is a disparity between what is predicted and what will actually come to pass. Our understanding of the processes that determine stream temperature are imperfect, and any predictions using them are similarly imperfect. Any resulting simulation of the future is less a diagram with survey point accuracy than a roadmap that identifies only the most obvious landmarks. Roadmaps, however, are useful for planning a journey and navigating to a destination. While only the broadest suggestions of possible management strategies are suggested by the model, they should point us in the right direction.

## METHODS FOR FIELD DATA COLLECTION

**Temperature Sets**
Hourly instantaneous stream temperatures were taken throughout the summer at seven locations in Sucker Creek and three tributary locations (see Map 1 for locations) using calibrated and audited logging devices. Each data set was reviewed, and it was determined that the data from 8/3/99 was most suitable to a basin-wide heat source simulation. Each data set, if required, was thinned to the 24 hourly observations taken during that day.

**Stream Discharge Measurements**
Flow measurements were done the first week of August at 11 mainstem sites and three tributaries via hand-held current meters. Measurement transects were chosen in areas with wadeable cross-sections and good stream velocities. Each transact consisted of a minimum of 10 individual measurements.

**Stream/Shade Conditions**
Habitat characteristics relating to riparian shade quality and quantity were measured from aerial photography, digital imagery and on site field measurements. The shading values calculated were: Shade Height, Shade Width, Shade Density. Values assumed for the "System Potential" simulation were based on forest characteristics appropriate to this ecoregion, soil class, species composition and expected tree density. Channel wetted widths and Zone of Disturbance widths were measured from field observations and aerial imagery.

## MODEL INPUTS

### ELEVATION/GRADIENT

Elevations were obtained from digital elevation information (Digital Elevation Model -DEM-type data). The elevation of the upstream and downstream point of each reach segments was derived. These elevations were related to the elapsed reach lengths so that elevation and gradient profiles could be calculated. See Figure 1 & 2. The modeled reach has some pool/riffle structure in the upper 21/2 miles. The remainder of the system is quite uniform with gradients generally below 1%.

Figure 1

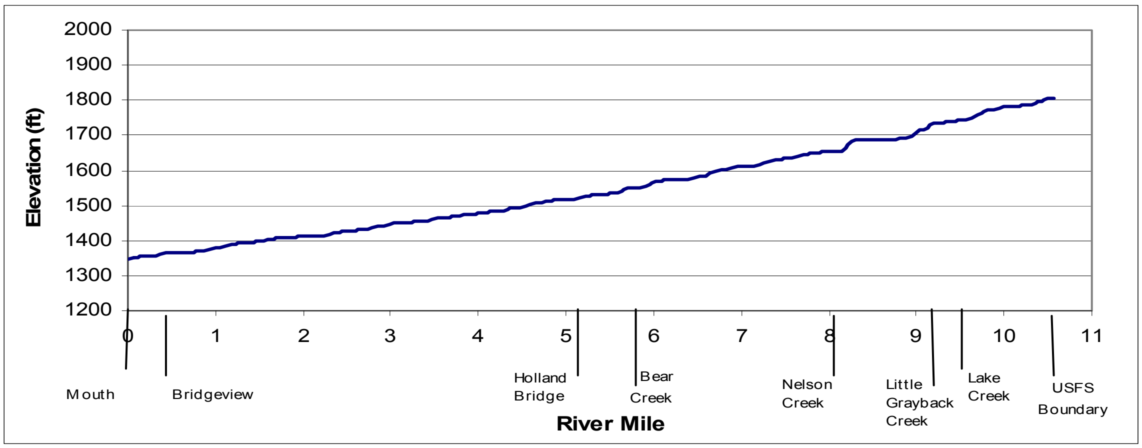
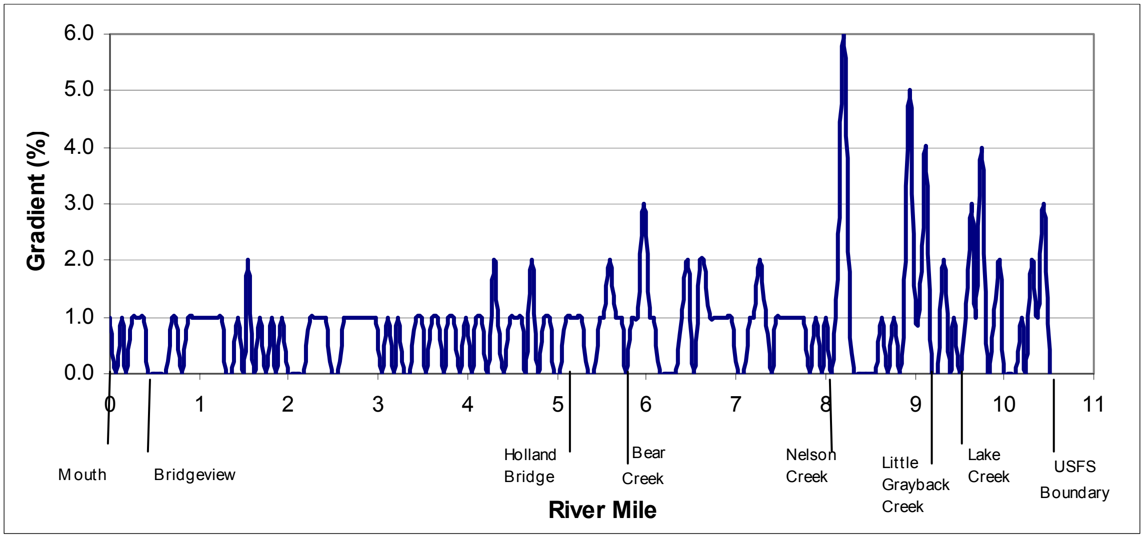


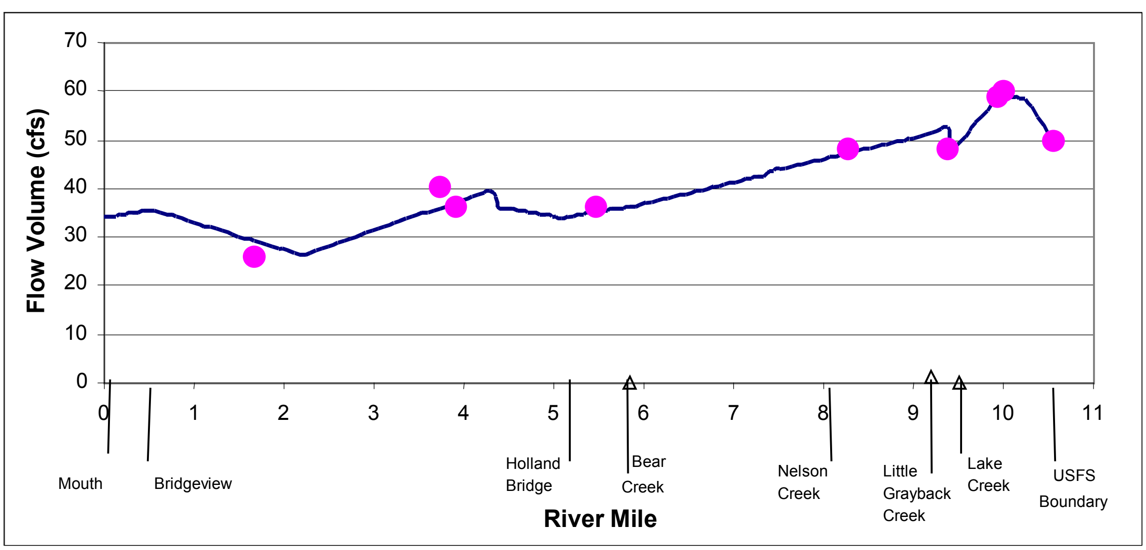
Figure 2




## FLOW VOLUME

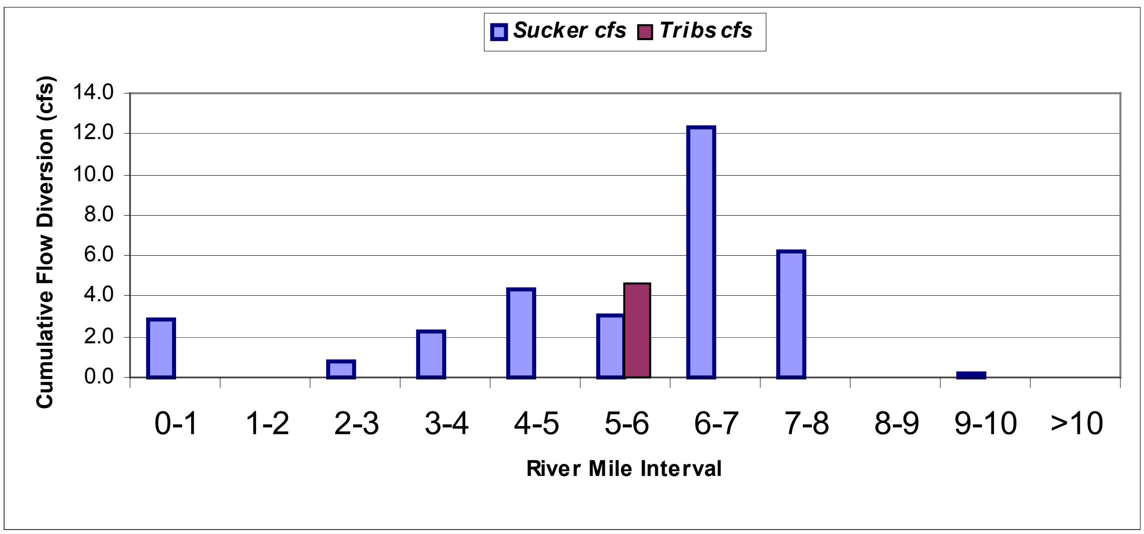
Flow was measured at the mainstem sites shown in Figure 3 as solid dots. The intervening flow was extrapolated so that a complete flow profile could be constructed. Tributary flows were also taken in at the mouth of Bear, Lake and Little Grayback Creeks. Open triangles show the flow contributed from these “major” tributaries. As can be seen, little flow was contributed from the Lake, Little Grayback or Bear Creek drainages.

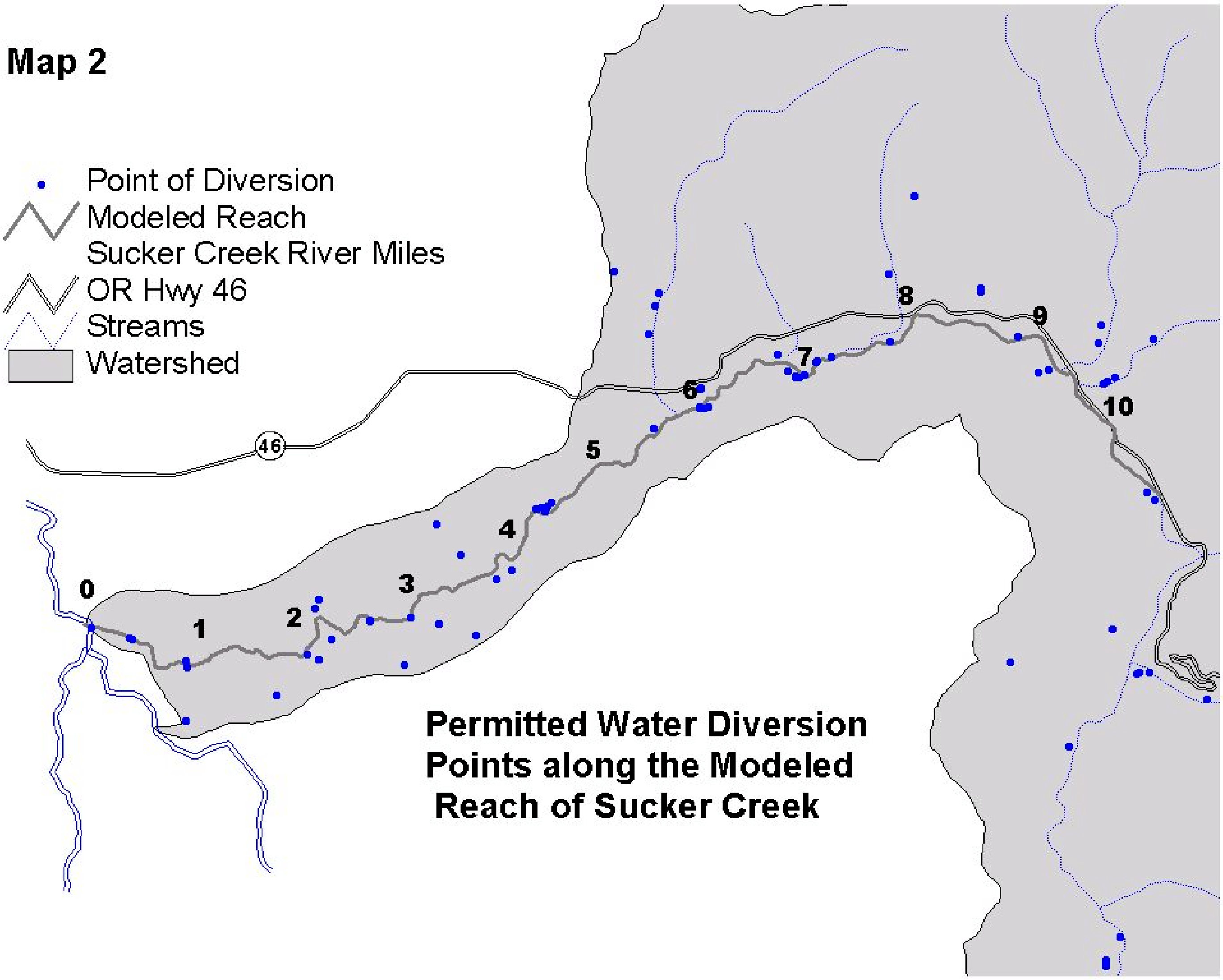
*Figure 3*



Significant flow in Sucker Creek is allocated for irrigation and domestic use. The modeled section of the main stem of Sucker Creek currently has legal water diversions amounting to 32.2 cfs in flow. The tributaries along this reach potentially divert an additional 4.7 cfs (mostly from Bear Creek). Not all of these points withdraw their full allocation all the time. These points of diversion along the modeled reach are identified in Map 2. No attempt was made to identify which diversions were active during the week that flows in Sucker Creek were measured. Figure 4 shows how much flow is potentially diverted between each mile of river. This gives an idea as to which sections of the modeled reach might be most prone to fluctuations in flow during the calibration phase and in the future condition predictions.

Figure 4

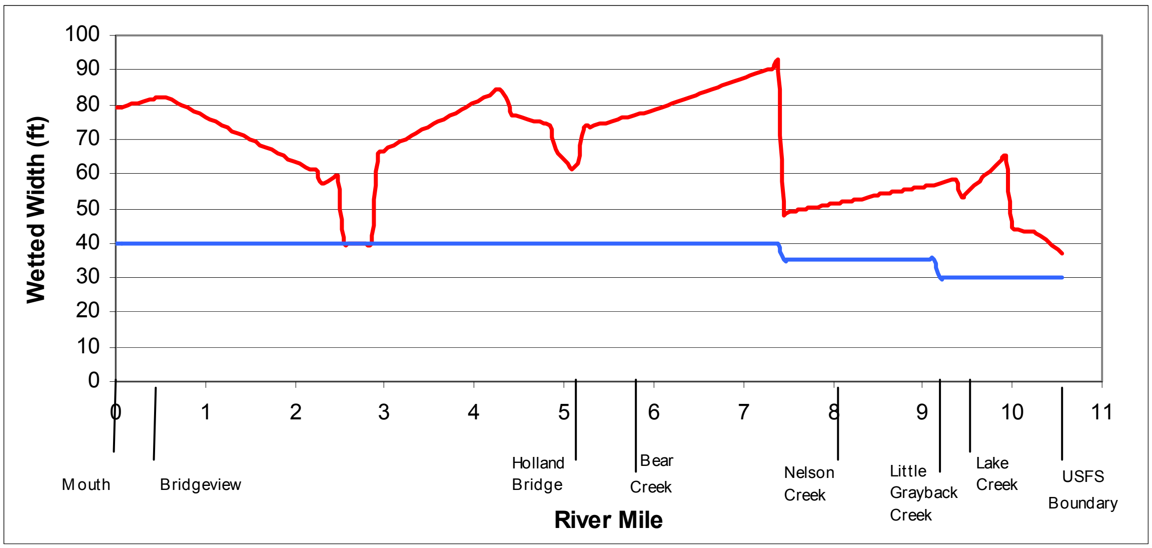



Map 2
Point of Diversion
Modeled Reach
Sucker Creek River Miles
OR Hwy 46
Streams
Watershed
46
0
1
2
3
4
5
6
7
8
9
10
Permitted Water Diversion
Points along the Modeled
Reach of Sucker Creek

## Channel Wetted Width

The wetted width profiles used are shown in figure 5. Current widths are shown as the red (upper) line and expected future widths are shown as the blue (lower) line. Current widths were measured from field observations and aerial photographs. The estimation of wetted widths at System Potential were taken from "Sucker Creek Watershed – Restoration Strategy for Private Lands on the Main Stem of Sucker Creek" dated May 17, 2001)

Figure 5



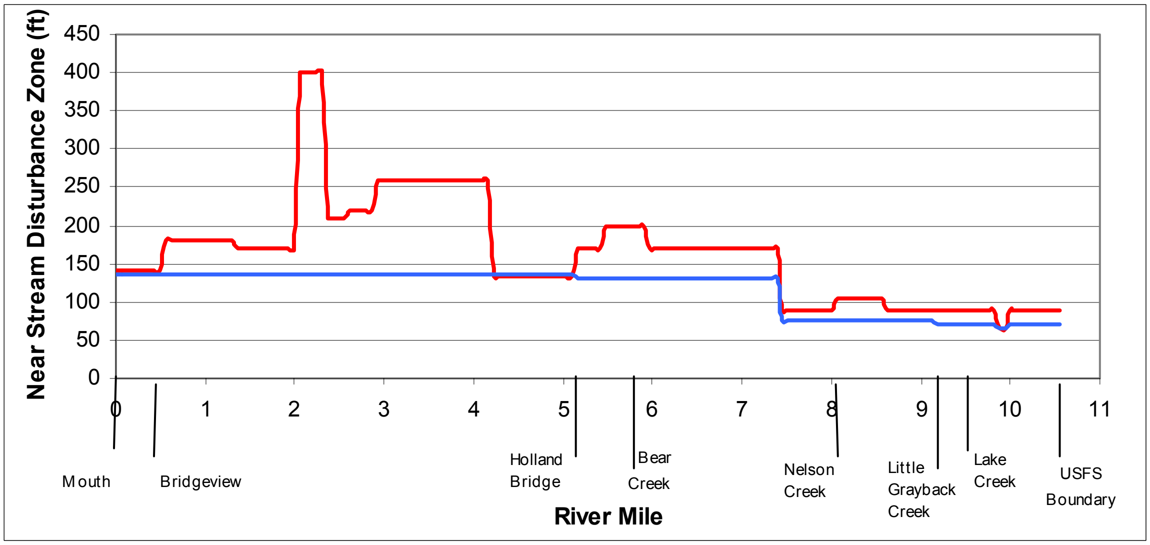

# NEAR STREAM DISTURBANCE ZONE (NSDZ)

The channel occupied by the stream is bounded by two banks with vegetation growing on each bank. The Near Stream Disturbance Zone (NSDZ) is defined as the distance between these two "walls" of vegetation. Comparing two channels of equal width, a larger NSDZ allows more solar energy to reach the water than does a narrow NSDZ. The reason is because shade can only block solar energy if the shadow falls over the water. The closer the tree is to the water, the more shade it provides to the stream. A pictorial example of narrow and wide NSDZs is shown in the two pictures on the bottom half of the next page. Both pictures are shown at the same scale.

NSDZ widths measured currently (red line) and estimated for System Potential conditions (blue line) are shown in figure 6. The expected future widths are taken from "Sucker Creek

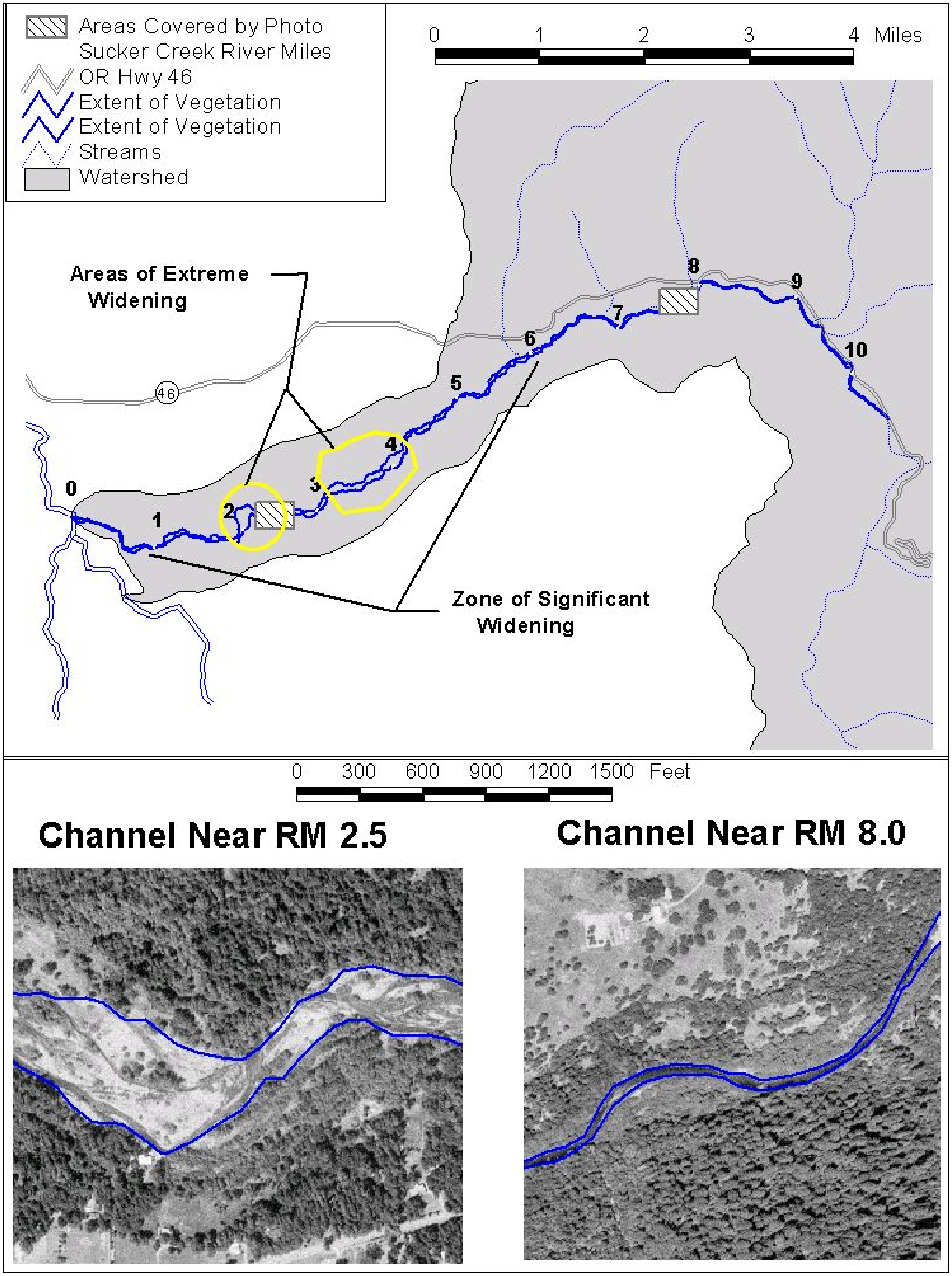
Watershed – Restoration Strategy for Private Lands on the Main Stem of Sucker Creek" , dated May 17, 2001

Figure 6



***Map 3***

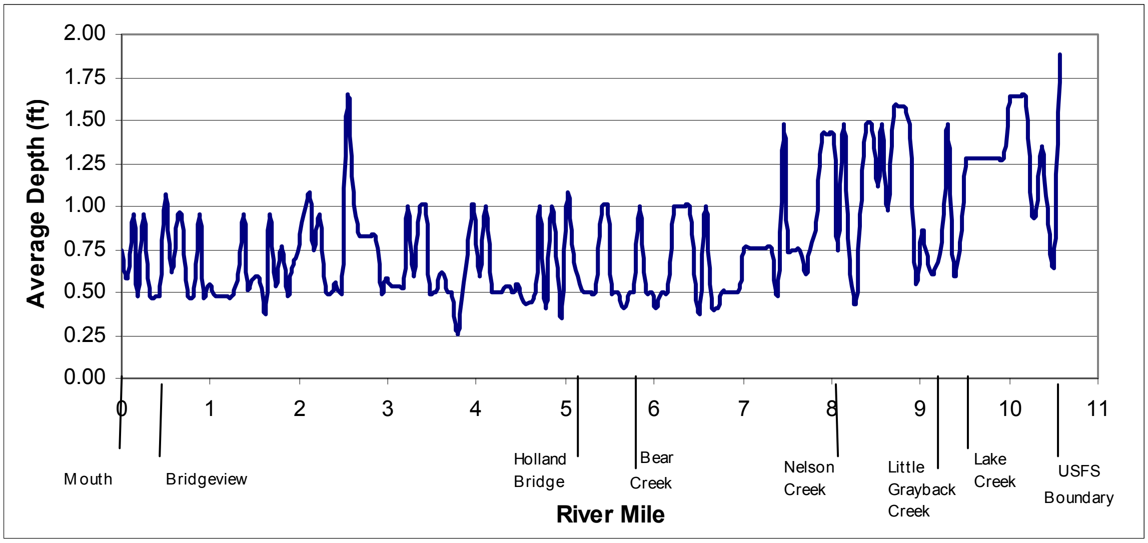
In map 3, significant widening is defined as a NSDZ greater than 100 feet, and extreme widening is defined as a NSDZ greater than 150 feet.



## AVERAGE DEPTH

Average depths for each segment was calculated from the flow volume and wetted width values used for that segment. Figure 7 shows the average depth profile used in the model for all simulations.

Figure 7




## FLOW VELOCITY

Average velocity for each segment was calculated from the segment slope and Manning's "n" used for that segment. The velocity profile is shown in Figure 8. Figure 9 Shows the resulting average time-of-travel along the modeled reach. The velocities used for calibration were also used for all future simulations.

Figure 8

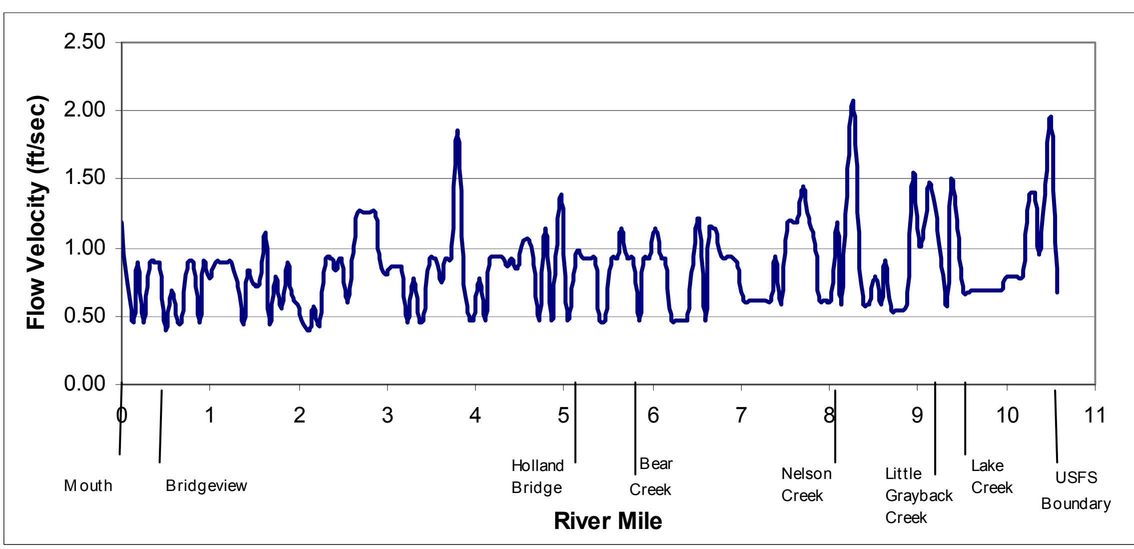
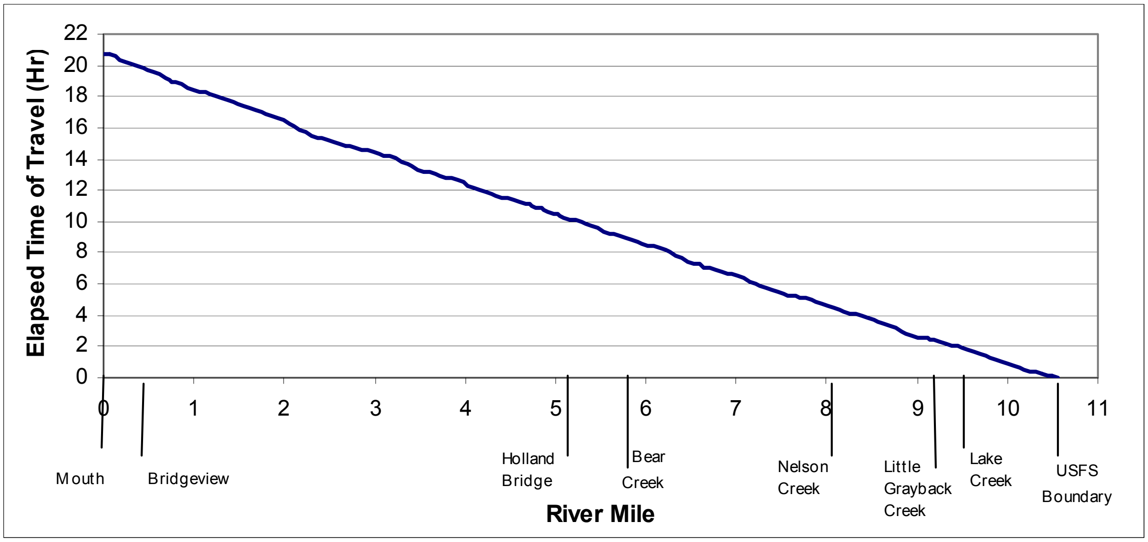


Figure 9



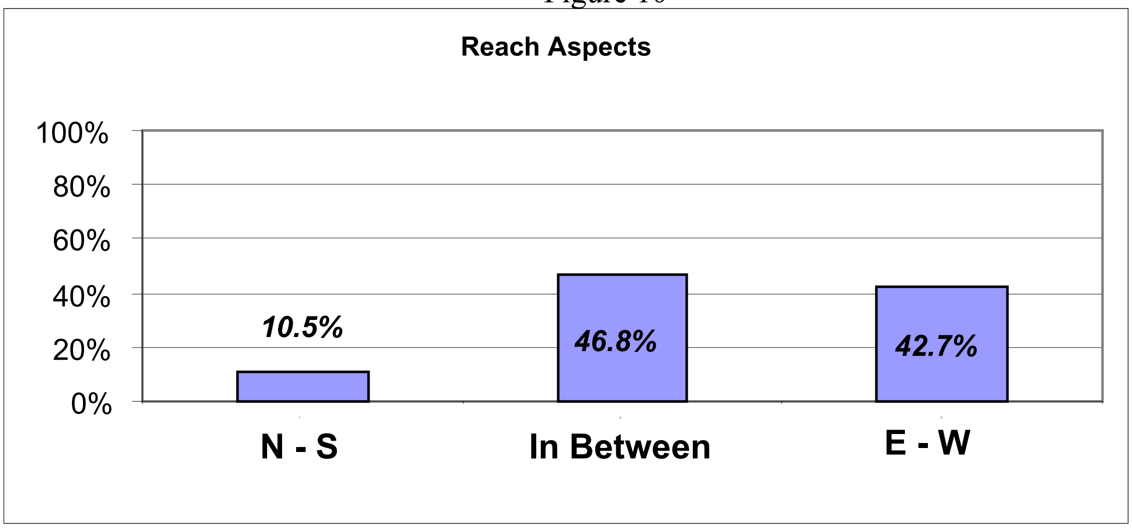

## CHANNEL SUBSTRATE

Channel substrate larger that cobble size can absorb solar energy and re-release it during the night. The lower part of Sucker Creek has very little substrate of this size (less than 10%), and therefore this energy pathway contributes little to stream temperatures. A uniform value of 10% bedrock composition was assumed for calibration and also used for the future condition simulation.

## Stream Aspect

Figure 10 shows the relative amount of the study reach headed in these general directions. Aspect is important because North – South streams are less influenced by riparian shading as a means of temperature control while East – West streams are greatly affected by riparian shade. Almost 90% of the stream miles should have an average or better than average response to riparian shade for temperature control.

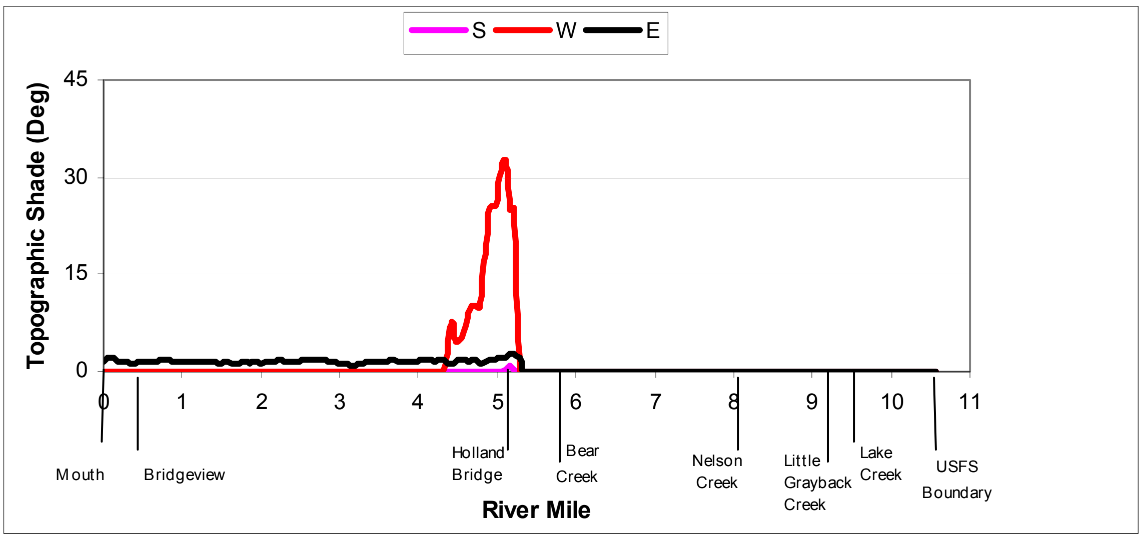
Figure 10



## TOPOGRAPHIC SHADING

Topographic shading is defined as the shading provided to the stream by ridgelines or hills. It is extremely localized and unique for each system. Southern shading can result in an appreciable lowering of solar energy during the day. East/West shading effectively shortens the amount of daylight hours by delaying local sunrise or hastening local sunset. Figure 11 shows the topographic shading experienced in the lower section of Sucker Creek. Only about one river mile is affected by some shading from the west. The net effect of topographic shading on Sucker Creek is minimal.

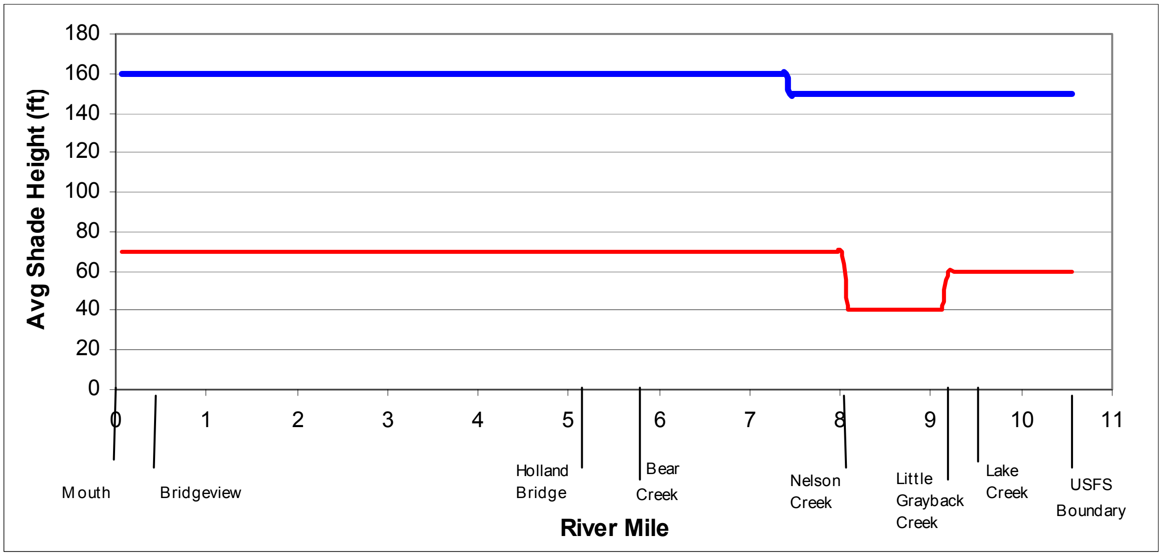
Figure 11



**Riparian Shade Height**

Shade height is one of three shade parameters that is assumed to change for future condition simulations. The present condition for shade height (left and right banks averaged together) are based on field measurements, is shown in Figure 12 as the lower (red) line. The assumed management and System Potential conditions for shade height is shown as the upper (blue) line. This height is based on the expected size of trees that would grow on these soils, with this rainfall and at this latitude.

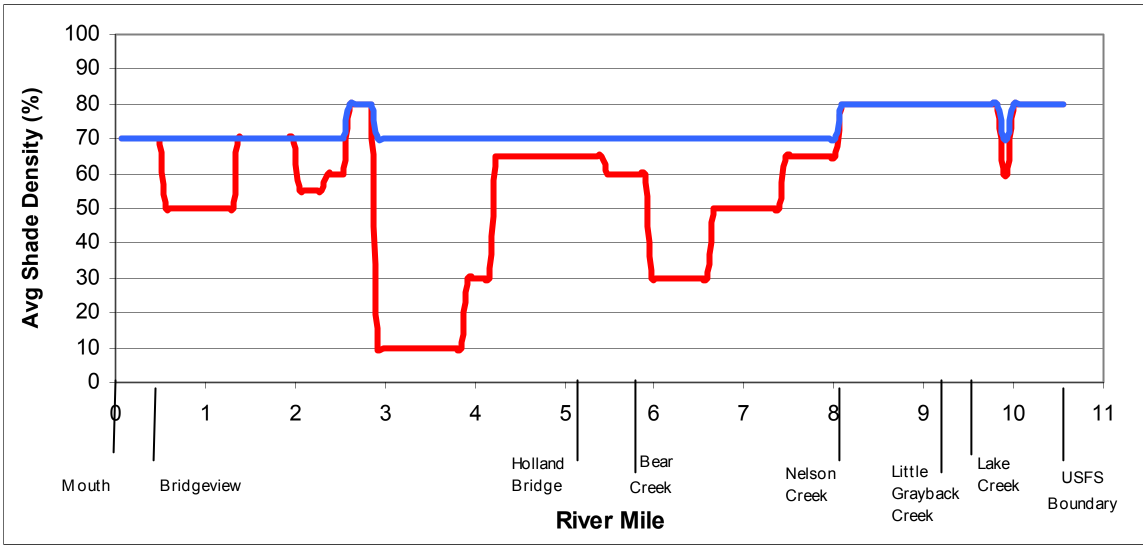
Figure 12



**Riparian Shade Density**

Shade density is also assumed to change in the future. The lower (red) line in Figure 13 is field measured shade density (Left and Right banks average together) as it exists today. The assumed future shade densities (top blue line in figure 13) are assumed to be at 70%. If present density is higher than 70%, then the present density is used. A density value of 70% is assumed to be conservative for the Sucker Creek Watershed so this should add a margin of safety to the future condition projections.

Figure 13

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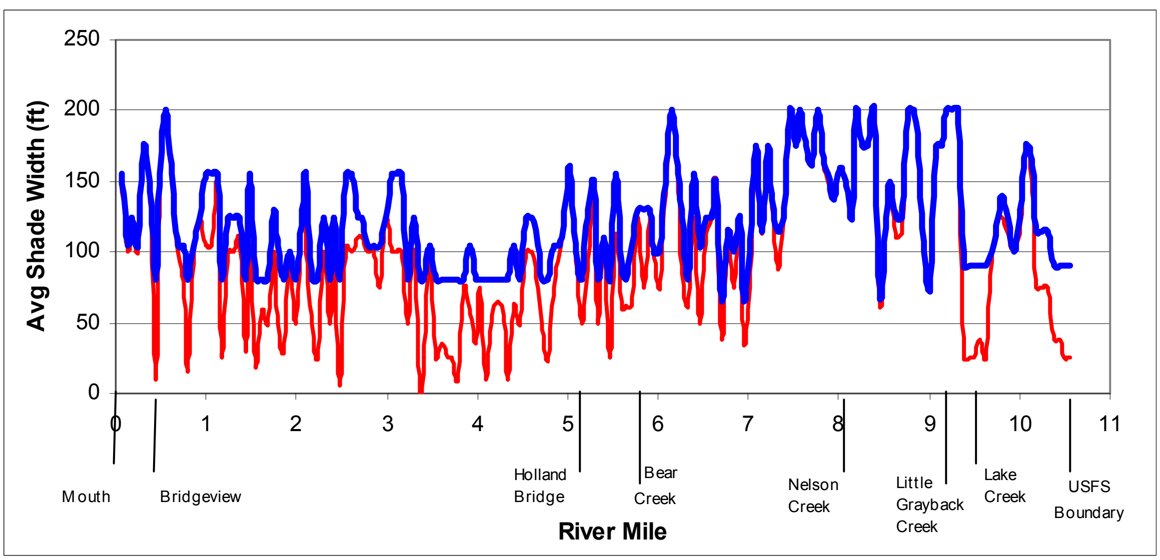
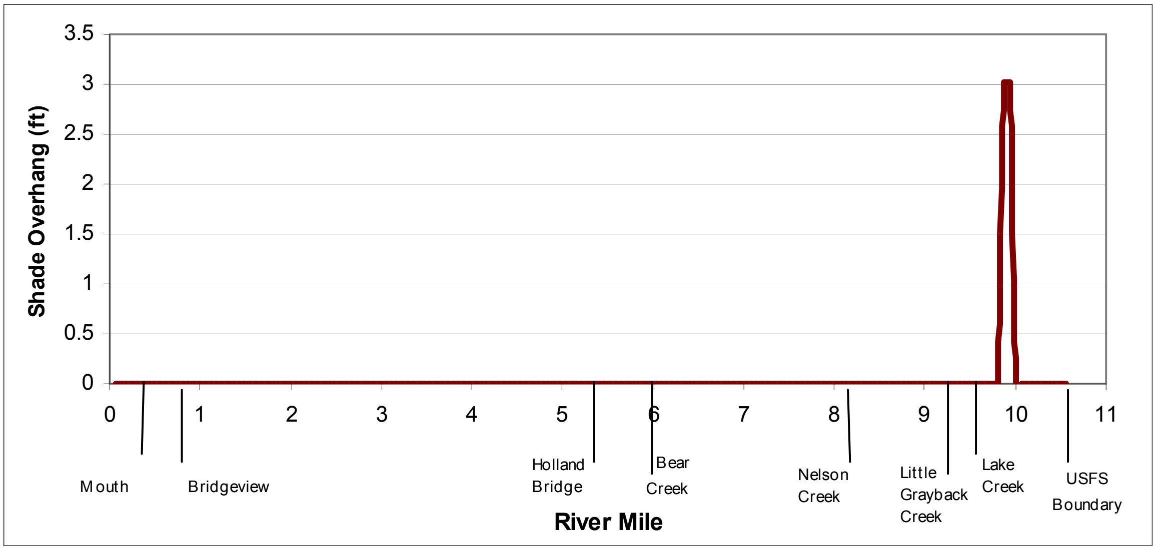
(thin
System

Figure 14



## SHADE OVERHANG

Shade overhang was assumed to be the same in the future as it is presently (see Figure 15). The present overhang values are very low, and will likely increase in the future. Assuming lower than expected values in the future introduces another margin of safety for future condition simulations.



## MODEL INPUT DATA SUMMARY

Below is a summary of the model parameters used, how they were derived, and if that parameter was changed between the calibration and the future condition simulations. Parameters in italic type are those used for model calibration.

| Data Class | Parameter | Method (measured/calculated) | Source | Future Condition Different from Calibration |
|---|---|---|---|---|
| Stream | Elevation | Measured | DEM Data | No |
| | Gradient | Calculated | GIS Utility | No |
| | Topographic Shade | Calculated | GIS Utility | No |
| | Stream Reach Aspect | Calculated | GIS Utility | No |
| Flow | Volume | Measured | Field Measurement | No |
| | Velocity | Measured/Calculated | Model calculated To field data | No |
| | Depth | Measured/Calculated | Model calculated To field data | No |
| Channel | Near Stream Disturbance Zone Width | Measured | Digital Photos | Yes |
| | Wetted Width | Measured/Calculated | Model calculated To field data | Yes |
| | Channel Substrate | Measured | Field Measurement | No |
| | | | | |
| Shade | Height | Measured | Field Measurement | Yes |
| | Width | Measured | Field Measurement | Yes |
| | Density | Measured | Field Measurement | Yes |
| | Overhang | Measured | Field Measurement | No |
| Stream Temperature | Main Stem | Measured | Field Measurement | --- |
| | Tributaries | Measured | Field Measurement | No |
| Weather | Humidity | Measured | Field Measurement | No |
| | Wind Speed | Measured | Field Measurement | No |
| | Air Temperature | Measured | Field Measurement | No |

## MODEL CA LIBRATION

All models require some calibration to make the computer simulation match the observed data. For this series of *Heat Source* simulations, the only parameters that changed during the calibration process were Manning's “n” and local wind speed. Care was taken so that model-calculated values for flow velocity and depth did not divert significantly from the field-observed values (usually recorded at flow volume measurement sites).

Any data obtained from field measurements or scaled from photos were used as recorded. Adjustments to the three calibration parameters ceased when the simulation output matched the observed field data. None of the calibration parameters were changed during the simulation of future conditions.

Most models are calibrated to one set of conditions. A unique feature of the *Heat Source* model is that it allows calibration simulations to be compared directly to observed stream temperature logged during an entire 24 hour day. This allows calibration to not only daily minimum and maximum values, but also the ability to fit modeled heating and cooling rates to observed data. For this study, the mainstem of Sucker Creek had seven data loggers where simulated vs. observed data sets could be compared. A summary of how well the modeled set matched the field measured set is shown below. Each logger summary is based on 24 data pairs (one pair for each hour throughout the day).

| Logger Location | Approximate River Mile | "r Squared" Value | Standard Deviation (Deg) | Standard Error (Deg) | |
|---|---|---|---|---|---|
| USFS Boundary | 10.6 | 1.000 | 0.01 | 0.01 | |
| U/S of Little Grayback Creek | 9.3 | 0.930 | 0.44 | 0.52 | |
| RM 7.45 | 7.5 | 0.845 | 0.73 | 0.83 | |
| U/S Bear Creek | 5.9 | 0.870 | 1.20 | 0.76 | |
| RM 2.2 | 2.2 | 0.996 | 1.82 | 0.13 | |
| Bridgeview | 0.5 | 0.971 | 1.65 | 0.34 | |
| Mouth | 0.0 | 0.965 | 1.35 | 0.41 | |
| | Avg | 0.940 | 1.029 | | Deg C |
| | Avg | | 1.851 | | Deg F |

Agreement between the calibration simulation and observed instream temperatures was very good to excellent. The average error expected from any temperature simulated should be well under one degree F.

# MODEL OUTPUT

Solar Flux

Figure 16 shows the total amount of solar energy available to heat the lower part of Sucker Creek on an early August day (uppermost black line, centered near 2440 BTU/SqFt/Day). This is the total potential energy available to the stream.

The next line down (red) shows the amount of energy that passed through the riparian vegetation on the day modeled (8/3/99) and actually entered the stream. Presently, at least 40% of the modeled reach of Sucker Creek experiences the maximum possible amount of solar loading.

The lowest line (dark blue) shows the amount of energy that would pass through the riparian vegetation if system potential conditions are achieved.

Figure 16

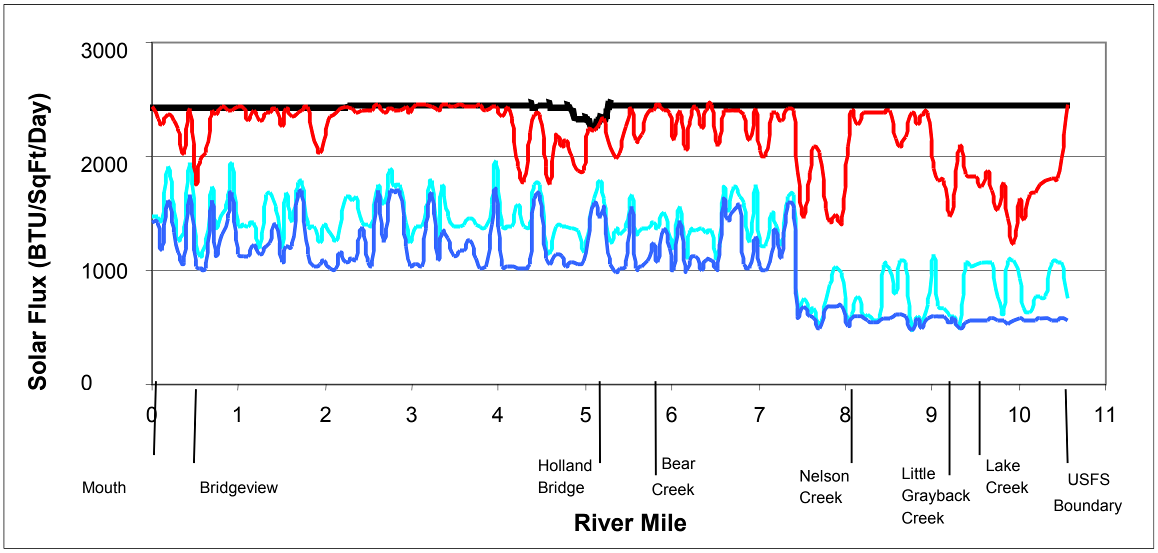
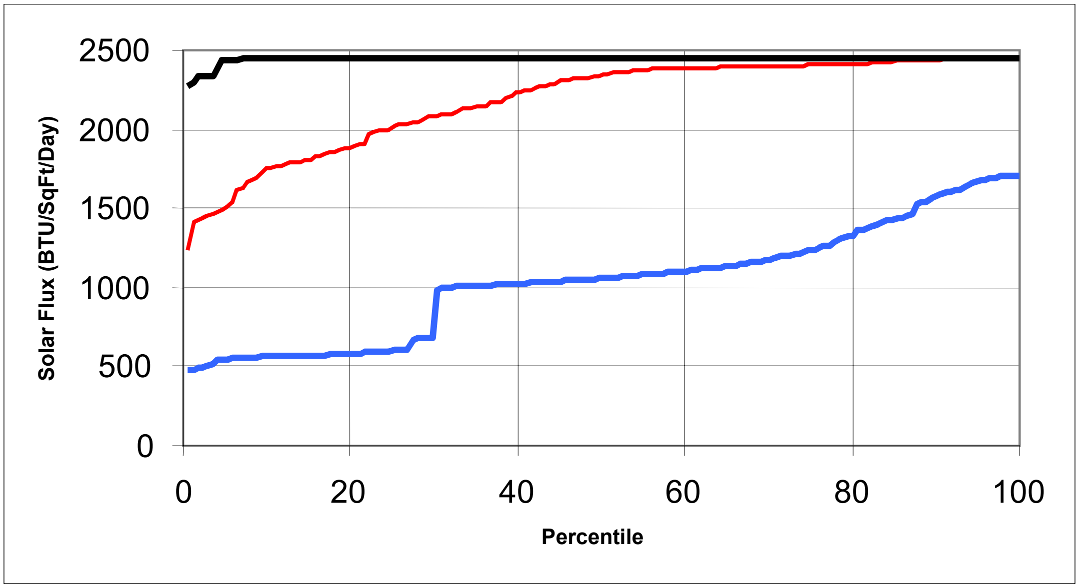


Figure 16 shows this same data presented as a cumulative frequency plot. Colors and symbols are the same as in figure 17.

Figure 17

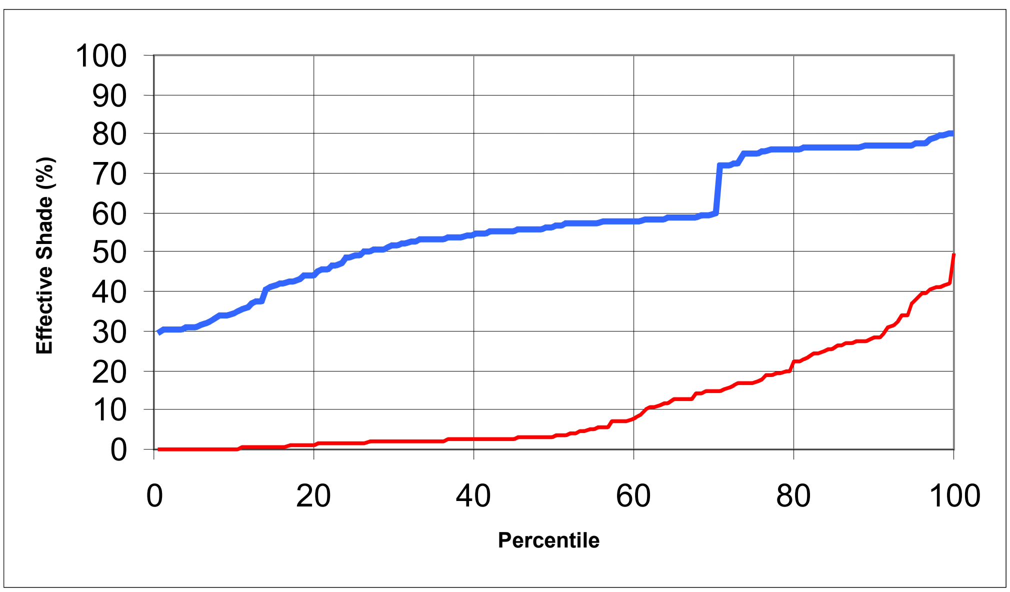



**Effective Shade in the Riparian Zone**

Effective shade is defined as the percentage of available solar flux that is intercepted by vegetation and topographic shading before it can enter a stream and cause heating.

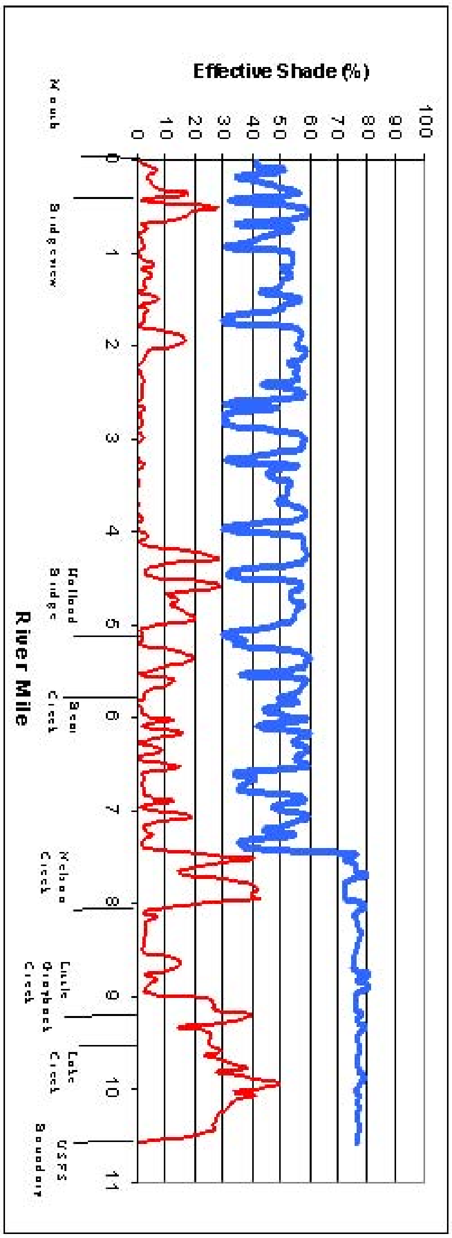
Figure 18 shows a cumulative frequency plot of the amount of effective shade calculated for current conditions (lowest red line), and at system potential conditions (blue line).

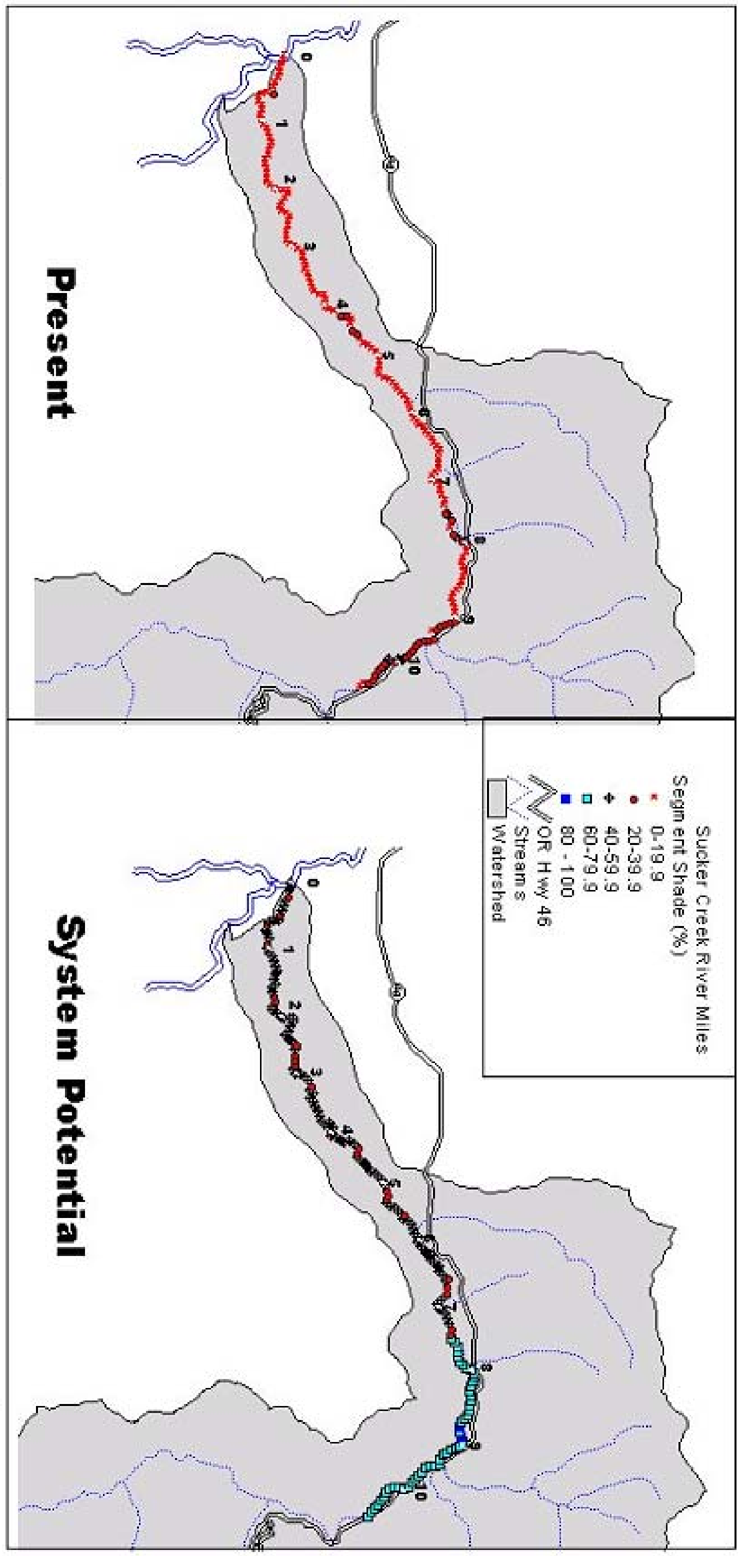
Figure 18



Map 4 and figure 19 show the amount of effective shading provided to the stream by riparian vegetation in the present (left map and lower red line in graph) and system potential (right map and upper blue line in graph) conditions.

**Map 4 and Figure 19**

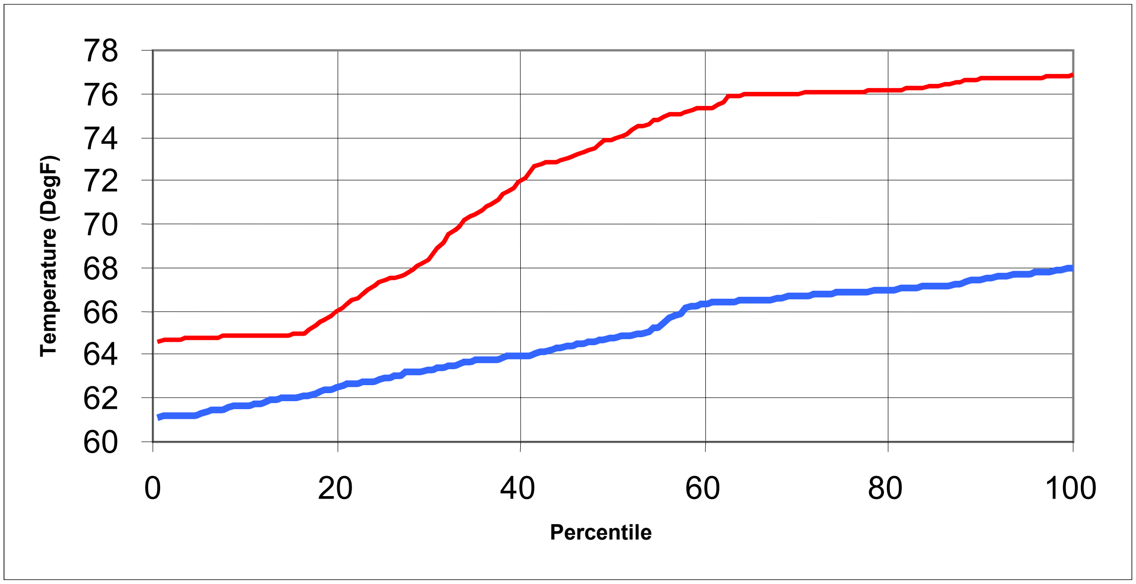


## Instream Temperature

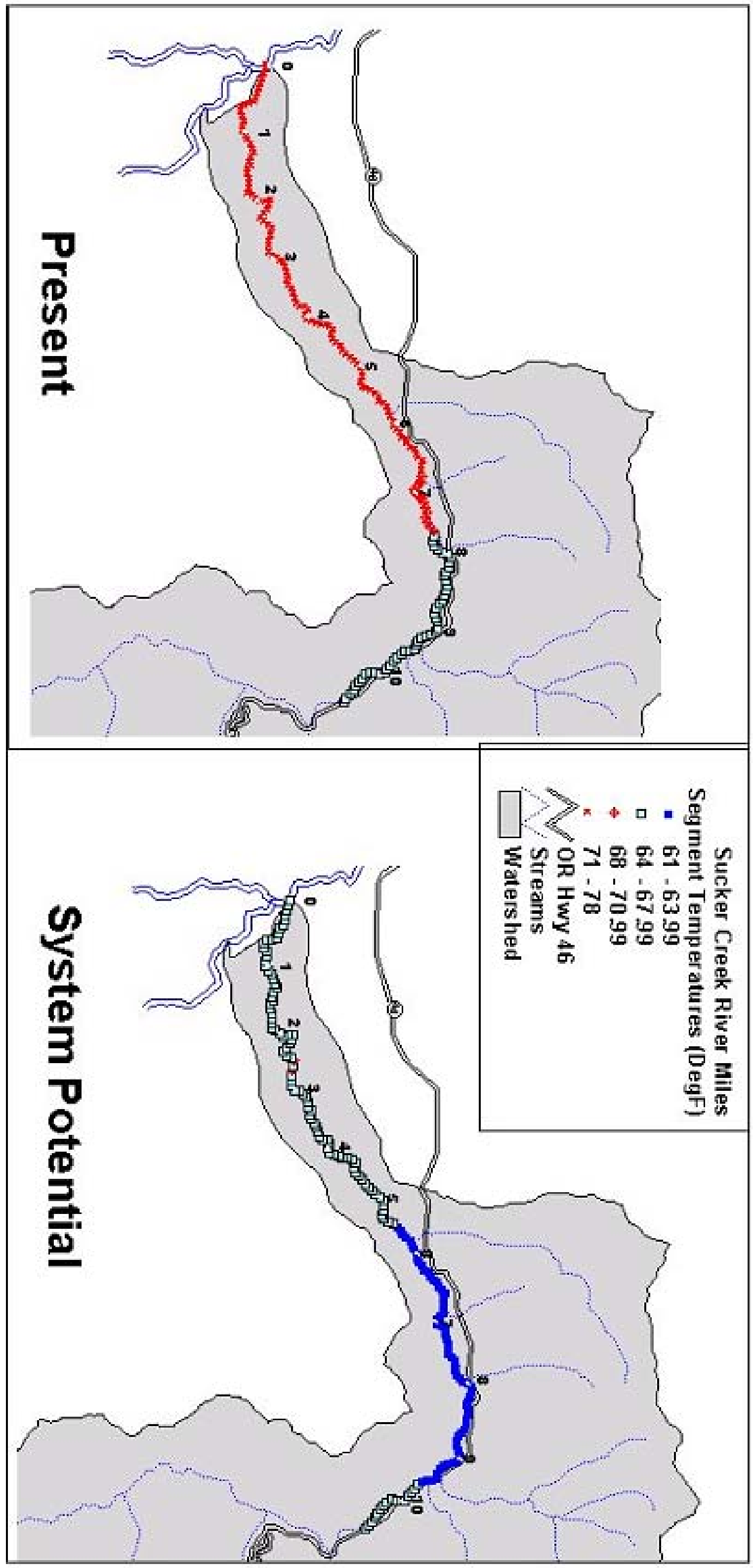
Figure 20 shows the frequency distribution of current temperatures (top red line) and temperatures expected at system potential conditions (bottom dark blue line). **All temperatures are as predicted for 4:00 in the afternoon on an early August day**. These projected temperatures do not take into account any potential cooling in tributary streams or increased interaction with subsurface water. Either of these two factors could result in even lower temperatures in Sucker Creek.

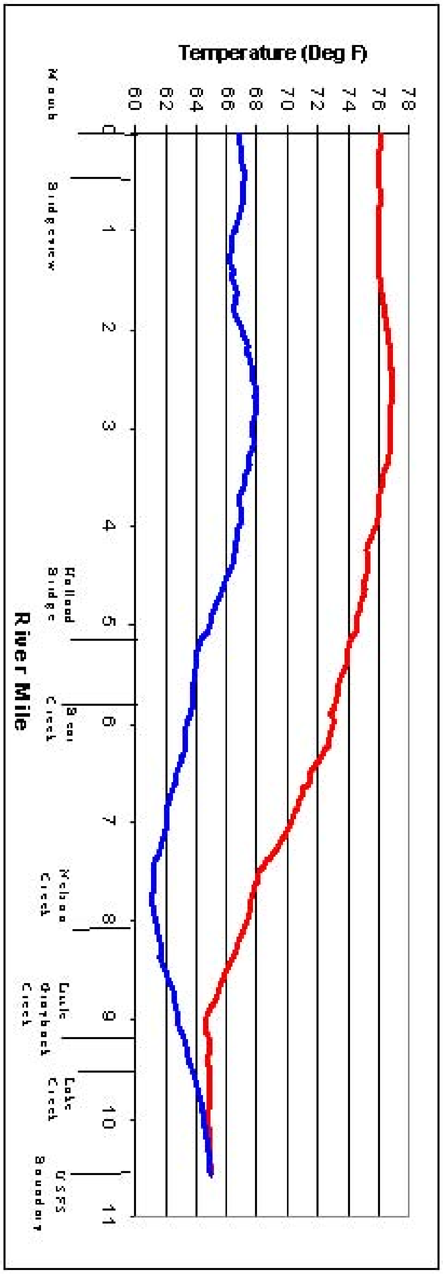
Figure 20




On the next page, Map 5 and Figure 21 show these same instream temperatures for current conditions (left map and upper red line in graph) and expected System Potential temperatures (right graph and lower blue line) .

# Map 5 and Figure 21



**Temperature Distributions**

The next two graphs (Figures 22 and 23) show the same temperature data information displayed in slightly different formats. They show the distribution of current temperatures and those expected at System Potential condition. The temperature intervals chosen are important for salmon life histories. Although greatly simplified, temperatures chronically above 58°F are can kill salmon embryos in stream gravels and temperatures chronically above 72°F can be lethal to juvenile fish. These distributions are distance weighted and **reflect conditions at 4:00 PM in early August.**

Figure 22

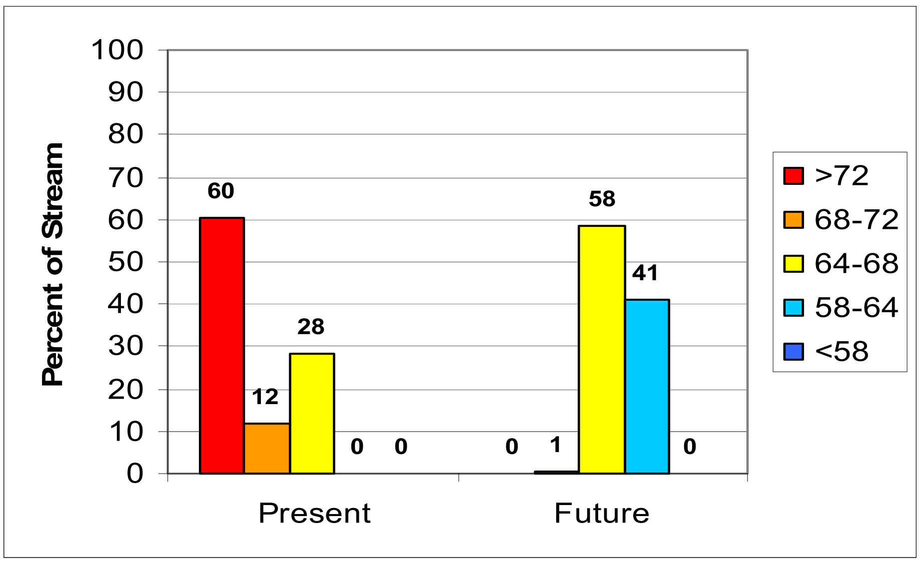
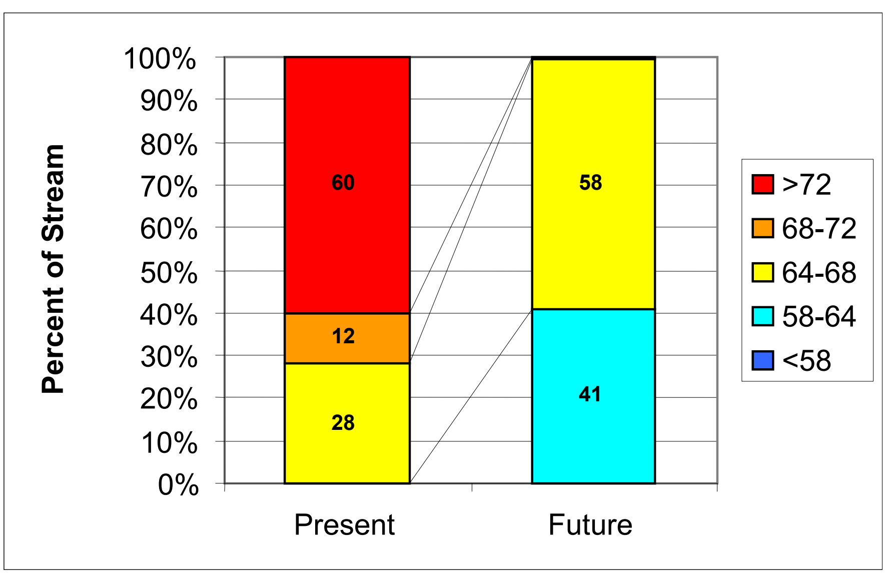



Figure 23



## SHADE IMPROVEMENTS VS. CHANNEL IMPROVEMENTS AS A MEANS OF TEMPERATURE CONTROL

In the System Potential simulations, both channel and shade improvement surrogate targets were used as defined in the TMDL. The following analysis was done to understand the relative temperature improvements that can be expected from improving channel-only or shade-only conditions.

Figure 24 shows 4:00 PM temperature profiles from the current condition (upper red line), System Potential (bottom dark blue line) and a simulation where only channel (wetted and near stream disturbance zone widths) improvements were made ( middle tan line). Figure 25 shows this same data as a frequency distribution plot (colors and symbols the same as Figure 24).

Figure 24

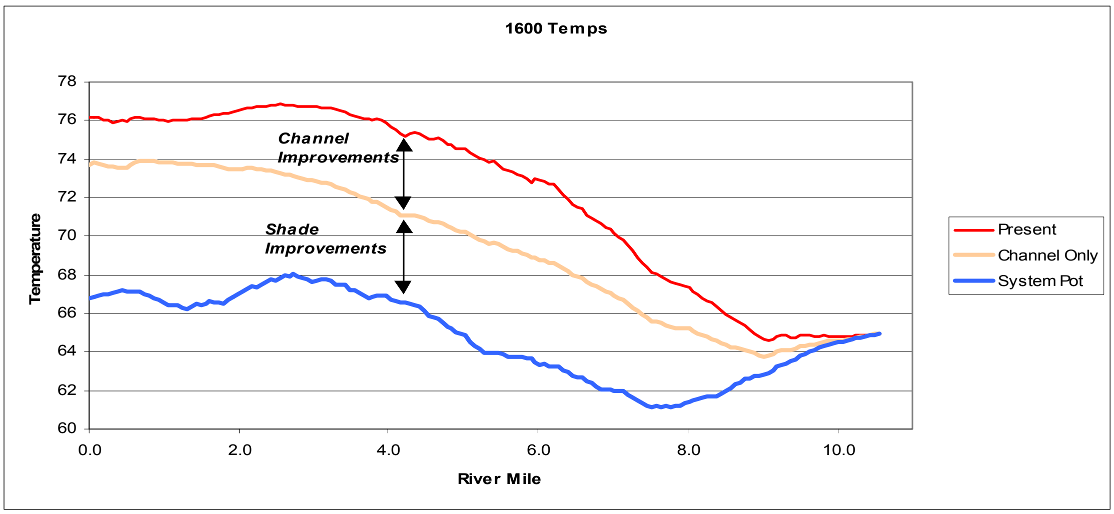
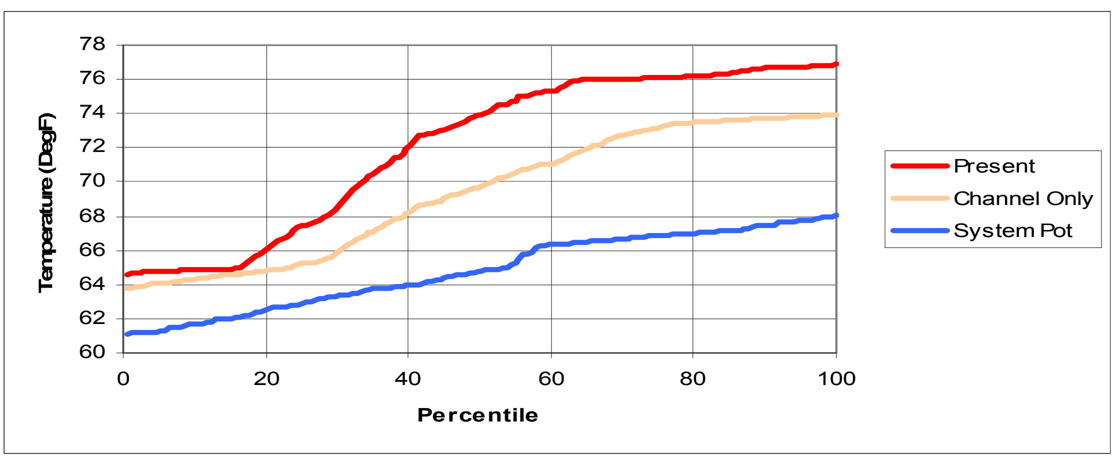



Figure 25



Narrowing wetted widths reduces the amount of surface area available to intercept solar energy. Narrowing the near stream disturbance zone allows more shading to the stream from adjacent tree belts. Another important aspect of channel conditions is the stability of the channel location within the floodplain. Current channel conditions are very unstable, Sucker Creek continually moves around the valley floor, knocking out belts of trees that provide shade. A stable channel would allow vegetation to mature, instead of knocking everything down during flood events. Mature vegetation conditions will only occur if riparian trees have a stable place "to stand". In the final analysis, the quality and quantity of shade produced depends so much on the stability of the streamside areas where it will grow, that separating out channel and shade improvements as separate process's is probably inappropriate. However, it does show that channel geometry, channel stability and shade quality/quantity all will play a role in the restoration of the Sucker Creek system.

# Appendix C

## Water Rig h ts Summary: Sucker Creek

| SUCKER STREAM SEGMENT | GRAYBACK USE | WATER CFS ALLOTMENT | USE TOTAL |
|---|---|---|---|
| Sucker Creek to E Fk Illinois | Irrigation<br>Fish/Wildlife<br>Agriculture<br>Industrial<br>Domestic | 48.30<br>0.18<br>0.01<br>16.99<br>0.04 | 65.52 |
| Bear Creek to Sucker Creek | Irrigation | 1.37 | 1.37 |
| Green Creek to Bear Creek | Irrigation | 0.31 | 0.31 |
| Nelson Cr to Sucker Cr | Irrigation | 0.02 | 0.02 |
| Unnamed Str to Sucker Cr | Domestic | 0.01 | 0.01 |
| Little Grayback to Sucker Cr | Domestic | 0.02 | 0.02 |
| Unnamed Str to Sucker Cr | Domestic | 0.01 | 0.01 |
| Lake Cr to Sucker Cr | Domestic | 0.18 | 0.18 |
| Grayback Cr to Sucker Cr | Irrigation<br>Industrial | 1.12<br>1.00 | 2.12 |
| Little Jim Cr to Sucker Cr | Industrial | 0.80 | 0.80 |
| Cave Cr to Sucker Cr | Irrigation<br>Industrial<br>Recreation | 0.05<br>11.50<br>0.01 | 11.56 |
| Panther Cr to Lake Cr | Domestic | 0.01 | 0.01 |
| Johnson Cr to Sucker Cr | Industrial | 4.00 | 4.00 |
| Yeager Cr to Sucker Cr | Industrial | 2.00 | 2.00 |
| Mule Cr to Sucker Cr | Industrial<br>Domestic | 8.00<br>0.01 | 8.01 |
| Unnamed Str to Sucker Cr | Industrial<br>Domestic | 7.99<br>0.01 | 8.00 |
| Bolan Cr to Sucker Cr | Industrial | 8.00 | 8.00 |
| E Fk Bolan Cr to Bolan Cr | Industrial | 2.00 | 2.00 |

*TOTALS BY USE*

| Irrigation | Fish/Wild | Agriculture | Industrial | Municipal | Domestic | Recreational |
|---|---|---|---|---|---|---|
| 51.17 | 0.18 | 0.01 | 62.28 | 0.00 | 0.29 | 0.01 |

# Appendix D

## Potential Sources of Project Funding

Funding is essential to implementing projects associated with this WQMP. There are many sources of local, state, federal, and private funds. The following is a partial list of assistance programs available for the Lower Sucker Creek Watershed.

Nonpoint Source Pollution 319, Oregon Department of Environmental Quality: Grants Grant funds available through Section 319 of the Water Quality Act of 1987 are a critical element in turning Oregon's Nonpoint Source control program into water quality protection realities in watersheds throughout the state. Each year, DEQ identifies programmatic and geographic targets, solicits project proposals, assembles a proposal package for EPA's review, develops contracts and agreements for disbursement of grant funds, oversees program implementation, and evaluates program accomplishments. To a greater degree each year, the projects are targeted to address needs related to the following ten major program element: 1. Standards, 2. Assessment, 3. Coordinated Watershed Planning, 4. Education, 5. Demonstration Projects, 6.Technical Assistance, 7.Cost-Share Assistance, 8.Stewardship, 9.Watershed Enhancement Projects, 10.Enforcement.

Oregon Watershed Enhancement Board (OWEB): OWEB funds watershed improvement projects with state money. This is an important piece in the implementation of Oregon's Salmon Plan. Current and past projects have included road relocation/closure/improvement projects, in-stream structure work, riparian fencing and revegetation, off stream water developments, and other management practices.

Environmental Quality Incentives Program (EQIP), U.S. Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS): The EQIP is a flexible, voluntary conservation program for farmers and ranchers who face serious threats to soil, water, and related natural resource concerns. Under the provisions of this program producers will work with a local USDA, NRCS representative to develop a conservation farm or ranch plan that addresses all natural resource concerns over a 5- to10-year period. Conservation options will be selected and implemented by the landowner. In Oregon this program could address such resource concerns as soil erosion, water and air quality, and habitat for fish and wildlife. Producers will be able to sign-up for EQIP contracts starting in February. Producers may contact local USDA Service Centers and the Natural Resources Conservation Service for information on possible eligibility for EQIP.

The Wetlands Reserve Program (WRP), USDA - NRCS: The WRP is a voluntary program offered nationwide which offers payment, based on the agricultural value, for wetlands that have previously been drained and converted to agricultural uses. The program pays up to 100% reimbursement for restoration costs. Landowners retain control of access of their property C no public access is required Landowners maintain ownership of the land and have the right to hunt, fish, trap, and pursue other appropriate recreational uses of the land, including any easement, can be sold. The program provides many additional benefits for the entire community, including better water quality, enhanced habitat for wildlife, reduced soil erosion, reduced flooding, and better water supply.

The Conservation Reserve Program (CRP), USDA - NRCS: The CRP is a highly competitive, voluntary program that offers annual rental payments and cost-share assistance to establish long-term resource conserving covers on eligible land. Enrolled lands remain in the program for 10-15 years. The Farm Service Agency (FSA) in DEQ of Agriculture is responsible for implementing CRP with the assistance of the NRCS. Landowners must compete for the CRP and decisions are made based on accrued benefit points. Lands are determined eligible for the CRP based on points earned for the presence of various resources. The ratings are done using an Environmental Benefits Index (EBI). In addition to containing various resources, eligibility for the CRP requires that land are: highly erodible, cropped wetlands, subject to scour erosion, located in national or State CRP conservation priority area.

Stewardship Incentive Program, USDA-Forest Service & Oregon Department of Forestry: Federal cost-sharing with woodland owners to protect and enhance all forest resources. Practices include tree planting, site preparation, wetland and riparian improvement. Woodland owners with forest land or land suitable for growing trees are eligible. Must own 5 to 1000 acres of forest land in western Oregon or 10 to 10000 acres in eastern Oregon. Cost-sharing ranges from 50 to 75 percent of costs.

Access & Habitat, Oregon Department of Fish and Wildlife (ODFW): The purpose of this program is to improve resource access and wildlife habitat through cooperation between landowners, ODFW, and hunters to manage wildlife on private lands. The Access and Habitat Board recognizes projects which involve funding from other organizations and agencies. Projects may include in-kind contributions of labor, equipment, and material. Typical projects are public access leases, water development, riparian restoration, fertilization, forage seeding, and tree and shrub planting.

The Riparian Tax Incentive Program, ODFW: The Riparian Tax Incentive Program, authorized by ORS 308A.350C308A.383, offers a property tax incentive to property owners for improving or maintaining qualifying riparian lands. Under this program, property owners receive complete property tax exemption for their riparian property. This can include land up to 100 feet from a stream. When the Riparian Tax Incentive law was passed in 1981, the Oregon Legislative Assembly declared that "it is in the best interest of the state to maintain, preserve, conserve and rehabilitate riparian lands to assure the protection of the soil, water, fish and wildlife resources of the state for the economic and social well-being of the state and its citizens." Healthy riparian zones are important to the resource by providing: cooler water due to shading resulting in better habitat for salmon, trout and steelhead; more and better varieties of habitat for wildlife; increased water during summer low flow periods; erosion control by stabilizing streambanks with protective vegetation; and flood control.

Partners for Fish and Wildlife Program, U.S. Fish and Wildlife Service: The mission of the U.S. Fish and Wildlife Service is, by working with others, to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. The Service's Partners for Fish and Wildlife program, formerly named the Partners for Wildlife program, helps accomplish this mission by offering technical and financial assistance to private (non-federal) landowners to voluntarily restore wetlands and other fish and wildlife habitats on their land. The program emphasizes the reestablishment of native vegetation and ecological communities for the benefit of fish and wildlife in concert with the needs and desires of private landowners.

Water Development Loan Program, Oregon Water Resources Department (OWRD): Low-cost financing program to develop state water resources. Examples of projects include water supply projects for communities of under 30,000, fish protection and watershed enhancement, and irrigation and drainage projects. The program is for public entities who do not have access to the public market or for whom such access might be prohibitively expensive. The enrollment period is year round.

Oregon Community Foundation: The Oregon Community Foundation operates a Community Grants Program with regular spring and fall cycles in which applications are accepted. The Community Grants Program is intended to support a wide variety of projects that address one or more of OCF's four primary funding objectives. Grant proposals may range from modest short-term projects and one-time capital expenses to extended projects (up to three years) promising significant long-term benefits for Oregon. In recent years OCF has awarded approximately 200 discretionary grants annually. While two-thirds of the grants have ranged in size from $5,000 to $25,000, awards may range up to $150,000 for projects with exceptional impact on communities. Applicants should note that the larger grants, usually awarded for multi-year projects, comprise only a small percentage of grants made in the Community Grants Program.

# APPENDIX E

## SUCKER CREEK WATERSHED

### Stream Shade and Channel Condition Assessment

*For Private Lands and Lands Managed by the Bureau of Land Management*

Prepared for:
The Oregon Department of Environmental Quality

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January 24, 2000

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## Introduction

The Sucker/Grayback Creek Watershed is part of the Rogue River Basin. Sucker Creek is a high value salmonid fish watershed with good numbers of coho salmon, chinook salmon and winter steelhead. Sucker Creek is one of the most important anadromous fish watersheds in the Rogue Basin. Beneficial uses include domestic and agricultural water supply, mining and cold water biota (salmonid). Land uses include timber harvest, agriculture, recreation and private homes. Sucker Creek and its main tributary, Grayback Creek, encompass 62,159 acres. Of the 62,159 acres within the watershed, 5,796 acres are managed by the BLM, 44,101 acres are managed by the USFS, 33 acres are State/County Ownership, 456 Oregon Caves, the remaining 12,000 acres are private lands.

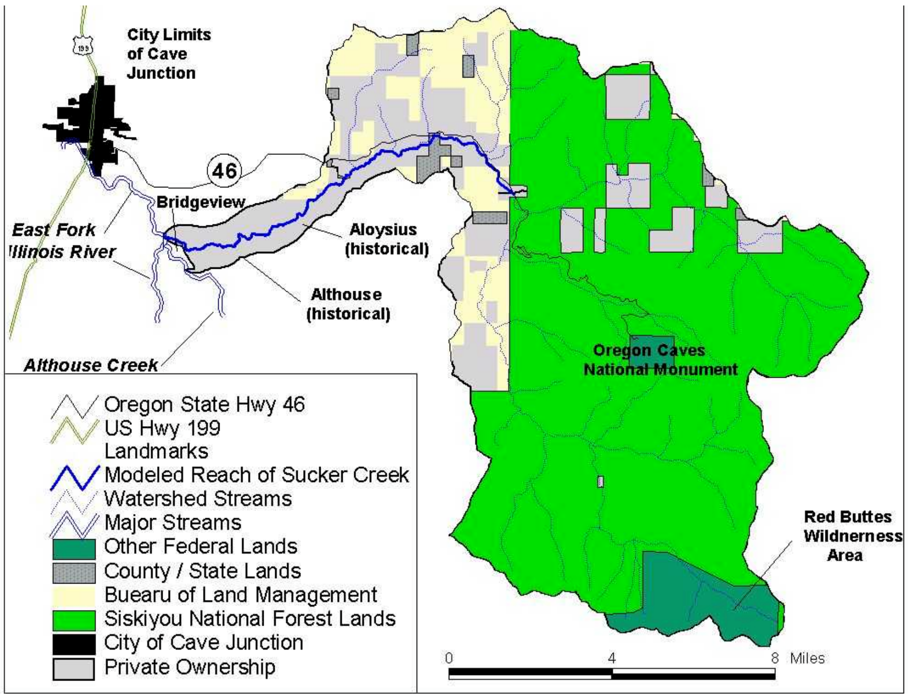



**Figure 1**. Ownership within the Sucker/Grayback Creek Watershed

The 1998 303(d) list of Water Quality Limited Waterbodies, prepared by DEQ, lists Sucker Creek from the mouth to the confluence with Grayback Creek as water quality limited for stream temperature, flow modification and habitat modification. This assessment addresses stream temperature. Sucker Creek at the mouth, has a summer average 7-day high of 71.9° F. The State standard is 64° degrees F.

The Clean Water Act requires that total maximum daily load (TMDL) be established for water bodies for which water quality standards are not being attained. A TMDL is calculated for pollutants determined by the Administrator of EPA as suitable for such calculation (Federal Pollution Control Act as amended by the Clean Water Act, 1987). The Load Allocation for nonpoint sources of pollution includes natural background levels and the Margin of Safety accounts for uncertainty. Pollution is defined in Section 502 of the Clean Water Act to be man caused or induced (Federal Pollution Control Act, as amended by the Clean Water Act, 1987).

Excessive summer water temperatures reduce the quality of rearing habitat for anadromous fish. TMDL uses "other appropriate measures" (or surrogates) as provided under EPA regulation [40CFR 130.2(i)]. The specific surrogates used to address stream temperature are percent effective shade and channel widening. Higher heat load values, which elevate surface water temperatures, result from a combination of riparian vegetation removal and/or channel widening that increases the streams surface area exposed to solar radiation.

In 1999 the Forest Service prepared a Water Quality Management Plan (WQMP) for federal lands in the Sucker Creek Watershed. The Bureau of Land Management (BLM), in cooperation with the Forest Service, completed a shade and channel assessment on 1.8 miles (65 acres) of BLM administered land on the main stem of Sucker Creek above the confluence of Grayback Creek. The results of the assessment can be found in the March 1, 1999 Sucker/Grayback WQMP prepared by the Forest Service, and will not be included in this document. This assessment covers the remaining 5,731 acres of BLM administered land. Figure 2 shows the area covered by this assessment.

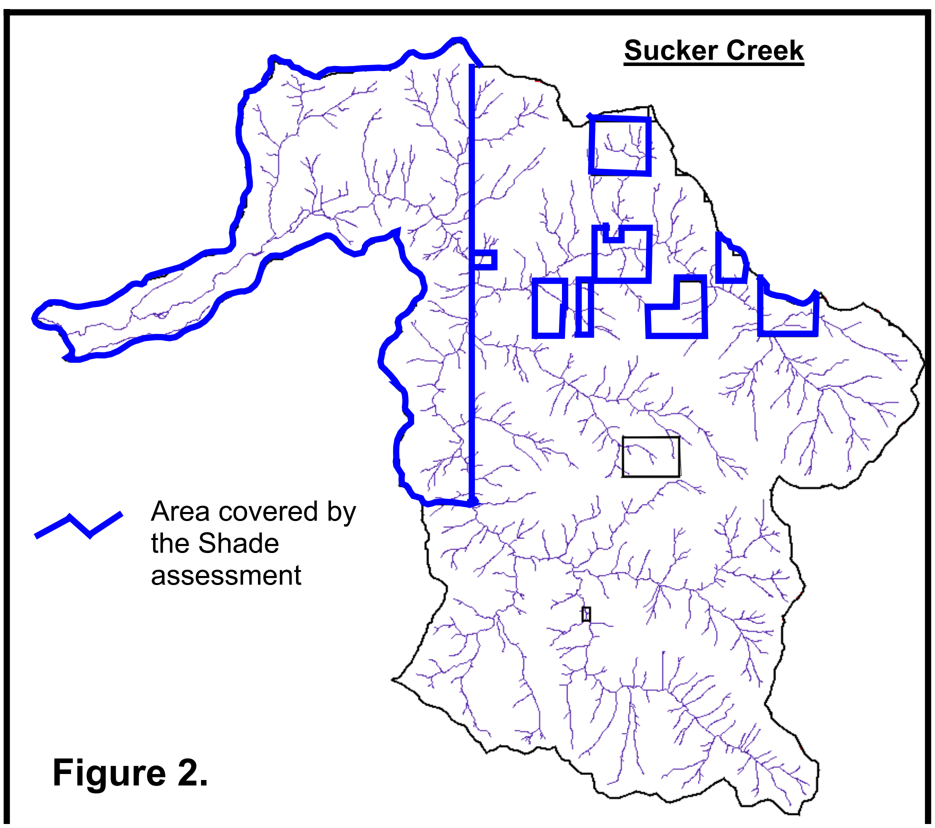



Figure 2.

## The Physics of Stream Temperature

Stream temperature is driven by the interaction of many variables. Energy exchange may involve solar radiation, longwave radiation, evaporative heat transfer, convective heat transfer, conduction, and advection (Lee,1980; Beschta 1984). With the exception of solar radiation, which only delivers heat energy, these processes are capable of both introducing and removing heat from a stream. While interaction of these variables is complex, certain of them are more important than others (when assessing what is influencing stream temperature) (Beschta, 1987). Solar radiation is the singularly most important radiant energy source for the heating of streams during daytime conditions (Brown, 1984; Beschta, 1997). For a stream with a given surface area and stream flow, any increase in the amount of heat entering a stream from solar radiation will have a proportional increase in stream temperature (Brown, 1972). Stream temperature is an expression of heat energy per unit volume, which in turn is an indication of the rate of heat exchange between a stream and its environment

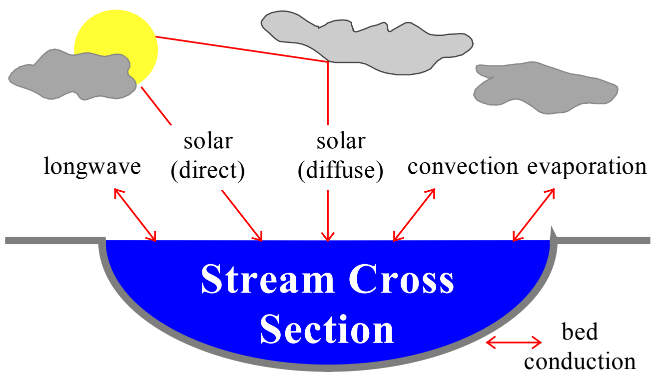



**Figure 3**. Thermodynamic (heat transfer) processes that heat or cool water.

When a stream surface is exposed to solar radiation, quantities of heat will be delivered to the stream system (Brown 1969, Beschta et al. 1987). Some of the incoming solar radiation will reflect off the stream surface, depending on the elevation of the sun. All solar radiation outside the visible spectrum (0.36μ to 0.76μ) is absorbed in the first meter below the stream surface and only visible light penetrates to greater depths (Wunderlich, 1972). Sellers (1965) reported that 50% of solar energy passing through the stream surface is absorbed in the first 10 cm of the water column. Removal of riparian vegetation, and the shade it provides, contributes to elevated stream temperatures (Rishel et al., 1982; Brown, 1983; Beschta et al., 1987). Exposure to direct solar radiation will often cause a dramatic increase in stream temperatures. When shaded throughout the entire day, far less heat energy will be transferred to the stream. The ability of riparian vegetation to shade the stream depends on vegetation height, density, stream width and position relative to the stream. Decreased shade levels result from a lack of adequate riparian vegetation to reduce sunlight reaching the stream surface (e.g. heat from incoming solar radiation).

Models have been developed based on a heat budget approach which estimate water temperature under different heat balance and flow conditions. Using mathematical relationships to describe heat transfer processes, the rate of change in water temperature on a summer day can be estimated.

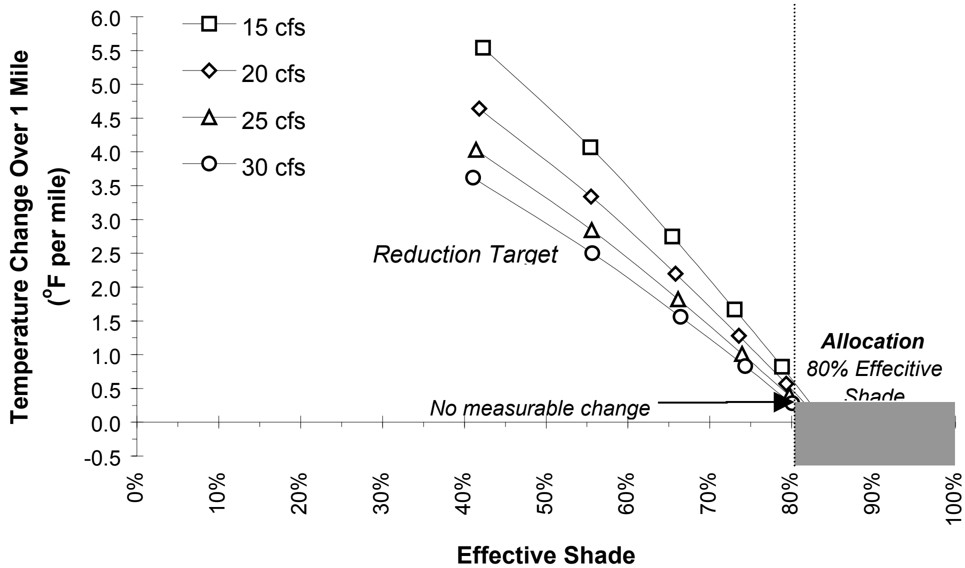



**Figure 4.** Stream shade, flow and water temperature change.

Figure 4 shows the relationship between stream flow and heating over 1 mile of stream for various shade values. As the shade values increase, a point is reached where the reduction in stream temperature may not be measurable. In the modeled values in Figure 4 (Boyd, 1999), at 80% shade there is little gain in stream temperature reduction for all flow values. This suggests that 80% stream shade is a threshold for optimum shading even though some benefit is gained in stream temperature reduction for higher shade values.

As channel width increases, a point is reached where mature conifers are not tall enough to totally shade the channel and optimum shade values may be less than 80%. Assuming a site potential tree is 150 feet tall, as channel width increases over 30 feet, shade decreases. As shown in figure 5, at stream widths above 40 feet, the optimum shade values fall below 80%. In channels wider than 30 feet, channel shape plays an important role in stream heating. If excessive sediment has deposited in the channel causing the channel to widen, there is more stream surface area exposed to heat transfer from solar radiation, and the result is increases in stream temperature. This is the case on the main stem of Sucker Creek (see channel discussion).

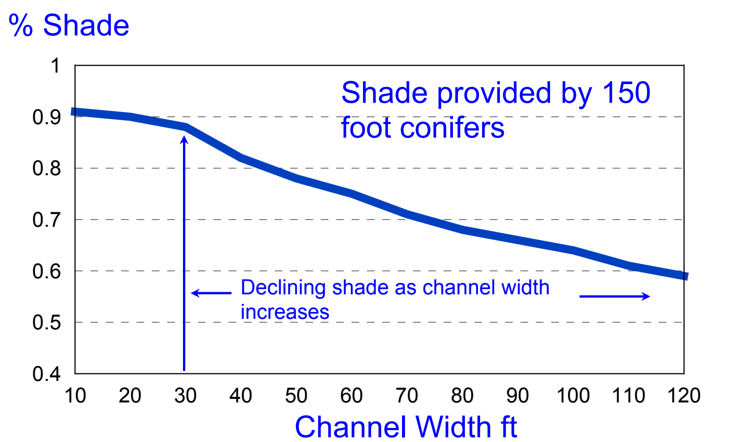



**Figure 5.** Shade decreases and channel width increases.

## Existing Shade and Potential Shade

Existing shade is simply a measure of the amount of shade provided by the existing vegetation to the stream. This may or may not be the "total potential shade" or the most shade possible given the channel characteristics (stream width) and sites ability to grow trees. Existing shade is a measure of the current condition. Site potential shade is the optimum shade that can be expected given the channel and site characteristics.

In theory, it is possible to reach 100% stream shade. However, small amounts of sunlight will penetrate the most densely stocked (>70% effective shade density) trees. So in reality, the upper limit of potential stream shade is not 100% but between 95 to 97%. Tributaries to the main stem of Sucker and Grayback Creek are considered small streams and are capable of reaching 90% plus shade. As a stream gets wider, at some point even the tallest of mature trees can't shade the entire channel width (figure 5). This is the case on the main stem of Sucker Creek. Unlike the tributaries, the main stem under the best of conditions can only reach a potential shade value of 55% to 60%.

## Stream Shade Assessment

The purpose of this assessment is to determine if any management activities, on lands managed by the BLM, are contributing to excess stream temperatures on main stem of Sucker. Primary watershed disturbance activities, which contribute to surface water temperatures increases, include forest management within riparian areas and roads. To determine the shade condition, the stream network was divided by tributaries and the main stem of Sucker Creek. Tributaries contributing 5% or more of stream flow to the main stem, as measured at the point of confluence, were considered to influence main stem temperatures and were included in the shade assessment.

Stream flow of the tributaries was estimated by measuring the drainage area of each tributary and multiplying that value times the average flow value per square mile in July/August as determined by the flow records of the Sucker Creek stream gage. That value was compared to the flow of the main stem at the confluence with the tributary. Tributaries included in the BLM shade assessment are Bear Creek and Little Grayback Creek.

Streams analyzed were broken into segments with similar characteristics and numbered. For each segment, vegetation and channel characteristics were estimated using 1997 aerial photographs. This information was used to estimate stream shade from "shade curves." A total of six sites were selected for field measurements on the tributaries and main stem of Sucker Creek. That information was compared with the information estimated from aerial photographs to determine the accuracy of the photo interpretation (see Comparison of Estimated and Measured Values Section). Note that recovery times where provided, are for growth of the shade producing streamside vegetation and do not take into account storm intervals or other natural disturbances nor the time for point bar development and associated channel changes prior to vegetation establishment.

## Bear Creek

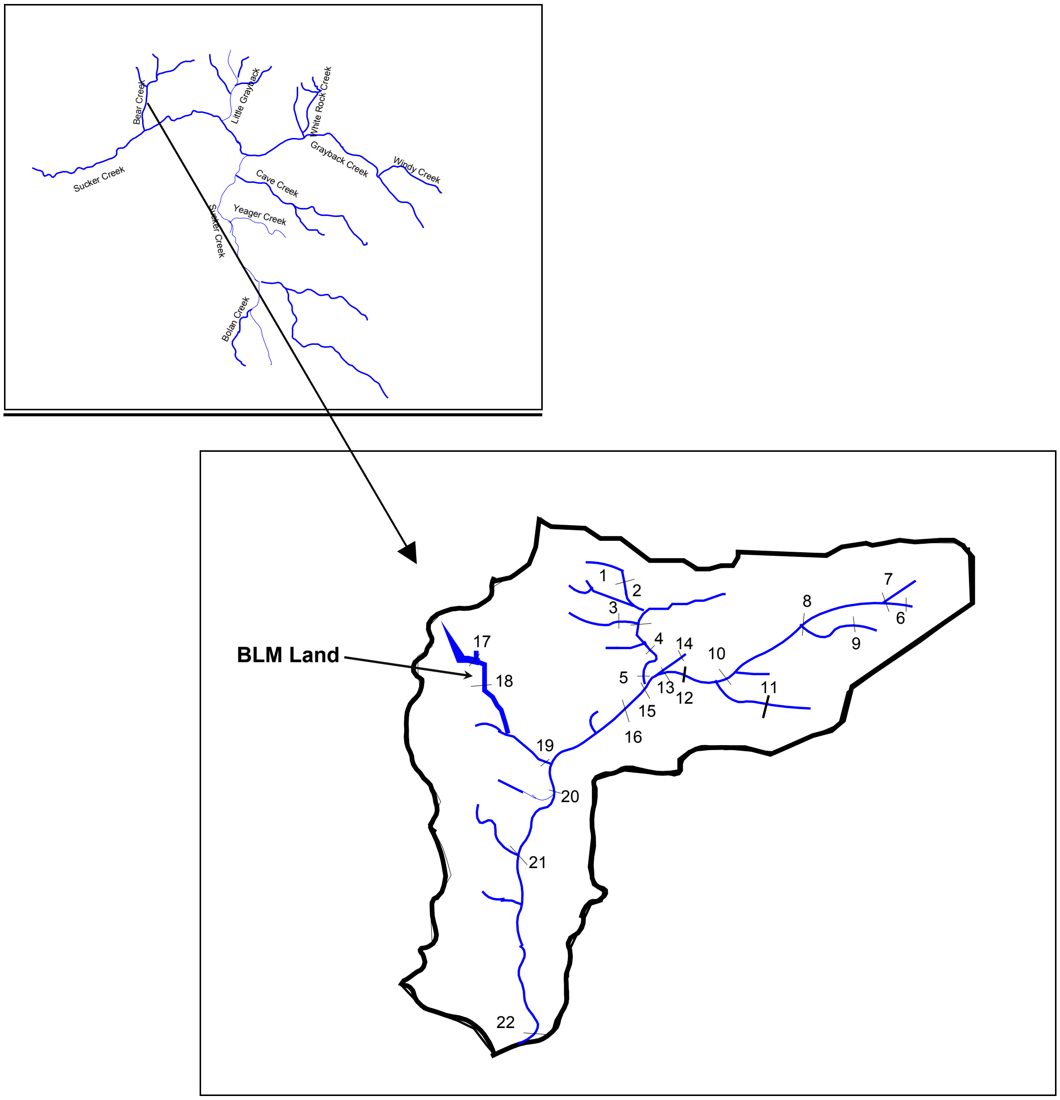



**Figure 6.** Bear Creek with stream reaches 1 through 22.

Bear Creek has a 4.7 square mile drainage area and is located at river mile 5 on Sucker Creek. It is predominately privately owned with some BLM administered land. Bear Creek contributes 5% of the stream flow to the main stem of Sucker Creek. The BLM manages 0.7 miles of perennial stream and 678 acres within the Bear Creek analysis area. Except for 0.4 miles of riparian area (reach 18) managed by the BLM, the entire drainage was harvested in the past. Reach 18 has the only remaining mature (unharvested) conifers within the perennial stream's riparian area. Prior to timber harvest the dominant vegetation providing stream shade was conifers. Presently the riparian vegetation consists of 95% hardwoods. For the most part, the hardwoods are densely stocked (>70% effective shade density). The active channel width varies from 3 to 15 feet. Because the channel is narrow, the hardwoods provide excellent stream shade. The shade value on BLM administered land ranges from 81% in the harvested areas to 98% in the unharvested area, above the 80% threshold for excellent stream shade (Table 1). During aerial photo interpretation, no upslope areas or stream banks on BLM managed lands were identified as contributing sediment to the stream channel.

**Table 1.** Bear Creek

| Reach Number | Length (ft) | Vegetation Type[1] | Channel Width (ft) | Vegetation Height (ft) | % Existing Shade | % Potential Shade | Ownership And Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 1000 | 90% Conifers 10% Hardwood | 5 | 40 | 96 | | Private Harvest |
| 2 | 1000 | 90% Conifers 10% Hardwood | 5 | 40 | 96 | | Private Harvest |
| 3 | 400 | 90% Conifers 10% Hardwood | 3 | 40 | 96 | | Private Harvest |
| 4 | 1000 | 70% Conifers 30% Hardwood | 5 | 30 | 86 | 96 | Private Harvest |
| 5 | 800 | 70% Conifers 30% Hardwood | 5 | 30 | 84 | 96 | Private Harvest |
| 6 | 400 | 100% Hardwoods | 3 | 15 | 88 | 96 | Private Harvest |
| 7 | 600 | 100% Hardwoods | 3 | 15 | 88 | 96 | Private Harvest |
| 8 | 1400 | 100% Hardwoods | 5 | 15 | 88 | 96 | Private Harvest |
| 9 | 800 | 100% Hardwoods | 3 | 20 | 89 | 96 | Private Harvest |
| 10 | 1000 | 100% Hardwoods | 5 | 20 | 89 | 96 | Private Harvest |
| 11 | 1000 | 100% Hardwoods | 3 | 20 | 89 | 96 | Private Harvest |
| 12 | 800 | 100% Hardwoods | 5 | 25 | 84 | 96 | Private Harvest |
| 13 | 800 | 100% Hardwoods | 5 | 25 | 90 | 96 | Private Harvest |
| 14 | 1000 | 100% Hardwoods | 3 | 15 | 86 | 96 | Private Harvest |
| 15 | 900 | 100% Hardwoods | 10 | 30 | 91 | 96 | Private Harvest |
| 16 | 1900 | 100% Hardwoods | 10 | 30 | 92 | 96 | Private Harvest |
| 17 | 400 | 100% Hardwoods | 3 | 10 | 81 | 96 | BLM Harvest |
| 18 | 1100 | 70% Conifers 30% Hardwood | 3 | 150 | 98 | | BLM |
| 19 | 2200 | 100% Hardwoods | 5 | 20 | 90 | | Private Harvest |
| 20 | 400 | No Vegetation | 10 | 0 | 0 | 96 | Private Harvest Large Slide |
| 21 | 2500 | 100% Hardwoods | 15 | 30 | 86 | 96 | Private |
| 22 | 5600 | 15% Conifers 85% Hardwood | 15 | 50 | 90 | 96 | Private Homes |

[1]Overstory vegetation type as determined through aerial photographic interpretation

## Little Grayback Creek

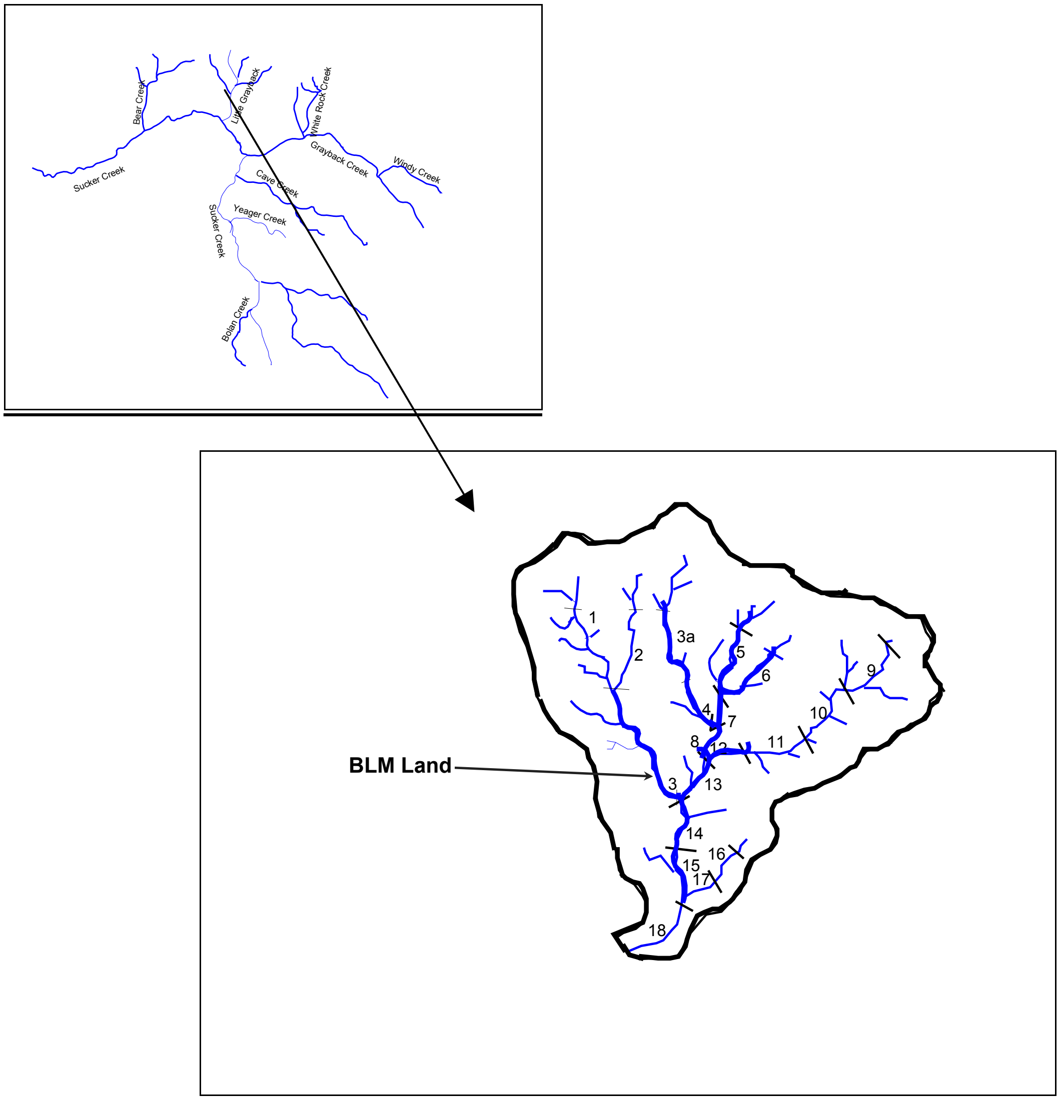



**Figure 7.** Little Grayback Creek with stream reaches 1 through 19.

Little Grayback Creek has a 3.7 square mile drainage area and is located at river mile 8.2 on Sucker Creek. It is predominately BLM administered land with about 1.2 square miles of private land and a small area managed by the Forest Service. Little Grayback Creek contributes 7% of the flow to the main stem of Sucker Creek. The BLM manages 4.4 mile of perennial stream and 1,985 acres within the Little Grayback analysis area. Within the land managed by the BLM, 39% of the riparian area has been harvested in the past. All of the private land has been harvested. The harvested riparian areas have regenerated with 100% hardwoods. Prior to timber harvest, the dominant vegetation providing stream shade was conifers. No unstable stream banks or sediment sources were detected on BLM managed land. The channel width varies from 3 feet to 10 feet. The average shade value on BLM managed land is 92%, well above the 80% threshold for excellent stream shade. Reach 15, with a length of 1,900 feet, has an existing shade value of 75% and is the only BLM managed land below the optimum 80% shade value

Full site potential shade is 96% (see shade curves in the appendix) and will be reached in 23 years on BLM administered land, without disturbance.

**Table 2.** Little Grayback Creek

| Reach Number | Length (ft) | Vegetation Type[1] | Channel Width (ft) | Vegetation Height (ft) | % Existing Shade | % Potential Shade | Ownership And Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 3000 | 100% Hardwood | 3 | 20 | 85 | 96 | Private Harvest |
| 2 | 2000 | 10% Conifers 90% Hardwood | 3 | 15 | 81 | 96 | Private Harvest |
| 3 | 38000 | 90% Conifers 10% Hardwood | 5 | 110 | 95 | | BLM |
| 3A | 4400 | 90% Conifers 10% Hardwood | 5 | 110 | 93 | | BLM |
| 4 | 1000 | 100% Hardwood | 5 | 20 | 88 | 96 | BLM |
| 5 | 2000 | 100% Hardwoods | 5 | 30 | 94 | | BLM Harvest |
| 6 | 2000 | 100% Hardwoods | 5 | 30 | 94 | | BLM Harvest |
| 7 | 1000 | 80%Coniers 20% Hardwoods | 5 | 120 | 93 | | BLM |
| 8 | 800 | 100% Hardwoods | 5 | 20 | 92 | | BLM |
| 9 | 1000 | 80% Conifers 20% Hardwoods | 5 | 120 | 94 | | Forest Service |
| 10 | 1000 | 100% Conifers | 10 | 120 | 95 | | Forest Service |
| 11 | 800 | 100% Conifers | 10 | 120 | 95 | | Forest Service |
| 12 | 800 | 50%Conifers 50% Hardwoods | 10 | 120w-20e* | 93 | | BLM |
| 13 | 1000 | 70% Conifers 30%Hardwoods | 10 | 120 | 94 | | BLM |
| 14 | 900 | 70% Conifers 30%Hardwoods | 10 | 120 | 94 | | BLM |
| 15 | 1900 | 100% Hardwoods | 10 | 20 | 75 | 95 | BLM Harvest |
| 16 | 400 | 70% Conifers 30%Hardwoods | 3 | 120 | 96 | | BLM |
| 17 | 1100 | 100% Hardwoods | 3 | 20 | 81 | 96 | BLM Harvest |
| 18 | 2200 | 100% Hardwoods | 10 | 25 | 77 | 96 | Private Homes |

[1]Overstory vegetation type as determined through aerial photographic interpretation
* w = west stream bank and e = east stream bank.

## Sucker Creek

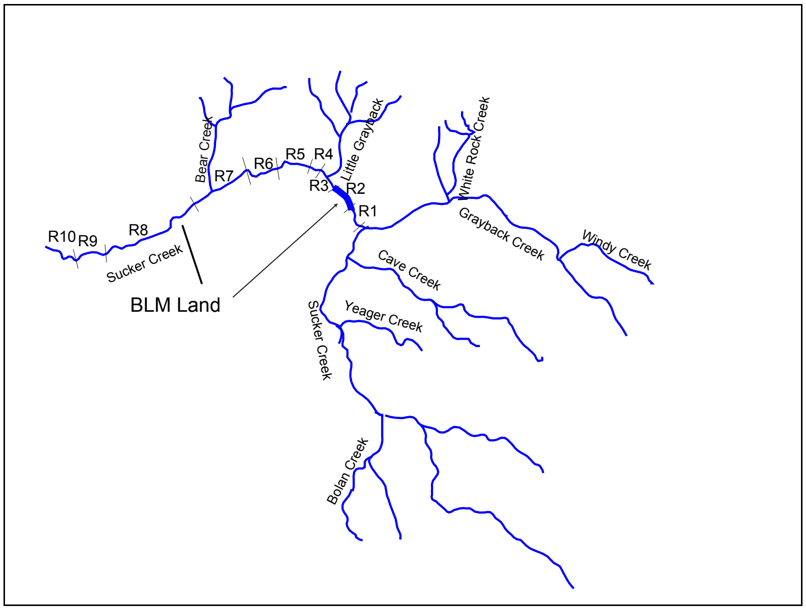



**Figure 8.** Sucker Creek with stream reaches 1 through 10.

The shade assessment covers lower Sucker Creek from the mouth to the confluence with Grayback Creek. The ownership is primarily private with 2,490 feet of the stream's riparian area managed by the BLM. The trees in this BLM reach have been harvested in the past. The riparian area has regenerated with a mixture of conifers and hardwoods. On BLM lands, the average tree height is 60 feet in Reach 3, 40 feet in Reach 4, and 70 feet in Reach 8. The main road, which provides access to the Sucker Creek Watershed, is located in the riparian area on Reach 3 and 4 of BLM administered land. There is currently a loss of approximately 5% stream shade because of the road, which lowers shade density.

The lower section of Sucker Creek has the most serious shade problems in the watershed. There are two factors contributing to this problem, riparian vegetation and channel condition. All of the mature conifers in the riparian area have been harvested or cleared. The vegetation is growing back on most of the main stem. On private land, the once predominately conifer vegetation, is now a mixture of half hardwoods and half conifers. The conifers are in the mid stages of growth cycle. A large channel such as Sucker Creek requires mature conifers to provide stream shade (see Potential Shade section). The hardwood component of the riparian vegetation will not reach a height sufficient to provide the needed shade. This will delay shade recovery.

Below Little Grayback Creek, the stream gradient decreases and the channel is sensitive to deposition from excessive sediment. The major storms of 1964 and 1996/1997 moved large amounts of sediment into this depositional area on the lower main stem. Comparison of historical and current aerial photos revealed the channel width has increased dramatically from increased sediment loading. The channel alignment is also unstable causing the stream to shift during large storms. In addition to the sediment sources identified in the Water Quality Management Plan completed by the Forest Service, eroding streambanks on the main stem have been the primary source of sediment on private land. The excessive width of the main stem increases solar radiation absorption, increasing stream heating. The average shade value on private land is 26%. Full site potential shade is 55% to 80% with an average of 61% . On lands managed by the BLM, the current average shade value is 40%. Site potential shade is 55% to 80% with an average of 58%. In the absence of natural disturbance, full recovery for all reaches is expected to take 70 years.

Table 3. Sucker Creek

| Reach Number | Length (ft) | Vegetation Type[1] | Channel Width (ft) | Vegetation Height (ft) | % Existing Shade | % Potential Shade | Ownership And Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 2100 | 30%Conifers 70% Hardwoods | 75 | 100 | 68 | 80 | Private Homes |
| 2 | 800 | 30%Conifers 70% Hardwoods | 75 | 40 | 40 | 80 | Private Homes |
| 3 | 2900<br>300 | 50% Conifers 50% Hardwoods | 75 | 60 | 50 | 80 | Private Homes<br>BLM |
| 4 | 860<br>4400 | 10% Conifers 90% Hardwoods | 110 | 40 | 26 | 55 | BLM<br>Private Homes |
| 5 | 5000 | 50% Conifers 50% Hardwoods | 110 | 70 | 20 | 55 | Private Homes |
| 6 | 1800 | 50% Conifers 50% Hardwoods | 110 | 70 | 25 | 55 | Private Homes |
| 7 | 7000 | 50% Conifers 50% Hardwoods | 110 | 70 | 25 | 55 | Private Homes |
| 8 | 1330<br>13970 | 50% Conifers 50% Hardwoods | 110 | 70 | 25 | 55 | BLM<br>Private Homes |
| 9 | 6000 | 50% Conifers 50% Hardwoods | 110 | 70 | 25 | 55 | Private Homes |
| 10 | 3000 | 90% Conifers 10% Hardwoods | 110 | 100 | 30 | 55 | Private Homes |

[1]Overstory vegetation type as determined through aerial photographic interpretation

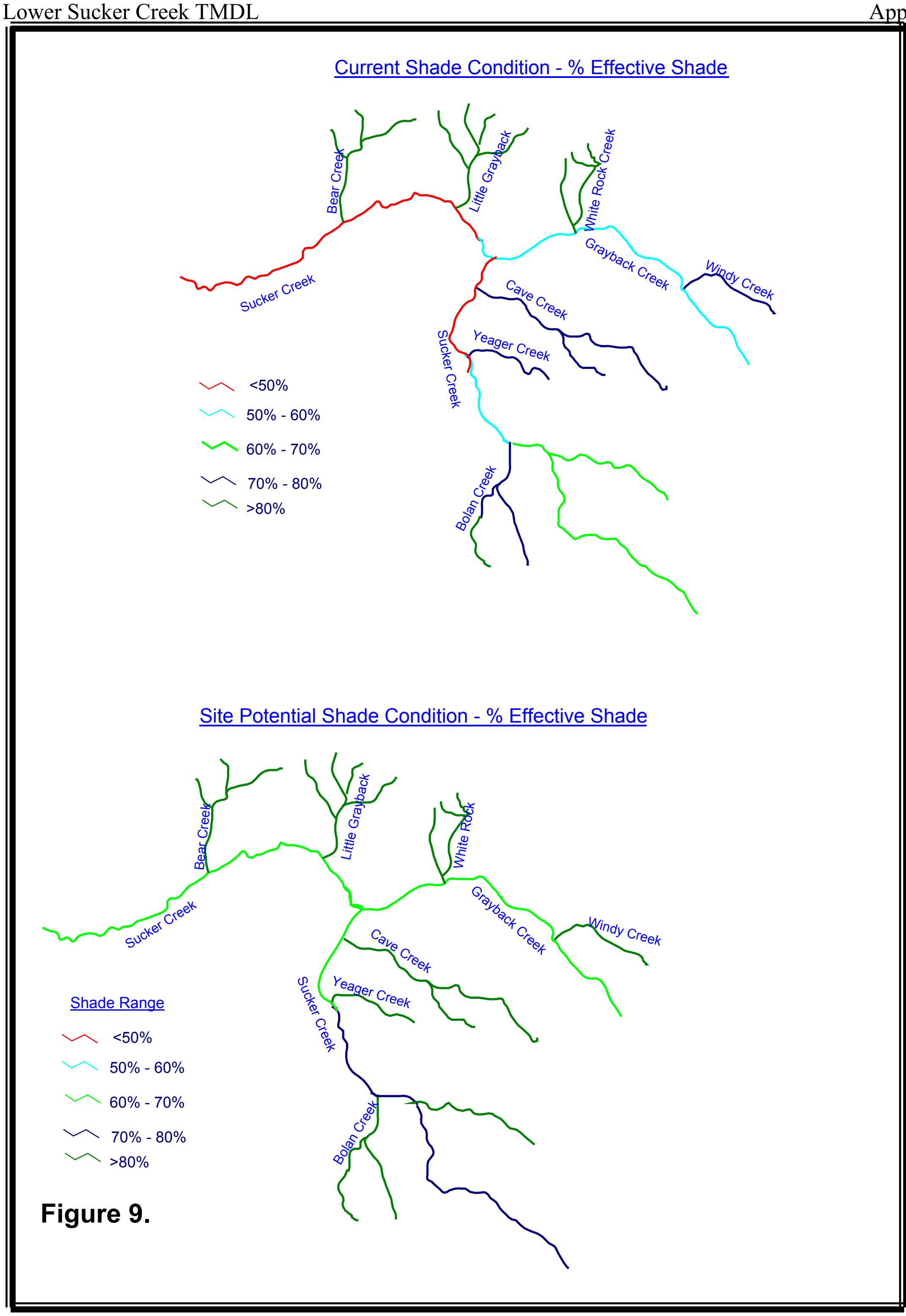



**Figure 9.** Existing and Site Potential Vegetation

**Table 4** Shade Summary for BLM and Private Land

| | BLM Managed Land | | Private Land | | BLM & Private | |
|---|---|---|---|---|---|---|
| **Location** | **% Average Existing Shade[1]** | **% Average Potential Shade[1]** | **% Average Existing Shade[1]** | **% Average Potential Shade[1]** | **% Average Existing Shade[1]** | **% Average Potential Shade[1]** |
| **Main Stem** | **40** | **80** | **26** | **61** | **31** | **65** |
| **Bear Creek** | **93** | **96** | **88** | **96** | **88** | **96** |
| **Little Grayback Creek** | **92** | **96** | **83** | **96** | **86** | **96** |

[1]Average shade is averaged for the length of the stream analyzed.

Table 4 summarizes the existing effective shade and potential effective shade for both BLM and private land. Effective shade is a measure of heat contribution to the stream and a descriptor of riparian condition as it relates to stream shade. A decrease in existing effective shade below potential effective shade can indicate a lack of adequate riparian vegetation. Human activities that contribute to degraded stream shade are timber harvest, roads, mining, agriculture and domestic homes.

As described in "The Physics of Stream Temperature" section of this report, optimum stream shade for streams less that 40 feet in width is 80% or greater. This applies to all of the tributaries of Sucker Creek. For the average shade value on Bear and Little Grayback Creeks, land managed by the BLM exceeds the threshold for optimum shade of 80%.

Reach 15 on Little Grayback Creek, with a length of 1,900 feet, has an existing shade value of 75%, slightly below optimum. Passive restoration is recommended for this reach allowing existing trees to continue to grow. The 2490 feet of riparian area managed by the BLM on the main stem of Sucker Creek is producing shade below the site potential effective shade (80% in Reach 3, 55% in Reach 4 and Reach 5). Steam shade will improve in both reaches as the confers grow to mature trees and as the channel recovers in Reach 8. Because the land on the main stem is predominately privately owned, very little benefit will be gained to overall shade recovery by any BLM restoration efforts. During aerial photographic interpretation , no sediment sources were detected on the BLM administered lands covered by this assessment

Solar energy reaching the stream is directly related to shade and can be used to give numeric value for a total daily maximum load (TMDL). Although a loading capacity for heat can be derived, it provides no new information to guide management beyond shade values. While a load value does not have direct value to guide management strategies for temperature, it does provide a unit of measurement for a TMDL required by DEQ and EPA. The following table displays the existing and potential loading for the area covered by this analysis.

**Table 5.** Loading Summary for BLM and Private Land (BTU/sqft/day)

| Location | BLM Land | | Private Land | | BLM & Private | |
|---|---|---|---|---|---|---|
| | **Existing Loading** BTUs/ftsq/day[1] | **Potential Loading** BTUs/ftsq/day[1] | **Existing Loading** BTUs/ftsq/day[1] | **Potential Loading** BTUs/ftsq/day[1] | **Existing Loading** BTUs/ftsq/day[1] | **Potential Loading** BTUs/ftsq/day[1] |
| Main Stem | 1464 | 610 | 1806 | 951 | 1781 | 927 |
| Bear Creek | 170 | 98 | 293 | 98 | 293 | 98 |
| Little Grayback Creek | 195 | 98 | 415 | 98 | 342 | 98 |

[1]Loading is averaged by the length of the stream analyzed.

## Stream Shade and Channel Morphology

Methods exist to assess the condition of a stream channel, as well as departure from its potential. Change in sediment and discharge can lead to a change in channel form. When sediment input increases over the transport capability of the stream, sediment deposition can result in channel filling, thereby increasing the width to depth ratio. An increase in stream width increases the streams surface area exposed to solar radiation.

During storm events, sediment sources from human activity can increase sediment input over natural levels, and contribute to channel widening and stream temperature increases. On small tributary streams, even if excessive sediment causes channel widening, the trees can potentially be tall enough to still provide full stream shade. However, on the main stem of Sucker Creek, where trees cannot fully shade the channel, channel widening can cause dramatic increases in summer stream temperature.

By organizing stream features into discreet combinations, streams can be put into various classes (Rosgen, 1994). Rosgen stream classification system has eight stream types. Stream typing can be used to indicate where sediment may have caused the channel shape to change. For each stream type, Rosgen has identified a "most frequent range" of values. If a stream is outside that range of values, such as width to depth ratio, it could indicate there is increased width that may be contributing to stream heating. Also, if a stream is a different stream type than what is normally expected, this could indicate that excessive sediment many have changed the channel.

Typical channel types found in watersheds with characteristics similar to Sucker Creek are:

Type "A" - channel is entrenched or confined. It is a high gradient (4% or greater) stream with a step pool configuration. The stream usually has large substrate such as boulders. It is considered a "transport" stream or has the ability to move large amounts of sediment for its size. This is the type of stream that is generally found in steep headwater sections of tributaries.

Type "B" –is moderately entrenched or confined and has a gradient less than 4%. The substrate can range from boulders to sand. It is also considered a transport stream. It has a pool/riffle configuration. This is the type of stream that is generally found on the lower main stem of tributary streams.

Type “C” – is slightly entrenched with well-developed flood plains such as point bars. It’s a low gradient stream of less than 2%. The substrate usually consists of cobbles, gravels and sands. It has a high sinuosity or meander pattern. It is considered a depositional stream, or a stream where excessive sediment will deposit, changing the channel shape. This is the type of stream that are generally found on larger main stem streams.

Atypical channel types found in the Sucker Creek Watershed:

Type “F” – is entrenched meandering fiffle/pool channel on low gradients( <2%) with high width/depth rations (>12). This is usually a meandering system, latterly unstable with high bank erosion rates.

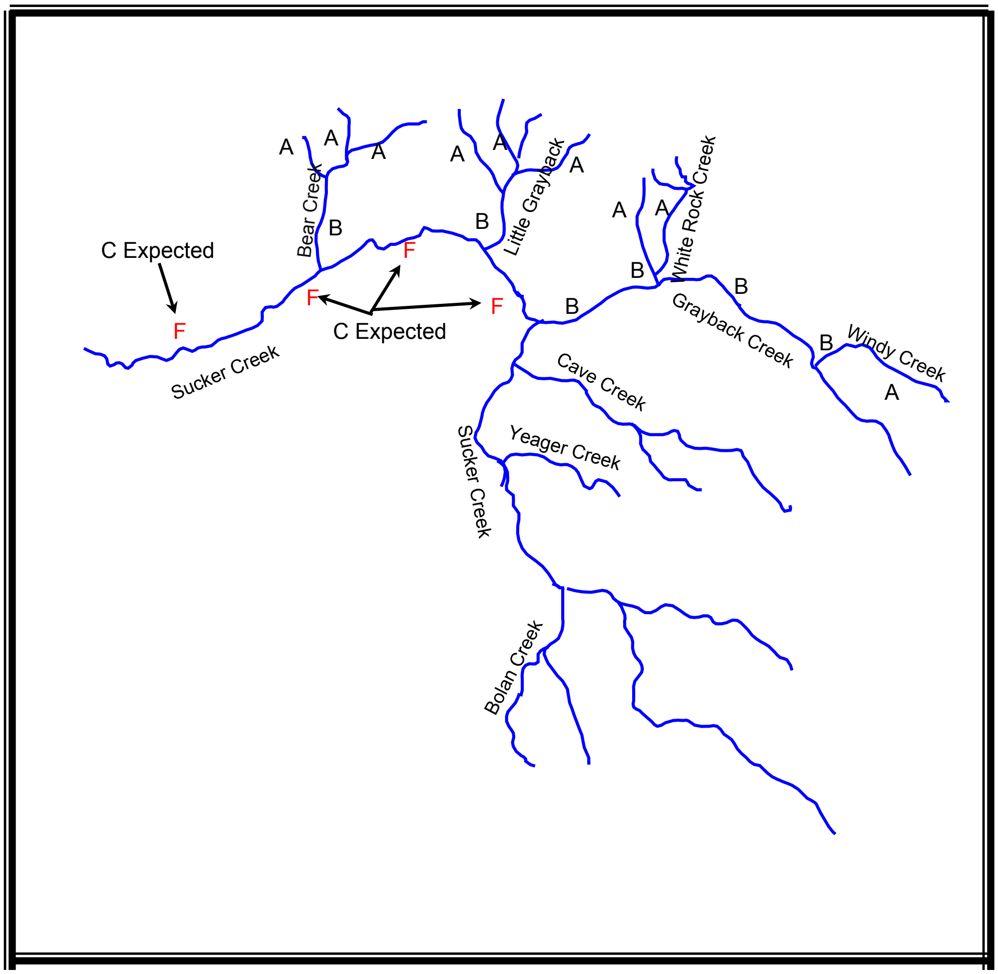



**Figure 10.** Rosgen stream type.

All of the streams, except the main stem of Sucker Creek, are the Rosgen channel types that are expected. Bear and Little Grayback Creeks are stream types “A” and “B.” Width to depth ratios measured in the field fall within the normal range for these types of channels. No increase in solar loading from channel widening is evident on BLM managed land. A healthy main stem of Sucker Creek would be a type “C”, meandering with connectivity to adjacent flood plains. The main stem is currently a type “F”, entrenched and extremely sensitive to disturbance with a poor recovery rate. It has an excessive width to depth ratio of 70 that is contributing to stream heating. The channel change from "C" to "F" was caused by a loss of large wood in the riparian area and sediment loading from both federal and private lands. In addition to the sediment sources identified in the Water Quality Management Plan completed by the Forest Service in March 1999, eroding streambanks on the main stem has been the primary source of sediment on private land.

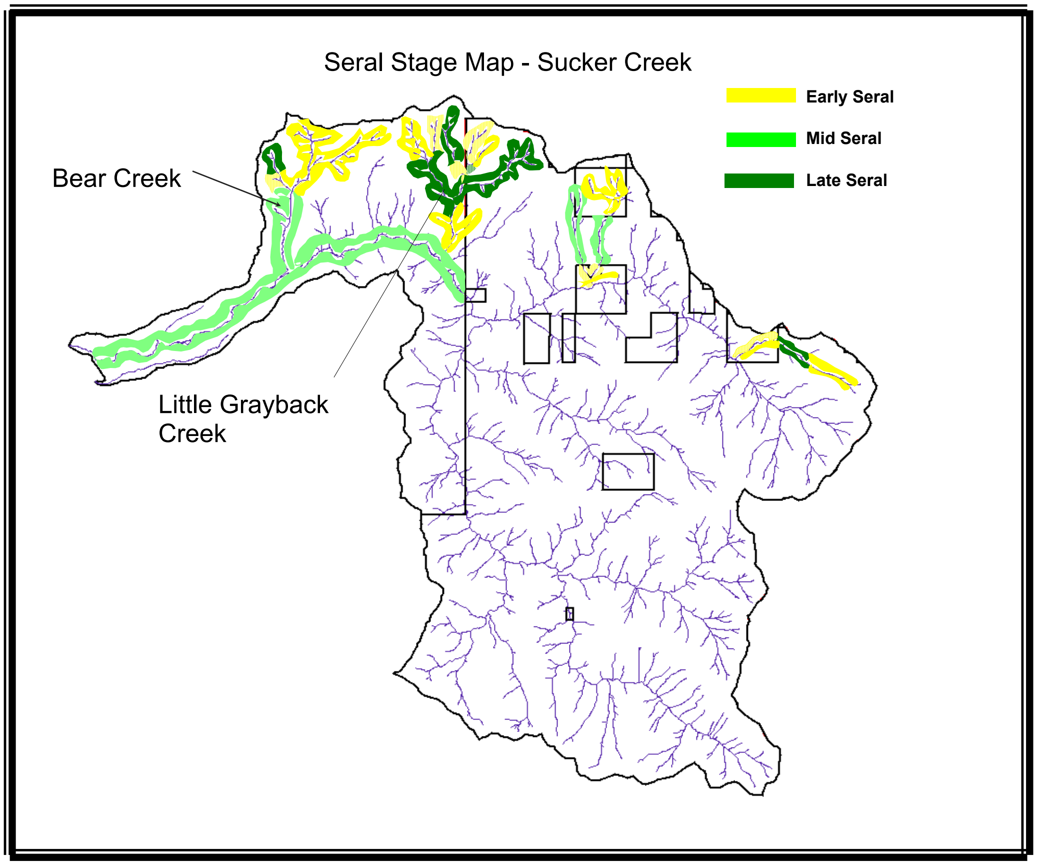
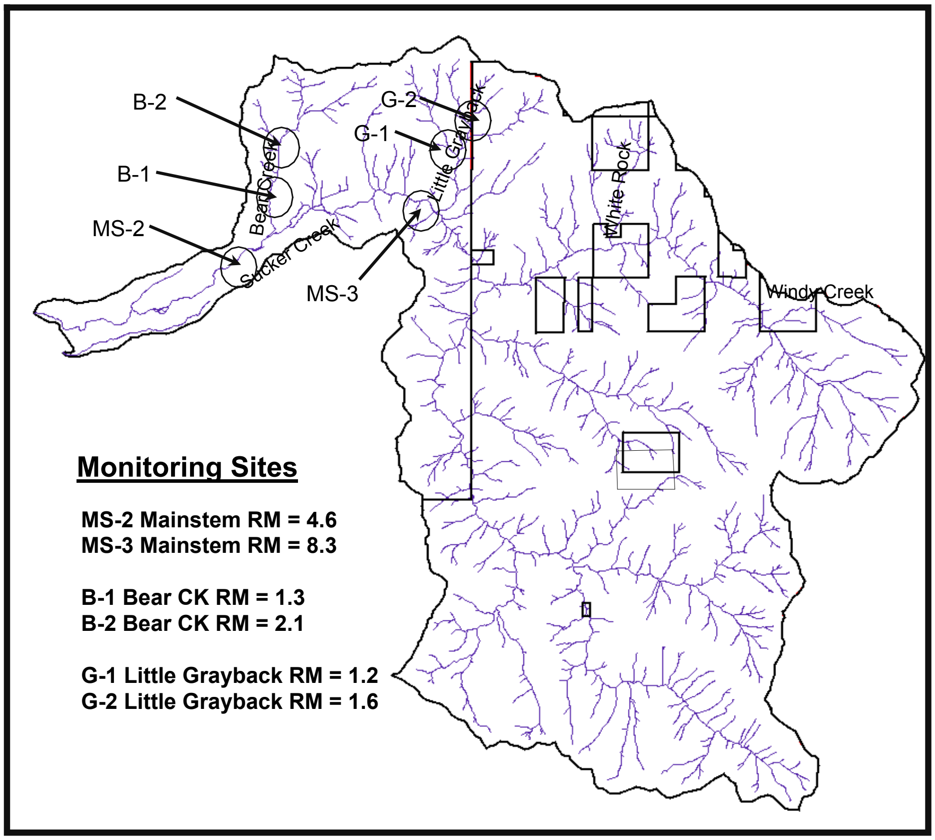



**Figure 11 .** Seral Stage map

As the result of past timber harvest, there is little mature (late seral) vegetation in the riparian areas on the lower main stem and its tributaries (figure 11). On Bear Creek, a small section managed by the BLM, contains the only remaining mature vegetation (figure 11, dark green area) on that stream. The BLM manages 4.4 miles of perennial stream within the Little Grayback analysis area. Approximately 39% of the riparian area managed by the BLM was harvested in the past. Those areas, as well as the small amount of private land, are in an early seral stage with vegetation consisting of 100% hardwoods (figure 11, yellow area). The remaining 61% of the riparian area managed by the BLM is in a late seral stage consisting of mature conifers.

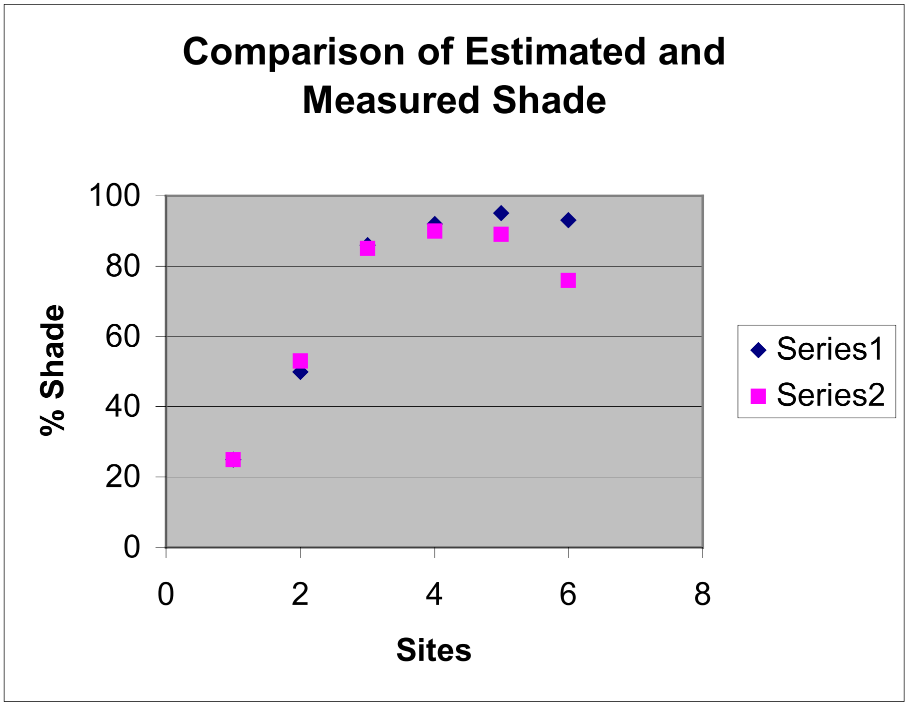
## Comparison of Estimated and Measured Values

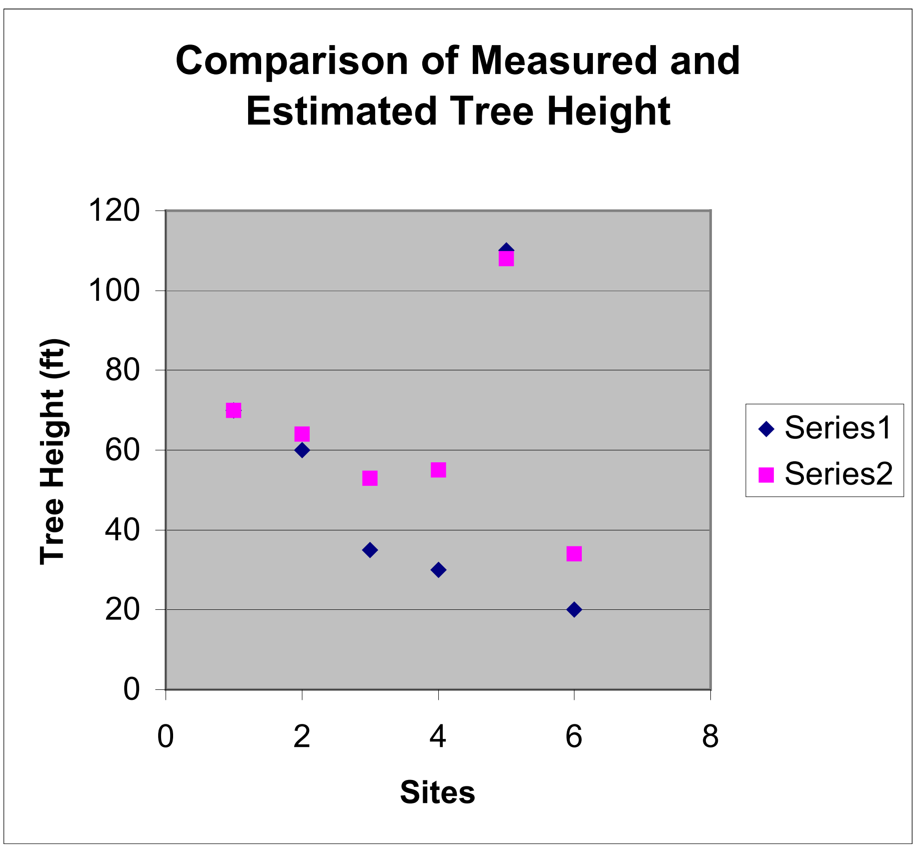


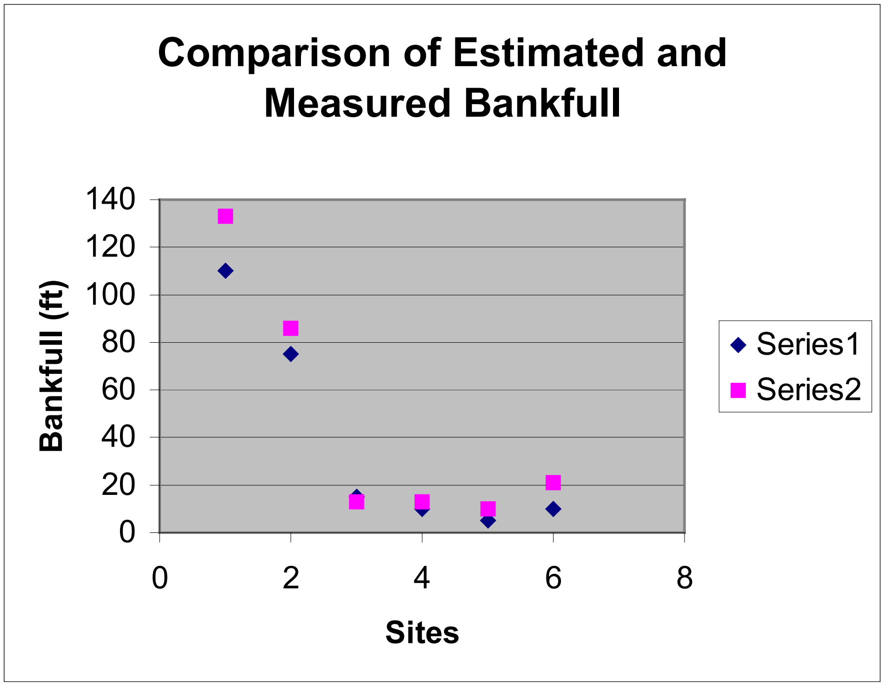

| SITE | SHADE (%) | | TREE HEIGHT (FT) | | BANKFULL (FT) | | CHANNEL TYPE | |
|---|---|---|---|---|---|---|---|---|
| | Estimated | Measured | Estimated | Measured | Estimated | Measured | Estimated | Measured |
| 1. MS–2 | **25** | **25** | **70** | **70** | **110** | **133** | **F** | **F** |
| 2. MS–3 | **50** | **53** | **60** | **64** | **75** | **86** | **F** | **F** |
| 3. B–1 | **86** | **85** | **35** | **53** | **15** | **13** | **B** | **B** |
| 4. B–2 | **92** | **90** | **30** | **55** | **10** | **13** | **B** | **B** |
| 5. G–1 | **95** | **89** | **110** | **108** | **5** | **10** | **A** | **A** |
| 6. G-2 | **93** | **76** | **20** | **34** | **10** | **21** | **B** | **A** |

**Measured Values**

**Estimated Values**






## References

Beschta, R.L. 1997. Riparian shade and stream temperature: an alternative perspective. Rangelands. 19(2):25-28.

Beschat, R.L, R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interaction. Pp. 191-232. University of Washington, Institute of Forest Resources, Contribution No. 57.

Beschta, R.L. and J. Weatherred. 1984. A computer model for predicting stream temperatures resulting from the management of streamside vegetation. USDA Forest Service. WSDG-AD-00009.

Boyd, M.S. 1996. Heat Source: stream temperature prediction. Master's Thesis. Department of Civil and Dioresource Engineering, Oregon State University, Corvallis, Oregon.

Brown, G.W. 1969. Predicting temperatures of small streams. Water Resource. Res. 5(1):68-75.

Brown, G.W. 1983. Chapter III, Water Temperature. Forestry and Water Quality. Oregon State University Bookstore. Pp 47-57.

Brown, G.W. 1972. An improved temperature model for small streams. Water Resources. Report 16, Oregon State University, Corvallis, Oregon.

Lee, R. 1980. Forest hydrology. Columbia University Press, Pp 349, New York.

Park, C.S. 1993. SHADOW stream temperature management program, USDA, USFS, Pacific Northwest Region.

Rishel, G.B, J.A. Lynch and E.S. Corbett. 1982. Seasonal stream temperature changes following forest harvesting. J. Environ. Wual. 11 ;112-116.

Rosgen, D.L. 1994. A classification of natural rivers, Catena, Vol 22, No. 3, International society of Soils Science.

Sellers, W.D. 1965. Physical climatology. University of Chicago Press. Chicago, IL. 272pp.

Wunderlich, T.E. 1972. Heat and mass transfer between a water surface and the atmosphere. Water Research Laboratory, Tennessee Valley Authority. Report No. 14, Norris Tennessee. Pp.4.20.