GUIDELINES FOR USING THE WETTED PERIMETER (WETP) COMPUTER PROGRAM OF THE MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

By
Frederick A. Nelson
Montana Department of Fish, Wildlife and Parks
1400 South 19th Avenue
Bozeman, Montana 59715

Revised
March, 1989

TABLE OF CONTENTS

INTRODUCTION

The wetted perimeter and flow relationships for selected riffle cross-sections are a useful tool for deriving instream flow recommendations for the rivers and streams of Montana. Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water (Figure 1). As the flow in a stream channel increases, the wetted perimeter also increases, but the rate of gain of wetted perimeter is not constant throughout the entire range of flows. Starting at zero flow, wetted perimeter increases rapidly for small increases in flow up to the point where the stream channel nears its maximum width. Beyond this break or inflection point, the increase of wetted perimeter is less rapid as flow increases. An example of a wetted perimeter-flow relationship showing a well-defined inflection point is given in Figure 2. The instream flow recommendation is selected at or near this inflection point.

The MDFWP developed in 1980 a relatively simple wetted perimeter predictive (WETP) computer model for use in its instream flow program. This model eliminates the relatively complex data collecting and calibrating procedures associated with the hydraulic simulation computer models in current use while providing more accurate and reliable wetted perimeter predictions.

The WETP computer program was written by Dr. Dalton Burkhalter, aquatic consultant, 1429 South 5th Avenue, Bozeman, Montana 59715. The program is written in FORTRAN IV and is located at the computer center, Montana State University, Bozeman. Direct all correspondence concerning the program to Fred Nelson, Montana Department of Fish, Wildlife and Parks, 1400 South 19th Avenue, Bozeman, Montana 59715.

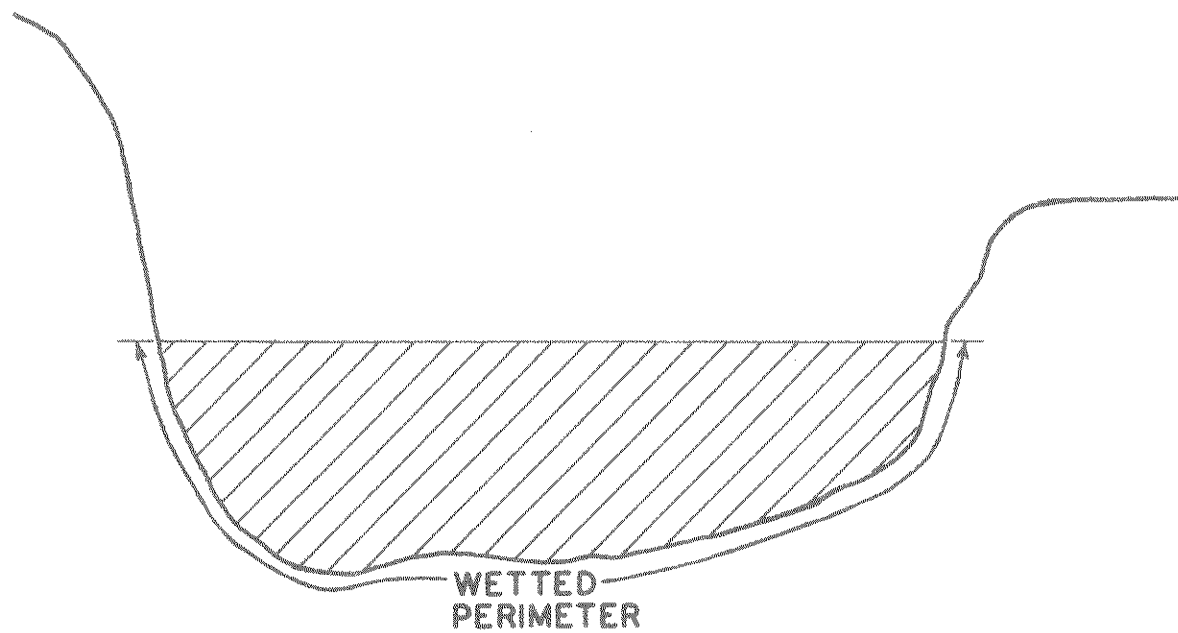

Figure 1. The wetted perimeter in a channel cross-section.

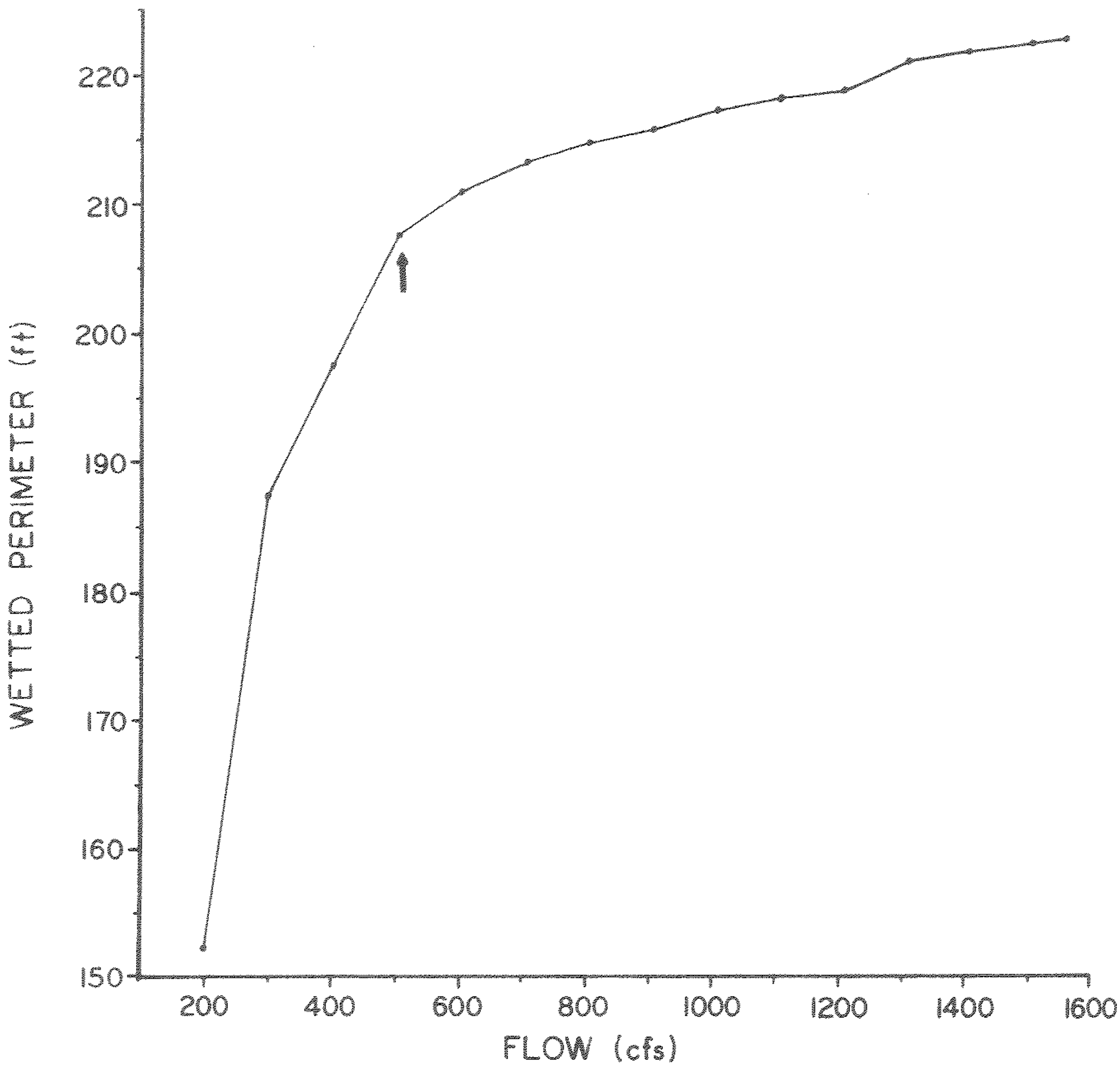

Figure 2. An example of a relationship between wetted perimeter and flow for a riffle cross-section.

DERIVING RECOMMENDATIONS USING WETTED PERIMETER

When formulating flow recommendations for a waterway, the annual flow cycle is generally divided into two separate periods. They consist of a relatively brief runoff or high flow period, when a large percentage of the annual water yield passes through the channel, and a non-runoff or low flow period, which is characterized by relatively stable base flows maintained primarily by groundwater outflows. For headwater rivers and streams, the high flow period generally includes the months of May, June and July, while the remaining months encompass the low flow period.

Method for the Low Flow Period

The wetted perimeter inflection point method is presently the primary method used by the MDFWP for deriving low flow recommendations for rivers and streams. This method is primarily based on the assumption that the food supply is a major factor influencing a stream's carrying capacity (the numbers and pounds of fish that can be maintained indefinitely by the aquatic habitat). The principal food of many of the juvenile and adult game fish inhabiting the streams of Montana is aquatic invertebrates, which are primarily produced in stream riffle areas. The method assumes that the game fish carrying capacity is related to food production, which in turn is related to the wetted perimeter in riffle areas. This method is a slightly modified version of the Washington Method (Collings, 1972 and 1974). The Idaho Method (White and Cochnauer, 1975 and White, 1976) is also based on a similar premise.

The plot of wetted perimeter versus flow for stream riffle cross-sections generally shows two inflection points, the uppermost being the more prominent. In the example (Figure 3), these inflection points occur at approximate flows of 8 and 12 cfs. Beyond the upper inflection point, large changes in flow cause only very small changes in wetted perimeter. The area available for food production is considered near optimal beyond this point. At flows below the upper inflection point, the stream begins to pull away from the riffle bottom until, at the lower inflection point, the rate of loss of wetted perimeter begins to rapidly accelerate. Once flows are reduced below the lower inflection point, the riffle bottom is being exposed at an even greater rate, causing the area available for food production to greatly diminish. The method is intended to establish a threshold below which a stream's food producing capacity begins to decline (upper inflection point) and a threshold at which the loss is judged unacceptable (lower inflection point).

The wetted perimeter-flow relationship may also provide an index of other limiting factors that influence a stream's carrying capacity. One such factor is cover. Cover, or shelter, has long been recognized as one of the basic and essential components of fish habitat. Cover serves as a means for avoiding predators and provides areas of moderate current speed used as resting and holding areas by fish. It is well documented that cover improvements typically increase the carrying capacity of streams, especially for larger-size fish. Cover can be significantly influenced by streamflow.

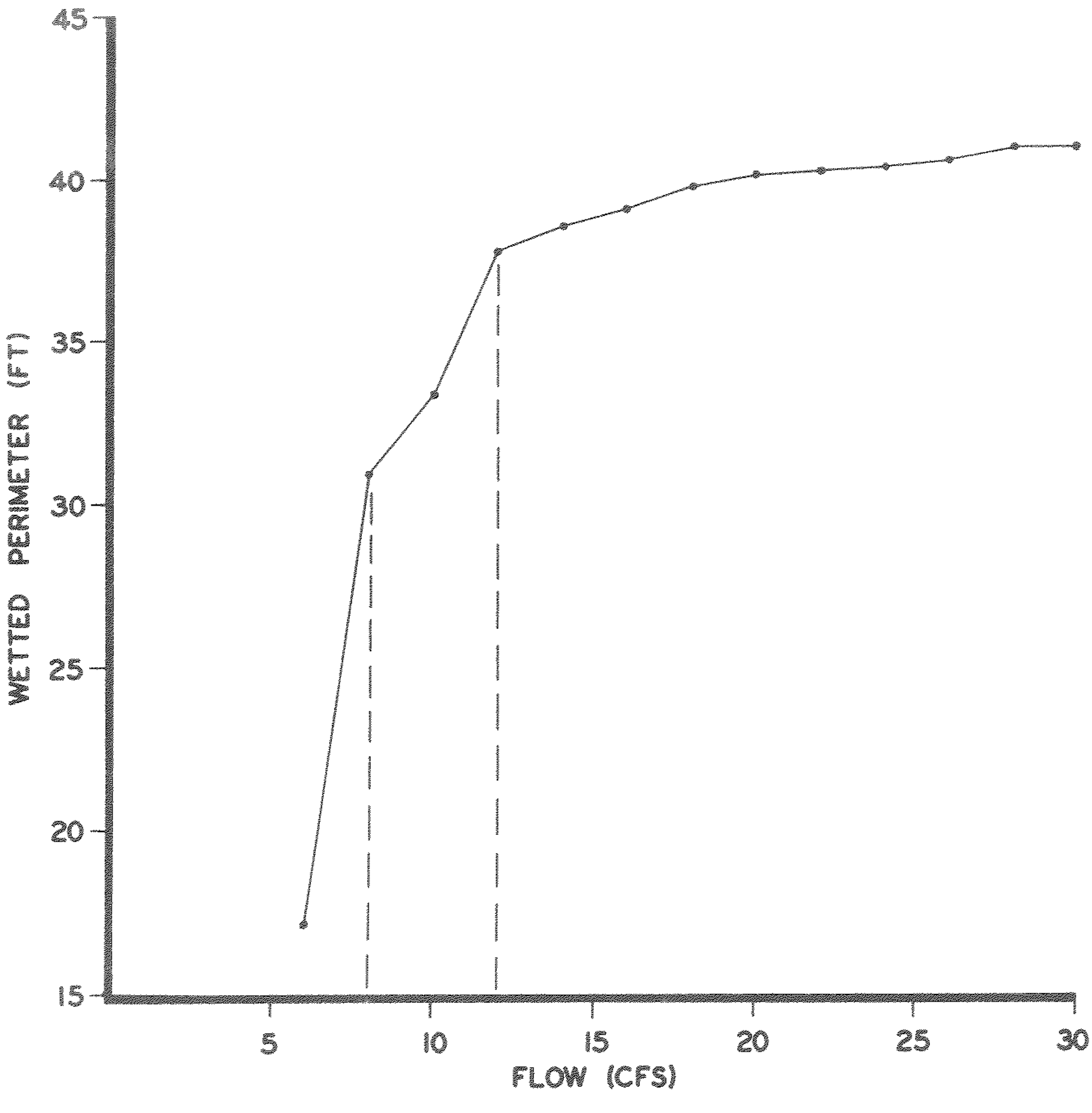

Figure 3. An example of a relationship between wetted perimeter and flow for a riffle cross-section.

In the headwater streams of Montana, overhanging and submerged bank vegetation and undercut banks are often important components of cover. The wetted perimeter-flow relationship for a stream channel may bear some similarity to the relationship between bank cover and flow. At the upper inflection point, the flow begins to pull away from the banks, decreasing the amount of bank cover associated with water. At flows below the lower inflection point, the water is sufficiently removed from the bank cover to severely reduce its value as fish shelter.

Riffles also are used by many game fish species for spawning and the rearing of their young. Thus, the protection of riffles insures that the habitat required for these critical life functions is also protected.

Another important consideration that supports the keying of recommendations to riffles is the fact that riffles are the area of a stream most affected by flow reductions. By providing a recommendation that wets a large portion of the available riffle area, we are, at the same time, helping to protect both runs and pools - areas where adult fish normally reside.

The wetted perimeter inflection point method provides a range of flows (between the lower and upper inflection points) from which a single instream flow recommendation can be selected. Flows below the lower inflection point are judged undesirable based on their probable impacts on food production, bank cover and spawning and rearing habitats, while flows exceeding the upper inflection point are considered to provide a near optimal habitat for fish. The lower and upper inflection points are believed to bracket those flows needed to maintain the low and high levels of aquatic habitat potential. These flow levels are defined as follows:

1. High Level of Aquatic Habitat Potential - That flow regime which will consistently produce abundant, healthy and thriving aquatic populations. In the case of game fish species, these flows would produce abundant game fish populations capable of sustaining a good to excellent sport fishery for the size of stream involved. For rare, threatened or endangered species, flows to accomplish the high level of aquatic habitat maintenance would: 1) provide the high population levels needed to ensure the continued existence of that species, or 2) provide the flow levels above those which would adversely affect the species.

2. Low Level of Aquatic Habitat Potential - Flows to accomplish a low level of aquatic habitat maintenance would provide for only a low population of the species present. In the case of game fish species, a poor sport fishery could still be provided. For rare, threatened or endangered species, their populations would exist at low or marginal levels. In some cases, this flow level would not be sufficient to maintain certain species.

The final flow recommendation is selected from this range of flows by a consensus of the fishery biologists who collected, summarized and analyzed all relevant field data for the streams of interest. The biologist's rating of the stream resource forms the basis of the flow selection process. Factors considered in the evaluation include the level of recreational use, the existing level of environmental degradation, water availability and the magnitude and composition of existing fish populations. The fish population information, which is essential for all streams, is a major consideration. A marginal or poor fishery would likely justify a flow recommendation at or near the lower inflection point unless other considerations, such as the presence of species of special concern (arctic grayling and cutthroat trout, for example), warrant a higher flow. In general, only streams with exceptional resident fish populations or those providing crucial spawning and/or rearing habitats for migratory populations would be considered for a recommendation at or near the upper inflection point. The process of deriving the flow recommendation for the low flow period thus combines a field method (wetted perimeter inflection point method) with a thorough evaluation by a field biologist of the existing stream resource.

A publication of the MDFWP (Leathe and Nelson, 1989) provides an up-to-date synopsis of the history of the wetted perimeter inflection point method, examines its theoretical and experimental basis, identifies its strengths and weaknesses as compared to other available methods, and provides a justification for its use in Montana. Refer to this publication to further explain the method.

DESCRIPTION OF THE WETP PROGRAM

The WETP program uses 2 to 10 sets of stage (water surface elevation) measurements taken at different known discharges (flows) to establish a rating curve. This curve has the equation, $Q = p(S - zf)^n$ where:

Q = discharge
S = stage height
zf = stage height at zero flow
p = a constant
n = a constant exponent.

The relationship of measured points, if perfect, would plot as a straight line on log-log paper with n equal to the slope of the line and p equal to the discharge when (S - zf) = 1. The actual line is determined by least squares regression using the measured points. Once the stage-discharge rating curve for each cross-section is determined, the stage at a flow of interest can be predicted. This rating curve, when coupled with the cross-sectional profile, is all that is needed to predict the wetted perimeter at most flows of interest.

Stage Height at Zero Flow

The stage height at zero flow (zf) may be taken as the lowest elevation in the cross-sectional profile for riffles but is more difficult to determine for non-riffles, particularly pools, in which case the procedures of Rantz (1982) should be consulted. The applicable portions of that paper are included in Appendix A.

The zf value for a non-riffle cross-section can also be measured in the field. It is the elevation of the thalweg (as referenced to the bench mark elevation) at the downstream control, which is typically the head of a riffle. The control is a channel feature that causes water to back up in an upstream direction.

The value of zf is controlled by use of an option record (OPTS) in the input data. If the option is set to one, zf is either set to a value supplied by the user or, in the absence of a supplied value, zf is automatically set to the lowest elevation in the cross-sectional profile. If the user does not want zf to equal the lowest elevation in the cross-sectional profile, the values for zf are entered on the XSEC records. The option record must be the first entry in the data file and is illustrated in Appendices B and C.

The option of setting zf to zero by setting the option record to zero is also available. All results for an earlier version of the WETP program were obtained with zf automatically set to zero. Option zero is included solely for the purpose of comparing results. Because the program now incorporates zf into the calculations, the accuracy of the hydraulic predictions for those flows of interest that are less than the lowest measured calibration flow should improve over calculations previously made with zf = 0.

Stage-Discharge Data

The program should be run using three sets of stage-discharge data collected at a high, intermediate and low flow. Additional data sets are desirable, but not mandatory. The three measurements are made when runoff is receding (high flow), near the end of runoff (intermediate flow) and during late summer-early fall (low flow). The high flow should be considerably less than the bankfull flow, while the low flow should approximate the lowest flow that normally occurs during the summer-fall field season. Sufficient spread between the highest and lowest calibration flows is needed for the program to compute a linear, sloping rating curve.

The WETP program will run using two sets of stage-discharge data. This practice is not recommended due to the potential for "two point" error. At times, however, only two points are obtainable and must be used in the derivation. Bovee and Milhous (1978) concluded that two points can be used effectively if done with care. To minimize "two point" error, they recommend that the calculations incorporate the stage at zero flow (zf) and that the higher calibration flow be at least twice as high as the lower one. They further concluded that the limit of reliability could be approached with only two data points, provided strict limitations were placed on the range of extrapolation. While the findings of the above authors remove some of the uncertainty associated with the use of two-point rating curves, abiding by their recommendations does not guarantee that "two-point" error will be eliminated in all cases.

Other Hydraulic Predictions

In addition to wetted perimeter (WETP), the program also predicts other hydraulic characteristics that may be useful in deriving flow recommendations. These are the mean depth (DBAR) in ft, mean velocity (VBAR) in ft/sec, top width (WDTH) in ft, cross-sectional area (AREA) in ft^2, stage (STGE) in ft, and maximum depth (DMAX) in ft.

A useful program option, termed the width-at-given-depth (WAGD) option, will calculate for up to 10 given depths the width (in ft) and percentage of the top width having depths greater than or equal to the given values. The width and percentage of the longest, continuous segment having the required depths is also listed for each flow of interest. This option is illustrated in Appendices B and C.

FIELD DATA REQUIREMENTS

The required inputs to the WETP program for each cross-section are:

1. Three sets of stage-discharge data measured at a high, intermediate and low flow. The stage height at zero flow (zf) is mandatory only when non-riffles are modeled.

2. The cross-sectional profile, which consists of channel elevations (vertical distances) and the horizontal distance of each elevation measurement from the headstake (zero point).

The following are needed to document field work:

1. Slides or photographs of the study area and cross-sections at the time field data are collected.

2. Field notebooks containing all surveying data, notes and calculations recorded in a neat, consistent manner.

FIELD METHODS

Equipment

1. A self-leveling or automatic level such as a Wild NAK1.

2. 25-ft, telescoping, fiberglass level rod.

3. 50-500 ft canyon line or other measuring tape. Tape should be calibrated to 0.1 ft.

4. Rebar cut in 30-inch pieces (stakes). Two stakes are needed per cross-section.

5. Two clamps (modified vise grips with flat jaws).

6. Engineers field notebook.

7. Pencils.

8. Current meter and rod, stopwatch and beeper box. Gurley or Price AA current meters are preferred.

9. Small sledge hammer.

10. Camera.

11. Fluorescent spray paint and flagging.

12. Forms for recording stream discharges and cross-sectional profiles.

13. A rod fitted with a porcelain, enameled, iron gage (Part No. 15405, Leupold and Stevens, Inc., P. O. Box 688, Beaverton, Oregon 97075) for measuring water depths. A current meter rod can be substituted.

14. Machete and tree pruner for trimming vegetation.

Selecting Study Areas and Placing Cross-Sections

Follow these guidelines when selecting study areas and placing cross-sections.

1. It is best to locate study areas and stake cross-sections during low water prior to the onset of runoff. A good time is the fall when flows are low, most waters are easily waded, and riffles are readily discernible. It will be difficult to select these sites during the high water period when data collection begins.

2. The selected study area is normally located near the stream's mouth. The study area is not intended to represent the channel form and flow regime that occur throughout the designated stream reach, which, in

the case of the smaller streams, typically encompasses the entire stream length between the headwaters and mouth. With this approach, the reach boundaries serve merely to identify those junior water users who will be subject to the instream right or reservation, which is monitored at or near the stream's mouth. Should the flow at this site fall below the granted instream flow, then all junior users within the designated reach must cease withdrawing water until the flow recovers. All upstream users are, thus, keying to a flow that is measured on the lower stream. Having similar flow regimes and channel configurations at the upper and lower reach boundaries are not required with this approach.

Designating only one reach is generally unacceptable for the larger waterways. Here, a limited number of reaches must be established using reasonable and defensible boundaries, such as major tributary inflows and dams. For example, the Madison River has four designated reaches: 1) Yellowstone Park boundary - Hebgen Reservoir, 2) Hebgen Dam - junction of the West Fork, 3) junction of the West Fork - Ennis Reservoir, and 4) Ennis Dam - mouth. Each reach may well encompass areas having a similar flow regime and channel configuration, although this is not a reach requirement. Again, the reach merely identifies those junior users who are subject to the granted instream right or reservation.

3. Place the cross-sections in riffles if the wetted perimeter inflection point method is used to derive recommendations. Cross-sections can be placed in a single riffle or a number of different riffles. Cross-sections should describe the typical riffle habitats within the stream segment being studied. Other critical habitat types can also be used, depending on your chosen method.

   For a particular riffle, the upper limit is three cross-sections placed at the riffle's head, middle and tail. Fewer can be used if the riffle is fairly uniform. To be safe, you may want to model two or three separate riffles in each study area. We recommend using at least three and preferably five riffle cross-sections when deriving the wetted perimeter-flow relationship for each study area. The WETP program accepts up to 10 cross-sections per study area.

   Theoretically, one strategically placed cross-section could effectively model the "typical" riffle habitat within a study area. More cross-sections (up to 5) are recommended under the assumption that this will result in a more accurate end product. The ability of the biologist to exercise good judgment is the crucial element when placing cross-sections to model a stream's riffle habitat.

4. The WETP model assumes that the water surface elevations at the water's edge on the left bank (WEL) and right bank (WER) of a cross-section are always equal at a requested flow. This is a valid assumption because the water surface elevations at WEL and WER generally remain within 0.1 ft of each other as the flow changes, provided the water surface elevations at WEL and WER were matched when the cross-section was established. Avoid placing cross-sections in areas where this assumption is likely to be violated, such as

sharp bends in rivers and multiple channels containing islands. If cross-sections through these areas are unavoidable, you should proceed with caution.

5. Place the headstake marking each cross-section well up on the bank. Drive the headstake almost flush with the ground and mark well. In addition to marking the cross-section and providing a fixed reference point for establishing elevations, the headstake is also your zero reference point for measuring horizontal distances across the cross-section. Headstakes for all the cross-sections within a study area should be located on the same bank.

   Another stake is driven on the bank opposite the headstake. Place this stake so that the water surface elevations at the WEL and WER of the established cross-section are equal or similar (within 0.05 ft). This will require the use of a level and level rod. This stake is used to mark the cross-section on the bank opposite the headstake and also to attach the measuring tape when the channel profile is measured, so should not be driven to ground level. Cross-sections, when established, should be roughly perpendicular to the banks. Eliminate all diagonal cross-sections.

6. Number the cross-sections consecutively from downstream to upstream (the downstream-most cross-section is #1).

7. Measure the distances between cross-sections. This is an optional measurement that might be useful in locating cross-sections during return trips.

8. Remember, the WETP model is invalidated if channel changes occur in the study area during data collection. For this reason, all field measurements should be completed during the period beginning when runoff is receding and ending with the onset of runoff the following year. The stream channel is expected to be stable during this period.

9. Over winter, headstakes can frost heave, changing their elevations. This is an important reason for completing all field measurements during the summer-fall period. However, this does not prevent you from placing your headstakes and establishing your cross-sections in fall and starting your measurements the following summer when runoff is receding.

Establishing Bench Marks

Establish a bench mark at or near your study area. The bench mark is a point that will not be disturbed or moved. A nail driven into the base of a tree, a fixed spot on a bridge abutment and a survey stake driven into the ground are examples of bench marks. Designating one of the cross-sectional headstakes within a study area as the bench mark is an acceptable practice, provided all field measurements are completed before the onset of winter. Bench marks should be well marked in the field and their locations described in your field notebook so they can be easily located during return trips. All channel and water surface elevations are established relative to the bench mark, which is assigned an elevation of 100.00 or 10.00 ft. Use 10.00 ft whenever possible.

For streams having "heavy" vegetative cover, the use of a single bench mark may not be practical. In this case, the individual headstakes can serve as bench marks. For example, the headstake for cross-section #1 could serve as the bench mark for cross-sections #1 and 2, while the headstake for cross-section #3 could serve as the bench mark for cross-sections #3, 4 and 5. Each headstake could also serve as the bench mark for that individual cross-section. While this is not the best surveying technique, certain stream reaches may require its use. Be sure to carefully record in your notebook which headstakes are used as bench marks to avoid confusion and errors on return trips.

Remember, channel and water surface elevations for all cross-sections within a study area do not have to be tied to a single bench mark for the WETP program to run properly. However, the use of a single bench mark demonstrates good field technique.

Surveying Techniques

The reader is referred to Spence (1975) and Bovee and Milhous (1978) for a discussion of the surveying techniques used to measure cross-sectional profiles and water surface elevations. Both papers should be read by those unfamiliar with the mechanics of surveying. All investigators must receive field training before attempting any measurements.

It is important to be consistent and to use good technique when collecting and recording data. Record all data in your notebook and complete all calculations while in the field, so that any surveying errors can be detected and corrected. Remember, your field notebooks may be examined in court or hearing proceedings. Good quality equipment such as an automatic level is also an asset.

Measuring Water Surface Elevations (Stages)

Water surface elevations should be measured for each cross-section at three different flows. If cross-sections are established prior to runoff (this practice is recommended), you must return to the study area at least three more times; when runoff is receding (high flow), near the end of runoff (intermediate flow) and during late summer or early fall (low flow).

It is unnecessary to collect surface elevation measurements for all of the cross-sections within a study area at the same flows. For example, if another cross-section is added to the study area at a later date, the calibration flows for this new cross-section do not have to match those for the other cross-sections. It is also unnecessary to have the same number of calibration flows for all of the cross-sections within a study area.

Water surface elevations are measured at the water's edge directly opposite the stake marking the cross-section on each bank. Visually line up the points (WEL and WER) in the cross-section where surface elevations will be measured. The stretching of a tape across the cross-section is unnecessary because the horizontal distances from the headstake to the WEL and WER are not needed. Measure water surface elevations to the nearest 0.01 ft. The mechanics of this measurement are discussed in Bovee and Milhous (1978). Once water surface elevations are calculated, repeat the measurements to check for surveying errors. If all cross-sections are tied to a single bench mark, water surface elevations should increase as the cross-sections progress upstream.

As previously discussed, the WETP model assumes that the water surface elevations at WEL and WER are always equal at a selected flow of interest. In a stream channel, the surface elevations at the WEL and WER of a cross-section should remain fairly equal as the flow varies, provided the elevations at WEL and WER were matched when the cross-section was established. Consequently, it is necessary to measure the water surface elevations at both WEL and WER during all return trips to verify this assumption. These two measurements should always be within approximately 0.1 ft of one another. For the larger waterways, a greater difference is allowable. Average these two measurements to obtain the water surface elevation that is entered on the coding sheets.

Measuring Stream Discharges

The flow through the study area must be measured each time water surface elevations are determined. On the larger waterways, it is best to locate study areas near USGS gage stations to eliminate a discharge measurement.

Use standard USGS methods when measuring discharges. Publications of Bovee and Milhous (1978), Buchanan and Somers (1969), and Smoot and Novak (1968) describe these methods and provide information on the maintenance of current meters. Read these publications before attempting any discharge measurements. Field training by USGS personnel is also mandatory.

Measuring Cross-Sectional Profiles

The channel profile has to be determined for each cross-section. Unlike the measurement of water surface elevations, this has to be done only once. It is best to measure profiles at the lowest calibration flow when wading is easiest. For the unwadable, larger waterways that require the use of a boat, profiles are best measured at the intermediate calibration flow.

For wadable streams, a measuring tape is stretched across the cross-section with the zero point set on top of the headstake. Setting the headstake at zero, while not mandatory, is a good practice that provides consistency in your field technique. Never attach the tape directly to the headstake. The tape is attached with a vise grip to a stake that is driven behind the headstake. A vise grip can be attached directly to the stake on the opposite bank to stretch and hold the tape in place.

Elevations are now measured between the headstake and water's edge using your level and level rod. Elevations are measured at major breaks in the contour. The horizontal distance of each elevation measurement from the headstake (zero point) is also recorded. Elevations are also measured between the water's edge at the opposite bank and the opposite stake and the horizontal distance from the headstake recorded for each measurement. Elevations of the exposed portions of instream rocks and boulders are also measured in this manner. Measure elevations to the nearest 0.01 ft and horizontal distances to the nearest 0.1 ft.

Be sure to collect profile measurements for points well above the water's edge. It is a good practice, although not mandatory, to begin at the headstake (distance of 0.0 ft) and end at the stake on the opposite bank. Remember, the highest elevations on both banks of the cross-sectional profile must be substantially higher than the stage at the highest calibration flow if predictions are to be made for flows of interest that exceed the highest calibration flow.

For small streams having a smooth bottom and little depth, the entire profile can be surveyed using your level and level rod. For larger streams, a different approach involving the measurement of water depths is used to determine the profile of the segment of the cross-section that contains water. Water depth is measured using a current meter rod or a rod fitted with a porcelain, enameled, iron gage. Do not use your level rod. (Prolonged use of your level rod in water ruins the foot markings on the rod.) Measure depths at all major breaks in the bottom contour. Generally, 30 or more depth measurements are needed for streams and creeks. Measure depths to the nearest 0.05 ft (current meter rod) or 0.01 ft (rod fitted with gage). For each depth measurement, record the horizontal distance from the headstake (zero point). The bottom elevation at each distance from the headstake is determined by subtracting the water depth from the water surface elevation (average for WEL and WER). For example, if the average water surface elevation is 9.26 ft and at 10.2 ft from the headstake the water depth is 0.40 ft, then the bottom elevation at this distance is 8.86 ft (9.26 ft minus 0.40 ft). Elevations for all points covered by water are calculated in this manner.

For the unwadable, larger waterways, cross-sectional profiles are measured using a boat, depth recorder and range finder. Graham and Penkal (1978) describe this technique.

The WETP program will handle vertical banks. When recording these data, the horizontal distance from the headstake to both the top and bottom of the vertical will be the same, but the elevations will be different.

The program <u>will not</u> handle undercut banks. These data have to be adjusted before being entered on the coding sheets. The best method is to treat undercuts as vertical banks. To accomplish this, the horizontal distance from the headstake to the top of the undercut is substituted for the horizontal distance to the bottom of the undercut, creating a vertical bank.

The program will handle islands, bars and multiple channels, provided the water surface elevations at all the water's edges in the cross-section remain relatively equal as the total stream flow changes. Because this is unlikely, these areas should be avoided when establishing cross-sections.

OFFICE METHODS

WETP Data Format

An example describing the WETP format is given in Appendix B. Much of the format is self-explanatory. Carefully examine this example and the explanatory notations before entering your data on the coding sheets.

The five cross-sections in the example were located in riffles. The stage height at zero flow (zf) was therefore set to the lowest elevation in the cross-sectional profile for each.

All elevations in the example were keyed to a single bench mark, which was assigned an elevation of 100.00 ft for illustration only. A bench mark elevation of 10.00 ft would be more appropriate and should be used whenever possible.

Enter the WETP data on the coding sheets in the following manner:

1. Flows of interest (up to 100 flows are accepted by the program)

   Integers in cfs or with decimal points (not to exceed six characters, including decimal point if used)

2. Cross-sectional profile (up to 150 sets of measurements are accepted)

   Distances from headstake - nearest 0.1 ft
   Channel elevations - nearest 0.01 ft

3. Stage-discharge data (2 to 10 sets of measurements are accepted)

   Stages (water surface elevations) - nearest 0.01 ft
   Discharges (flows) - nearest 0.1 cfs

4. Stage height at zero flow (zf) (one for each non-riffle cross-section)

   zf - nearest 0.01 ft

If the cross-sectional profile, stage-discharge and zf data are entered as described above, decimal points <u>are not</u> needed. However, decimal points can be used if desired.

Selecting Flows of Interest

You will be extrapolating data for flows of interest that are less than the lowest measured calibration flow for a particular cross-section. The extrapolation of data beyond the highest calibration flow is a less desirable option because our main interest is to derive minimum flow recommendations. Remember, the stage-discharge rating curve generally flattens out at extremely high (above bankfull) and extremely low flows.

At these flows, the predicted stages from the measured rating curve are questionable and could lead to inaccurate hydraulic predictions.

Bovee and Milhous (1978) recommend the following limits when selecting flows of interest:

1. Two point stage-discharge rating curve

   Hydraulic predictions should not be made for flows that are less than 0.77 times the minimum measured flow, nor for flows higher than 1.3 times the maximum measured flow.

2. Three point (or greater) stage-discharge rating curve

   Hydraulic predictions should not be made for flows that are less than 0.4 times the minimum measured flow, nor for flows higher than 2.5 times the maximum measured flow.

These are only guidelines, not hard and fast rules. Common sense, rather than the strict adherence to a suggested guideline, should govern the extent of your extrapolations.

WETP Data Output

The output for the input example in Appendix B is given in Appendix C. Carefully examine this output.

Detecting Errors

Practicing good technique when surveying cross-sections and measuring flows will eliminate errors (except data entry and coding errors) in your WETP input and lead to reliable hydraulic predictions at the requested flows of interest. Despite precautions, errors can go undetected. However, most will become evident when you examine your printouts and do the following:

1. Check for data entry errors

   Carefully proof the profile and stage-discharge data on the printouts to detect errors made by the data entry people. Few printouts are without these errors. Format and recording errors on the coding sheets are other major causes for errors in the profile and stage-discharge data.

2. Check for error messages

   The vast majority of error messages that occasionally appear on the printouts are the result of format errors on the coding sheets. In general, these are easily corrected before the printout is sent to the cooperator.

   An error message will appear when predictions are requested for flows of interest having stages that are higher than the highest elevations in the cross-sectional profile. Additional profile measurements collected higher up on the banks will correct this problem if deemed necessary.

3. Examine the cross-sectional profiles

   Look for sudden elevation decreases in the cross-sectional profiles. For example, elevations that suddenly drop from 7.42 ft to 5.35 ft then jump to 7.36 ft are suspect. Sudden elevation increases are also suspect. These, however, could reflect large rocks within the cross-sectional profile.

4. Examine the r^2 values

   If the r^2 value for a stage-discharge rating curve is less than approximately 0.90, the cross-section should be eliminated from the analysis. Low r^2 values may be due to errors, so recheck the stage and discharge measurements before eliminating these cross-sections. A faulty discharge calculation may be the culprit. For those cross-sections having only two sets of stage-discharge measurements (remember, this practice is not recommended), r^2 values are automatically 1.000 and, consequently, of no use in assessing the reliability of the hydraulic predictions.

   Near perfect r^2 values (>0.96) are the norm. If your values are not consistently 0.96 or higher, your surveying and discharge measuring skills need improving.

5. Examine the stages

   At each calibration flow, the measured stage (water surface elevation) should <u>increase</u> as the cross-sections progress upstream, provided all cross-sections are keyed to the same bench mark. If a decrease occurs (i.e., water is flowing uphill), errors are present. For example, the stages for cross-sections 1, 2, 3, 4 and 5 at the calibration flow of 23.8 cfs are 4.87, 5.23, 5.36, 6.53 and 5.96 ft, respectively. All stages for cross-sections 4 and 5 need rechecking to determine which cross-section is incorrect. If errors cannot be found, eliminate the offending cross-sections. Allowing such errors to go undetected in the field is indicative of shoddy technique.

   For each cross-section, calculate the increase of the measured stage between the low and intermediate calibration flows and the intermediate and high calibration flows. Increases should be similar for all riffle cross-sections. For example, if the stage between the low and intermediate calibration flows for riffle cross-sections 1, 2, 3, 4 and 5 increases by 0.31, 0.22, 0.20, 0.24 and 0.94 ft, respectively, stage measurements for cross-section 5 should be rechecked. If an error is not found, eliminate cross-section 5 from the analysis.

6. Compare the stages to the cross-sectional profile

   For each cross-section, compare the measured stages at the calibration flows to the elevations in the cross-sectional profile to see if the stages and profile elevations are "in line." For example, the stages for a riffle cross-section in a small stream are around 4 ft and the lower elevations in the profile are about 1 ft. The magnitude of this difference (3 ft) indicates errors.

7. Examine the zf values

   The zf value, taken as the lowest elevation in the cross-sectional profile for riffles, should generally increase as the riffle cross-sections progress upstream, provided all cross-sections are keyed to the same bench mark. If an upstream riffle cross-section has a zf value that is significantly less than that of its downstream neighbor, the accuracy of the profile is suspect. A recording or data entry error is often responsible. For example, a profile elevation of 4.94 ft is entered as .94 ft, causing the zf value to be excessively low.

8. Compare measurements to predictions

   Include the flow at which you measured cross-sectional profiles as one of your requested flows of interest. At this flow, your field measurements will include the top width (WDTH), maximum depth (DMAX) and stage (STGE) for each cross-section. On the printout, compare these measured values to the predictions. If the measured and predicted values are dissimilar, errors are present.

9. Compare predictions for all cross-sections

   Compare the hydraulic predictions for all riffle cross-sections at one of the lower flows of interest to see if the predictions are similar. For example, at a flow of 5.0 cfs the predicted wetted perimeters for riffle cross-sections 1, 2, 3, 4 and 5 are 4.23, 19.74, 18.62, 16.72 and 23.49 ft, respectively. The value for cross-section 1 is out of line with the others and, consequently, is suspect.

<u>Plotting Wetted Perimeter-Flow Relationships</u>

The computed wetted perimeters for all riffle cross-sections at each flow of interest are averaged and the flow recommendation is selected from the plot of average wetted perimeter versus flow. Average wetted perimeters are listed in the far right column on the printouts.

As a general guideline when plotting wetted perimeter-flow relationships for mountain streams, the flows on the x axis should extend a little beyond the stream's average annual flow. Because the inflection points typically fall well below the average annual flow, extending the plot far beyond this point is unnecessary. The limit of the lower flow is a judgment decision based on how comfortable you are with your data extrapolations.

You may have to change the scale on your plots a number of times to better define the inflection points. Do not be concerned if a lower inflection point is not discernible on your final plot. If it is not evident, simply state so in the narrative. The uppermost point, which is far more useful when deriving most recommendations, is typically well-defined for riffles and easily located on the plots. A department computer program that calculates changes in slope on the wetted perimeter-flow curves is available to aid in selecting inflection points if needed.

If the upper inflection point flow on the composite plot is, in your judgment, too high relative to water availability, you should plot the individual wetted perimeter-flow relationships comprising the composite to see if any single relationship is overly influencing the composite. This could be the cause of a "high" recommendation. You may choose to remove the offending cross-section from the composite.

As a general guideline, upper inflection point flows for mountain streams equal, on average, about 40% of the average annual flow. The percentage can vary considerably for individual streams, commonly ranging between 25 and 75%.

OTHER USES FOR THE WETP OUTPUT

The wetted perimeter inflection point method, as previously described, is the primary method the MDFWP is presently using to derive instream flow recommendations for the waterways of Montana. The WETP program and output can also be used in other ways for deriving recommendations. Some of these uses are discussed in the following examples.

Passage of Migratory Trout

Many streams provide important spawning and rearing habitats for migratory salmonids. Sufficient stream flows are needed not only to maintain spawning and rearing habitats, but also to pass adults through shallow riffle areas and other natural barriers while moving to their upstream spawning sites.

Trout passage criteria relating to stream depth have been developed in Oregon and Colorado (Table 1). These criteria, when used in conjunction with the WETP output for critical riffles, can be used to derive minimum passage flows. For example, passage criteria developed by the Colorado Division of Wildlife for streams 20 ft and wider indicate that the minimum average depth needed to pass trout through riffles is 0.5-0.6 ft. The output for the Tobacco River (Table 2) shows that the average depth for all five riffle cross-sections exceeds 0.5 ft, the approximate minimum average depth required for passage, at a flow of 120 cfs. A flow of at least 120 cfs is therefore recommended during the spawning period to facilitate the passage of adult trout to upstream spawning areas.

Table 1. Trout passage criteria (from Wesche and Rechard, 1980).

Species	Source	Minimum Depth (ft)	Average Depth (ft)	Where Developed
Large Trout ≥20 inches	Thompson 1972	0.6	--	Oregon
Other Trout <20 inches	Thompson 1972	0.4	--	Oregon
Trout (on streams 20 ft or greater)	Colo. Div. of Wild. 1976	--	0.5-0.6 across riffles	Colorado
Trout (on streams 10-20 ft wide)	Colo. Div. of Wild. 1976	--	0.2-0.4 across riffles	Colorado

Table 2. Average depths for five riffle cross-sections in the Tobacco River, Montana, at selected flows of interest. Average depths were derived using the WETP computer program.

Flow (cfs)	Average Depth (ft)				
	Riffle cs #1	Riffle cs #2	Riffle cs #3	Riffle cs #4	Riffle cs #5
100	.44	.65	.79	.68	.47
110	.49	.69	.85	.72	.52
120	.54	.73	.91	.75	.57

The minimum depth criteria developed in Oregon could also be used in conjunction with the WAGD option of the WETP program to derive passage recommendations. For this evaluation, criteria are developed requiring at least a certain percentage of the top width of a cross-section to have water depths greater than or equal to the minimum needed for fish passage. In Oregon, at least 25% of the top width and a continuous portion equaling at least 10% of the top width are used (Thompson, 1972). The flow that satisfies these criteria for all cross-sections is recommended.

Goose Nesting Requirement

The maintenance of adequate flows around islands selected by Canada geese for nesting is necessary to insure that the nests are protected from mammalian predators. Under low flows, predators have easy access to the islands and can significantly reduce goose production. The security of the islands is a primary factor in their selection as nest sites by geese. This security is provided by adequate side channel flows, which are a function of depth, width, and velocity. Because wetted perimeter is a function of both width and depth, its relationship to discharge may be the best indicator of the minimum flows that are needed to maintain secure nesting islands.

The wetted perimeter inflection point method is applied to the shallowest area of the side channel bordering each nesting island. A wetted perimeter-side channel discharge curve is generated for each cross-section and the inflection point determined. A curve correlating the side channel flow to the total river flow is also derived during the field season. From these curves, the total river discharge that would provide the inflection point flow in each side channel is determined. The final recommendation is derived by averaging the recommendations for each island or choosing the river flow that would maintain at least the inflection point flow around all the islands being sampled in the study area. The latter method is preferred.

Minimum depth and width criteria could also be developed and used in conjunction with the WAGD option of the WETP program to formulate flow recommendations for nesting.

Maintenance of Spawning and Rearing Habitats in Side Channels

Side channels provide important and sometimes critical spawning and rearing habitats for many cold- and warm-water fish species. The maintenance of these habitats depends on adequate side channel flows.

The wetted perimeter inflection point method, when applied to the riffle areas of critical side channels, will provide a measure of the side channel flow that is needed to maintain the spawning and rearing habitats at acceptable levels. When this side channel recommendation is used in conjunction with a curve correlating the side channel flow to the total river flow, the total river flow that would maintain adequate side channel flow can be determined.

This method is applied to a series of side channels and the final recommendation derived by averaging the recommendations for each or choosing the river flow that would maintain at least the inflection point flow in all the sampled side channels. The latter method is again preferred.

Recreational Floating Requirement

Minimum stream depth and width criteria have been developed for various types of boating craft by the Cooperative Instream Flow Service Group of the U.S. Fish and Wildlife Service (Hyra, 1978). These are listed in Table 3.

Table 3. Required stream width and depth for various recreation craft.

Recreation Craft	Required Depth (ft)	Required Width (ft)
Canoe-kayak	0.5	4
Drift boat, row boat-raft	1.0	6
Tube	1.0	4
Power boat	3.0	6
Sail boat	3.0	25

These criteria are minimal and would not provide a satisfactory experience if the entire river was at this level. However, if the required depths and widths are maintained in riffles and other shallow areas, then these minimum conditions will only be encountered a short time during the float and the remainder of the trip will be over water of greater depths.

Cross-sections are placed in the shallowest area along the waterway. The WAGD option of the WETP program is used to determine the flow that will satisfy the minimum criteria for the craft of interest. For example, if deriving a recommendation for power boats, the flow providing depths $\geq$ 3.0 ft for at least a 6.0 ft, continuous length of top width is recommended. When a series of cross-sections are used, the results for each cross-section are analyzed separately and the flow satisfying the criteria for all cross-sections is recommended.

This analysis can be expanded using additional criteria. For example, in addition to the above criteria for power boats, it can also be required that a certain percentage of the top width, such as 25%, has depths $\geq$ 3.0 ft. Remember, you will have to justify all criteria used in your analysis.

FINAL CONSIDERATIONS

Be sure to compare your instream flow recommendations to water availability. For gaged streams, many summary flow statistics, such as the mean and median monthly flows of record, are available for comparison. For ungaged streams, instantaneous flow measurements collected by various state and federal agencies and simulated data are useful. The primary purpose is to determine if the recommendation is reasonable when compared to water availability. It is also desirable, for future planning, to define the period in which water in excess of the recommendation is available for consumptive uses and to quantify this excess.

It is common for the low flow recommendations for many of the headwater rivers and streams to equal or exceed the normal water availability for the months of November through March. This is the winter period when the natural flows are lowest for the year. These naturally occurring low flows, when coupled with the adverse effects of surface and anchor ice formation and the resulting scouring of the channel at ice-out, can impact the fishery. Consequently, water depletions during the winter have the potential to be extremely harmful to the already stressed fish populations. For headwater rivers and streams, it is generally accepted that little or no water should be removed during the critical winter period if fish populations are to be maintained at existing levels.

The recommendations derived from the wetted perimeter inflection point method only apply to the low flow or non-runoff months. For the high flow or runoff period, flow recommendations should be based on those flows judged necessary for flushing bottom sediments and maintaining the existing channel morphology. This method, termed the dominant discharge/channel morphology concept (Montana Department of Fish and Game, 1979), requires at least ten years of continuous USGS gage records for deriving high flow recommendations, so cannot be applied to most streams.

LITERATURE CITED

Bovee, K. D. and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and techniques. Instream Flow Information Paper: No. 5. Cooperative Instream Flow Service Group, Fort Collins, CO. 131 pp.

Buchanan, T. J. and W. P. Somers. 1969. Discharge measurements at gaging stations. Techniques of Water Resources Investigations of the United States Geological Survey, Book 3, Chapter A8.

Collings, Mike. 1972. A methodology for determining instream flow recommendations for fish. In Proceedings of Instream Flow Methodology Workshop. Washington Dept. of Ecology, Olympia, WA. pp. 72-86.

_______________. 1974. Generalization of spawning and rearing discharges for several Pacific salmon species in western Washington. USGS, Open File Report. 39 pp.

Colorado Division of Wildlife. 1976. Required instream flows Crystal River and Avalanche Creek. Open File Letter. Colorado Division of Wildlife, Denver, CO. 33 pp.

Graham, P. J. and R. F. Penkal. 1978. Aquatic environmental analysis in the lower Yellowstone River. Montana Department of Fish, Wildlife and Parks, Helena. 254 pp.

Hyra, R. 1978. Methods of assessing instream flows for recreation. Instream Flow Information Paper: No. 6. Cooperative Instream Flow Service Group, Fort Collins, CO. 49 pp.

Leathe, S and F. Nelson. 1989. A literature evaluation of Montana's wetted perimeter inflection point method for deriving instream flow recommendations. Montana Department of Fish, Wildlife and Parks, Helena. 70 pp.

Montana Department of Fish and Game, 1979. Instream flow evaluation for selected streams in the upper Missouri River basin. Montana Department of Fish, Wildlife and Parks, 1420 East Sixth Avenue, Helena, MT 59620. 254 pp.

Rantz, S. E. (and others). 1982. Measurement and computation of streamflow: Volume 2. Computation of discharge. Geological Survey Water-Supply Paper 2175. U.S. Government Printing Office, Washington, D.C.

Smoot, G. F. and C. E. Novak. 1968. Calibration and maintenance of vertical-axis type current meters. Techniques of Water Resources Investigations of the United States Geological Survey, Book 8, Chapter B2.

Spence, L. E. 1975. Guidelines for using Water Surface Profile program to determine instream flow needs for aquatic life. Montana Dept. of Fish, Wildlife and Parks, Helena. Prelim. Draft. 22 pp.

Thompson, K. E. 1972. Determining streamflows for fish life. In Proc. Instream Flow Requirement Workshop, Pacific NW River Basins Comm., Portland, OR. pp. 31-50.

Wesche, T. A. and P. A. Rechard. 1980. A summary of instream flow methods for fisheries and related research needs. Eisenhower Consortium Bulletin 9. Water Res. Research Inst., Univ. of Wyoming, Laramie. 122 pp.

White, Robert G. 1976. A methodology for recommending stream resource maintenance flows for large rivers. In Proceedings of the Symp. and Spec. Conf. on Instream Flow Needs, ed. J. F. Orsborn and C. H. Allman. Vol. II, pp. 367-386. Amer. Fish. Soc., Bethesda, MD.

White, Robert and Tim Cochnauer. 1975. Stream resource maintenance flow studies. Idaho Dept. of Fish and Game and Idaho Coop. Fishery Research Unit Report. 136 pp.

APPENDIX A

Calculation of stage height at zero flow (zf) from Rantz (1982)

period. On the other hand, if, as is usually the case, discharge measurements are lacking to define the upper end of the rating, the defined lower part of the rating curve must be extrapolated to the highest stage experienced. Such extrapolations are always subject to error, but the error may be reduced if the analyst has a knowledge of the principles that govern the shape of rating curves. Much of the material in this chapter is directed toward a discussion of those principles, so that when the hydrographer is faced with the problem of extending the high-water end of a rating curve he can decide whether the extrapolation should be a straight line, or whether it should be concave upward or concave downward.

The problem of extrapolation can be circumvented, of course, if the unmeasured peak discharge is determined by use of the indirect methods discussed in chapter 9. In the absence of such peak-discharge determinations, some of the uncertainty in extrapolating the rating may be reduced by the use of one or more of several methods of estimating the discharge corresponding to high values of stage. Four such methods are discussed in the section titled "High-flow Extrapolation."

In the discussions that follow it was generally impractical to use both English and metric units, except where basic equations are given. Consequently English units are used throughout, unless otherwise noted.

STAGE-DISCHARGE CONTROLS

The subject of stage-discharge controls was discussed in detail in chapter 3, but a brief summary at this point is appropriate.

The relation of stage to discharge is usually controlled by a section or reach of channel downstream from the gage that is known as the station control. A section control may be natural or manmade; it may be a ledge of rock across the channel, a boulder-covered riffle, an overflow dam, or any other physical feature capable of maintaining a fairly stable relation between stage and discharge. Section controls are often effective only at low discharges and are completely submerged by channel control at medium and high discharges. Channel control consists of all the physical features of the channel that determine the stage of the river at a given point for a given rate of flow. These features include the size, slope, roughness, alinement, constrictions and expansions, and shape of the channel. The reach of channel that acts as the control may lengthen as the discharge increases, introducing new features that affect the stage-discharge relation.

Knowledge of the channel features that control the stage-discharge relation is important. The development of stage-discharge curves where more than one control is effective, and where the number of

measurements is limited, usually requires judgment in interpolating between measurements and in extrapolating beyond the highest measurements. That is particularly true where the controls are not permanent and the various discharge measurements are representative of changes in the positioning of segments of the stage-discharge curve.

GRAPHICAL PLOTTING OF RATING CURVES

Stage-discharge relations are usually developed from a graphical analysis of the discharge measurements plotted on either rectangular-coordinate or logarithmic plotting paper. In a preliminary step the discharge measurements available for analysis are tabulated and summarized on a form such as that shown in figure 139. Discharge is then plotted as the abscissa, corresponding gage height is plotted as the ordinate, and a curve or line is fitted by eye to the plotted points. The plotted points carry the identifying measurement numbers given in figure 139; the discharge measurements are numbered consecutively in chronological order so that time trends can be identified.

At recording-gage stations that use stilling wells, systematic and significantly large differences between inside (recorded) gage heights and outside gage heights often occur during periods of high stage, usually as a result of intake drawdown (see section in chapter 4 titled, "Stilling Wells"). For stations where such differences occur, both inside and outside gage heights for high-water discharge measurements are recorded on the form shown in figure 139, and in plotting the measurements for rating analysis, the outside gage readings are used first. The stage-discharge relation is drawn through the outside gage readings of the high-water discharge measurements and is extended to the stage of the outside high-water marks that are observed for each flood event. The stage-discharge relation is next transposed to correspond with the inside gage heights obtained from the stage-recorder at the times of discharge measurement and at flood peaks. It is this transposed stage-discharge relation that is used with recorded stages to compute the discharge.

The rationale behind the above procedure is as follows. The outside gage readings are used for developing the rating because the hydraulic principles on which the rating is based require the use of the true stage of the stream. The transposition of the rating to inside (recorded) stages is then made because the recorded stages will be used with the rating to determine discharge. The recorded stages are used for discharge determination because if differences exist between inside and outside gage readings, those differences will be known only for those times when the two gages are read concurrently. If the

Form 9-207
Rev. 11-59

UNITED STATES DEPARTMENT OF THE INTERIOR
Geological Survey (Water Resources Division)
DISCHARGE MEASUREMENT SUMMARY SHEET

Station No. 11-4770

Discharge measurements of *Eel River at Scotia, Calif.* during the year ending Sept. 30, 1966

No.	Date	Made by	Width	Area	Mean velocity	Gage height	Discharge	Rating shift adj.	Percent diff.	Method	No. secs.	Gage height change	Time	Meas. rated	Water temp. °C	Inside gage	REMARKS
	1965																
495	Aug 31	Hammond McGuire	153	W 199	0.78	8.92	155			0.6	34	-.01	1.2	F	[illegible]	8.98	
496	Oct. 5	La Rue	155	W 148	0.82	8.79	121			.6	26	.0	.5	F	[illegible]	8.87	Zero flow =8.5 ± 0.05
497	Nov 2	do	154	W 158	0.85	8.88	135			.6	29	.0	.5	G	60	8.99	Zero flow =8.5 ± 0.05
498	30	La Rue Crumrine	454	2,030	2.47	12.52	5,010			.6, 2/8	33	-.01	1.1	G	46	12.49	
	1966																
499	Jan. 3	La Rue	553	6,790	7.19	21.03	49,800			2/8	29	+0.52	1.75	G/F	46	21.09	
500	25	Hammond Crumrine	512	2350	1.73	12.74	4,050			.6, 2/8	25	-.02	1.3	P	45	12.80	peak (Jan 5) 45.84
501	25	do	506	2270	1.71	12.73	3,880			.6, 2/8	28	0	2	F	—	12.80	
502	31	La Rue	543	3960	4.18	16.08	16,500			.6, 2/8	32	-.07	1.25	G	—	16.13	
503	Feb. 21	do	533	3000	2.70	13.85	8,100			2/8	36	-.03	1.4	G	48	13.86	
504	Mar. 31	do	2-Channels		—	13.59	7,420			2/8	37	.00	1.6	G	57	13.59	
505	Apr. 28	do	454	1890	1.90	12.13	3,600			.6, 2/8	36	-.01	1.3	G	58	12.16	
506	June 1	Palmer	434	1200	0.83	10.62	1,000			.6, 2/8	40	0	1.7	G	62	10.64	
507	July 6	do	196	193	1.56	7.82	302			.6	39	0	.9	G	70	7.83	
508	Aug. 8	do	184	W 126	1.11	9.40	140			.6	38	[illegible]	.75	F/P	67	—	Zero flow [illegible]
509	Sept. 12	Hammond	77	W 74.1	1.48	9.26	110			.6	31	0	.8	F	66	9.35	Zero flow [illegible]
510	Oct. 4	Palmer	184	116	[illegible]	[illegible]	117			.6	34	[illegible]	[illegible]	F	64	[illegible]	

Computed by W - Wading

FIGURE 139.—Example of form used for tabulating and summarizing current-meter discharge measurements

outside gage heights were used with the rating to determine discharge, variable corrections, either known or assumed, would have to be applied to recorded gage heights to convert them to outside stages. We have digressed here to discuss differences between inside and outside gage heights, because in the discussions that follow no distinction between the two gages will be made.

The use of logarithmic plotting paper is usually preferred for graphical analysis of the rating because in the usual situation of compound controls, changes in the slope of the logarithmically plotted rating identify the range in stage for which the individual controls are effective. Furthermore, the portion of the rating curve that is applicable to any particular control may be linearized for rational extrapolation or interpolation. A discussion of the characteristics of logarithmic plotting follows.

The measured distance between any two ordinates or abscissas on logarithmic graph paper, whose values are printed or indicated on the sheet by the manufacturer of the paper, represents the difference between the logarithms of those values. Consequently, the measured distance is related to the ratio of the two values. Therefore, the distance between pairs of numbers such as 1 and 2, 2 and 4, 3 and 6, 5 and 10, are all equal because the ratios of the various pairs are identical. Thus the logarithmic scale of either the ordinates or the abscissas is maintained if all printed numbers on the scale are multiplied or divided by a constant. This property of the paper has practical value. For example, assume that the logarithmic plotting paper available has two cycles (fig. 140), and that ordinates ranging from 0.3 to 15.0 are to be plotted. If the printed scale of ordinates is used and the bottom line is called 0.1, the top line of the paper becomes 10.0, and values between 10.0 and 15.0 cannot be accommodated. However, the logarithmic scale will not be distorted if all values are multiplied by a constant. For this particular problem, 2 is the constant used in figure 140, and now the desired range of 0.3 to 15.0 can be accommodated. Examination of figure 140 shows that the change in scale has not changed the distance between any given pair of ordinates; the position of the ordinate scale has merely been transposed.

We turn now to a theoretical discussion of rating curves plotted on logarithmic graph paper. A rating curve, or a segment of a rating curve, that plots as a straight line of logarithmic paper has the equation,

$$Q = p(G - e)^N, \tag{53}$$

where

Q is discharge;

$(G - e)$ is head or depth of water on the control—this value is indicated by the ordinate scale printed by the manufacturer or

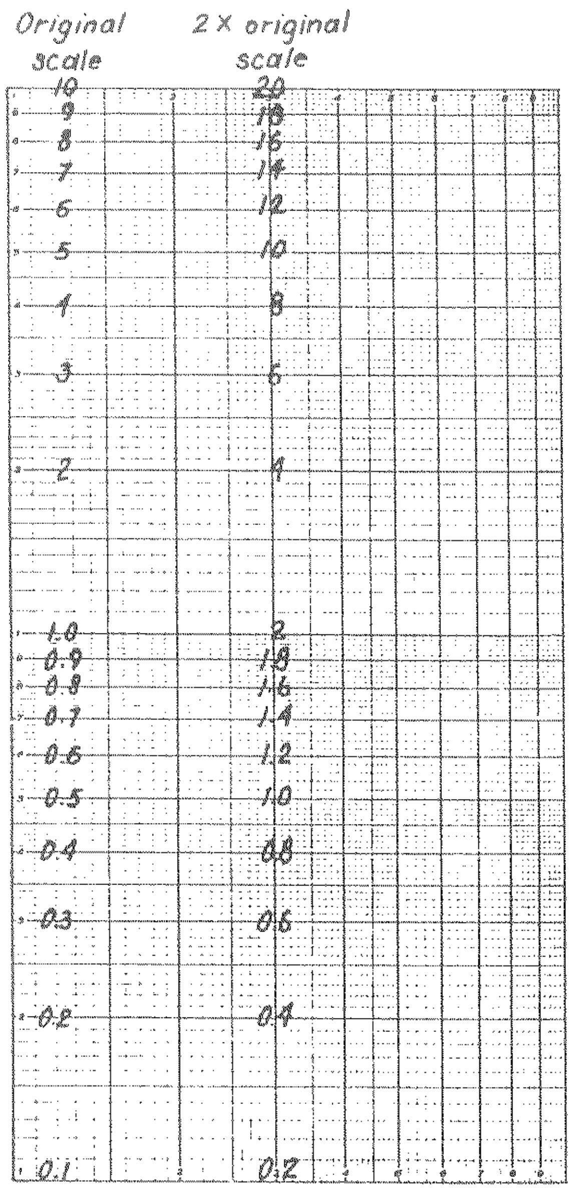

FIGURE 140.—Example showing how the logarithmic scale of graph paper may be transposed.

by the ordinate scale that has been transposed, as explained in the preceding paragraph;

G is gage height of the water surface;

e is gage height of zero flow for a section control of regular shape, or the gage height of effective zero flow for a channel control or a section control of irregular shape;

p is a constant that is numerically equal to the discharge when the head $(G - e)$ equals 1.0 ft or 1.0 m, depending on whether English or metric units are used; and

N is slope of the rating curve. (Slope in equation 53 is the ratio of the horizontal distance to the vertical distance. This unconventional way of measuring slope is necessary because the dependent variable Q is always plotted as the abscissa.)

We assume now that a segment of an established logarithmic rating is linear, and we examine the effect on the rating of changes to the control. If the width of the control increases, p increases and the new rating will be parallel to and to the right of the original rating. If the width of the control decreases, the opposite effect occurs; p decreases and the new rating will be parallel to and to the left of the original rating. If the control scours, e decreases and the depth $(G - e)$ for a given gage height increases; the new rating moves to the right and will no longer be a straight line but will be a curve that is concave downward. If the control becomes built up by deposition, e increases and the depth $(G - e)$ for a given gage height decreases; the new rating moves to the left and is no longer linear but is a curve that is concave upward.

When discharge measurements are originally plotted on logarithmic paper, no consideration is given to values of e. The gage height of each measurement is plotted using the ordinate scale provided by the manufacturer or, if necessary, an ordinate scale that has been transposed as illustrated in figure 140. We refer now to figure 141. The inside scale $(e = 0)$ is the scale printed by the paper manufacturer. Assume that the discharge measurements have been plotted to that scale and that they define the curvilinear relation between gage height (G) and discharge (Q) that is shown in the topmost curve. For the purpose of extrapolating the relation, a value of e is sought, which when applied to G, will result in a linear relation between $(G - e)$ and Q. If we are dealing with a section control of regular shape, the value of e will be known; it will be the gage height of the lowest point of the control (point of zero flow). If we are dealing with a channel control or section control of irregular shape, the value of e is the gage height of *effective* zero flow. The gage height of effective zero flow is not the gage height of some identifiable feature on the irregular section control or in the channel but is actually a mathematical constant that is considered as a gage height to preserve the concept of a logarithmically linear head-discharge relation. Effective zero flow is usually determined by a method of successive approximations.

In successive trials, the ordinate scale in figure 141 is varied for e values of 1, 2 and 3 ft, each of which results in a different curve, but each new curve still represents the same rating as the top curve. For example, a discharge of 30 ft³/s corresponds to a gage height (G) of 5.5 ft on all four curves. The true value of e is 2 ft, and thus the rating plots as a straight line if the ordinate scale numbers are increased by that value. In other words, while even on the new scale a discharge of 30 ft³/s corresponds to a gage height (G) of 5.5 ft, the head or depth on the control for a discharge of 30 ft³/s is $(G-e)$, or 3.5 ft; the linear rating marked $e = 2$ crosses the ordinate for 30 ft³/s at 5.5 ft on the new scale and at 3.5 ft on the manufacturer's, or inside, scale. If values of e smaller than the true value of 2 ft are used, the rating curve will be concave upward, if values of e greater than 2 ft are used, the curve will be concave downward. The value of e to be used for a rating curve, or for a segment of a rating curve, can thus be determined by adding or subtracting trial values of e to the numbered scales on the logarithmic plotting paper until a value is found that results in a straight-line plot of the rating. It is important to note that if the logarithmic ordinate scale must be transposed by multiplication or division to accommodate the range of stage to be plotted, that transposition must be made before the ordinate scale is manipulated for values of e.

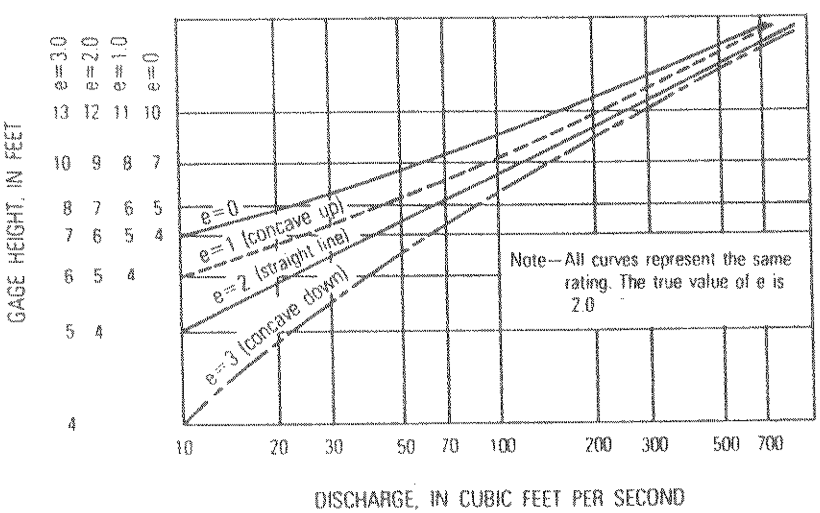

FIGURE 141.—Rating-curve shapes resulting from the use of differing values of effective zero flow.

A more direct solution for e, as described by Johnson (1952) is illustrated in figure 142. A plot of G versus Q has resulted in the solid-line curve which is to be linearized by subtracting a value of e from each value of G. The part of the rating between points 1 and 2 is chosen, and values of G_1, G_2, Q_1 and Q_2 are picked from the coordinate scales. A value of Q_3 is next computed, such that

$$Q_3^2 = Q_1 Q_2.$$

From the solid-line curve, the value of G_3 that corresponds to Q_3 is picked. In accordance with the properties of a straight line on logarithmic plotting paper,

$$(G_3 - e)^2 = (G_1 - e)(G_2 - e). \qquad (54)$$

Expansion of terms in equation 54 leads to equation 55 which provides a direct solution for e.

$$e = \frac{G_1 G_2 - G_3^2}{G_1 + G_2 - 2G_3} \qquad (55)$$

A logarithmic rating curve is seldom a straight line or a gentle curve for the entire range in stage. Even where a single cross section of the channel is the control for all stages, a sharp break in the

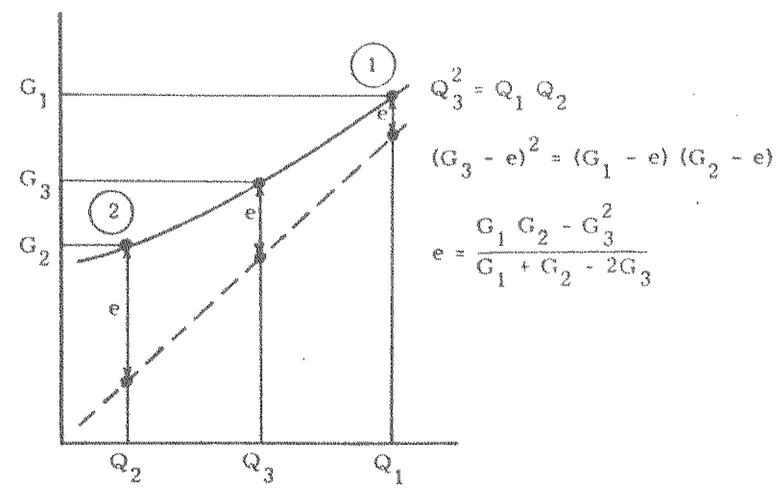

FIGURE 142.—Schematic representation of the linearization of a curve on logarithmic graph paper.

contour of the cross section, such as an overflow plain, will cause a break in the slope of the rating curve. Commonly, however, a break in slope is due to the low-water control being drowned out by a downstream section control becoming effective or by channel control becoming effective.

The use of rectangular-coordinate paper for rating analysis has ...rtain advantages, particularly in the study of the pattern of shifts ...he lower part of the rating. A change in the low-flow rating at ...ny sites results from a change in the elevation of effective zero flow ...e), which means a constant shift in gage height. A shift of that kind is more easily visualized on rectangular-coordinate paper because on that paper the shift curve is parallel to the original rating curve, the two curves being separated by a vertical distance equal to the change in the value of e. On logarithmic paper the two curves will be separated by a variable distance which decreases as stage increases. A further advantage of rectangular-coordinate paper is the fact that the point of zero flow can be plotted directly on rectangular-coordinate paper, thereby facilitating extrapolation of the low-water end of the rating curve. That cannot be done on logarithmic paper because zero values cannot be shown on that type of paper.

As a general rule logarithmic plotting should be used initially in developing the general shape of the rating. The final curve may be displayed on either type of graph paper and used as a base curve for the analysis of shifts. A combination of the two types of graph paper is frequently used with the lower part of the rating plotted on an inset of rectangular-coordinate paper or on a separate sheet of rectangular-coordinate paper.

A–5

SECTION CONTROLS

ARTIFICIAL CONTROLS

At this point we digress from the subject of logarithmic rating curves to discuss the ratings for artificial section controls. A knowledge of the rating characteristics of controls of standard shape is necessary for an understanding of the rating characteristics of natural controls, almost all of which have irregular shapes. On pages that follow we first discuss thin-plate weirs, then broad-crested weirs, and finally flumes.

Thin-plate weirs are generally used in small clear-flowing streams, particularly where high accuracy is desired and adequate maintenance can be provided, as in small research watersheds. Flumes are preferred for use in small streams and canals that carry sediment and debris, and in other situations where the head loss (backwater) associated with a thin-plate weir is unacceptable. Most types of flume may also be used under conditions of submergence, as opposed to free-flow

conditions, thereby permitting them to operate with even smaller head loss but with some loss of accuracy of the stage-discharge relation. The broad-crested weirs are commonly used in the larger streams.

TRANSFERABILITY OF LABORATORY RATINGS

Standard shapes or dimensions are commonly used in building artificial controls, and many of these standard structures have been rated in laboratory model studies (World Meteorological Organization, 1971). The transfer of a laboratory discharge rating to a structure in the field requires the existence, and maintenance, of similitude between laboratory model and prototype, not only with regard to the structure, but also with regard to the approach channel. For example, scour and (or) fill in the approach channel will change the head-discharge relation, as will algal growth on the control structure. Both the structure and the approach channel must be kept free from accumulations of debris, sediment, and vegetal growth. Flow conditions downstream from the structure are significant only to the extent that they control the tailwater elevation, which may influence the operation of structures designed for free-flow conditions.

Because of the likelihood of the existence or development of conditions that differ from those specified in a laboratory model study, the policy of the Geological Survey is to calibrate the prototype control in the field by discharge measurements for the entire range of stage that is experienced. (See section in chapter 3 titled, "Artificial Controls.") In-place calibration is sometimes dispensed with where the artificial control is a standard thin-plate weir having negligible velocity of approach.

THIN-PLATE WEIRS

The surface of the weir over which the water flows is the crest of the weir. A thin-plate weir has its crest beveled to a chisel edge and is always installed with the beveled face on the downstream side. The crest of a thin-plate weir is highly susceptible to damage from floating debris, and therefore such weirs are used as control structures almost solely in canals whose flow is free of floating debris. Thin-plate weirs are not satisfactory for use in canals carrying sediment-laden water because they trap sediment and thereby cause the gage pool to fill with sediment, sometimes to a level above the weir crest. The banks of the canal must also be high enough to accommodate the increase in stage (backwater) caused by the installation of the weir, the weir plate being an impedance to flow in the canal. The commonly used shapes for thin-plate weirs are rectangular, trapezoidal, and triangular or V-notch.

APPENDIX B

Example of WETP input format

IBM ← Title and location of study area

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: Bear Creek-Big Hole Drainage - SW, SE, Sec. 34, T2N, R12W

PROGRAMMER: Fred Nelson   DATE: 6-27-84

PUNCHING INSTRUCTIONS

PAGE 1 OF 4

CARD ELECTRO NUMBER

IDENTIFICATION SEQUENCE

FORTRAN STATEMENT

OPTS	1												
QARD	1.5												
QARD	2												
QARD	2.5												
QARD	3												
QARD	3.5												
QARD	4												
QARD	5												
QARD	6												
QARD	7												
QARD	8												
QARD	9												
QARD	10												
QARD	15												
QARD	20												
QARD	25												
QARD	30												
QARD	40												
QARD	50												
QARD	60												
XSEC	1												
	1	0	9657	9	9642	15	9600	16	9424	21	9411	30	9389
	1	41	9386	51	9383	60	9363	61	9297	63	9283	64	9273
	1	68	9253	73	9243	78	9233	83	9233	88	9223	93	9233

Flows of interest.
Up to 100 flows allowed.
Enter as integers or with decimal points.

Profile Data

Distance from headstake

Channel elevation

Reads as 1.5 ft

Reads as 96.00 ft

Do not enter profile data past space 70.

Cross-section identification

Stage Height At Zero Flow (zf) Option

I. Riffles

Set OPTS to one.

zf will equal lowest elevation on cross-sectional profile.

II. Non-Riffles

Set OPTS to one and enter zf on the XSEC records.

III. Want zf to equal zero.

Set OPTS to zero.

Use only for comparing results.

* A standard card form, IBM electro 888157, is available for punching statements from this form

** Number of forms per pad may vary slightly

IBM — FORTRAN Coding Form — GX28-7327-6 U/M 050** Printed in U.S.A.

PROGRAM: Bear Creek — PAGE 2 OF 4

Statement	Cont.													Comment
	1	98	9238	103	9243	108	9243	113	9243	118	9248	123	9263	
	1	128	9268	133	9273	135	9283	140	9314	150	9330	159	9350	
	1	162	9407	170	9485	182	9502	194	9536					
CAL1	1		9359		334									← Calibration data for CS#1 - high flow
CAL2	1		9321		113									← " " - intermediate flow
CAL3	1		9283		38									← " " - low flow
XSEC	2													
	2	0	9726	4	9719	10	9676	19	9632	20	9463	25	9404	
	2	35	9383	43	9396	44	9357	52	9356	54	9342	63	9342	
	2	75	9332	77	9323	80	9318	85	9313	90	9313	91	9293	
	2	96	9293	101	9293	107	9288	113	9298	117	9293	120	9273	
	2	125	9273	130	9273	135	9273	137	9293	138	9323	139	9393	
	2	140	9435	147	9464	155	9483	158	9515	168	9531	179	9536	
	2	190	9552											
CAL1	2		9390		334									Water surface elevations
CAL2	2		9357		113									Each is the average for the WEL and WER
CAL3	2		9323		38									Without decimal points, reads as 93.90, 93.57 and 93.23 ft
XSEC	3													
	3	0	9799	10	9782	20	9755	29	9724	36	9706	46	9674	
	3	51	9662	52	9602	63	9600	74	9607	81	9618	90	9630	
	3	99	9636	109	9636	118	9619	127	9601	130	9590	133	9585	
	3	138	9575	141	9565	147	9555	150	9550	155	9540	160	9535	
	3	165	9530	170	9515	175	9525	180	9520	185	9515	190	9540	
	3	195	9545	198	9550	199	9590	200	9697	201	9717	210	9709	

*A standard card form, IBM electro 888157, is available for punching statements from this form.

**Number of forms per pad may vary slightly

IBM FORTRAN Coding Form

GX28-7327-6 U/M 050
Printed in U.S.A.

Program: Bear Creek — Page 3 of 4

Statement	Cont.												
	3	195	9545	198	9550	199	9590	200	9697	201	9717	210	9709
	3	220	9707	224	9741	231	9746	240	9748	250	9751		
CAL1	3		9663		334								
CAL2	3		9626		113								
CAL3	3		9590		38								
XSEC	4												
	4	0	9863	10	9848	14	9824	24	9813	34	9809	43	9800
	4	50	9785	60	9766	70	9761	80	9746	90	9734	96	9700
	4	101	9687	108	9673	109	9661	110	9661	116	9661	121	9656
	4	130	9656	140	9656	145	9656	147	9651	153	9646	158	9646
	4	160	9636	165	9626	170	9626	175	9616	185	9626	195	9626
	4	200	9631	205	9636	210	9636	215	9636	220	9641	223	9646
	4	228	9646	234	9651	238	9656	242	9661	244	9666	250	9667
	4	255	9687	261	9717	265	9742	272	9748	278	9763	287	9754
	4	295	9740	310	9743	342	9745	346	9793	353	9829	361	9829
CAL1	4		9714		334								
CAL2	4		9685		113								
CAL3	4		9661		38								
XSEC	5												
	5	0	9830	10	9806	14	9793	16	9769	18	9675	19	9640
	5	22	9625	30	9615	40	9615	50	9625	58	9615	60	9625
	5	65	9620	70	9630	80	9635	90	9635	98	9645	102	9655
	5	105	9675	106	9688	110	9706	119	9690	122	9680	129	9687
	5	135	9705	141	9736	149	9747	152	9775	161	9782	170	9788

Handwritten notes:

} Calibration flows. Without decimal points, reads as 33.4, 11.3 and 3.8 cfs (beside the CAL1–CAL3 lines of card 3)

For non-riffle cross-sections enter zf here (arrow pointing to the circled blank field on the XSEC line of card 5)

* Number of forms per pad may vary slightly.

GX28-7327-6 U/M 050**
Printed in U.S.A.

IBM FORTRAN Coding Form

PROGRAM: Bear Creek

PAGE 4 OF 4

FORTRAN STATEMENT

```
     5 180 9777 190 9765 200 9754 215 9748 231 9746 242 9753
     5 244 9809 248 9831 254 9842 265 9842
CAL1 5     9725      334
CAL2 5     9697      113
CAL3 5     9675       38
D .4 1.0
POOL 1 2 3 4 5
POOL 3 4 5
```

Optional Entry

In this example, results are also averaged for CS# 3, 4 and 5. Use as many POOL entries as needed.

Mandatory Entry

Prints results for each cross-section as well as the averages for all cross-sections.

Width-At-Given-Depth (WAGD) Option

Up to 10 depths allowed. Separate depths of interest with single space. In this example, asking for length of top width having depths ≥ .4 ft and 1.0 ft.

APPENDIX C

Example of WETP data output

```
Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W
PROGRAM WETP

          *** MONTANA DEPT. OF FISH, WILDLIFE AND PARKS ***

                Program WETP Rev. 1-84 (16 June 1984)

Program WETP calculates the following parameters for a stream
cross-section. Up to 10 stream cross-sections may be pooled
together to obtain an average of pooled cross-sections. Cross-
sections may be defined by up to 150 points.

  WETP - wetted perimeter
  DBAR - average depth
  VBAR - average velocity throughout cross-sectional area
  WDTH - top width of cross-section
  AREA - cross-sectional area
  STGE - water surface elevation
  DMAX - maximum depth
  WTOT - width at a depth > or = to a given value
  WMAX - max. cont. width at a depth > or = to a given value
  PTOT - ratio of WTOT/WDTH expressed as a percent
  PMAX - ratio of WMAX/WDTH expressed as a percent
```

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

CROSS-SECTION DATA

1		2		3		4		5						
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
.0	96.57	.0	97.26	.0	97.99	.0	98.63	.0	98.30					
.9	96.42	.4	97.19	1.0	97.82	1.0	98.48	1.0	98.06					
1.5	96.00	1.0	96.76	2.0	97.55	1.4	98.24	1.4	97.93					
1.6	94.24	1.9	96.32	2.9	97.24	2.4	98.13	1.6	97.69					
2.1	94.11	2.0	94.63	3.6	97.06	3.4	98.09	1.8	96.75					
3.0	93.89	2.5	94.04	4.6	96.74	4.3	98.00	1.9	96.40					
4.1	93.86	3.5	93.83	5.1	96.62	5.0	97.85	2.2	96.25					
5.1	93.83	4.3	93.96	5.2	96.02	6.0	97.66	3.0	96.15					
6.0	93.63	4.4	93.57	6.3	96.00	7.0	97.61	4.0	96.15					
6.1	92.97	5.2	93.56	7.4	96.07	8.0	97.46	5.0	96.25					
6.3	92.83	5.4	93.42	8.1	96.18	9.0	97.34	5.8	96.15					
6.4	92.73	6.3	93.42	9.0	96.30	9.6	97.00	6.0	96.25					
6.8	92.53	7.5	93.32	9.9	96.36	10.1	96.87	6.5	96.20					
7.3	92.43	7.7	93.23	10.9	96.36	10.8	96.73	7.0	96.30					
7.8	92.33	8.0	93.18	11.8	96.19	10.9	96.66	8.0	96.35					
8.3	92.33	8.5	93.13	12.7	96.01	11.0	96.61	9.0	96.35					
8.8	92.23	9.0	93.13	13.0	95.90	11.6	96.61	9.8	96.45					
9.3	92.33	9.1	92.93	13.3	95.85	12.1	96.56	10.2	96.55					
9.8	92.38	9.6	92.93	13.8	95.75	13.0	96.56	10.5	96.75					
10.3	92.43	10.1	92.93	14.1	95.65	14.0	96.56	10.6	96.88					
10.8	92.43	10.7	92.88	14.7	95.55	14.5	96.56	11.0	97.06					
11.3	92.43	11.3	92.98	15.0	95.50	14.7	96.51	11.9	96.90					
11.8	92.48	11.7	92.93	15.5	95.40	15.3	96.46	12.2	96.80					
12.3	92.63	12.0	92.73	16.0	95.35	15.8	96.46	12.9	96.87					
12.8	92.68	12.5	92.73	16.5	95.30	16.0	96.36	13.5	97.05					
13.3	92.73	13.0	92.73	17.0	95.15	16.5	96.26	14.1	97.36					
13.5	92.83	13.5	92.73	17.5	95.25	17.0	96.26	14.9	97.47					
14.0	93.14	13.7	92.93	18.0	95.20	17.5	96.16	15.2	97.75					
15.0	93.30	13.8	93.23	18.5	95.15	18.5	96.26	16.1	97.82					
15.9	93.50	13.9	93.93	19.0	95.40	19.5	96.26	17.0	97.88					
16.2	94.07	14.0	94.35	19.5	95.45	20.0	96.31	18.0	97.77					
17.0	94.85	14.7	94.64	19.8	95.50	20.5	96.36	19.0	97.65					
18.2	95.02	15.5	94.83	19.9	95.90	21.0	96.36	20.0	97.54					
19.4	95.36	15.8	95.15	20.0	96.97	21.5	96.36	21.5	97.48					
.0	.00	16.8	95.31	20.1	97.17	22.0	96.41	23.1	97.46					
.0	.00	17.9	95.36	21.0	97.09	22.3	96.46	24.2	97.53					
.0	.00	19.0	95.52	22.0	97.07	22.8	96.46	24.4	98.09					
.0	.00	.0	.00	22.4	97.41	23.4	96.51	24.8	98.31					
.0	.00	.0	.00	23.1	97.46	23.8	96.56	25.4	98.42					
.0	.00	.0	.00	24.0	97.48	24.2	96.61	26.5	98.42					
.0	.00	.0	.00	25.0	97.51	24.4	96.66	.0	.00					
.0	.00	.0	.00	.0	.00	25.0	96.67	.0	.00					
.0	.00	.0	.00	.0	.00	25.5	96.87	.0	.00					
.0	.00	.0	.00	.0	.00	26.1	97.17	.0	.00					
.0	.00	.0	.00	.0	.00	26.5	97.42	.0	.00					

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

.0	.00	.0	.00	.0	.00	27.2	97.48	.0	.00
.0	.00	.0	.00	.0	.00	27.8	97.63	.0	.00
.0	.00	.0	.00	.0	.00	28.7	97.54	.0	.00
.0	.00	.0	.00	.0	.00	29.5	97.40	.0	.00
.0	.00	.0	.00	.0	.00	31.0	97.43	.0	.00
.0	.00	.0	.00	.0	.00	34.2	97.45	.0	.00
.0	.00	.0	.00	.0	.00	34.6	97.93	.0	.00
.0	.00	.0	.00	.0	.00	35.3	98.29	.0	.00
.0	.00	.0	.00	.0	.00	36.1	98.29	.0	.00

CALIBRATION DATA

1		2		3		4		5							
Q	S	Q	S	Q	S	Q	S	Q	S	Q	S	Q	S	Q	S
33.4	93.59	33.4	93.90	33.4	96.63	33.4	97.14	33.4	97.25						
11.3	93.21	11.3	93.57	11.3	96.26	11.3	96.85	11.3	96.97						
3.8	92.83	3.8	93.23	3.8	95.90	3.8	96.61	3.8	96.75						

REGRESSION CURVE CONSTANTS

CONSTANTS AND R-SQUARED VALUES ARE GIVEN FOR THE
REGRESSION LOG (S - ZF) = A + B * LOG Q

1		2		3		4		5							
A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
-.429	.377	-.514	.391	-.299	.313	-.549	.358	-.382	.279						

R2	R2	R2	R2	R2	R2	R2	R2
.987	.984	.992	.997	1.000			
ZF	ZF	ZF	ZF	ZF	ZF	ZF	ZF
92.23	92.73	95.15	96.16	96.15			

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W
COMPUTED VALUES

FLOW=	1.5 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		6.21	5.10	6.28	8.20	8.75	.00	.00	.00	.00	.00	6.91
DBAR		.24	.23	.36	.16	.34	.00	.00	.00	.00	.00	.26
VBAR		1.01	1.37	.71	1.19	.52	.00	.00	.00	.00	.00	.96
WDTH		6.11	4.73	5.97	8.14	8.46	.00	.00	.00	.00	.00	6.68
AREA		1.49	1.09	2.12	1.26	2.87	.00	.00	.00	.00	.00	1.77
STGE		92.66	93.09	95.72	96.49	96.61	.00	.00	.00	.00	.00	94.91
DMAX		.43	.36	.57	.33	.46	.00	.00	.00	.00	.00	.43
WTOT	.40	.34	.00	2.55	.00	3.01	.00	.00	.00	.00	.00	1.18
WMAX		.34	.00	2.55	.00	2.16	.00	.00	.00	.00	.00	1.01
PTOT		5.60	.00	42.66	.00	35.64	.00	.00	.00	.00	.00	16.78
PMAX		5.60	.00	42.66	.00	25.51	.00	.00	.00	.00	.00	14.75
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
FLOW=	2.0 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		6.82	5.70	6.55	8.91	8.86	.00	.00	.00	.00	.00	7.37
DBAR		.27	.25	.40	.18	.38	.00	.00	.00	.00	.00	.29
VBAR		1.11	1.54	.82	1.28	.63	.00	.00	.00	.00	.00	1.07
WDTH		6.71	5.28	6.19	8.84	8.53	.00	.00	.00	.00	.00	7.11
AREA		1.81	1.30	2.45	1.57	3.20	.00	.00	.00	.00	.00	2.06
STGE		92.71	93.13	95.77	96.52	96.65	.00	.00	.00	.00	.00	94.96
DMAX		.48	.40	.62	.36	.50	.00	.00	.00	.00	.00	.47
WTOT	.40	.84	1.50	3.19	.00	4.57	.00	.00	.00	.00	.00	2.02
WMAX		.84	1.50	3.19	.00	4.57	.00	.00	.00	.00	.00	2.02
PTOT		12.51	28.47	51.53	.00	53.61	.00	.00	.00	.00	.00	29.23
PMAX		12.51	28.47	51.53	.00	53.61	.00	.00	.00	.00	.00	29.23
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
FLOW=	2.5 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		7.12	6.11	6.83	9.28	8.95	.00	.00	.00	.00	.00	7.66
DBAR		.30	.26	.43	.20	.40	.00	.00	.00	.00	.00	.32
VBAR		1.19	1.67	.91	1.36	.72	.00	.00	.00	.00	.00	1.17
WDTH		6.98	5.66	6.43	9.21	8.58	.00	.00	.00	.00	.00	7.37

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

AREA		2.10	1.50	2.73	1.84	3.47	.00	.00	.00	.00	.00	2.33
STGE		92.76	93.17	95.82	96.55	96.69	.00	.00	.00	.00	.00	95.00
DMAX		.53	.44	.67	.39	.54	.00	.00	.00	.00	.00	.51
WTOT	.40	1.90	1.59	3.79	.00	4.80	.00	.00	.00	.00	.00	2.42
WMAX		1.90	1.59	3.79	.00	4.80	.00	.00	.00	.00	.00	2.42
PTOT		27.16	28.19	58.96	.00	55.89	.00	.00	.00	.00	.00	34.04
PMAX		27.16	28.19	58.96	.00	55.89	.00	.00	.00	.00	.00	34.04
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
FLOW=	3.0 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		7.25	6.39	7.08	12.11	9.03	.00	.00	.00	.00	.00	8.37
DBAR		.33	.29	.45	.18	.43	.00	.00	.00	.00	.00	.34
VBAR		1.27	1.78	1.00	1.41	.81	.00	.00	.00	.00	.00	1.25
WDTH		7.09	5.91	6.64	12.04	8.63	.00	.00	.00	.00	.00	8.06
AREA		2.36	1.69	2.99	2.13	3.71	.00	.00	.00	.00	.00	2.58
STGE		92.79	93.20	95.86	96.58	96.71	.00	.00	.00	.00	.00	95.03
DMAX		.56	.47	.71	.42	.56	.00	.00	.00	.00	.00	.54
WTOT	.40	2.46	1.68	4.34	.28	5.19	.00	.00	.00	.00	.00	2.79
WMAX		2.46	1.68	4.34	.28	5.19	.00	.00	.00	.00	.00	2.79
PTOT		34.64	28.34	65.41	2.32	60.14	.00	.00	.00	.00	.00	38.17
PMAX		34.64	28.34	65.41	2.32	60.14	.00	.00	.00	.00	.00	38.17
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
FLOW=	3.5 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		7.38	6.60	7.33	12.54	9.10	.00	.00	.00	.00	.00	8.59
DBAR		.36	.31	.47	.19	.45	.00	.00	.00	.00	.00	.36
VBAR		1.35	1.88	1.09	1.45	.89	.00	.00	.00	.00	.00	1.33
WDTH		7.19	6.10	6.86	12.46	8.68	.00	.00	.00	.00	.00	8.26
AREA		2.60	1.86	3.23	2.42	3.93	.00	.00	.00	.00	.00	2.81
STGE		92.83	93.23	95.89	96.60	96.74	.00	.00	.00	.00	.00	95.06
DMAX		.60	.50	.74	.44	.59	.00	.00	.00	.00	.00	.57
WTOT	.40	2.96	1.75	4.73	.64	5.74	.00	.00	.00	.00	.00	3.16
WMAX		2.96	1.75	4.73	.64	5.74	.00	.00	.00	.00	.00	3.16
PTOT		41.18	28.68	68.94	5.10	66.10	.00	.00	.00	.00	.00	42.00
PMAX		41.18	28.68	68.94	5.10	66.10	.00	.00	.00	.00	.00	42.00

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 4.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		7.49	6.69	7.47	13.37	9.16	.00	.00	.00	.00	.00	8.84
DBAR		.39	.33	.49	.20	.47	.00	.00	.00	.00	.00	.38
VBAR		1.42	1.98	1.16	1.48	.97	.00	.00	.00	.00	.00	1.40
WDTH		7.29	6.16	6.97	13.28	8.71	.00	.00	.00	.00	.00	8.48
AREA		2.82	2.02	3.44	2.70	4.12	.00	.00	.00	.00	.00	3.02
STGE		92.86	93.26	95.93	96.62	96.76	.00	.00	.00	.00	.00	95.08
DMAX		.63	.53	.78	.46	.61	.00	.00	.00	.00	.00	.60
WTOT	.40	4.42	1.82	4.96	.96	7.10	.00	.00	.00	.00	.00	3.85
WMAX		4.42	1.82	4.96	.96	7.10	.00	.00	.00	.00	.00	3.85
PTOT		60.72	29.46	71.12	7.23	81.55	.00	.00	.00	.00	.00	50.02
PMAX		60.72	29.46	71.12	7.23	81.55	.00	.00	.00	.00	.00	50.02
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 5.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		7.69	6.86	7.69	13.76	9.25	.00	.00	.00	.00	.00	9.05
DBAR		.43	.37	.54	.24	.51	.00	.00	.00	.00	.00	.42
VBAR		1.55	2.15	1.30	1.55	1.12	.00	.00	.00	.00	.00	1.53
WDTH		7.45	6.28	7.13	13.66	8.75	.00	.00	.00	.00	.00	8.65
AREA		3.23	2.32	3.84	3.22	4.46	.00	.00	.00	.00	.00	3.42
STGE		92.91	93.30	95.98	96.66	96.80	.00	.00	.00	.00	.00	95.13
DMAX		.68	.57	.83	.50	.65	.00	.00	.00	.00	.00	.65
WTOT	.40	5.03	2.37	5.31	3.04	7.50	.00	.00	.00	.00	.00	4.65
WMAX		5.03	1.94	5.31	3.04	7.50	.00	.00	.00	.00	.00	4.56
PTOT		67.45	37.74	74.45	22.25	85.68	.00	.00	.00	.00	.00	57.51
PMAX		67.45	30.84	74.45	22.25	85.68	.00	.00	.00	.00	.00	56.13
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 6.0 CFS

AVG

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

XSEC		1	2	3	4	5						
WETP		7.87	7.26	9.51	14.33	9.77	.00	.00	.00	.00	.00	9.75
DBAR		.47	.39	.47	.26	.52	.00	.00	.00	.00	.00	.42
VBAR		1.67	2.31	1.42	1.62	1.26	.00	.00	.00	.00	.00	1.66
WDTH		7.60	6.63	8.89	14.22	9.22	.00	.00	.00	.00	.00	9.31
AREA		3.60	2.60	4.22	3.70	4.77	.00	.00	.00	.00	.00	3.78
STGE		92.96	93.35	96.03	96.70	96.83	.00	.00	.00	.00	.00	95.17
DMAX		.73	.62	.88	.54	.68	.00	.00	.00	.00	.00	.69
WTOT	.40	5.34	4.14	5.61	3.55	7.78	.00	.00	.00	.00	.00	5.28
WMAX		5.34	2.14	5.61	3.55	7.78	.00	.00	.00	.00	.00	4.88
PTOT		70.21	62.47	63.16	24.96	84.38	.00	.00	.00	.00	.00	61.04
PMAX		70.21	32.22	63.16	24.96	84.38	.00	.00	.00	.00	.00	54.99
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 7.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		8.00	7.76	10.47	14.47	10.23	.00	.00	.00	.00	.00	10.19
DBAR		.51	.40	.47	.29	.52	.00	.00	.00	.00	.00	.44
VBAR		1.78	2.45	1.51	1.69	1.39	.00	.00	.00	.00	.00	1.76
WDTH		7.69	7.10	9.76	14.34	9.64	.00	.00	.00	.00	.00	9.71
AREA		3.93	2.86	4.63	4.13	5.05	.00	.00	.00	.00	.00	4.12
STGE		93.01	93.38	96.07	96.73	96.86	.00	.00	.00	.00	.00	95.21
DMAX		.78	.65	.92	.57	.71	.00	.00	.00	.00	.00	.73
WTOT	.40	5.57	4.65	5.81	4.01	7.97	.00	.00	.00	.00	.00	5.60
WMAX		5.57	4.65	5.81	4.01	7.97	.00	.00	.00	.00	.00	5.60
PTOT		72.44	65.43	59.54	27.93	82.73	.00	.00	.00	.00	.00	61.62
PMAX		72.44	65.43	59.54	27.93	82.73	.00	.00	.00	.00	.00	61.62
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 8.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		8.12	8.22	11.00	14.67	10.53	.00	.00	.00	.00	.00	10.51
DBAR		.55	.41	.49	.31	.54	.00	.00	.00	.00	.00	.46
VBAR		1.89	2.57	1.59	1.76	1.50	.00	.00	.00	.00	.00	1.86
WDTH		7.76	7.53	10.22	14.54	9.89	.00	.00	.00	.00	.00	9.99
AREA		4.24	3.12	5.02	4.54	5.32	.00	.00	.00	.00	.00	4.45
STGE		93.05	93.42	96.11	96.75	96.89	.00	.00	.00	.00	.00	95.24
DMAX		.82	.69	.96	.59	.74	.00	.00	.00	.00	.00	.76

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

WTOT	.40	5.89	4.67	5.94	4.42	8.09	.00	.00	.00	.00	.00	5.80
WMAX		5.89	4.67	5.94	4.42	8.09	.00	.00	.00	.00	.00	5.80
PTOT		75.88	62.11	58.12	30.42	81.75	.00	.00	.00	.00	.00	61.66
PMAX		75.88	62.11	58.12	30.42	81.75	.00	.00	.00	.00	.00	61.66
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
FLOW=	9.0 CFS											
XSEC		1	2	3	4	5						AVG
WETP		8.22	9.21	11.49	14.87	10.82	.00	.00	.00	.00	.00	10.92
DBAR		.58	.40	.51	.33	.55	.00	.00	.00	.00	.00	.47
VBAR		1.99	2.65	1.67	1.83	1.62	.00	.00	.00	.00	.00	1.95
WDTH		7.82	8.48	10.64	14.73	10.15	.00	.00	.00	.00	.00	10.36
AREA		4.53	3.39	5.40	4.91	5.56	.00	.00	.00	.00	.00	4.76
STGE		93.08	93.45	96.15	96.78	96.92	.00	.00	.00	.00	.00	95.28
DMAX		.85	.72	1.00	.62	.77	.00	.00	.00	.00	.00	.79
WTOT	.40	6.33	4.70	6.06	5.74	8.19	.00	.00	.00	.00	.00	6.21
WMAX		6.33	4.70	6.06	5.74	8.19	.00	.00	.00	.00	.00	6.21
PTOT		80.92	55.46	56.93	39.01	80.73	.00	.00	.00	.00	.00	62.61
PMAX		80.92	55.46	56.93	39.01	80.73	.00	.00	.00	.00	.00	62.61
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
FLOW=	10.0 CFS											
XSEC		1	2	3	4	5						AVG
WETP		8.32	9.29	11.95	15.06	11.11	.00	.00	.00	.00	.00	11.15
DBAR		.61	.43	.52	.35	.56	.00	.00	.00	.00	.00	.49
VBAR		2.08	2.74	1.74	1.90	1.72	.00	.00	.00	.00	.00	2.04
WDTH		7.89	8.53	11.03	14.91	10.41	.00	.00	.00	.00	.00	10.55
AREA		4.80	3.65	5.76	5.26	5.80	.00	.00	.00	.00	.00	5.05
STGE		93.12	93.48	96.18	96.80	96.94	.00	.00	.00	.00	.00	95.30
DMAX		.89	.75	1.03	.64	.79	.00	.00	.00	.00	.00	.82
WTOT	.40	6.75	4.73	6.23	6.03	8.29	.00	.00	.00	.00	.00	6.41
WMAX		6.75	4.73	6.23	6.03	8.29	.00	.00	.00	.00	.00	6.41
PTOT		85.54	55.45	56.49	40.46	79.65	.00	.00	.00	.00	.00	63.52
PMAX		85.54	55.45	56.49	40.46	79.65	.00	.00	.00	.00	.00	63.52
WTOT	1.00	.00	.00	.66	.00	.00	.00	.00	.00	.00	.00	.13
WMAX		.00	.00	.39	.00	.00	.00	.00	.00	.00	.00	.08

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

PTOT		.00	.00	5.99	.00	.00	.00	.00	.00	.00	.00	1.20
PMAX		.00	.00	3.53	.00	.00	.00	.00	.00	.00	.00	.71
FLOW=	15.0 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		9.30	10.40	14.20	15.79	12.30	.00	.00	.00	.00	.00	12.40
DBAR		.69	.51	.57	.44	.59	.00	.00	.00	.00	.00	.56
VBAR		2.50	3.12	2.02	2.21	2.20	.00	.00	.00	.00	.00	2.41
WDTH		8.72	9.47	13.02	15.60	11.48	.00	.00	.00	.00	.00	11.66
AREA		6.01	4.80	7.43	6.80	6.83	.00	.00	.00	.00	.00	6.37
STGE		93.26	93.61	96.32	96.90	97.03	.00	.00	.00	.00	.00	95.43
DMAX		1.03	.88	1.17	.74	.88	.00	.00	.00	.00	.00	.94
WTOT	.40	7.30	5.99	6.96	8.58	8.49	.00	.00	.00	.00	.00	7.46
WMAX		7.30	5.99	6.96	8.58	8.49	.00	.00	.00	.00	.00	7.46
PTOT		83.77	63.26	53.47	54.98	73.92	.00	.00	.00	.00	.00	65.88
PMAX		83.77	63.26	53.47	54.98	73.92	.00	.00	.00	.00	.00	65.88
WTOT	1.00	.33	.00	2.57	.00	.00	.00	.00	.00	.00	.00	.58
WMAX		.33	.00	2.57	.00	.00	.00	.00	.00	.00	.00	.58
PTOT		3.84	.00	19.70	.00	.00	.00	.00	.00	.00	.00	4.71
PMAX		3.84	.00	19.70	.00	.00	.00	.00	.00	.00	.00	4.71
FLOW=	20.0 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		10.02	10.62	16.20	16.29	12.78	.00	.00	.00	.00	.00	13.18
DBAR		.76	.61	.61	.50	.65	.00	.00	.00	.00	.00	.63
VBAR		2.83	3.45	2.22	2.47	2.60	.00	.00	.00	.00	.00	2.71
WDTH		9.33	9.51	14.82	16.08	11.88	.00	.00	.00	.00	.00	12.32
AREA		7.08	5.80	9.01	8.08	7.70	.00	.00	.00	.00	.00	7.53
STGE		93.38	93.72	96.43	96.99	97.11	.00	.00	.00	.00	.00	95.52
DMAX		1.15	.99	1.28	.83	.96	.00	.00	.00	.00	.00	1.04
WTOT	.40	7.65	6.31	8.94	12.16	8.62	.00	.00	.00	.00	.00	8.74
WMAX		7.65	6.31	7.32	12.16	8.62	.00	.00	.00	.00	.00	8.41
PTOT		81.96	66.33	60.31	75.66	72.55	.00	.00	.00	.00	.00	71.36
PMAX		81.96	66.33	49.43	75.66	72.55	.00	.00	.00	.00	.00	69.19
WTOT	1.00	2.28	.00	3.99	.00	.00	.00	.00	.00	.00	.00	1.25
WMAX		2.28	.00	3.99	.00	.00	.00	.00	.00	.00	.00	1.25
PTOT		24.39	.00	26.90	.00	.00	.00	.00	.00	.00	.00	10.26
PMAX		24.39	.00	26.90	.00	.00	.00	.00	.00	.00	.00	10.26
FLOW=	25.0 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		10.59	10.80	16.39	16.61	12.98	.00	.00	.00	.00	.00	13.47
DBAR		.82	.70	.70	.56	.70	.00	.00	.00	.00	.00	.70

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

VBAR		3.11	3.76	2.41	2.72	2.96	.00	.00	.00	.00	.00	2.99
WDTH		9.80	9.54	14.84	16.37	12.02	.00	.00	.00	.00	.00	12.51
AREA		8.04	6.66	10.39	9.20	8.43	.00	.00	.00	.00	.00	8.54
STGE		93.48	93.81	96.53	97.05	97.17	.00	.00	.00	.00	.00	95.61
DMAX		1.25	1.08	1.38	.89	1.02	.00	.00	.00	.00	.00	1.12
WTOT	.40	7.82	7.37	10.37	13.47	8.72	.00	.00	.00	.00	.00	9.55
WMAX		7.82	7.37	7.80	13.47	8.72	.00	.00	.00	.00	.00	9.04
PTOT		79.85	77.28	69.83	82.29	72.54	.00	.00	.00	.00	.00	76.36
PMAX		79.85	77.28	52.53	82.29	72.54	.00	.00	.00	.00	.00	72.90
WTOT	1.00	4.77	1.69	4.96	.00	1.49	.00	.00	.00	.00	.00	2.58
WMAX		4.77	1.69	4.96	.00	1.32	.00	.00	.00	.00	.00	2.55
PTOT		48.70	17.75	33.40	.00	12.40	.00	.00	.00	.00	.00	22.45
PMAX		48.70	17.75	33.40	.00	10.94	.00	.00	.00	.00	.00	22.16

FLOW= 30.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		10.84	11.60	16.55	16.87	13.15	.00	.00	.00	.00	.00	13.80
DBAR		.90	.73	.78	.61	.75	.00	.00	.00	.00	.00	.75
VBAR		3.36	4.03	2.59	2.94	3.31	.00	.00	.00	.00	.00	3.25
WDTH		9.93	10.20	14.86	16.59	12.13	.00	.00	.00	.00	.00	12.74
AREA		8.92	7.44	11.58	10.19	9.07	.00	.00	.00	.00	.00	9.44
STGE		93.57	93.89	96.61	97.11	97.22	.00	.00	.00	.00	.00	95.68
DMAX		1.34	1.16	1.46	.95	1.07	.00	.00	.00	.00	.00	1.20
WTOT	.40	8.13	8.53	11.34	14.29	9.04	.00	.00	.00	.00	.00	10.27
WMAX		8.13	8.53	8.21	14.29	8.77	.00	.00	.00	.00	.00	9.59
PTOT		81.87	83.66	76.28	86.13	74.50	.00	.00	.00	.00	.00	80.49
PMAX		81.87	83.66	55.25	86.13	72.29	.00	.00	.00	.00	.00	75.84
WTOT	1.00	5.39	2.02	5.46	.00	3.28	.00	.00	.00	.00	.00	3.23
WMAX		5.39	1.89	5.46	.00	2.27	.00	.00	.00	.00	.00	3.00
PTOT		54.27	19.82	36.74	.00	27.08	.00	.00	.00	.00	.00	27.58
PMAX		54.27	18.56	36.74	.00	18.72	.00	.00	.00	.00	.00	25.66

FLOW= 40.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		11.51	12.94	17.23	17.29	13.44	.00	.00	.00	.00	.00	14.48
DBAR		1.00	.79	.89	.70	.83	.00	.00	.00	.00	.00	.84
VBAR		3.82	4.48	2.93	3.35	3.93	.00	.00	.00	.00	.00	3.70
WDTH		10.45	11.35	15.39	16.96	12.32	.00	.00	.00	.00	.00	13.29
AREA		10.47	8.94	13.65	11.93	10.17	.00	.00	.00	.00	.00	11.03
STGE		93.73	94.02	96.74	97.22	97.31	.00	.00	.00	.00	.00	95.80
DMAX		1.50	1.29	1.59	1.06	1.16	.00	.00	.00	.00	.00	1.32
WTOT	.40	9.07	9.47	13.45	15.01	10.09	.00	.00	.00	.00	.00	11.42
WMAX		9.07	9.47	8.95	15.01	8.90	.00	.00	.00	.00	.00	10.28

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

PTOT		86.79	83.43	87.40	88.51	81.89	.00	.00	.00	.00	.00	85.60
PMAX		86.79	33.43	58.17	88.51	72.23	.00	.00	.00	.00	.00	77.83
WTOT	1.00	6.84	4.68	6.04	.88	5.12	.00	.00	.00	.00	.00	4.71
WMAX		6.84	4.68	6.04	.88	5.12	.00	.00	.00	.00	.00	4.71
PTOT		65.49	41.22	39.25	5.17	41.55	.00	.00	.00	.00	.00	38.54
PMAX		65.49	41.22	39.25	5.17	41.55	.00	.00	.00	.00	.00	38.54
FLOW=	50.0 CFS											
XSEC		1	2	3	4	5						AVG
WETP		13.02	13.27	17.72	17.64	13.80	.00	.00	.00	.00	.00	15.09
DBAR		1.00	.89	.98	.78	.88	.00	.00	.00	.00	.00	.91
VBAR		4.20	4.86	3.24	3.72	4.51	.00	.00	.00	.00	.00	4.11
WDTH		11.86	11.54	15.76	17.26	12.61	.00	.00	.00	.00	.00	13.81
AREA		11.90	10.29	15.45	13.44	11.09	.00	.00	.00	.00	.00	12.43
STGE		93.86	94.14	96.86	97.31	97.38	.00	.00	.00	.00	.00	95.91
DMAX		1.63	1.41	1.71	1.15	1.23	.00	.00	.00	.00	.00	1.43
WTOT	.40	9.68	9.52	14.83	15.61	10.94	.00	.00	.00	.00	.00	12.11
WMAX		9.68	9.52	14.83	15.61	9.08	.00	.00	.00	.00	.00	11.74
PTOT		81.58	82.49	94.08	90.46	86.73	.00	.00	.00	.00	.00	87.07
PMAX		81.58	82.49	94.08	90.46	72.01	.00	.00	.00	.00	.00	84.12
WTOT	1.00	7.28	5.40	6.64	3.70	7.34	.00	.00	.00	.00	.00	6.07
WMAX		7.28	5.40	6.64	3.70	7.34	.00	.00	.00	.00	.00	6.07
PTOT		61.37	46.82	42.12	21.42	58.23	.00	.00	.00	.00	.00	45.99
PMAX		61.37	46.82	42.12	21.42	58.23	.00	.00	.00	.00	.00	45.99
FLOW=	60.0 CFS											
XSEC		1	2	3	4	5						AVG
WETP		14.72	13.51	18.15	18.22	14.34	.00	.00	.00	.00	.00	15.79
DBAR		.99	.99	1.06	.83	.91	.00	.00	.00	.00	.00	.96
VBAR		4.48	5.22	3.52	4.06	5.03	.00	.00	.00	.00	.00	4.46
WDTH		13.48	11.65	16.08	17.81	13.10	.00	.00	.00	.00	.00	14.42
AREA		13.41	11.50	17.04	14.79	11.92	.00	.00	.00	.00	.00	13.73
STGE		93.97	94.25	96.96	97.38	97.45	.00	.00	.00	.00	.00	96.00
DMAX		1.74	1.52	1.81	1.22	1.30	.00	.00	.00	.00	.00	1.52
WTOT	.40	9.93	9.75	14.85	16.07	11.67	.00	.00	.00	.00	.00	12.45
WMAX		9.93	9.56	14.85	16.07	9.24	.00	.00	.00	.00	.00	11.93
PTOT		73.64	83.69	92.35	90.22	89.14	.00	.00	.00	.00	.00	85.81
PMAX		73.64	82.04	92.35	90.22	70.55	.00	.00	.00	.00	.00	81.76
WTOT	1.00	7.63	6.14	7.06	5.79	7.90	.00	.00	.00	.00	.00	6.91
WMAX		7.63	6.14	7.06	5.79	7.90	.00	.00	.00	.00	.00	6.91
PTOT		56.58	52.71	43.93	32.49	60.37	.00	.00	.00	.00	.00	49.22
PMAX		56.58	52.71	43.93	32.49	60.37	.00	.00	.00	.00	.00	49.22

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W
COMPUTED VALUES

FLOW= 1.5 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	6.28	8.20	8.75	.00	.00	.00	.00	.00	7.74
DBAR		.00	.00	.36	.16	.34	.00	.00	.00	.00	.00	.28
VBAR		.00	.00	.71	1.19	.52	.00	.00	.00	.00	.00	.81
WDTH		.00	.00	5.97	8.14	8.46	.00	.00	.00	.00	.00	7.52
AREA		.00	.00	2.12	1.26	2.87	.00	.00	.00	.00	.00	2.08
STGE		.00	.00	95.72	96.49	96.61	.00	.00	.00	.00	.00	96.27
DMAX		.00	.00	.57	.33	.46	.00	.00	.00	.00	.00	.45
WTOT	.40	.00	.00	2.55	.00	3.01	.00	.00	.00	.00	.00	1.85
WMAX		.00	.00	2.55	.00	2.16	.00	.00	.00	.00	.00	1.57
PTOT		.00	.00	42.66	.00	35.64	.00	.00	.00	.00	.00	26.10
PMAX		.00	.00	42.66	.00	25.51	.00	.00	.00	.00	.00	22.72
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 2.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	6.55	8.91	8.86	.00	.00	.00	.00	.00	8.11
DBAR		.00	.00	.40	.18	.38	.00	.00	.00	.00	.00	.32
VBAR		.00	.00	.82	1.28	.63	.00	.00	.00	.00	.00	.91
WDTH		.00	.00	6.19	8.84	8.53	.00	.00	.00	.00	.00	7.85
AREA		.00	.00	2.45	1.57	3.20	.00	.00	.00	.00	.00	2.40
STGE		.00	.00	95.77	96.52	96.65	.00	.00	.00	.00	.00	96.32
DMAX		.00	.00	.62	.36	.50	.00	.00	.00	.00	.00	.50
WTOT	.40	.00	.00	3.19	.00	4.57	.00	.00	.00	.00	.00	2.59
WMAX		.00	.00	3.19	.00	4.57	.00	.00	.00	.00	.00	2.59
PTOT		.00	.00	51.53	.00	53.61	.00	.00	.00	.00	.00	35.05
PMAX		.00	.00	51.53	.00	53.61	.00	.00	.00	.00	.00	35.05
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 2.5 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	6.83	9.28	8.95	.00	.00	.00	.00	.00	8.35
DBAR		.00	.00	.43	.20	.40	.00	.00	.00	.00	.00	.34
VBAR		.00	.00	.91	1.36	.72	.00	.00	.00	.00	.00	1.00
WDTH		.00	.00	6.43	9.21	8.58	.00	.00	.00	.00	.00	8.07

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

AREA		.00	.00	2.73	1.84	3.47	.00	.00	.00	.00	.00	2.68
STGE		.00	.00	95.82	96.55	96.69	.00	.00	.00	.00	.00	96.35
DMAX		.00	.00	.67	.39	.54	.00	.00	.00	.00	.00	.53
WTOT	.40	.00	.00	3.79	.00	4.80	.00	.00	.00	.00	.00	2.86
WMAX		.00	.00	3.79	.00	4.80	.00	.00	.00	.00	.00	2.86
PTOT		.00	.00	58.96	.00	55.89	.00	.00	.00	.00	.00	38.28
PMAX		.00	.00	58.96	.00	55.89	.00	.00	.00	.00	.00	38.28
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 3.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	7.08	12.11	9.03	.00	.00	.00	.00	.00	9.41
DBAR		.00	.00	.45	.18	.43	.00	.00	.00	.00	.00	.35
VBAR		.00	.00	1.00	1.41	.81	.00	.00	.00	.00	.00	1.07
WDTH		.00	.00	6.64	12.04	8.63	.00	.00	.00	.00	.00	9.10
AREA		.00	.00	2.99	2.13	3.71	.00	.00	.00	.00	.00	2.94
STGE		.00	.00	95.86	96.58	96.71	.00	.00	.00	.00	.00	96.38
DMAX		.00	.00	.71	.42	.56	.00	.00	.00	.00	.00	.56
WTOT	.40	.00	.00	4.34	.28	5.19	.00	.00	.00	.00	.00	3.27
WMAX		.00	.00	4.34	.28	5.19	.00	.00	.00	.00	.00	3.27
PTOT		.00	.00	65.41	2.32	60.14	.00	.00	.00	.00	.00	42.62
PMAX		.00	.00	65.41	2.32	60.14	.00	.00	.00	.00	.00	42.62
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 3.5 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	7.33	12.54	9.10	.00	.00	.00	.00	.00	9.66
DBAR		.00	.00	.47	.19	.45	.00	.00	.00	.00	.00	.37
VBAR		.00	.00	1.09	1.45	.89	.00	.00	.00	.00	.00	1.14
WDTH		.00	.00	6.86	12.46	8.68	.00	.00	.00	.00	.00	9.33
AREA		.00	.00	3.23	2.42	3.93	.00	.00	.00	.00	.00	3.19
STGE		.00	.00	95.89	96.60	96.74	.00	.00	.00	.00	.00	96.41
DMAX		.00	.00	.74	.44	.59	.00	.00	.00	.00	.00	.59
WTOT	.40	.00	.00	4.73	.64	5.74	.00	.00	.00	.00	.00	3.70
WMAX		.00	.00	4.73	.64	5.74	.00	.00	.00	.00	.00	3.70
PTOT		.00	.00	68.94	5.10	66.10	.00	.00	.00	.00	.00	46.71
PMAX		.00	.00	68.94	5.10	66.10	.00	.00	.00	.00	.00	46.71

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 4.0 CFS

												AVG
XSEC		1	2	3	4	5						
WETP		.00	.00	7.47	13.37	9.16	.00	.00	.00	.00	.00	10.00
DBAR		.00	.00	.49	.20	.47	.00	.00	.00	.00	.00	.39
VBAR		.00	.00	1.16	1.48	.97	.00	.00	.00	.00	.00	1.20
WDTH		.00	.00	6.97	13.28	8.71	.00	.00	.00	.00	.00	9.66
AREA		.00	.00	3.44	2.70	4.12	.00	.00	.00	.00	.00	3.42
STGE		.00	.00	95.93	96.62	96.76	.00	.00	.00	.00	.00	96.44
DMAX		.00	.00	.78	.46	.61	.00	.00	.00	.00	.00	.62
WTOT	.40	.00	.00	4.96	.96	7.10	.00	.00	.00	.00	.00	4.34
WMAX		.00	.00	4.96	.96	7.10	.00	.00	.00	.00	.00	4.34
PTOT		.00	.00	71.12	7.23	81.55	.00	.00	.00	.00	.00	53.30
PMAX		.00	.00	71.12	7.23	81.55	.00	.00	.00	.00	.00	53.30
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 5.0 CFS

												AVG
XSEC		1	2	3	4	5						
WETP		.00	.00	7.69	13.76	9.25	.00	.00	.00	.00	.00	10.23
DBAR		.00	.00	.54	.24	.51	.00	.00	.00	.00	.00	.43
VBAR		.00	.00	1.30	1.55	1.12	.00	.00	.00	.00	.00	1.32
WDTH		.00	.00	7.13	13.66	8.75	.00	.00	.00	.00	.00	9.85
AREA		.00	.00	3.84	3.22	4.46	.00	.00	.00	.00	.00	3.84
STGE		.00	.00	95.98	96.66	96.80	.00	.00	.00	.00	.00	96.48
DMAX		.00	.00	.83	.50	.65	.00	.00	.00	.00	.00	.66
WTOT	.40	.00	.00	5.31	3.04	7.50	.00	.00	.00	.00	.00	5.28
WMAX		.00	.00	5.31	3.04	7.50	.00	.00	.00	.00	.00	5.28
PTOT		.00	.00	74.45	22.25	85.68	.00	.00	.00	.00	.00	60.79
PMAX		.00	.00	74.45	22.25	85.68	.00	.00	.00	.00	.00	60.79
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 6.0 CFS

AVG

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

XSEC		1	2	3	4	5						
WETP		.00	.00	9.51	14.33	9.77	.00	.00	.00	.00	.00	11.20
DBAR		.00	.00	.47	.26	.52	.00	.00	.00	.00	.00	.42
VBAR		.00	.00	1.42	1.62	1.26	.00	.00	.00	.00	.00	1.43
WDTH		.00	.00	8.89	14.22	9.22	.00	.00	.00	.00	.00	10.77
AREA		.00	.00	4.22	3.70	4.77	.00	.00	.00	.00	.00	4.23
STGE		.00	.00	96.03	96.70	96.83	.00	.00	.00	.00	.00	96.52
DMAX		.00	.00	.88	.54	.68	.00	.00	.00	.00	.00	.70
WTOT	.40	.00	.00	5.61	3.55	7.78	.00	.00	.00	.00	.00	5.65
WMAX		.00	.00	5.61	3.55	7.78	.00	.00	.00	.00	.00	5.65
PTOT		.00	.00	63.16	24.96	84.38	.00	.00	.00	.00	.00	57.50
PMAX		.00	.00	63.16	24.96	84.38	.00	.00	.00	.00	.00	57.50
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 7.0 CFS

												AVG
XSEC		1	2	3	4	5						
WETP		.00	.00	10.47	14.47	10.23	.00	.00	.00	.00	.00	11.72
DBAR		.00	.00	.47	.29	.52	.00	.00	.00	.00	.00	.43
VBAR		.00	.00	1.51	1.69	1.39	.00	.00	.00	.00	.00	1.53
WDTH		.00	.00	9.76	14.34	9.64	.00	.00	.00	.00	.00	11.25
AREA		.00	.00	4.63	4.13	5.05	.00	.00	.00	.00	.00	4.60
STGE		.00	.00	96.07	96.73	96.86	.00	.00	.00	.00	.00	96.55
DMAX		.00	.00	.92	.57	.71	.00	.00	.00	.00	.00	.73
WTOT	.40	.00	.00	5.81	4.01	7.97	.00	.00	.00	.00	.00	5.93
WMAX		.00	.00	5.81	4.01	7.97	.00	.00	.00	.00	.00	5.93
PTOT		.00	.00	59.54	27.93	82.73	.00	.00	.00	.00	.00	56.73
PMAX		.00	.00	59.54	27.93	82.73	.00	.00	.00	.00	.00	56.73
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 8.0 CFS

												AVG
XSEC		1	2	3	4	5						
WETP		.00	.00	11.00	14.67	10.53	.00	.00	.00	.00	.00	12.07
DBAR		.00	.00	.49	.31	.54	.00	.00	.00	.00	.00	.45
VBAR		.00	.00	1.59	1.76	1.50	.00	.00	.00	.00	.00	1.62
WDTH		.00	.00	10.22	14.54	9.89	.00	.00	.00	.00	.00	11.55
AREA		.00	.00	5.02	4.54	5.32	.00	.00	.00	.00	.00	4.96
STGE		.00	.00	96.11	96.75	96.89	.00	.00	.00	.00	.00	96.59
DMAX		.00	.00	.96	.59	.74	.00	.00	.00	.00	.00	.77

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

WTOT	.40	.00	.00	5.94	4.42	8.09	.00	.00	.00	.00	.00	6.15
WMAX		.00	.00	5.94	4.42	8.09	.00	.00	.00	.00	.00	6.15
PTOT		.00	.00	58.12	30.42	81.75	.00	.00	.00	.00	.00	56.77
PMAX		.00	.00	58.12	30.42	81.75	.00	.00	.00	.00	.00	56.77
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 9.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	11.49	14.87	10.82	.00	.00	.00	.00	.00	12.39
DBAR		.00	.00	.51	.33	.55	.00	.00	.00	.00	.00	.46
VBAR		.00	.00	1.67	1.83	1.62	.00	.00	.00	.00	.00	1.71
WDTH		.00	.00	10.64	14.73	10.15	.00	.00	.00	.00	.00	11.84
AREA		.00	.00	5.40	4.91	5.56	.00	.00	.00	.00	.00	5.29
STGE		.00	.00	96.15	96.78	96.92	.00	.00	.00	.00	.00	96.61
DMAX		.00	.00	1.00	.62	.77	.00	.00	.00	.00	.00	.79
WTOT	.40	.00	.00	6.06	5.74	8.19	.00	.00	.00	.00	.00	6.67
WMAX		.00	.00	6.06	5.74	8.19	.00	.00	.00	.00	.00	6.67
PTOT		.00	.00	56.93	39.01	80.73	.00	.00	.00	.00	.00	58.89
PMAX		.00	.00	56.93	39.01	80.73	.00	.00	.00	.00	.00	58.89
WTOT	1.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PTOT		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PMAX		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

FLOW= 10.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	11.95	15.06	11.11	.00	.00	.00	.00	.00	12.70
DBAR		.00	.00	.52	.35	.56	.00	.00	.00	.00	.00	.48
VBAR		.00	.00	1.74	1.90	1.72	.00	.00	.00	.00	.00	1.79
WDTH		.00	.00	11.03	14.91	10.41	.00	.00	.00	.00	.00	12.12
AREA		.00	.00	5.76	5.26	5.80	.00	.00	.00	.00	.00	5.61
STGE		.00	.00	96.18	96.80	96.94	.00	.00	.00	.00	.00	96.64
DMAX		.00	.00	1.03	.64	.79	.00	.00	.00	.00	.00	.82
WTOT	.40	.00	.00	6.23	6.03	8.29	.00	.00	.00	.00	.00	6.85
WMAX		.00	.00	6.23	6.03	8.29	.00	.00	.00	.00	.00	6.85
PTOT		.00	.00	56.49	40.46	79.65	.00	.00	.00	.00	.00	58.87
PMAX		.00	.00	56.49	40.46	79.65	.00	.00	.00	.00	.00	58.87
WTOT	1.00	.00	.00	.66	.00	.00	.00	.00	.00	.00	.00	.22
WMAX		.00	.00	.39	.00	.00	.00	.00	.00	.00	.00	.13

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

PTOT		.00	.00	5.99	.00	.00	.00	.00	.00	.00	.00	2.00
PMAX		.00	.00	3.53	.00	.00	.00	.00	.00	.00	.00	1.18

FLOW= 15.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	14.20	15.79	12.30	.00	.00	.00	.00	.00	14.10
DBAR		.00	.00	.57	.44	.59	.00	.00	.00	.00	.00	.53
VBAR		.00	.00	2.02	2.21	2.20	.00	.00	.00	.00	.00	2.14
WDTH		.00	.00	13.02	15.60	11.48	.00	.00	.00	.00	.00	13.37
AREA		.00	.00	7.43	6.80	6.83	.00	.00	.00	.00	.00	7.02
STGE		.00	.00	96.32	96.90	97.03	.00	.00	.00	.00	.00	96.75
DMAX		.00	.00	1.17	.74	.88	.00	.00	.00	.00	.00	.93
WTOT	.40	.00	.00	6.96	8.58	8.49	.00	.00	.00	.00	.00	8.01
WMAX		.00	.00	6.96	8.58	8.49	.00	.00	.00	.00	.00	8.01
PTOT		.00	.00	53.47	54.98	73.92	.00	.00	.00	.00	.00	60.79
PMAX		.00	.00	53.47	54.98	73.92	.00	.00	.00	.00	.00	60.79
WTOT	1.00	.00	.00	2.57	.00	.00	.00	.00	.00	.00	.00	.86
WMAX		.00	.00	2.57	.00	.00	.00	.00	.00	.00	.00	.86
PTOT		.00	.00	19.70	.00	.00	.00	.00	.00	.00	.00	6.57
PMAX		.00	.00	19.70	.00	.00	.00	.00	.00	.00	.00	6.57

FLOW= 20.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	16.20	16.29	12.78	.00	.00	.00	.00	.00	15.09
DBAR		.00	.00	.61	.50	.65	.00	.00	.00	.00	.00	.59
VBAR		.00	.00	2.22	2.47	2.60	.00	.00	.00	.00	.00	2.43
WDTH		.00	.00	14.82	16.08	11.88	.00	.00	.00	.00	.00	14.26
AREA		.00	.00	9.01	8.08	7.70	.00	.00	.00	.00	.00	8.26
STGE		.00	.00	96.43	96.99	97.11	.00	.00	.00	.00	.00	96.84
DMAX		.00	.00	1.28	.83	.96	.00	.00	.00	.00	.00	1.02
WTOT	.40	.00	.00	8.94	12.16	8.62	.00	.00	.00	.00	.00	9.91
WMAX		.00	.00	7.32	12.16	8.62	.00	.00	.00	.00	.00	9.37
PTOT		.00	.00	60.31	75.66	72.55	.00	.00	.00	.00	.00	69.51
PMAX		.00	.00	49.43	75.66	72.55	.00	.00	.00	.00	.00	65.88
WTOT	1.00	.00	.00	3.99	.00	.00	.00	.00	.00	.00	.00	1.33
WMAX		.00	.00	3.99	.00	.00	.00	.00	.00	.00	.00	1.33
PTOT		.00	.00	26.90	.00	.00	.00	.00	.00	.00	.00	8.97
PMAX		.00	.00	26.90	.00	.00	.00	.00	.00	.00	.00	8.97

FLOW= 25.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	16.39	16.61	12.98	.00	.00	.00	.00	.00	15.33
DBAR		.00	.00	.70	.56	.70	.00	.00	.00	.00	.00	.65

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

VBAR		.00	.00	2.41	2.72	2.96	.00	.00	.00	.00	.00	2.70
WDTH		.00	.00	14.84	16.37	12.02	.00	.00	.00	.00	.00	14.41
AREA		.00	.00	10.39	9.20	8.43	.00	.00	.00	.00	.00	9.34
STGE		.00	.00	96.53	97.05	97.17	.00	.00	.00	.00	.00	96.92
DMAX		.00	.00	1.38	.89	1.02	.00	.00	.00	.00	.00	1.10
WTOT	.40	.00	.00	10.37	13.47	8.72	.00	.00	.00	.00	.00	10.85
WMAX		.00	.00	7.80	13.47	8.72	.00	.00	.00	.00	.00	9.99
PTOT		.00	.00	69.83	82.29	72.54	.00	.00	.00	.00	.00	74.89
PMAX		.00	.00	52.53	82.29	72.54	.00	.00	.00	.00	.00	69.12
WTOT	1.00	.00	.00	4.96	.00	1.49	.00	.00	.00	.00	.00	2.15
WMAX		.00	.00	4.96	.00	1.32	.00	.00	.00	.00	.00	2.09
PTOT		.00	.00	33.40	.00	12.40	.00	.00	.00	.00	.00	15.27
PMAX		.00	.00	33.40	.00	10.94	.00	.00	.00	.00	.00	14.78

FLOW= 30.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	16.55	16.87	13.15	.00	.00	.00	.00	.00	15.52
DBAR		.00	.00	.78	.61	.75	.00	.00	.00	.00	.00	.71
VBAR		.00	.00	2.59	2.94	3.31	.00	.00	.00	.00	.00	2.95
WDTH		.00	.00	14.86	16.59	12.13	.00	.00	.00	.00	.00	14.53
AREA		.00	.00	11.58	10.19	9.07	.00	.00	.00	.00	.00	10.28
STGE		.00	.00	96.61	97.11	97.22	.00	.00	.00	.00	.00	96.98
DMAX		.00	.00	1.46	.95	1.07	.00	.00	.00	.00	.00	1.16
WTOT	.40	.00	.00	11.34	14.29	9.04	.00	.00	.00	.00	.00	11.55
WMAX		.00	.00	8.21	14.29	8.77	.00	.00	.00	.00	.00	10.42
PTOT		.00	.00	76.28	86.13	74.50	.00	.00	.00	.00	.00	78.97
PMAX		.00	.00	55.25	86.13	72.29	.00	.00	.00	.00	.00	71.22
WTOT	1.00	.00	.00	5.46	.00	3.28	.00	.00	.00	.00	.00	2.92
WMAX		.00	.00	5.46	.00	2.27	.00	.00	.00	.00	.00	2.58
PTOT		.00	.00	36.74	.00	27.08	.00	.00	.00	.00	.00	21.27
PMAX		.00	.00	36.74	.00	18.72	.00	.00	.00	.00	.00	18.49

FLOW= 40.0 CFS

XSEC		1	2	3	4	5						AVG
WETP		.00	.00	17.23	17.29	13.44	.00	.00	.00	.00	.00	15.98
DBAR		.00	.00	.89	.70	.83	.00	.00	.00	.00	.00	.81
VBAR		.00	.00	2.93	3.35	3.93	.00	.00	.00	.00	.00	3.41
WDTH		.00	.00	15.39	16.96	12.32	.00	.00	.00	.00	.00	14.89
AREA		.00	.00	13.65	11.93	10.17	.00	.00	.00	.00	.00	11.92
STGE		.00	.00	96.74	97.22	97.31	.00	.00	.00	.00	.00	97.09
DMAX		.00	.00	1.59	1.06	1.16	.00	.00	.00	.00	.00	1.27
WTOT	.40	.00	.00	13.45	15.01	10.09	.00	.00	.00	.00	.00	12.85
WMAX		.00	.00	8.95	15.01	8.90	.00	.00	.00	.00	.00	10.96

Bear Creek - Big Hole Drainage - SW, SE, SEC 34, T2N, R12W

PTOT		.00	.00	87.40	88.51	81.89	.00	.00	.00	.00	.00	85.93
PMAX		.00	.00	58.17	88.51	72.23	.00	.00	.00	.00	.00	72.97
WTOT	1.00	.00	.00	6.04	.88	5.12	.00	.00	.00	.00	.00	4.01
WMAX		.00	.00	6.04	.88	5.12	.00	.00	.00	.00	.00	4.01
PTOT		.00	.00	39.25	5.17	41.55	.00	.00	.00	.00	.00	28.66
PMAX		.00	.00	39.25	5.17	41.55	.00	.00	.00	.00	.00	28.66
FLOW=	50.0 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		.00	.00	17.72	17.64	13.80	.00	.00	.00	.00	.00	16.39
DBAR		.00	.00	.98	.78	.88	.00	.00	.00	.00	.00	.88
VBAR		.00	.00	3.24	3.72	4.51	.00	.00	.00	.00	.00	3.82
WDTH		.00	.00	15.76	17.26	12.61	.00	.00	.00	.00	.00	15.21
AREA		.00	.00	15.45	13.44	11.09	.00	.00	.00	.00	.00	13.33
STGE		.00	.00	96.86	97.31	97.38	.00	.00	.00	.00	.00	97.18
DMAX		.00	.00	1.71	1.15	1.23	.00	.00	.00	.00	.00	1.36
WTOT	.40	.00	.00	14.83	15.61	10.94	.00	.00	.00	.00	.00	13.79
WMAX		.00	.00	14.83	15.61	9.08	.00	.00	.00	.00	.00	13.17
PTOT		.00	.00	94.08	90.46	86.73	.00	.00	.00	.00	.00	90.42
PMAX		.00	.00	94.08	90.46	72.01	.00	.00	.00	.00	.00	85.52
WTOT	1.00	.00	.00	6.64	3.70	7.34	.00	.00	.00	.00	.00	5.89
WMAX		.00	.00	6.64	3.70	7.34	.00	.00	.00	.00	.00	5.89
PTOT		.00	.00	42.12	21.42	58.23	.00	.00	.00	.00	.00	40.59
PMAX		.00	.00	42.12	21.42	58.23	.00	.00	.00	.00	.00	40.59
FLOW=	60.0 CFS											
												AVG
XSEC		1	2	3	4	5						
WETP		.00	.00	18.15	18.22	14.34	.00	.00	.00	.00	.00	16.90
DBAR		.00	.00	1.06	.83	.91	.00	.00	.00	.00	.00	.93
VBAR		.00	.00	3.52	4.06	5.03	.00	.00	.00	.00	.00	4.20
WDTH		.00	.00	16.08	17.81	13.10	.00	.00	.00	.00	.00	15.66
AREA		.00	.00	17.04	14.79	11.92	.00	.00	.00	.00	.00	14.58
STGE		.00	.00	96.96	97.38	97.45	.00	.00	.00	.00	.00	97.26
DMAX		.00	.00	1.81	1.22	1.30	.00	.00	.00	.00	.00	1.44
WTOT	.40	.00	.00	14.85	16.07	11.67	.00	.00	.00	.00	.00	14.20
WMAX		.00	.00	14.85	16.07	9.24	.00	.00	.00	.00	.00	13.39
PTOT		.00	.00	92.35	90.22	89.14	.00	.00	.00	.00	.00	90.57
PMAX		.00	.00	92.35	90.22	70.55	.00	.00	.00	.00	.00	84.37
WTOT	1.00	.00	.00	7.06	5.79	7.90	.00	.00	.00	.00	.00	6.92
WMAX		.00	.00	7.06	5.79	7.90	.00	.00	.00	.00	.00	6.92
PTOT		.00	.00	43.93	32.49	60.37	.00	.00	.00	.00	.00	45.60
PMAX		.00	.00	43.93	32.49	60.37	.00	.00	.00	.00	.00	45.60