ProjectID: 31023

Stream Gaging Installation and Operations in the Lewis, Salmon/Washougal, and Gray/Elochoman Subbasins
Province: Lower Columbia
Sponsor: Ecology

RESPONSE TO ISRP'S QUESTIONS

Following are our specific responses to the additional questions raised by the ISRP relevant to this project:

Question 1: However, more information should be provided as to how the critical reaches/tributaries will be chosen, the marginal addition in monitoring they will provide, and why the combination of 8 continuous/6 staff gages was chosen. How will the eight flow gages and six staff gages be distributed among the subbasins? How will the sites be chosen? Is there a priority plan already in place? Are the monitoring sites selected based on existing fish use or potential fish use? Do other gages in place also provide continuous data?

Response: We have completed preliminary hydrologic assessments for the Lewis, Salmon/Washougal, and Gray/Elochoman Subbasins (Attachment 1 below). Attachment 2 (below) is a series of watershed maps depicting potential stream gauging sites in each of the proposed watersheds based on the sitting criteria also listed below. Our experience in other watersheds of similar extent and complexity around the state leads us to believe that eight continuous stream gauges and six staff gauges in each watershed is a reasonable starting point to gather baseline data at a scale that will be useful and relevant to water managers. A network of this size will generally support IFIM in-stream flow processes, as well as TMDL studies. However, as an adaptive management principle, if this number proves larger or smaller than optimal, we will either look for resources to add more gauges, or if fewer gauges are needed, we will propose to move any excess gauges to other priority watersheds.

If this project is funded, a first step will be to contact local agency representatives and landowners, and complete site reconnaissance trips through each watershed. Many of our preliminary proposed sites were previously occupied by USGS gauging stations that have since been abandoned or dropped. These sites offer some historic data against which current data could be compared. Sites that were historically gauged also offer a reasonable likelihood that the site is still measurable and accessible. We note, also, that this project is important in part because current stream flow data are lacking from these basins. This project would help fill that important data gap.

The general relationship between in-stream flows and salmon recovery was recently evaluated by the Washington Independent Science Panel (see Attachment 3 below). This project will provide direct measurement and near real-time reporting of actual in-stream flows.

In general, potential stream gauging sites will be prioritized according to the following criteria:

- Does the proposed site measure stream flow from a stream reach, tributary, or sub-basin segment that is important to existing or potential salmonid stocks, is already identified as a monitoring or reference site in an in-stream flow study or rule, or which has other hydrologic or management significance?
- Does the site support other important watershed management, protection, or restoration actions (e.g. water-right purchases, Total Maximum Daily Load studies, IFIM studies, etc.)?
- Where is the site in relationship to other current stream gauging sites (i.e. – we do not intend to duplicate any existing stream gauging efforts by other agencies or management interests).
- Has the site ever been gauged previously? Sites having historic data provide opportunity to compare current data against an historical baseline.
- Does the site provide a stable, measurable stream cross-section?
- Is the site accessible?
- Can entry permission be gained from the landowner?
- Are all worker safety concerns manageable at the site?

Question 2: What is the relevance of the 6 cross-channel measurements to be taken annually?

Response: Stream gauges measure water depth relative to a reference point. That depth is related to stream flow by measuring the fully-integrated, cross-channel flow across a range of stage heights. The 6 cross-channel measurements are used to measure a wide range of flows at each site to improve the accuracy of the regression equation derived for the relationship between stage height and total flow.

From Attachment 4 (below):

> "<u>Calculating Stream Discharge</u>
> A rating curve is developed that relates river stage height to instantaneous flow. Four to six times a year we take instantaneous flow measurements and corresponding stage heights. The rating curve is produced using regression analysis of instantaneous flow measurement and stage height. Providing the timing of these four to six instantaneous measurements cover the entire range of stage heights measured during the year and the stream bed has been unaltered by sediment deposition or erosion, a reasonably accurate rating curve can be expected. . If the rating curve does not cover the full range of the stage recorded, the curve can be extended to equal twice the lowest or highest measurement recorded. Any extension of the curves beyond this will only be used to estimate flow and the corresponding flow numbers will be qualified to signify they are only an estimate."

Question 3: What are the potential fish benefits?

Response: Fish will benefit when on-going water management decisions in these basins can be supported by continuous, near real-time stream flow data (as just one example - when we can actively take steps to augment in-stream flows or reduce water withdrawals as streams approach critical low-flow periods). Fish will also benefit when we can accurately measure seasonal hydrologic variability including extreme flood or wash-out events (e.g. are we targeting the most cost-effective habitat improvements? – are fish limited by critical low-flow events, or are they limited by severe wash-out events during winter storms?). Will we know whether a habitat project has had the desired effect if we fail to account for natural hydrologic variability (droughts or other unusual seasonal flows)? Failing to adequately measure stream flow assumes that in-stream flows have no important effect on fish success. Measuring flows allows fish biologists, land managers, and other interested parties to evaluate the potential effect of stream flows on fish, as well as the effect of their activities on stream flows.

ATTACHMENTS:

Attachment 1: Preliminary Hydrologic and Stream Gauging Assessments of the Lewis, Salmon/Washougal, and Gray/Elochoman subbasins

Attachment 2: Watershed Maps Depicting Preliminary Proposed Stream Gauging Sites.

Attachment 3: Independent Science Panel Technical Memorandum 2002-1
February 15, 2002 Instream Flows for Salmon

Attachment 4: Determination of Instantaneous Flow Measurements on Rivers and Streams

Attachment 1:

Lower Columbia Stream Gaging Proposal

Funding has been proposed to "purchase and install eight continuous, real time, telemetered streamflow gages, and six staff gages, at critical reaches and tributaries in each of three subbasins". The subbasins, which drain into the Columbia River, are:

1. Grays River / Elochoman River basin,
2. Lewis River / Kalama River basin, and
3. Salmon Creek / Washougal River basin.

All basins are home to several species of threatened or endangered salmonids. Although average streamflow, flood peaks, and other flow statistics can be predicted from regional studies by transferring data from nearby basins, it has been found that low-flow characteristics cannot be predicted in this manner. There is presently no high-tech method of monitoring minimum instream flows, testing for flow reductions, or detecting other changes in streamflow without traditional streamflow gaging.

The management of surface water in Washington requires a gaging network capable of monitoring water diversions, minimum instream flows, and water availability. Implementation of the Instream Resource Protection Program (IRPP), development of future Basin Management Plans, and tracking of water availability, require access to adequate streamflow information.

With this in mind, the remainder of this proposal suggests where in these basins the gaging should be placed to be effective.

Elochoman and Grays River subbasin

Elochoman and Grays subbasin contains streams that drain to the Columbia River along the southern slopes of the Willapa Hills between Longview and Frankfort, WA. Principal streams include Abernathy and Mill Creeks and Elochoman and Grays River. The basin, mostly in Wahkiakum County, has an area of about 510 sq. mi. with a mean annual runoff-of approximately 3,000 cfs, 1000 cfs from the Grays River, 400 cfs from the Elochoman River, and 150 cfs each from Mill Creek and Abernathy Creek, with the remainder from minor streams. All major streams flow primarily southward toward their confluence with the Columbia.

The Elochoman and Grays River are the largest streams in the basin with the Grays River being the greater. Other streams are smaller and drain from lower elevations. The headwaters of all streams are thickly forested and receive 80 to 125 inches of annual precipitation.

Minimum instream flows have not been set in this basin, and there are no closures to water withdrawals. Small diversions for irrigation and domestic use occur in the lowest part of the basin, but for the most part, there is no regulation or diversion in the upper watersheds. An Instream Flow Incremental Method (IFIM) fish habitat analysis was completed for the Washougal River in 1999.

There is presently no USGS gaging activity in these watersheds. However there are historic records from the following USGS stations:

14245500 - Germany Creek near Longview, 1949
14246000 – Abernathy Creek near Longview, 1949-58
14246500 – Mill Creek near Cathlamet, 1949-56
14247500 – Elochoman River near Cathlamet, 1941-71
14248000 – Skamokawa Creek near Skamokawa, 1949-50
14248200 - Jim Crow Creek , 1949-50
14249000 – Grays River above South Fork, 1956-75
14249500 – Grays River below South Fork, 1956-60
14250000 - Grays River near Grays River, 1949-51
14250500 – West Fork Grays River near Grays River, 1949-69
14251000 – Hull Creek at Grays River, 1949

As part of this proposal we would re-establish several of these historic stations. This would allow us to take advantage of the older records and allow statistical comparison with future streamflow. We would either reoccupy the existing station or locate a station nearby. Historic stations of interest, along with the equipment proposed are:

Abernathy Creek – 20 sq. mi. – RECORDER
Germany Creek – 23 sq. mi. – STAFF
Mill Creek – 28 sq. mi. – RECORDER
Elochoman River – 66 sq. mi. – RECORDER
Skamokawa Creek – 17 sq. mi. – RECORDER
Jim Crow Creek – 5.5 sq. mi. – STAFF
Grays River above South Fork – 40 sq. mi. – RECORDER
Grays River near Grays River – 61 sq. mi. – RECORDER
West Fork Grays River – 15 sq. mi. – STAFF
Hull Creek – 12 sq. mi. - STAFF

We would also establish new gaging stations at the following sites:

West Fork Skamakawa Creek – STAFF
South Fork Grays River near mouth – STAFF

The proposed streamflow gaging network in WRIA 25 includes six continuous RECORDERS and six STAFF gages.

Lewis / Kalama River basin

The Lewis / Kalama River basin covers portions of northern Clark, southern Cowlitz, and western Skamania counties. The basin covers an area of about 1300 sq. mi. with a mean annual runoff of approximatelly 7,400 cfs, 6100 cfs from the Lewis River (includes 1000 cfs from the East Fork Lewis River), and 1300 cfs from the Kalama River. The Lewis River drains about 80 percent of basin with the Kalama River draining the remaining 20 percent.

The Lewis River and its tributaries originate in the western slopes of the Cascade Mountains, including the west slope of Mount Adams and the south slope of Mount St. Helens, and flow south and southwest through forested highlands and farmlands at lower elevations. The streambeds are deeply incised into the basaltic redrock and the streams drop some 10,000 feet in about 110 miles to the Columbia River. The principal tributary streams to the Lewis River in its upper reaches are Muddy River, Pine and Rush Creeks, and, in its lower reaches, Canyon and Cedar Creeks and East Fork Lewis River.

The East Fork of the Lewis River is the largest tributary of the Lewis River with a drainatge area of 217 sq. mi. The river runs about 43 miles from its source to its convergence at approximately river mile 3.5 of the mainstem Lewis River. Major tributaries within the eastern portion of the East Fork include Rock and Yacolt Creeks. Major tributaries in the western portion of the East Fork drainage are Mason, Jenny, Breeze, and McCormick Creeks. Elevations range from 4,400 ft in the eastern portion to approximately 200 ft. at its confluence with the mainstem.

Flow in the Lewis River is affected by upstream hydroelectric reservoirs.

The Kalama River heads on the southwestern slopes of Mount St. Helens and flows west-southwesterly until joining the Columbia River about two miles north of Kalama.

Although minimum instream flows have not been set, some tributaries are closed to further appropriation of water. They include:

Cedar Creek, a tributary of the Lewis River,
Gee Creek, a tributary of the Lewis River,
Lockwood Creek, a tributary of the East Fork Lewis River, and
Mason Creek, another tributary of the East Fork Lewis River.

Also, an Instream Flow Incremental Methodology (IFIM) fish habitat analysis was completed on the East Fork Lewis River in 1999.

The USGS has active gaging in the Lewis River drainage, but none on the Kalama River. They have four active stream gages, four lake/reservoir gages, and one powerplant tailwater gage. The active stream gages are:

14216500 – Muddy River below Clear Cr. Near Cougar
14219800 – Speelyai Creek near Cougar
14220500 – Lewis River at Ariel

14222500 – East Fork Lewis River near Heisson

Historically, the USGS was very active in this basin and records are available form the following stations:

Lewis River Basin
14213200 – Lewis River near Trout Lake, 1959-72
14213500 - Big Creek below Skookum Meadow, 1927-31, 1955-70
14214000 - Rush Creek above Meadow Creek, 1955-65
14214200 – Rush Creek above Meadow Creek near Guller, 1929-30
14214500 – Meadow Creek below Lone Butte Meadow, 1927-31, 1955-65
14215000 – Rush Creek above Falls, 1928-31, 1956-74
14215500 – Curly Creek near Cougar, 1955-70
14216000 – Lewis River above Muddy River, 1927-34, 1955-70
14216300 – Clearwater Creek near mouth, 1981-1989
14216350 – Muddy River above Clear Creek, 1981-83
14216500 – Muddy River below Clear Creek, 1927-1971
14216800 – Pine Creek near Cougar, 1957-70
14216900 – Pine Creek at mouth, 1982
14217000 – Lewis River at Peterson Ranch, 1909-10
14217500 – Swift Creek near Cougar, 1924-34, 1954-55
14217600 – Swift Reservoir near Cougar, 1958-82
14218000 – Lewis river near Cougar, 1910-12, 1924-50
14218300 – Dog Creek at Cougar, 1956, 1958-71
14219000 – Canyon Creek near Amboy, 1922-34
14219500 – Lewis River near Amboy, 1922-34
14221000 – Chelatchie Creek at Amboy, 1951
14221500 – Cedar creek near Ariel, 1951-55, 1961-66
14222000 – East Fork Lewis River near Yacolt, 1951
14222700 – East Fork Lewis River tributary near Woodland, 1950-1969

Kalama River
14222920 – Kalama River near Cougar, 1969-70
14222930 – Fossil Creek near Cougar, 1969-70
14222950 – Dry Creek near Cougar, 1969-71
14222960 – Merrill Lake near Cougar, 1969-71
14222970 – Spring Creek near Cougar, 1969-71
14222980 – Kalama River below Falls, 1969-71, 1980-85
14223000 – Kalama River near Kalama, 1911-13, 1916-30
14223500 – Kalama River below Italian Creek, 1947-71
14223600 – Kalama River above Spencer Creek, 1980

As part of this proposal we would re-establish several of these historic stations. This would allow us to take advantage of the older records and allow statistical comparison with future streamflow. We would either reoccupy the existing station or locate a station nearby. If all proposed stations are not installed on Salmon Creek (see Salmon/Washougal) then related equipment will be used in additional gages on either the Kalama or the Lewis River. Also, two continuous recording gages originally planned for Gray/Elochoman will be installed in these basins. The Lewis basin is by far the largest of the three subbasins in this proposal and the additional gaging would be most effective installed within. This proposal also takes advantage of the location of current USGS station.

Historic stations of interest, along with the equipment proposed are:

Lewis River above Muddy River - RECORDER
Cedar creek near Ariel – RECORDER
Canyon Creek near Amboy – RECORDER
Swift Creek near Cougar, - STAFF
Pine Creek near Cougar or Pine Creek at mouth – STAFF
Muddy River below Clear Creek – RECORDER
Curly Creek near Cougar - STAFF
Kalama River near Kalama – RECORDER
Kalama River below falls – RECORDER

We would also establish new gaging stations at the following sites:

Lewis river near mouth – RECORDER
Johnson Creek near mouth – STAFF
Rush Creek near mouth - RECORDER
East Fork Lewis River near Ecology site 27D090 – RECORDER
Mason Creek near mouth – RECORDER
Rock Creek near Moulton – RECORDER
Yacolt Creek near Mouth - STAFF
Gabar Creek – STAFF

The proposed streamflow gaging network in WRIA 27 includes ten continuous RECORDERS and six STAFF gages.

Washougal River and Salmon Creek basins

The Washougal River and Salmon Creek basins include about 490 sq. mi. in Clark and Skamania counties in southern Washington. The mean annual runoff is approximately 2,000 cfs, 1400 cfs from the Washougal River, 300 cfs from Salmon Creek, 200 cfs from Lacamas Creek, with the remainder from minor streams.

The Washougal River, the largest stream in the area, originates in the Cascade mountain range. From its origin, the Washougal River flows southwesterly approximately 33 miles to its confluence with the Columbia River at River Mile (RM) 121 at the city of Camas. The Washougal River watershed encompasses about 240 square miles. The lower two miles of the river are in the Columbia River valley. A narrow, shallow valley characterizes the next eleven miles upstream. Beyond this valley is a narrow, deep canyon extending into the Cascade foothills. Major tributaries include the Little Washougal River, Cougar Creek, Canyon Creek, West Fork Washougal River, and Dougan Creek.

Salmon Creek is a low elevation stream, originating in the foothills of the Cascade Mountains, but draining mostly low-lands. Streams that form the Salmon Creek drainage flow west across plains and terraces and discharge into Lake River. Lake River starts at the outlet of Vancouver Lake and flows parallel to the Columbia River through a series of marshes to its confluence with the Columbia River.

Annual precipitation averages 83 inches in the Washougal River basin and 48 inches in the Salmon Creek basin. Both streams and their tributaries originate in mountains less than 4,500 feet in elevation, too low for maintenance of perennial snow.

Although minimum instream flows have not been set in these basins, some streams have been closed to further water appropriations since the early 1950's. They include:

Burnt Bridge Creek
Fifth Plain Creek
Gibbons Creek
Salmon Creek
Whipple Creek

Presently, the USGS has no active gaging program in these basins. However, there is some gaging activity by both Clark County and Clark County Public Utility. Each agency has two gages within the Salmon Creek drainage and has made extensive miscellaneous measurements within the basin.

Clark County presently has a continuous gaging station on:

Salmon Creek at 156th Street bridge
Salmon Creek at Klineline Pond

Clark County Public Utility presently has a continuous gaging station on:

Salmon Creek at discontinued U.S. Geological Survey (USGS) station 14212000
Salmon Creek at Northcutt Farms near discontinued USGS gage 14213000.

They also maintain staff gages on:

Woodin Creek at SR503 bridge
Cougar Creek
Curtin Creek at 139th Street bridge

Historically, USGS gaging included:

14143500 - Washougal River near Washougal, Wash 1944-1981
14144000 - Little Washougal River near Washougal , Wash, 1951-1955

14144500 - Lacamas Creek at Proebstel, Wash, 1951
14211895 - Burnt Bridge Creek at 112th Ave, Vancouver, Wash, 1998-2000
14211898 - Burnt Bridge Creek at 18th St. , Vancouver, Wash, 1998-2000
14211901 - Cold Creek at mouth, Vancouver, Wash, 1998-2000
14211902 - Burnt Bridge Creek near mouth, Vancouver, Wash, 1998-2000
14212000 - Salmon Creek near Battle Ground, Wash, 1943-1990
14212500 - Salmon Creek near Brush Prairie, Wash, 1941-1942
14213000 - Salmon Creek near Vancouver, Wash, 1951, 1988-1989

There have also been a number of crest stage and other partial flow stations within the basins at various times.

As part of this proposal we would re-establish several of these historic stations. This would allow us to take advantage of the older records and allow statistical comparison with future streamflow. We would either reoccupy the existing station or locate a station nearby. However, before establishing any stations we will contact local government to identify their gaging locations and may modify our plans accordingly. Historic stations of interest, along with the equipment proposed are:

Salmon Creek near Battle Ground – drainage 18 sq. mi.- RECORDER
Salmon Creek near Brush Prairie – drainage 64 sq. mi. - STAFF
Salmon Creek near Vancouver – drainage 81 sq. mi. - RECORDER
Burnt Bridge Creek near mouth - STAFF
Washougal River near Washougal - drainage 108 sq. mi. - RECORDER
Little Washougal River near Washougal – RECORDER

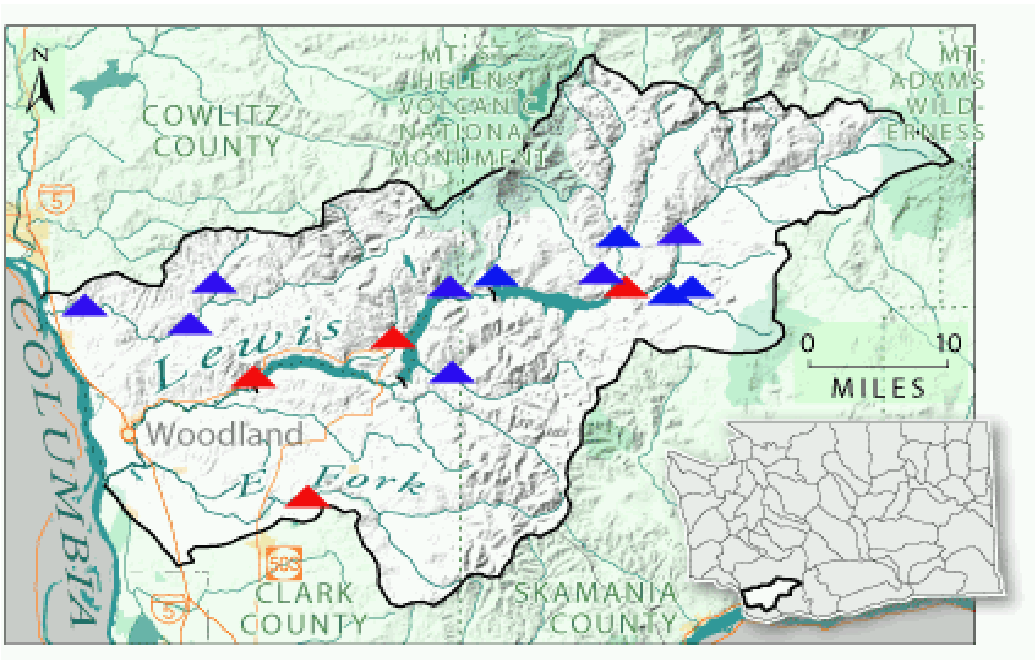
NOTE: Two of the proposed Salmon Creek stations are currently gagged by the Clark County Public Utility. If this is to continue into the future, the equipment proposed for these stations will be shifted to the Lewis River basin (Lewis basin).

We would also establish new gaging stations at the following sites:

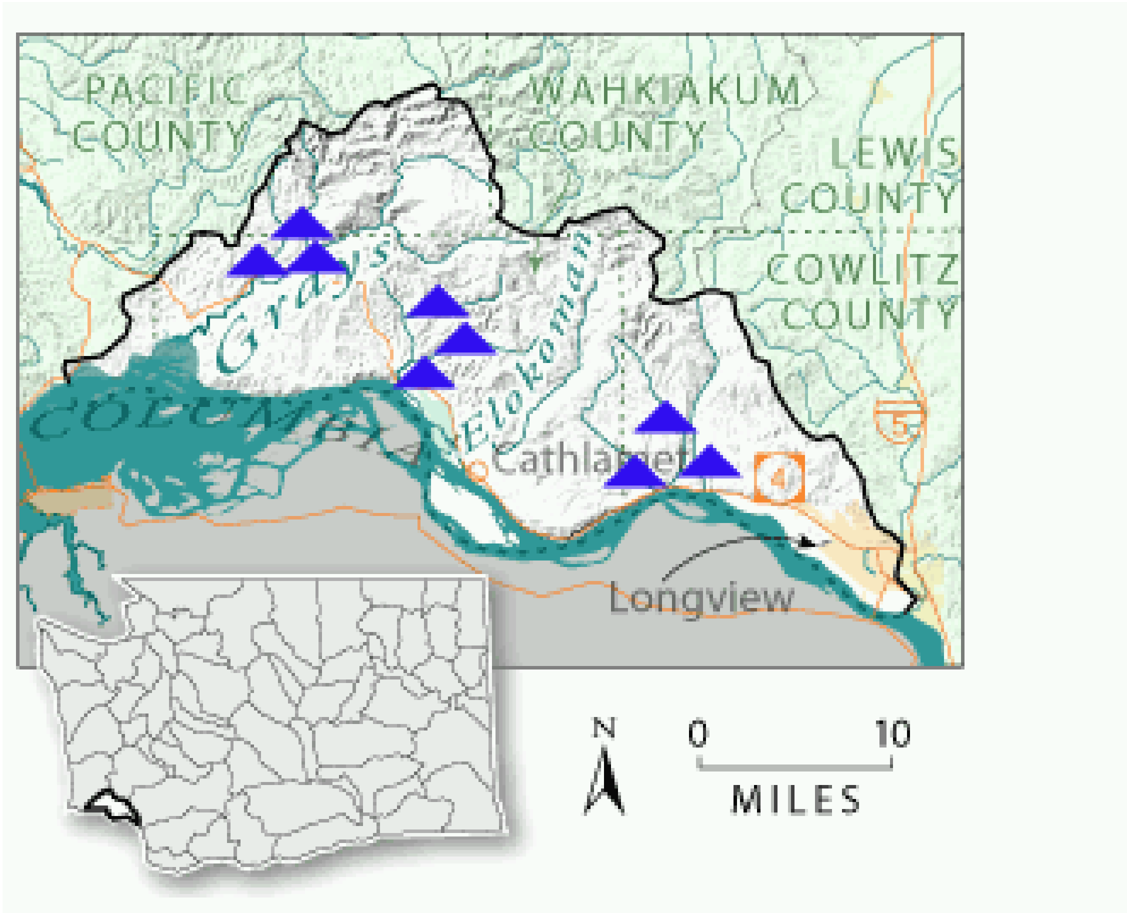
Lacamas Creek above Lacamas Lake – RECORDER
Lacamas Creek below Lacamas Lake (or on Lacamas Lake) - STAFF
Washougal River near mouth – STAFF
West Fork Washougal River – RECORDER
Canyon Creek and McCloskey Creek – RECORDER on one, STAFF on other
Washougal River above Washougal Hatchery – RECORDER
Dougan Creek near mouth - STAFF

This gaging network includes eight continuous RECORDERS and six STAFF gages.

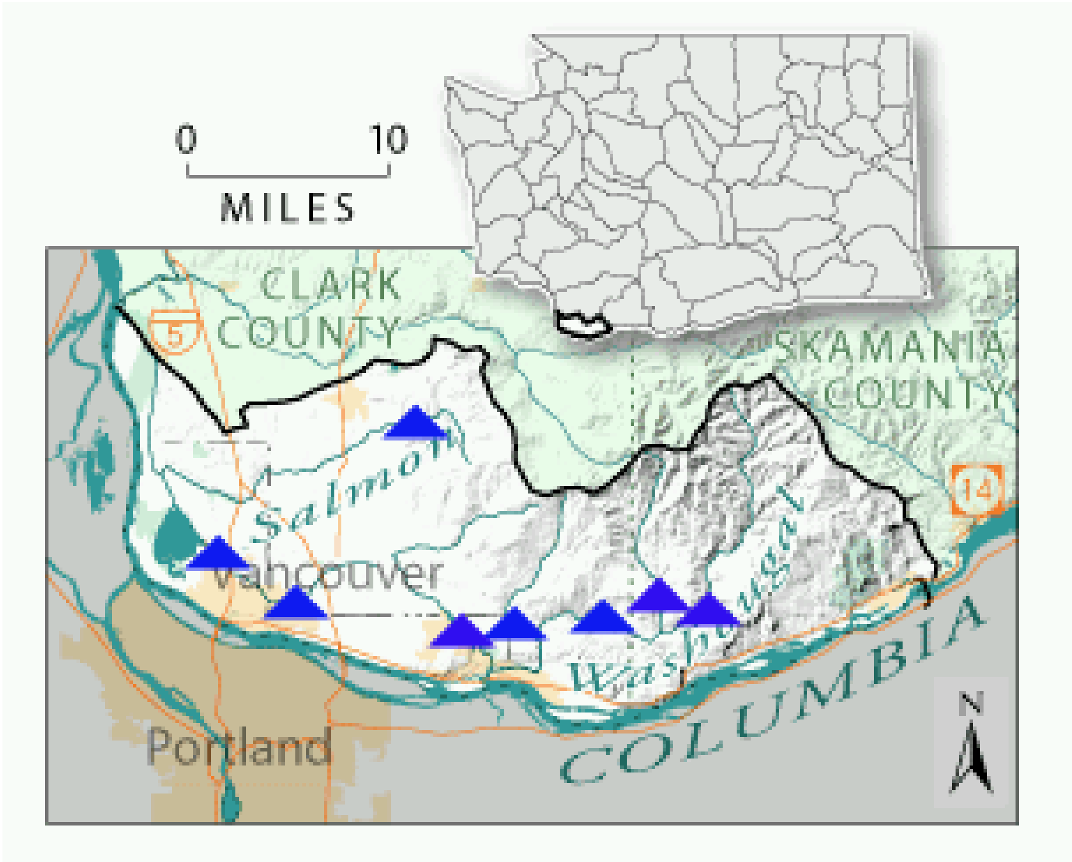
<u>Attachment 2:</u>



WRIA 27 Lewis/Kalama: proposed gauge locations



WRIA 25 Grays/Elochoman: proposed gauge locations


0
10
MILES
CLARK
COUNTY
5
SKAMANIA
COUNTY
14
Salmon
Vancouver
Washougal
COLUMBIA
Portland
N

Attachment 3:

Independent Science Panel
Technical Memorandum 2002-1
February 15, 2002
Instream Flows for Salmon
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Technical Memorandum 2002-1

INSTREAM FLOWS FOR SALMON

February 15, 2002

Independent Science Panel1

Water of sufficient quantity and quality is prerequisite to the recovery and protection of fishes. Water is needed for migration of adults to spawning areas, spawning, egg incubation, emergence of fry, growth of juveniles, and migration of smolts. The importance of stream flows in Washington was apparent this past year when faced with drought conditions, human demands for water, and salmon protected under the Endangered Species Act, the Governor ordered implementation of statewide water conservation measures and subsequently developed a Washington water action-strategy. As the human population of Washington continues to increase, we will place even greater demands on water resources, potentially leading to increases in the frequency of emergency water conservation measures to preserve both public water supplies and to provide sustaining flows in streams for salmon and other fishes. In some cases, overappropriated streams may become severely dewatered as competing demands for water incrementally reduce natural stream flows to a trickle. Salmon, trout, and char in these streams have little chance for survival during draughts. Moreover, continuing shortages of water to maintain instream flows for fish will constrain future recovery efforts for threatened and endangered species of salmon.

The Independent Science Panel2 (ISP) provides scientific oversight and review of the State of Washington's efforts to recover salmon. We have critiqued the Statewide Strategy to Recover Salmon (ISP Report 2000-1) and are advising the State's Monitoring Oversight Committee as they develop a statewide monitoring program for watershed health with a focus on salmon recovery. Both plans contain elements directed toward instream flows for fish. Because instream flow is such a key element, we wish to reemphasize its importance for fish in this memorandum and the importance of scientific analyses that develop quantitative relationships between stream flows and the needs of salmon and other fishes.

Scientific understanding of instream flows has improved in the last 40 years. Ascertaining how much water should be left in streams has been an ongoing effort since the late 1960s when resource managers were faced with questions of resource protection in the face of an ever-dwindling water supply. In general, most early efforts in western United States were focused on defining instream flow minima – or the absolute lowest amount of water that should remain in the stream to protect existing aquatic resources – with the rest of the water available for out-of-stream use. A minimum flow regime assumes that a single flow is sufficient for the whole life history of the fish, which is not necessarily the case. An analogy would be for humans to be subjected to the minimum environmental conditions (e.g., air quality, water quality and quantity, space) that could keep us alive. Current understanding is that aquatic ecosystems and fish populations require more than just a chronic minimum flow condition. Flow needs will vary by life stage. For example, flow conditions needed to provide spawning habitat and egg incubation may differ from conditions needed for adult migration and juvenile rearing.

Stream flows provide three important functions: (1) They are the medium where fish and other aquatic organisms live and propagate; (2) they provide the forces to create and maintain stream channels and off-channel habitats, riparian communities, instream habitat through distribution of large wood that creates pools, riffles, and spawning areas; and (3) they rejuvenate riparian vegetation on floodplains and recharge water tables, which are important to fish and humans, through flows over banks. Stream flows also help regulate stream temperatures – a critical characteristic of the stream environment that affects how much oxygen fish have, how well they grow, how well they survive environmental challenges, availability of food, and the kinds of other organisms in the stream. All these are critical for survival of fish and maintaining productive habitat.
In natural systems, fish populations evolved under flow conditions provided by the natural hydrograph, including high flows during spring runoff or winter storms, and lower flows during summer months. These populations were also subjected to flow extremes, including those associated with floods and drought. As a result, the flow regime during one year may be favorable for salmonid production, and the next year it may be unfavorable. Thus, salmonid populations can and often do fluctuate partially in response to varying climatic conditions. It is this interannual variability in flow conditions that helps determine the suitability and productivity of streams for salmonids, and at the same time creates and maintains habitat diversity and connectivity.

The natural hydrographs of many of Washington’s streams, in contrast, have been altered to some degree by human activities. In some, water is over-appropriated. This means that the number of legally recognized water rights in some streams will at times exceed the average amount of water that exists in the streams without regard for what fish need. It is in over-appropriated streams that salmonid habitat recovery efforts will be especially problematic. In contrast, stream flows that are not limited by potential water withdrawals offer important opportunities to protect water for fish.

Although it is controversial, the wise management of water is essential for humans and fish. Decisions for how much water fish need depend on credible scientific information. Integrating credible scientific information will not only require commitment of resources, but it may also require creative use of Western water rights law. We recommend that technical analyses and studies be conducted to quantify the amounts of water necessary to recover and sustain viable populations of salmon and other fishes. Analyses should be done from a watershed perspective and must consider flows that provide for both the spatial requirements of different life history stages, as well as flows that promote and maintain ecological and hydrological functions and connectivity to important in-channel habitats and adjoining features. Further studies should strive to not only define the relationships of flow to habitat, but also how the habitat affects the abundance and health of fish, something that has typically been overlooked in most instream flow investigations. Because of the urgency in defining appropriate instream flows under Western water rights law and the complex relationship between stream flows and fish, however, even thorough analyses will leave uncertainties. Conservation science offers two solutions to address these kinds of uncertainties: (1) precautionary approaches, where instream flows are risk-adverse to protect fish while scientific uncertainty is high, and (2) adaptive management, where instream flows are set, the effects on fish monitored, and the instream flows are altered to achieve the desired level of protection. Integrating adaptive management in setting instream flows will require creativity and persistence.

The ISP recognizes that there are opportunities available in Washington to protect flows for fish. For example, the Washington Department of Ecology continues to work with the Washington Department of Fish and Wildlife to evaluate instream flow needs for streams and rivers in the state. These opportunities should not be ignored.

The Independent Science Panel was formed in 1998 by the Salmon Recovery Act (77.85.040 RCW). Members of the Independent Science Panel include: Drs. Ken Currens (Chair), Dudley Reiser (Vice Chair), Hiram Li, John McIntyre, and Walter Megahan.

Attachment 4

Determination of Instantaneous Flow Measurements on Rivers and Streams

Method - Instantaneous Measurement with Swoffer Model 2100

Overview
The Surface Hydrology Unit (SHU) of Ecology's Environmental and Trends Monitoring Section provides flow information in support of three activities. The first is to meet the instantaneous flow needs of the Ambient Freshwater Monitoring Program. The second is to provide rating curves for continuous flow monitoring work to support Total Maximum Daily Load (TMDL) calculations. The final area is in support of the Water Resource Program establishment of minimum in-stream flows using two methods, the In-stream Flow Incremental Methodology (IFIM) and by Toe Width Measurement.

Instantaneous flow measurements (discharge) are an integral element of both the Ecology Ambient Freshwater Monitoring Program and the Watershed Assessment Section TMDL work. Discharge measurements are primarily used within both of these programs to address two issues. The first is to address the variability intruded into other parameters that are directly influenced by seasonal and annual flow patterns. The removal of this variability (flow adjusting or normalizing the parameter with respect to flow) often enhances our ability to detect long term changes in water quality (trends). The second is to address parameter specific relative contribution or flux from a stream with respect to its receiving water. In both cases it is paramount the discharge measurement be as accurate as possible.

Within the SHU we do not measure river/stream discharge each time water quality information is collected. Instead we rely on two methods to estimate stream flow at the time of sampling. The first is to gather this information from existing stream gages operated by other governmental agencies, primarily the USGS, the Corps of Engineers, and the Bureau of Reclamation. The second method is to create our own rating curves that relates river stage to discharge. Where this method is used, the river stage is measured and recorded when the water quality sample is collected or a data logger recorders the stream stages height on a set time interval. In addition, at least four to six times a year we measure stream flow and record the corresponding stage. These measurements are made at various stage heights encompassing the stage recorded during the water quality sampling. The instantaneous flow measurements are then plotted against stage height to develop a rating curve. Ideally, this rating curve covers the full range of the stage height recorded during the sampling.

Measuring Stage Height
We currently use four methods to establish stage height, reference points, wire weight gages, staff gages, and continuous stage height recorders.

Reference Point Measurement

A reference point is a fixed point or datum on the bridge or other structure from which a measurement can made to the surface of the water under all flow conditions.

The distance from this reference point to the water surface is measured with a weighted fiberglass measuring tape. The weighted tape is lowered to the water surface just to the point were the wake from the water passing by the weight forms a slight distinctive "V" shape. The distance from the reference point to the water surface is recorded to the nearest 100th of a foot.

1) Find the RP mark on the bridge (directions are provided on the run sheets).
2) Lower the weighted tape until it just touches the water (a distinctive "V" should downstream of the weight). Raise the weight to make sure you are just touching the water.
3) Read the tape at the edge of the RP to the hundredth of a foot.
4) Record the time, RP measurement and the correction factor for the tape (written on the side of the tape) in the yellow flow book.

Wire Weight Gage

The process of measuring stage height with a wire weight gage is almost identical to that used with reference point. The only minor differences are the wire weight gage has a greater level of accuracy than does the weighted fiberglass tape and the reference point for a wire weight gage is within the gage box itself. A wire weight gage is a self-contained weighted measuring device that is permanently attached to a bridge. The wire weight is lowered to the water surface just to the point were the wake from the water passing by the weight forms a slight distinctive "V" shape. The distance from the check bar (internal reference point) to the water surface is recorded to the nearest 100th of foot.

1) Open the Wire Weight Gage box.
2) Take the C-Bar measurement
- Make sure the metal bar located in the bottom front of the gage is slid forward to block the exit of the weight.
- Disengage the cog on the right side of the gage and lower the weight until it just touches the C-Bar.
- Read the number in the counter on the left side of the gage for feet (<u>5</u>.07) and the number under the pointer on the right for hundredth of a foot (5.<u>07</u>). Be careful to record the proper foot when the pointer is near the turn over point.
- Record the C-Bar measurement in the yellow flow book.
- Slide the C-Bar out of the way.
3) Lower the weight until it just touches the water (a distinctive "V" should form downstream of the weight). Raise the weight to make sure you are just touching the water.
4) Read the measurement as described in 2c above.
5) Engage the cog on the right side of the gage and wind up the weight.
6) Record the time and the measurement in the yellow flow book.
7) Close and lock the gage box (make sure the handle to the gage is in the proper position that will not impair opening the box in the future.

Staff Gage

A Staff Gage is a graduated measuring device securely fixed to a permanent structure in the streambed from which river stage height can be read directly to the 100th of a foot.

Where the flows fluctuate greatly it may be necessary to set staff gages in series to accommodate a variety of stream levels.

1) Read the mean water level on the staff (binoculars may be required).
2) Record the time and measurement in the yellow flow book.

Continuous Stage Height Recorders
This portion of this documentation is expected by January 2003.

Instantaneous Flow Measurement

- Stream discharge measurements are made using 5 methods:
  1. Measuring Water Depths and Velocities by Wading
  2. Measuring Water Depths and Velocities From a Bridge
  3. Measuring Water Depths and Velocities From a Boat
  4. Measuring Water Depth and Velocity from a Boat using a 5/8-inch Sectional Rod and a USGS Top Set Wading Rod.
  5. Acoustic Doppler Current Profiler

- Selecting a Representative Cross Section to Measure Discharge
  The selection of a suitable stream cross section for measuring discharge is very important and cannot be over emphasized. Site selection is, in most cases, the most important factor in developing accurate flow information. The limitations of a poor cross section can not be over come by the ability of the individual taking the measurement. The following characteristics should be present at an ideal cross section:
    1. The stream course should be relatively straight and free flowing for 200-300 ft both upstream and downstream of the measurement site. The site, however, should be free from excessive turbulence.
    2. The stream channel should be free from vegetative growth and be relatively stable (free from major seasonal scouring or deposition of bed material).
    3. The steam bed should be relatively uniform with only minor irregularities (no large cobble or boulders).
    4. During low flow conditions (typically Aug-Oct) the stream channel should be confined to a single course.
    5. The stream bank should be stable and able to contain the maximum stream discharge (floods).

  If these characteristics are met the cross section should be relatively stable under most conditions and the stream flow should be uniformly distributed across the cross section. It is, however, unrealistic to assume all stream cross sections will meet all of these characteristics. Therefore, complete and accurate field notes describing the cross section and noting the exception to these characteristics are vital when determining the relative accuracy of the discharge measurement.

1. Measuring Water Depths and Velocities by Wading
   Equipment
   - 150 ft Rope

- Life Vest
- Safety Harness
- Swoffer Meter Model 2100
- Wading Rod w/Swoffer adapter
- Flow Recording Sheet
- 300 ft Measuring Tape (Graduated in 1/10th ft)
- 100 ft Weighted Tape (Graduated in 1/10th ft)
- 2 - 3ft Stakes
- Garden Rake
- Chest Waders
- Shovel
- Machete
- Keys for USGS gages

Site preparation
Ideally the cross section to be measured will meet all of the selection criteria, however, some do not. If the cross section selected is compromised by excessive aquatic plants, the presence of woody debris or has minor irregularities in the stream bed (rocks and manageable boulders) an attempt should be made to minimize their impact on flow measurements. This may require physical removal of interference and minor alterations of the streambed with the aid of a garden rake or shovel. After the cross section has been cleared the stream banks are inspected to insure they are confining enough to provide a distinct edge. If the streambed has a gentle sloping bank, rocks or other available material are used to make a defined steam edge. Care should be taken to insure that minimal water by-passes these structures. Do not change the section after starting a measurement as this will alter the flow characteristics and therefore the accuracy of your measurement.

Dividing the stream channel into segments
Stream discharge is approximated by multiplying the average velocity by the cross sectional area of the stream. Because most stream velocity and bottom contours vary as you proceed across the stream channel the cross section is divided into manageable segments. A measuring tape (tagline)is stretched across the stream perpendicular to the cross section to be measured. The tape is anchored to the surrounding vegetation\debris or to stakes driven in for attachment points. Width of the stream channel is noted and divided into conveniently measurable segments. Ideally the total number of segments should be larger enough to ensure no more than 10% of the total flow is from any one segment. For example, if the stream is relatively uniform with a width of 12 feet the distance between segment of 1 or 0.5 ft would be adequate. If, however, the flow is unequally distributed measuring points should be closer together where velocity or bottom irregularities are the greatest. In this case the distance would be 1 ft for uniform segments and 0.5 ft near the area of greatest variability.

Measuring stream velocity of the stream segments
Stream velocities not only vary horizontally as one proceeds across the stream cross section, it also varies vertically. Currently two methods are used to address vertical

variability within a segment, one applies with stream depths less than 1.5 feet and the other for streams over 1.5 feet in depth. For stream segments under 1.5 feet in depth the velocity is measured at sixth-tenths of the depth (six-tenths method). For streams with depths greater than 1.5 feet the velocity is measured at two-tenth and eight-tenths of the depth and the results are averaged (two-tenths/eight-tenths method).

Summary of Measuring Water Depths and Velocities by Wading

1) Record station information.
2) Measure and record stage height in the proper column.
3) Select a suitable stream cross section for measurement.
4) Determine which safety requirements are warranted based on in-stream conditions.
5) Prepare cross section by removing debris, rocks and confining stream edges.
6) Stretch measuring tape across the stream channel perpendicular to stream flow and note total stream width.
7) Divide stream with into segments (18-20) with no more than 10 percent in any one.
8) Turn knob on Swoffer meter to Calibration. It should read 185-186. If it is does not change the 9 volt battery. Record the Calibration # in the proper space on the Flow Measurement Form.
9) Install the propeller on the wading rod and tighten the allen screw.
10) Turn the knob on the Swoffer meter to Ave. Velocity.
11) Measure the depth of the first segment by reading the water level on the wading rod.
12) Adjust the wading rod to the proper depth.
    For < 1.5 feet total depth use the scale on the wading rod to place the swoffer sensor at 6 tenths depth.
    For > 1.5 feet total depth adjust the wading rod so that the swoffer sensor is at half the total depth for the 8 tenths depth and double the total depth for 2 tenths depth.
13) Press the start button on the Swoffer meter.
14) Record the velocity.
15) Continue to measure velocities by pressing the start button until 2 measurements are within 0.05 of each other or a maximum of 4 measurements have been recorded.
16) Proceed across the stream and repeating steps 11-15 at each segment.
17) Upon completion of the flow measurement turn the knob on the Swoffer meter to Calibration and record the number.
18) Remove the propeller assembly from the wading rod.
19) Measure and record the stage height.
20) Return equipment to vehicle.

2. Measuring Water Depths and Velocities From a Bridge

Equipment

- Bridge Board or Crane with attachments
- Type A or Type B Reel

- Swoffer Meter Model 2100
- Flow Recording Sheet
- 300 ft Measuring Tape (Graduated in 1/10th ft)
- 100 ft Weighted Tape(Graduated in 1/10th ft)
- Lead fish
- Warning Signs and Cones
- Keys for USGS Gages
- Weighted Tape

Measuring stream velocity and dividing the stream channel into segments

Measuring discharge from a bridge is almost identical to the in-stream discharge measurement discussed above, the only difference being the equipment used to position the flow measuring sensor. The bridge method also uses the Swoffer current meter to determine in-stream velocities. The flow sensor is suspended below weighted lead fish (Columbus or C-type weights) and is raised and lowered using a type A or type B USGS reel attached to a bridge board or portable bridge crane. The stream is divided into segments and velocities with respect to depths are measured the same when measuring from a bridge or when wading.

Summary of Measuring Water Depths and Velocities from a Bridge

1) Record station information.
2) Measure and record stage height in the proper column.
3) Determine which safety requirements are warranted based on bridge walkways
4) Determine the weight of the lead fish required to measure the flow.
5) If the lead weight is < 50 lbs a bridge board should be used. If the lead weight is > 50 lbs then the bridge crane should be used.
6) Stretch measuring tape across the stream channel perpendicular to stream flow and note total stream width.
7) Divide stream with into segments (18-20) with no more than 10 percent in any one.
8) Turn knob on Swoffer meter to Calibration. It should read 185-186. If it is does not change the 9 volt battery. Record the Calibration # in the proper space on the Flow Measurement Form.
9) Install the propeller on the wading rod and tighten the allen screw.
10) Turn the knob on the Swoffer meter to Ave. Velocity.
11) Measure the depth of the first segment by zeroing the depth dial at the water surface (back fin of the weight is level with the water surface) and lower the weight until it touches the stream bottom.
12) Record the depth in the proper column of the Discharge Measurement Notes Form (see Figure 1)
13) Adjust the lead fish to proper depth. See Flow Depth Correction Sheets
    - For < 2.5 feet total depth use the 6 tenths depth correction sheets.
    - For > 2.5 feet total depth use the 8 tenths depth and 2 tenths depth correction sheets.
14) Press the start button on the Swoffer meter.
15) Record the velocity.

16) Continue to measure velocities by pressing the start button until 2 measurements are within 0.05 of each other or at least 4 measurements have been recorded.
17) Proceed across the stream and repeating steps 11-15 at each segment.
18) Upon completion of the flow measurement turn the knob on the Swoffer meter to Calibration and record the number.
19) Remove the propeller assembly from the lead fish.
20) Measure and record the stage height.
21) Return equipment to the vehicle.

3. Measuring Water Depths and Velocities From a Boat

Equipment

- USGS Boat Equipment-Model 4600 (boom and cross-piece assembly)
- USGS Type A or B sounding reel
- Swoffer Flow Meter Model 2100
- Marsh-McBirney Model 2000 flow meter (used under special situations)
- 5/8-inch aluminum hand held top-set flow measuring rod (4 ft sections)
- USGS Top Setting Wading Rod
- 300 ft measuring tape (graduated in 1/10th ft)
- 100 ft measuring tape (graduated in 1/10th ft)
- Kevlar rope (tag-line) and spool
- Nylon straps
- Kevlar boat tagline cable harness
- USGS sounding weights (lead fish) available in 7, 15, 30, 50, or 75 lbs
- Cable grips
- Fence posts and maul
- Warning floats and anchors

Boat Measurement Equipment Set-up

1) After locating a suitable cross section for flow monitoring, anchor the warning floats approximately 500 feet above and below the intended cross-section or if necessary use a spotter.
2) Back on shore, insert the boom and cross-piece assembly into the oar-lock sockets and secure with the through bolts and nuts. When assembled the boom should lie atop of the bow and be secured to the cross-piece assembly. Arrows drawn on the cross-piece assembly identify which side of the assembly faces toward the bow of the boat.
3) The flow gear set-up starts from the opposite shore from where you intend to start the flow measurement, working from the downstream side of the cross-section with the bow orientated upstream.
4) The deck hand locates the tree to be used, or drives a fence post at an angle slightly away from the stream when trees are not available. Wrap a nylon strap around the tree, connect the kevlar cable harness and then attach the end of the kevlar rope (tag line) into the harness. Persons handling the tag line should always wear gloves made of leather or cotton.

5) With the deck hand in the bow of the boat holding the tag line and spool, the boat operator maneuvers the boat across the stream while maintaining an upstream orientation.
6) Once on the opposite bank, attach the second nylon strap to an available tree or fence post. Attach the cable harness and come-along to the strap. Pulling the tag line to take up slack, place the line into the cable harness. Crank in the come-along to tighten the tag line firmly enough to not allow up and downstream movement of the boat. For visibility the tag line should be flagged with brightly colored surveyor tape at about 2-meter intervals.
7) With the boat facing upstream, hook the tag line to one side of the guide spindle and clamp into position. Repeat the procedure with the opposite guide spindle. This allows horizontal movement along the cross section by hand pulling the tag line to position the boat. To maintain position along the tag line, the cable clamp affixed to the crosspiece should be clamped to the tag line.

Measuring Water Depth and Velocity from a Boat using The Boat Measurement Equipment.

Measuring discharge from a boat is almost identical to the in-stream discharge measurement discussed above, the only difference being a boat is used to position the flow measuring sensor with respect to the streams cross section. The Boat Measurement Method also uses the Swoffer current meter suspended below weighted lead fish (Columbus or C-type weights) that is raised and lowered using a type A or type B USGS reel. The stream is divided into segments and velocities with respect to depths are measured the same when measuring from a bridge or when wading. For conditions which the 5/8-inch top-set rod and USGS rod cannot be used (depth > 10 ft or velocities > 2 feet per second), use the boom and cross-piece assembly gear, sounding-reel, and appropriate weighted fish. The operating procedures for this equipment is described in the previous section. The deck hand can verify the fish (and velocity sensor) is oriented upstream when the fish contacts the water surface. This is particularly important in streams with low velocities. In fact, even when the fish is not visible, the deck hand can hold the cable from the velocity sensor forward (upstream), ensuring proper orientation. When a single operator is alone in the boat the tender verifies fish orientation and when the fish contacts the water surface.

Summary of Measuring Water Depths and Velocities from a Boat

1) Record station information.
2) Measure and record stage height in the proper column.
3) Determine which safety requirements based on in-stream conditions.
4) Determine the weight of the lead fish required to measure the flow.
5) Divide stream with into segments (18-20) with no more than 10 percent in any one.
6) Turn knob on Swoffer meter to Calibration. It should read 185-186. If it is does not change the 9 volt battery. Record the Calibration number.
7) Install the propeller on the wading rod and tighten the allen screw.
8) Turn the knob on the Swoffer meter to Ave. Velocity.

9) Measure the depth of the first segment by zeroing the depth dial at the water surface (back fin of the weight is level with the water surface) and lower the weight until it touches the stream bottom.

10) Record the depth

11) Adjust the lead fish to proper depth. See Flow Depth Correction Sheets

    For < 2.5 feet total depth use the 6 tenths depth correction sheets.

    For > 2.5 feet total depth use the 8 tenths depth and 2 tenths depth correction sheets.

12) Press the start button on the Swoffer meter.

13) Record the velocity.

14) Continue to measure velocities by pressing the start button until 2 measurements are within 0.05 of each other or a maximum of 4 measurements have been recorded.

15) Proceed across the stream and repeating steps 11-15 at each segment.

16) Upon completion of the flow measurement turn the knob on the Swoffer meter to Calibration and record the number.

17) Remove the propeller assembly from the lead fish.

18) Measure and record the stage height.

19) Return equipment to the vehicle.

4. Measuring Water Depth and Velocity from a Boat using a 5/8-inch Sectional Rod and a USGS Top Set Wading Rod.

<u>Equipment</u>

USGS Top-Set Wading Rod

For depths up to 4 feet and velocities less than 4 feet per second the USGS top-set wading rod can be used. To use the USGS top set rod from a boat is identical to that used while wading. The total depth is measured directly from the rod and the scale on the wading rod is used as a guide to adjusted the sensor to the proper depth. For stream segments under 1.5 feet in depth the velocity is measured at sixth-tenths of the depth (six-tenths method). For streams with depths greater than 1.5 feet the velocity is measured at two-tenth and eight-tenths of the depth and the results are averaged (two-tenths/eight-tenths method).

Sectional 5/8- inch Rod

The 5/8-inch top-set wading rod can be used within cross-sections up to 10 feet deep with velocities less than 2 feet per second. The rod is pieced together with 4 feet sections. Depth is measured by lowering the rod to the stream bottom then reading the 1/10ths ft increments graduated on the rod. Once depth is known, the operator raises the rod to the surface and sets the adjustable sensor unit to the appropriate depth. For depths less than 1.5 feet, the 6/10ths setting is used. For depths greater than 1.5 feet, set the sensor at the 2/10ths and 8/10ths locations on the graduated rod. Note: Calculate Depths Directly Do Not Used Flow Depth Correction Sheets. Once both measurements are achieved move to the next measuring location.

Measuring Water Depth and Velocity from a Boat using The Boat Measurement Equipment.

Measuring discharge from a boat is almost identical to the in-stream discharge measurement discussed above, the only difference being a boat is used to position the flow measuring sensor with respect to the streams cross section. The Boat Measurement Method also uses the Swoffer current meter suspended below weighted lead fish (Columbus or C-type weights) that is raised and lowered using a type A or type B USGS reel. The stream is divided into segments and velocities with respect to depths are measured the same when measuring from a bridge or when wading. For conditions which the 5/8-inch top-set rod and USGS rod cannot be used (depth > 10 ft or velocities > 2 feet per second), use the boom and cross-piece assembly gear, sounding-reel, and appropriate weighted fish. The operating procedures for this equipment is described in the previous section. The deck hand can verify the fish (and velocity sensor) is oriented upstream when the fish contacts the water surface. This is particularly important in streams with low velocities. In fact, even when the fish is not visible, the deck hand can hold the cable from the velocity sensor forward (upstream), ensuring proper orientation. When a single operator is alone in the boat the tender verifies fish orientation and when the fish contacts the water surface.

Summary of Measuring Water Depths and Velocities from a Boat using a 5/8-inch Sectional Rod and a USGS Top Set Wading Rod.

1) Record station information.
2) Measure and record stage height in the proper column.
3) Determine which safety requirements based on in-stream conditions.
4) Divide stream with into segments (18-20) with no more than 10 percent in any one.
5) Turn knob on Swoffer meter to Calibration. It should read 185-186. If it is does not change the 9 volt battery. Record the Calibration number.
6) (For 5/8 -inch Rod Only) Determine the number of section of rod you will need for the depth of the stream.
7) (For 5/8-inch Rod Only) Install Swoffer sensor in plastic housing and adjust thumb screw.
8) Install the propeller on the rod assembly and tighten the allen screw.
9) Record the depth
10) Adjust the Swoffer sensor to proper depth.
    For < 1.5 feet total depth use the 6 tenths depth correction sheets.
    For > 1.5 feet total depth use the 8 tenths depth and 2 tenths depth.
11) Press the start button on the Swoffer meter.
12) Record the velocity.
13) Continue to measure velocities by pressing the start button until 2 measurements are within 0.05 of each other or a maximum of 4 measurements have been recorded.
14) Proceed across the stream and repeating steps 11-15 at each segment.
15) Upon completion of the flow measurement turn the knob on the Swoffer meter to Calibration and record the number.
16) Remove the propeller assembly from the rod assembly.
17) Measure and record the stage height.

18) Return equipment to the vehicle.

5. Acoustic Doppler Current Profiler

This portion of this documentation is expected by January 2003.

Calculating Stream Discharge

A rating curve is developed that relates river stage height to instantaneous flow. Four to six times a year we take instantaneous flow measurements and corresponding stage heights. The rating curve is produced using regression analysis of instantaneous flow measurement and stage height. Providing the timing of these four to six instantaneous measurements cover the entire range of stage heights measured during the year and the stream bed has been unaltered by sediment deposition or erosion, a reasonably accurate rating curve can be expected. . If the rating curve does not cover the full range of the stage recorded, the curve can be extended to equal twice the lowest or highest measurement recorded. Any extension of the curves beyond this will only be used to estimate flow and the corresponding flow numbers will be qualified to signify they are only an estimate.

Quality Assurance:

- The quality assurance and quality control include three main elements 1) a written procedure manual, 2) a method for tracking calibration of flow meters and 3) a blind comparison of flow information generated by USGS

Written Procedure Manual

The SHU has a written protocol for is flow measuring work. This protocol will be reviewed semi-annually to ensure it remains current. All new personnel will be issued a personal copy and will be required to read the document before they begin their hands-on field training. Annually, all staff will be required to attend a field technique review section to ensure everyone remain current and are following the established protocols.

Method for Tracking Calibration of Flow Meters

The Department of Ecology is currently preparing documentation for quality assurance during calibration of flow meters. This documentation is expected by January 2003.

Blind Comparison of Flow Information Generated by different Monitoring Entities

The Department of Ecology is currently preparing documentation for conducting blind comparisons of flow information generated by different monitoring entities. This documentation is expected by January 2003.