YOUNGS CREEK HYDROELECTRIC PROJECT
(FERC Project No. 10359)

RESIDENT TROUT MONITORING PLAN

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November 1993

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EXECUTIVE SUMMARY

In association with the construction and operation of the Youngs Creek Hydroelectric Project, Snoqualmie River Hydro developed a plan to monitor resident trout. The Youngs Creek monitoring plan is designed to assess changes in the abundance of resident trout. Annual counts of the number of trout in ten pools provides an index of trout abundance. The monitoring plan is designed to ensure that project related changes in streamflow do not prevent the trout population from rebounding following a decline.

The objective of most monitoring plans is to determine project impacts by assessing the abundance of a resource before and after the project. These evaluations are confounded by natural population cycles in response to non-project related factors. Reliance on such before and after tests thus involves a large degree of chance. Pre-project monitoring may occur during a low or high point in a natural cycle and mask project related effects. Instead of evaluating the trout population before and after a project, the Youngs Creek monitoring plan uses trend analysis to assess changes in trout abundance.

By monitoring population trends, mitigation measures will be implemented if the population fails to rebound following a catastrophic decline or if the population undergoes a steady, statistically significant decline. There is a risk that minor decreases in the average trout population may not be detected. There is also a risk that if the population does not rebound following a decline, higher instream flows may be implemented due to non-project related factors. Rather than rely on chance, the Youngs Creek trout monitoring plan is designed to affect a balance of risk between the project and the resource.

INTRODUCTION

Snoqualmie River Hydro (SRH) recently received a license from the Federal Energy Regulatory Commission (FERC) to build a hydroelectric project on Youngs Creek in Snohomish County, Washington. The hydroelectric project is designed to be a run-of-the-river facility, using a 10 ft high weir with little or no storage capacity to divert water in excess of minimum flow requirements. The project is designed to divert water from Youngs Creek at river mile (RM) 5.00, elevation 1,530 ft. mean sea level (MSL), pass the water through turbines to generate electricity and return the water to Youngs Creek at RM 2.4; 600 ft. MSL. The project proponent, Snoqualmie River Hydro (SRH) anticipates the project will generate 7.5 MW with an estimated annual energy production of 29.5 million kilowatt hours.

Surveys of the physical and biological characteristics of the 2.6 mile Youngs Creek project reach were conducted between 1988 and 1991 to assess the effects of reduced flows on aquatic resources in the project reach. The project reach is located upstream of an anadromous fish migration barrier located at RM 1.0. Biological surveys indicated that Youngs Creek supports a resident population of rainbow trout *(Oncorhynchus mykiss)*. In addition to biological and physical surveys of Youngs Creek, an instream flow study was conducted using the Physical Habitat Simulation (PHABSIM) component of the Instream Flow Incremental Methodology (IFIM).

The instream flow study was conducted under the review and approval of state, federal and local resource agencies and tribes. A final instream flow report was submitted to the FERC in February 1991, and consensus was reached with the Washington Department of Wildlife (WDW) and other interested parties on a seasonal flow release schedule in March 1991. To ensure the project will not harm aquatic resources in Youngs Creek, SRH agreed to monitor the abundance of trout in Youngs Creek and institute appropriate flow adjustments if the trout population decreased.

An application for license to construct and operate the project was submitted to the FERC by SRH during August 1990. On 5 May 1992, the FERC issued a license to SRH to construct, operate, and maintain the Youngs Creek Hydroelectric Project (FERC No. 10359). In the 5 May 1992 Order, the FERC included a license article requiring SRH to monitor the trout population and submit the results to the Commission, including proposed minimum flow increases if monitoring indicated increased flows are warranted:

> <u>*Article 408.*</u> *At least 90 days before the start of project operation, the licensee shall file with the Commission for approval a monitoring plan to determine changes in the resident trout population in Youngs Creek with the minimum flows in effect required by Article 411.*
>
> *The licensee shall prepare the plan after consultation with the Washington Department of Wildlife and the U.S. Fish and Wildlife Service. The licensee shall include with the plan documentation of consultation and copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by*

the plan. The licensee shall allow a minimum of 30 days for the agencies to comment and to make recommendations prior to filing the plan with the Commission. If the Licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on project-specific information.

The plan shall include: (a) monitoring of the pre-project trout populations until the project becomes operational; (b) monitoring of project effects on trout populations for 5 years after commencement of project operations, and subsequently thereafter should minimum flow increases be deemed necessary to protect the trout resource; (c) a schedule for providing the monitoring results to the Washington Department of Wildlife and U.S. Fish and Wildlife Service; and (d) schedules for: (1) implementation of the monitoring program; (2) consultation with the Washington Department of Wildlife and U.S. Fish and Wildlife Service concerning the results of the monitoring; and (3) filing the results, agency comments, and licensee's response to agency comments with the Commission. If results of the monitoring determine that increases in flows are warranted (according to criteria defined in this monitoring plan), then SRH shall submit to the Commission for approval a proposal to increase minimum flows in the bypass reach of Youngs Creek to protect aquatic resources.

The Commission reserves the right to require changes to the plan. Project operation shall not begin until the licensee is notified by the Commission that the plan is approved. Upon Commission approval the licensee shall implement the plan, including any changes required by the Commission.

This report describes the monitoring plan prepared in response the License Article 408. The plan represents the efforts of SRH representatives as well as resource agency biologists. The plan is designed to incorporate results of annual monitoring efforts to assess population trends and ensure the project does not impact aquatic resources in the project reach.

OBJECTIVES, DEFINITIONS AND ASSUMPTIONS

The objective of the resident trout monitoring plan is to assess annual changes in the trout population in the Youngs Creek project reach. For the Youngs Creek monitoring plan, the term *population* is defined as the number of trout greater than 60 mm (total length). Although surveys conducted during pre-licensing investigations have identified only rainbow trout in the Youngs Creek bypass reach, all resident species of *Oncorhynchus* and *Salvelinus* will be recorded to quantify trout abundance. The monitoring plan is not intended to determine the total population of trout in the project reach, but uses the number of trout observed in a series of pools in the project reach as an index of trout abundance.

Resident trout populations typically undergo natural fluctuations in abundance. Floods, droughts and other natural events may also cause changes in trout populations. Confirming a direct cause and effect relationship in trout population changes is often difficult even when a change is sudden and dramatic. In spite of this difficulty, many aquatic monitoring programs are designed to compare populations before and after a project is constructed. Relying strictly on pre-project populations levels to determine project impacts may lead to erroneous conclusions. Measuring a low trout population level prior to project construction may mask project related impacts or incorrectly suggest a stream restoration measure is beneficial. Except for the initial year of project operation, the Youngs Creek monitoring plan is designed to evaluate population trends rather than strictly compare trout abundance before and after project construction. Adjustments to the instream flow requirements will be required if:

1) the trout population gradually declines (ie. decreasing trend), or
2) a catastrophic population decline is not followed by a population increase.

Site-specific surveys, instream flow studies and the collective experience of agency and SRH representatives at other hydroelectric sites suggest that the project flow regime should not dramatically impact the resident trout population in Youngs Creek. Project related impacts from the flow adjustment are expected to be discernible only over a period of several years. Large floods or other non-project related events may suddenly and catastrophically affect the trout population in the project reach. A catastrophe is defined as a 75 percent drop in trout abundance over a one year period. Under typical operating conditions, all parties agree a catastrophic reduction in trout abundance in the project reach could not reasonably be attributed to project related instream flow changes. Should a catastrophic decline in trout abundance occur, the monitoring program is designed to monitor the ability of the population to rebound. Instream flow requirements will be adjusted based on the lack of population recovery rather than meeting a population density target. The monitoring plan is not intended to determine the cause of trout population changes or to determine project-related impacts. Monitoring the trout population will assess changes in abundance, regardless of the cause of the changes.

All parties agree a catastrophic reduction in trout abundance in the project reach could not reasonably be attributed to project related instream flow changes, except under one condition. If a catastrophic decline in trout abundance occurs during the first year of operation, the project cannot be ruled out as a possible mechanism of the decline. If a catastrophic decline occurs during the first year of project operation, the pre-project population mean will be used to define a population density target that must be met to confirm the project flow regime was not a cause of the population decline.

FIELD PROCEDURES

Monitoring efforts will consist of counts of the abundance of resident trout using direct underwater observation techniques. Northcote and Wilkie (1963) found that diver counts in small streams can be quite precise, but tend to undercount the number of fish actually present. Since the objective of the Youngs Creek Monitoring Plan is to identify annual changes in a population index rather than the total number of fish in the project reach, bias associated with underwater observation was deemed acceptable. The ability to observe salmonids using direct underwater survey techniques can vary with season, time of day, water temperature and turbidity. In an effort to improve survey precision and repeatability, a single survey will be undertaken annually during summer, low flow, daylight hours.

While underwater observation is subject to habitat specific bias, the effect of the bias on assessing annual population trends can be minimized by monitoring only one habitat type and strict adherence to standardized field procedures. Snorkel surveys will be conducted in accordance with underwater census techniques developed for small streams by Hankin and Reeves (1988). Because of the size of the pools in Youngs Creek and excellent underwater visibility, a single diver will be used to collect all observations. The diver will enter the water downstream of a selected pool and proceed slowly upstream until one complete pass is made within the sampling site. To ensure complete visual coverage of the area below and to each side of the diver, the lateral distance between the diver and the shoreline will be assessed. At sites where the pool width exceeds the visual capability of the diver, pools will be surveyed by conducting multiple longitudinal passes. It is assumed that fish disturbed in shallow water will move to deep water. Therefore, to minimize the possibility of redundant observations, deep water areas within each sampling site will be surveyed first.

The surveyor will snorkel in an upstream direction recording data from each pool separately. Observations recorded during each survey will include the number of trout observed and an estimate of the length of each trout in 30 mm size brackets. Only trout greater than 60mm (total length) will be used to define relative abundance since moving clusters of smaller fish can be difficult to count. The number of fish per pool will be used to assess changes in trout abundance. The number of fish observed will be recorded by individual pools to increase the robustness of statistical analyses. Measurements will be taken of total stream discharge, underwater visibility (horizontal secchi disk), and the minimum and maximum water temperature over the duration of the sampling period to ensure consistent year to year comparisons.

Descriptive measurements for pool units include unit area, maximum depth, control feature and residual pool depth (Table 1). Residual pool depth is an indication of pool quality and has been previously used for project impact assessment (Lisle 1987). The residual pool depth is the difference in depth or bed elevation between a pool and the downstream riffle crest. Residual pool dimensions characterize low-flow conditions which often determine the capacity of streams to produce fish. A detailed description of field procedures can be found in the Timber-Fish-Wildlife Ambient Monitoring Manual (Schuett-Hames et al. 1992).

To minimize the potential effects of increased recreational fishing pressure, fish monitoring efforts will concentrate on relatively inaccessible areas in the Youngs Creek bypass reach. Specific areas to be avoided include Youngs Creek at RM 2.4 (powerhouse), RM 5.0 (diversion) and the sandstone "potholes" below RM 2.6. Another consideration is the presence of extremely steep terrain between RM 4.8 and RM 5.0, where foot surveys are precluded by large waterfalls and steep bedrock chutes.

For the Youngs Creek monitoring plan, annual surveys are initiated at approximately RM 2.6, above a series of sandstone scour pools popular with users of a nearby campground. To reach the survey starting point, follow the first spur road off of the "Youngs River Truck Trail". The spur road provides good access to the stream and is approximately 0.1 mile upstream from the Youngs Creek powerhouse. The surveys are initiated approximately 1,000 feet upstream from the end of the spur road in the middle of the NE 1/4 of Section 30 (T27N, R8E). Once the initial monitoring pool is located, surveyors will proceed upstream reporting physical conditions and numbers of fish in every third pool. If a given pool changes over time to such a degree that it can no longer be considered a pool, the next closest pool will be sampled in its place and identified for subsequent surveys.

An attempt to establish a sampling control site upstream of the project was considered but rejected. Differences in stream gradient, habitat conditions and anticipated fishing pressure preclude the development of a true experimental control.

Table 1. YOUNGS CREEK 1992 RESIDENT TROUT SNORKEL SURVEYS
Number of fish per pool observed by snorkeler
Survey conducted on 11 August 1992
Trout < 60 mm considered young - of - year and not included in results

Habitat Unit (Pools)	Length (m)	Width (m)	Avg. Depth (m)	Max. Depth (m)	No. Fish at	Length (mm)	Total No. Fish/Pool
1	5.9	4.7	0.5	0.6	2	90	
					1	120	
					1	150	4
2	6.7	6.1	0.6	0.9	2	90	
					3	120	
					2	150	7
3	8.8	4.9	0.7	0.9	2	90	
					5	120	
					3	150	10
4	4.6	8.2	0.5	0.8	1	90	
					1	120	2
5	3.7	4.9	0.4	0.5	2	90	
					1	120	
					1	150	4
6	10.7	7	0.7	0.9	11	90	
					12	120	
					2	150	25
7	7.9	4.9	0.3	0.5	1	90	
					1	120	
					1	150	3
8	20.7	7	0.8	1.2	10	90	
					12	120	
					3	150	
					1	180	26
9	11.9	4.9	0.7	0.9	4	90	
					6	120	
					1	150	
					1	240	12
10	3.4	3.7	0.2	0.4	1	120	1
MEAN:	8	5	0.5	0.7			9.4

Water discharge = 0.23 cms. (8.0 cfs)
Water temperature = 15 - 16 degrees celsius
Underwater Visibility = 5.0 cm
Length of survey reach = 1.3 km
Length of project reach = 3.4 km

Total Fish Count = 94
Standard Deviation = 9.17
Sample Variance = 84.04

STATISTICS AND DECISION CRITERIA

The objective of the resident trout monitoring plan is to assess annual changes in the number of trout in a series of selected pools in the Youngs Creek project reach. The monitoring plan is not intended to determine the total abundance of trout in the project reach, but to assess annual population changes using the number of fish observed in pool habitat as an index or indicator of the trout population. If trout abundance (according to statistical criteria) does not significantly decline during project operation, the instream flow release will be considered adequate to protect the fishery resource.

The following discussion represents a simplified explanation of the decision analysis process. A detailed description of the decision analysis process including flow diagrams, statistical tests associated with each decision step, annotated descriptions of each decision step and a key to statistical symbols is included in the Appendix.

The monitoring plan is designed to monitor two primary types of population change: statistically significant trends and sudden catastrophic declines. A catastrophic decline is defined as a severe (>75%) drop in trout abundance in one year. The analysis for statistically significant trends is as follows:

Significant Population Trend

A minimum of three years of snorkel survey estimates will be collected after the project begins operation to identify significant population trends. The number of fish in individual pools will be recorded over time and the trend for each pool analyzed using least squares regression. The statistical test examines the average of the slopes of a regression line for each of the 10 pools.

A Student's t-test will be used to compare the mean pool slope versus a slope of zero. If a statistically significant positive trend in the trout population can be shown after three years of post-project monitoring, the flow schedule in effect at that time will be considered adequate to protect fisheries resources and monitoring will stop. If, after three years of operation, no significant positive trend is observed population monitoring will continue.

After a fourth year of operation, the population trend will again be statistically compared to the hypothesis of no change. If a statistically significant positive trend in the trout population is indicated, the project will be assumed to have no net impact on fisheries resources and monitoring will stop. If, after four years of operation, no significant positive trend is observed population monitoring will continue.

After a fifth year of operation, the population trend will be examined for a statistically significant negative trend. Using a single sample t-test, the mean slope of the regressions will be compared to a slope of zero. If the mean slope of the regressions is significantly negative ($P=0.10$), the FERC will be petitioned to increase the instream flow in consultation with WDW and U.S. Fish and Wildlife Service (USFWS) representatives. If the mean slope of the regressions for the 10 pools over the five year period is not significantly negative (i.e., significant increase or no significant change) the flow schedule currently in effect will be considered adequate to protect fisheries resources and monitoring will stop. If the instream flow schedule is increased due to a significant decline in the trout population over a five year period, the monitoring plan will be reset and a new three to five year monitoring period initiated. The analysis for population trends assumes that a catastrophic decline in the population has not occurred. Tests to determine a catastrophic decline are as follows:

Sudden Catastrophic Population Decline

Large floods or other non-project related events have been observed to cause sudden declines in resident fish populations. All parties agree a catastrophic (>75%) reduction of the trout population over a one year period could not reasonably be attributed to project-induced instream flow changes except as noted in the following paragraph. The monitoring plan is designed to accommodate these unexpected events by assessing population trends rather than meeting a goal based on pre-project trout densities. The exception to this agreement pertains to the first year of project operation.

If a catastrophic decline in trout abundance occurs during the first year of operation, the project cannot be ruled out as a possible mechanism of the decline. To determine a catastrophic decline during the first year of operation, at least three years of pre-project surveys will be used to derive a pre-project population mean. The average number of fish per pool for the initial year of operation is then compared to the average number of fish per pool observed during pre-project surveys. If the number of fish per pool decreases by 75 percent or more, the results will indicate the population has suffered a catastrophic decline.

If a catastrophic population decline occurs during the first year of operation, the pre-project density of trout will serve as a standard to judge subsequent post-project surveys. Annual monitoring will continue until the post-project population has rebounded and is not significantly less than the pre-project population mean. If the population has not rebounded within five years, or if a second, consecutive, catastrophic decline occurs, SRH will petition the FERC to increase flows in the bypass reach. Following an increase in the instream flow release schedule, monitoring will continue using the pre-project population mean to confirm the project flow regime is not a cause of the population decline. Exhibit A of the Appendix includes a flow diagram describing the decision process to be used in the event of a catastrophic population decline during the first year of project operation.

SCHEDULE AND AGENCY REVIEW PROCESS

Surveys of trout abundance in the project reach will be conducted annually until the FERC determines the prescribed flow regime adequately protects the aquatic resources of Youngs Creek. Snorkel surveys of the ten selected pools in the project reach were conducted on 8 August 1991 and on 11 August 1992. Surveys will be repeated in early August each year until the project is constructed and will continue for at least three additional years following power generation. Project construction is expected to start during Spring 1993 with project operation expected in the Fall 1994.

The project is considered operational once electricity is generated. The project must operate through a spring and early summer season before a subsequent survey can be considered to represent post-project conditions. Assuming the project reach will be surveyed during early August each year, the following schedule will apply:

Project Operations Begin	Initial Post-Project Monitoring Survey
16 August - 31 December 1994	August 1995
01 January - 28 February 1995	August 1995
01 March - 15 August 1995	August 1996

If initial project operation is delayed beyond 15 August 1995, the corresponding dates will be adjusted by one full year.

Results will be examined following the statistical analyses and decision criteria described above after each annual snorkel survey is completed. Results of the analyses and SRH recommendations will be provided to the WDW and USFWS project representatives by 31 October of each year. Resource agency representatives will be provided 30 days to review the material and provide written comments to SRH. An agency/SRH consultation meeting will be held approximately two weeks after the survey results are submitted to review the status of the monitoring plan. The intent of this monitoring plan is to work interactively with resource agency personnel to ensure proposed flow releases do not harm fisheries resources. Should unexpected events occur, with obvious adverse effects on the results of the monitoring plan, all parties agree to take such effects into deliberation. The FERC reserves the right to require changes to the plan with WDW, USFWS and SRH reserving the right to submit recommended changes to the FERC.

Snoqualmie River Hydro will file the results, agency comments and SRH's response to agency comments with the FERC by 30 November of each year. If results of the monitoring plan determine that increases in flows are warranted (according to criteria defined in the monitoring plan), then SRH shall submit to the Commission a proposal to increase minimum flows in the

Youngs Creek bypass reach. If the FERC approves the proposal to modify the Youngs Creek flow regime, SRH will implement the modification no later than 28 February of the following year.

The time periods for initial project operation will also be used to determine the appropriate survey schedule following any FERC-mandated increase in the minimum instream flow release. For instance, if a modification to the instream flow release is implemented prior to 28 February, the next scheduled snorkel survey will describe conditions under the new flow regime. If a flow adjustment is implemented between 1 March and 15 August, the snorkel survey conducted in the following year will be used to evaluate trout abundance under the new flow regime.

REFERENCES CITED

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish, Aquat. Sci. Vol 45. 834 - 843.

Lisle, T.E., 1987. Using "residual depths" to monitor pool depths independently of discharge. Res. Note PSW-394. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 4p.

Northcote, T.G. and D.W. Wilkie. 1963. Underwater census of stream fish populations. Trans. Am. Fish. Soc. 92:146-151.

Schuett-Hames D., L. Bullchild, S. Hall and A. Pleus. 1992. Timber-Fish-Wildlife Ambient Monitoring Manual. Northwest Indian Fisheries Commission, TFW-AM9-92-002.

TFMP. 1990. Twin Falls Mitigation Plan - Pre-Project Results. Twin Falls Hydroelectric Project (FERC No. 4885), Twin Falls Hydro Associates. Hosey & Associates Engineering Company. July 1990. 16pp. + app.

APPENDIX 1

ANNOTATED DECISION ANALYSIS FLOW DIAGRAM

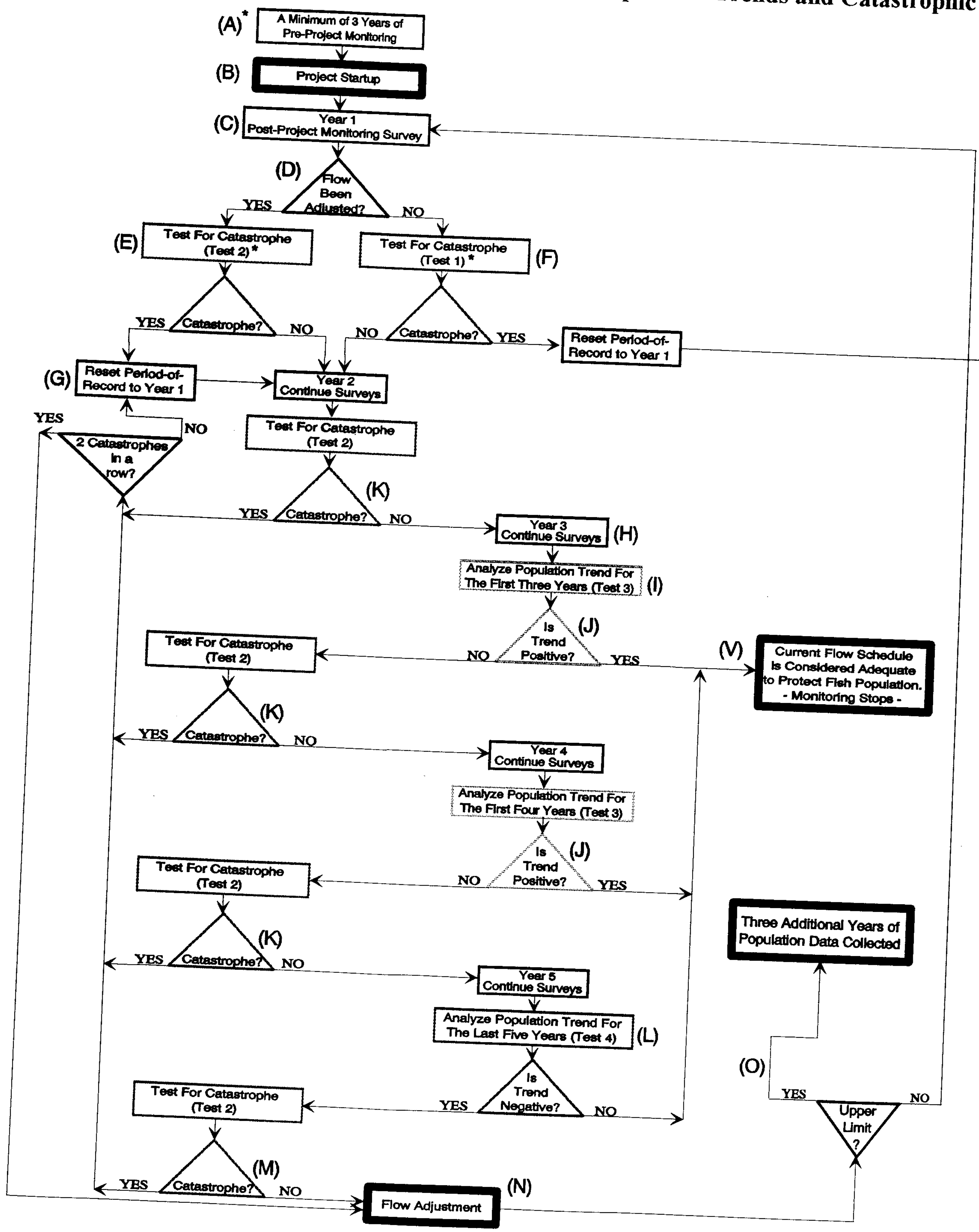
RESIDENT TROUT MONITORING PLAN

YOUNGS CREEK HYDROELECTRIC PROJECT

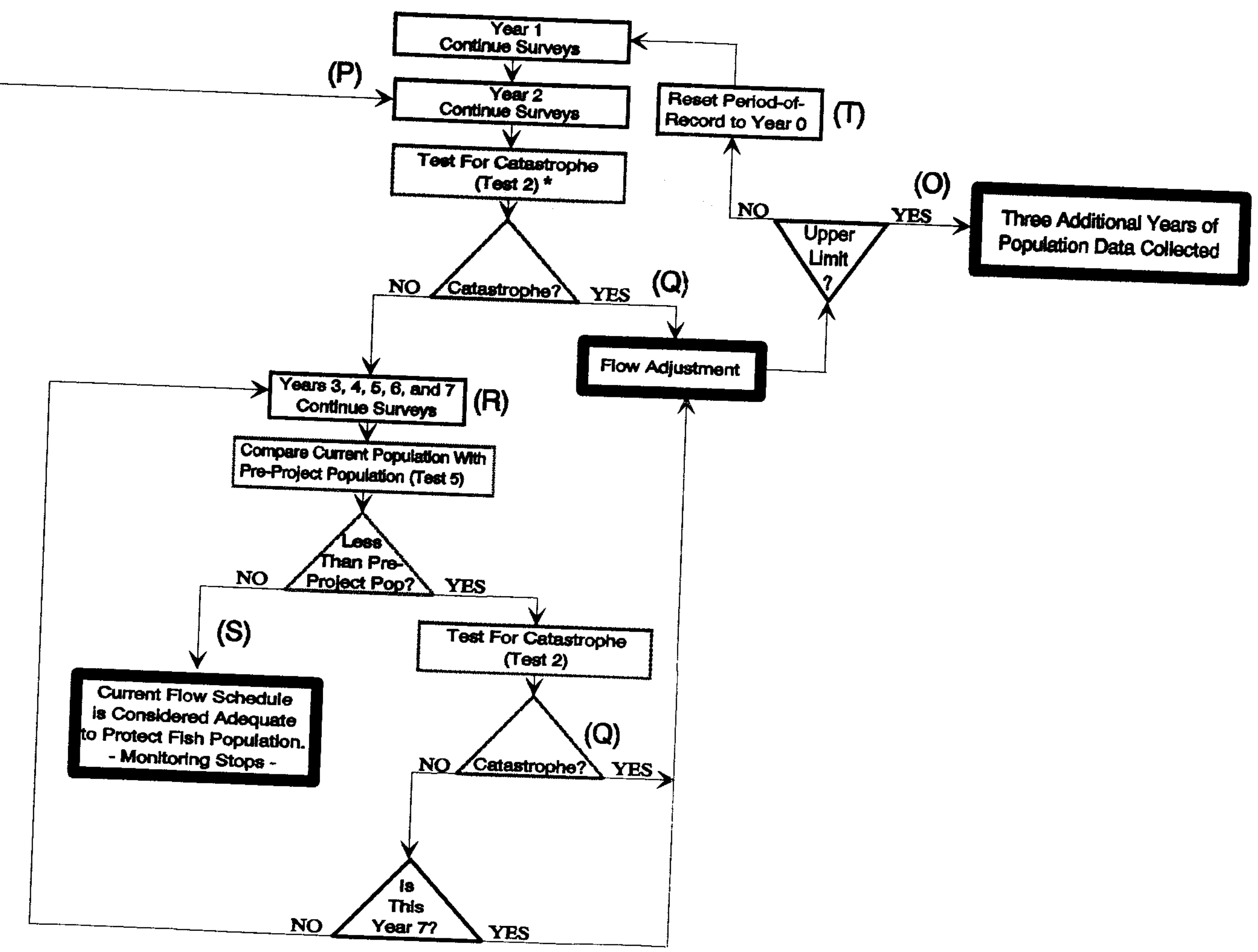
FERC PROJECT NO. 10359

Exhibit	A.	Decision Process to Assess Trout Population Trends and Catastrophic Declines.
Exhibit	B.	Statistical Tests Associated with each Decision Step.
Exhibit	C.	Annotated Description of Decision Steps.
Exhibit	D.	Key to Statistical Symbols.

Exhibit A. Annotated Decision Analysis Flow Diagram for the Youngs Creek Trout Monitoring Plan. Decision Process to Assess Trout Population Trends and Catastrophic Declines.



Decision Process to be Used in the Event of a Catastrophic Population Decline During the First Year of Project Operation.



*Numbers in parentheses refer to statistical tests described in Exhibit B. Letters in Parentheses refer to annotated descriptions in Exhibit C.

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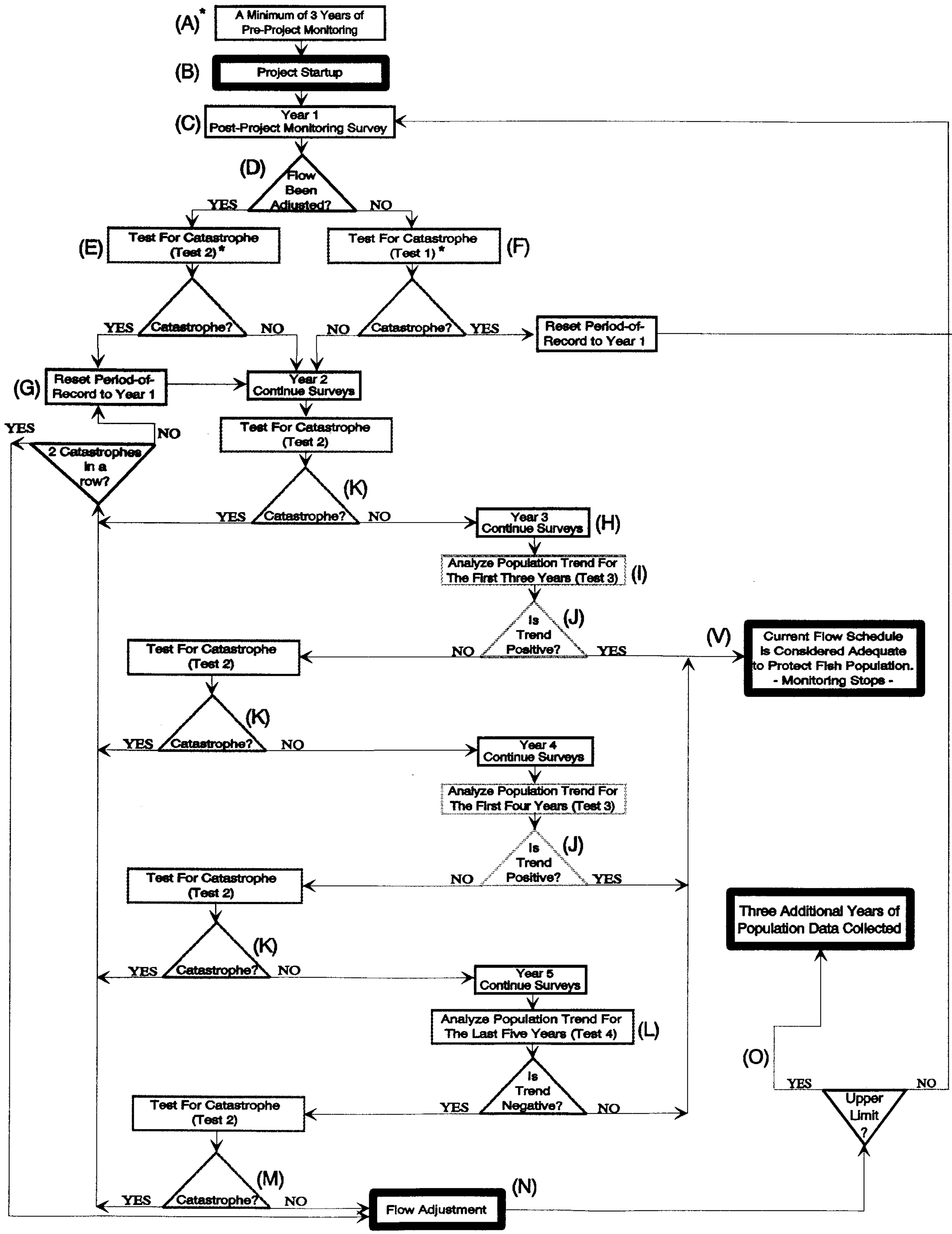
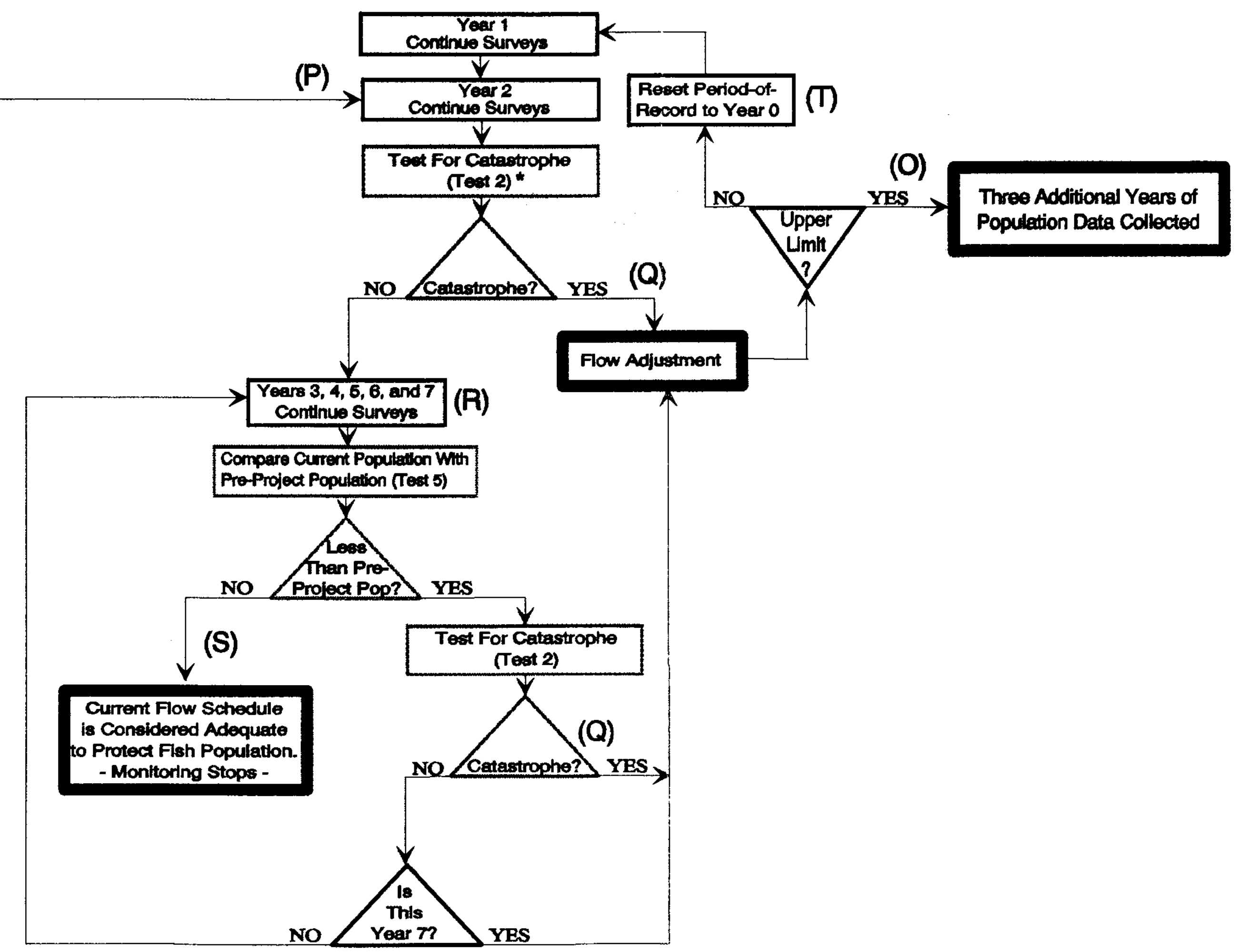
Exhibit A. Annotated Decision Analysis Flow Diagram for the Youngs Creek Trout Monitoring Plan. Decision Process to Assess Trout Population Trends and Catastrophic Declines.



Decision Process to be Used in the Event of a Catastrophic Population Decline During the First Year of Project Operation.



*Numbers in parentheses refer to statistical tests described in Exhibit B.
Letters in Parentheses refer to annotated descriptions in Exhibit C.

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Exhibit B. Annotated Decision Analysis Flow Diagram for the Youngs Creek Trout Monitoring Plan. Statistical Tests Associated with each Decision Step.

Test #1. Test for Catastrophe Using Pre-Project Data

This test is designed to determine if the fish population (trout >60mm) has dropped more than 75 percent from pre-project levels (catastrophe). Test #1 would be used only once, to test for a catastrophe during the year of operation following initial Project start-up. Test #2 would be utilized for all subsequent catastrophe testing.

1. Find the average number of fish per pool for the current year (l) by adding up the total number of fish observed during the survey and dividing by the total number of pools surveyed.

$$l = \frac{\sum_{i=1}^{j} F_i}{j}$$

Where F_i is the number of fish in each of j pools.

2. Find the average number of fish per pool observed during **before project** conditions ($\bar{B}_P$) by adding up the average number of fish observed during all annual surveys and dividing by the total number of annual surveys (n). (E.g. if 10 pools were surveyed for each of 3 years, n = 3).

$$\bar{B}_P = \frac{\sum_{i=1}^{n} L_i}{n}$$

Where L_i is the average number of fish in each of n annual surveys.

3. If the fish per pool proportion decreases by 75 percent, a catastrophe has occurred.

$$IF \left[\frac{l}{\bar{B}_P}\right] \leq 0.25 \rightarrow CATASTROPHE$$

Test #2. Test for Catastrophe Using Post-Project Data

Test #2 is designed to determine if a catastrophic decline in the fish population has occurred since the preceding annual survey. A catastrophe in this case is defined as a 75 percent drop in the trout population (>60 mm) since the project began operating, or since the most recent catastrophe. Test #2 would be used for all catastrophe testing with the exception of the first year of operation following initial Project start-up.

1. Find the average number of fish per pool for the current year (l) by adding up the total number of fish observed during the survey and dividing by the total number of pools surveyed.

$$l = \frac{\sum_{i=1}^{j} F_i}{j}$$

Where F_i is the number of fish in each of j pools.

2. Find the average number of fish per pool observed prior to the current survey ($\bar{A}_P$). Starting with the initial survey **after project** start-up or the last catastrophe, add up the number of fish observed in each pool survey (L) and divide by the total number of pools surveyed. (E.g. if 10 pools were surveyed for each of 5 years, $n = 5$). If no catastrophes have occurred, use all surveys back to the initial project startup; even if the flow regime has been adjusted.

$$\bar{A}_P = \frac{\sum_{i=1}^{n} L_i}{n}$$

Where L_i is the average number of fish in each of n annual surveys.

3. If the fish per pool proportion decreases by 75 percent, a catastrophe has occurred.

$$IF \left[\frac{l}{\bar{A}_P}\right] \leq 0.25 \rightarrow CATASTROPHE$$

Test #3. Test for Positive Population Trends

Test #3 was devised to analyze population trends for significant increases in the preceding three to four years. The test examines the average of the slopes of a regression line for each of j pools. An increase is defined as a slope significantly greater than zero ($P = 0.10$). This test would be used following the third and fourth years after project startup or a fixed incremental flow adjustment.

To increase the power of the test, the number of fish within each surveyed pool would be followed from year to year rather than a comparison of the annual average fish per pool. The slope (number of fish over time) for each pool is determined using a simple linear regression. A Student's t-test compares the slope averaged for j pools versus a slope of zero (Zar 1984).

1. For each individual pool, use a linear regression analysis ($Y = mX + b$) of the number of fish (Y) on time (year X).
2. Note the slope coefficient (m_i) for each pool (j).
3. Find the standard deviation of slopes (S_m).
4. Do a single sample t-test for the mean slope versus a slope of zero.

$$t = \frac{\left[\left(\sum m_i\right) / \#\ of\ Pools\right] - 0}{S_m / \sqrt{\#\ of\ Pools}}$$

5. Determine the critical t value using a table of t-distributions with D.F. = (j # of pools) - 1, and a one-tailed $P = 0.10$.
6. If t calculated is greater than t critical, a significant difference exists and it can be concluded that a significant positive population trend has developed.

Test #4. Test for Negative Population Trends

Test #4 was devised to analyze population trends for significant decreases in the preceding five years. A significant decrease is defined as a slope of the annual fish per pool averages which is significantly less than a slope of zero. This test would be used following the fifth year of surveys after project startup or a flow adjustment.

To increase the power of the test, individual pools within the stream would be followed from year to year rather than the stream average fish per pool. The average slope for each pool is determined using a simple linear regression. A Student's *t*-test compares the mean pool slope versus a slope of zero (Zar 1984).

1. For each individual pool, use a linear regression analysis ($Y = mX + b$) of the number of fish (Y) on time (year X).

2. Note the slope coefficient (m_i) for each pool (j).

3. Find the standard deviation of the slopes (S_m)

4. Do a single sample *t*-test for the mean slope versus a slope of zero:

$$t = \frac{\left[\left(\sum m_i\right) / \#\ of\ Pools\right] - 0}{S_m \ / \ \sqrt{\#\ of\ Pools}}$$

5. Determine the critical t value using a table of t-distributions with D.F. = (j # of pools) - 1, and a one-tailed $P = 0.10$.

6. If t calculated is less than $-t$ critical, a significant difference exists and it can be concluded that a significant negative population trend has developed.

Test #5. Comparison of Post First-Year-Catastrophe Population With Pre-Project Population.

Test #5 compares post-project population numbers with those found during pre-project surveys to look for evidence that the pre-project stream carrying capacity has been reduced. The test is only used following a catastrophic decline in the trout population during the first year of project operations following initial startup.

Test #5 uses at least three years of pre-project population numbers to derive a pre-project population mean. If the post-project population is not significantly less than the pre-project population mean, the population is considered to have rebounded from the earlier catastrophic decline.

1. Find the average number of fish per pool for the current year (l) by adding up the total number of fish observed during the survey and dividing by the total number of pools surveyed.

$$l = \frac{\sum_{i=1}^{j} F_i}{j}$$

Where F_i is the number of fish in each of j pools.

2. Find the average number of fish per pool during before-project monitoring ($\bar{B}_P$) by adding up the average number of fish observed during all annual surveys and dividing by the total number of annual surveys (n). (If 10 pools were surveyed for each of 3 years, n = 3).

$$\bar{B}_P = \frac{\sum_{i=1}^{n} L_i}{n}$$

Where L_i is the average number of fish in each of n annual surveys.

3. Find the before-project population standard deviation (S_b) using individual pool counts. The value of (S_b) is determined from a one-way analysis of variance with each pool serving as a level. (S_b) is the within-pool mean-squared error. If there are j pools surveyed for n years each, the degrees of freedom associated with (S_b) is $j(n-1)$. (E.g. if 10 pools were surveyed for three years each, DF = 20). This method takes full account of the matching of pools across years.

4. Do a single sample t-test for the mean before-project population ($\bar{B}_P$) versus the average number of fish per pool for the current year (l).

$$t = \frac{\bar{B}_P - l}{S_b \sqrt{\frac{1}{j}(\frac{1}{n} + 1)}}$$

5. Determine the critical t value using a table of t-distributions with D.F. $= j(n - 1)$, and a one-tailed $P = 0.10$.

6. If t calculated is greater than t critical, a significant difference exists and it can be concluded that a significant negative population trend has developed.

References

Zar, J.H. 1984. Biostatistical Analysis. Prentice-Hall Inc., Englewood Cliffs, New Jersey. 718 pp.

Exhibit C. Annotated Decision Analysis Flow Diagram for the Youngs Creek Trout Monitoring Plan. Description of Individual Decision Steps.

A) Pre-project trout abundance will be used to define a baseline of no net loss criteria to assess catastrophic population declines during the first year of project operation. If the trout population does not suffer a catastrophic decline in the first year of operation, pre-project data will not be used to guide future decisions.

B) *Project Startup* is defined as the first year of operation following the initial generation of electricity or the first year of operation following an adjustment to the instream flow regime.

C) Post-project monitoring consists of annual snorkel surveys of a series of 10 pools in the project reach during late July or August.

D) If, after five years of continued monitoring, the trout population in the project reach has undergone a statistically significant decline, the project's instream flow regime will be increased. After adjusting the instream flow regime in the project reach, annual monitoring will continue. Data collected in years prior to the flow adjustment will not be used to guide future decisions.

E) Catastrophe Test 2 compares the average number of fish per pool for the current year to the average number of fish per pool observed following project startup. If a catastrophic decline is observed, the monitoring plan is restarted. If a catastrophic decline does not occur, monitoring continues.

F) Catastrophe Test 1 compares the average number of fish/pool for the current year to the average number of fish per pool using pre-project data. If the current population is greater than 25 percent of the pre-project mean, monitoring continues and the population trend is tested for significant decline. If a catastrophic decline is observed, monitoring continues but the population must recover to a level not significantly less than the pre-project population mean.

G) If a catastrophic decline in the trout population has occurred in comparison to preceding surveys, the monitoring plan is restarted. This path would occur only if the project has been in operation for at least five years without suffering a catastrophic population decline. Under this scenario, it is assumed a catastrophic decline in succeeding years would not be a result of project instream flow requirements. After a catastrophe, the baseline for subsequent catastrophic tests includes only those surveys beginning with the year of catastrophic decline up to the current year.

H) At least three years of post-project data are required in order to assess the population trend. During Years 1 and 2, only tests for catastrophic declines are conducted. During Year 3, tests for both catastrophic decline and population trends are conducted.

I) Because of the inability to control major variables such as floods or drought, the post-project population is not compared to a pre-project baseline after the initial year of operation. The demonstration of no net loss at Year 3 is defined as a slope significantly (P=0.10) greater than zero.

J) If the trout population is significantly increasing (P=0.10) during post-project monitoring Years 3 or 4, monitoring will stop and the flow regime in effect at that time will become the permanent flow schedule. If a statistically significant increase in the trout population cannot be demonstrated in Years 3 or 4, the instream flow regime will not be modified. Even if the trout population has undergone a statistically significant (but not catastrophic) decline during Years 3 and 4, the instream flow regime will not be modified but monitoring will continue.

K) If the results of the catastrophe test (during Years 2-4) do not demonstrate a 75 percent population decline, the project will continue to operate under the flow schedule in effect and monitoring will be conducted the following summer.

L) The test for population trend during Year 5 is similar to Test 3 in that both tests are designed to identify statistically significant changes. While Test 3 is checking for significant increases, Test 4 is designed to identify significant decreases.

M) The instream flow regime is adjusted only if a catastrophic decline has not occurred and the average slope of the regressions of fish per pool is statistically less than a slope of zero.

N) If annual monitoring of trout abundance determines that a flow adjustment is warranted, Snoqualmie River Hydro (SRH) in consultation with resource agencies, shall submit a proposal to the FERC to increase flows in the Youngs Creek bypass reach.

O) If the trout population undergoes a significant gradual decline, or two successive catastrophic declines, project instream flow requirements will be adjusted. The flow adjustment will be implemented in an attempt to eliminate the project as a potential cause of a population decline. It is possible that additional monitoring could demonstrate a continuing decline in the trout population even though the flow adjustment is implemented. If flow adjustment does not reverse the decline of the population, SRH reserves the right to submit a proposal to the FERC to eliminate further flow adjustments. Any SRH proposal to eliminate further flow adjustments due to financial impacts must be accompanied by a proposal to continue monitoring for three additional years. The additional monitoring will provide a project record of at least two complete trout life cycles to assess whether non-flow related mitigative measures can be implemented to reverse the decline of the trout population.

P) If a catastrophic decline is observed during the first year of operation, a second year of monitoring is conducted before any remedial action is taken. After the second year of monitoring, the population is examined to determine if a second catastrophic decline has occurred. If a second catastrophe is observed, SRH in consultation with resource agencies, shall submit a proposal to the FERC to increase flows in the Youngs Creek bypass reach. If the population has not suffered a second catastrophic decline, monitoring continues and the population is tested against pre-project levels.

Q) If a second catastrophic decline is observed anytime following the first catastrophe, the instream flow is adjusted. Flow adjustments will continue until the population recovers to pre-project levels or the upper flow limit is reached.

R) Monitoring continues for five additional years for a total of up to seven years of monitoring between each flow adjustment, provided there is no catastrophic decline in the trout population. Monitoring can continue for a maximum of seven post-catastrophe years before the flow regime is adjusted. This extended monitoring period provides two complete life cycles before a flow adjustment is initiated. This extended monitoring is deemed appropriate since the population must recover to a target population level rather than simply demonstrating an increasing trend.

S) If, during Years 3,4,5,6 or 7, the post-catastrophe population recovers to pre-project levels, monitoring stops.

T) The monitoring program is restarted after each flow adjustment until the upper limit is reached. Unlike the monitoring "restarts" in Step C, the baseline is not changed; the population continues to be tested against population levels observed under pre-project conditions.

Exhibit D. Annotated Decision Analysis Flow Diagram for the Youngs Creek Trout Monitoring Plan. Key to Statistical Symbols.

Key to Statistical Symbols

$\bar{A}_P$ = average number of fish per pool for all years **after project** operations or since the previous catastrophe.

$\bar{B}_P$ = average number of fish per pool for all years **before project** operations.

F_i = number of fish observed in one pool during one survey.

j = number of pools surveyed in the project reach in one year.

l = average number of fish per pool for the current year.

L = average number of fish per pool observed in a previous year.

n = total number of annual surveys.

m_i = slope coefficient of the number of fish over time for each pool.

P = probability; refers to the chance of a larger value from a Student's t-distribution table.

S_b = standard deviation of **before project** individual pool counts.

Sm = standard deviation of the regression slopes of the number of fish over time for all pools.

t = Student's *t*-distribution is the deviation of the estimated mean from that of the population mean. An estimate of the standard deviation of the population estimated from the sample data.

APPENDIX 2

AGENCY COMMENTS

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

P.O. BOX 47600 • Olympia, Washington 98504-7600 • (206) 459-6000

September 23, 1993

Mr. Phil Hilgert
Beak Consultants, Inc.
12931 Northeast 126th Place
Kirkland, WA 98034-7715

Dear Mr. Hilgert:

We appreciate the opportunity to review the Draft Youngs Creek Hydroelectric Project Resident Trout Monitoring Plan. We concur with the comments of Dr. Hal Beecher of the Department of Wildlife in his September 9 letter.

This is a very sound monitoring plan and is well written. We appreciate your excellent work and cooperation in addressing our concerns about project impacts on resident fish populations.

Please contact Brad Caldwell of my staff if you have any questions at (206) 459-6127.

Sincerely,

Hedia Adelsman
Program Manager
Water Resources Program

HA:JM:km

cc: Toby Freeman, Freeman Consulting
Lon Covin, Hydro West
Hal Beecher, Wildlife
Lynn Childers, USFWS
Bob Newman, NWRO Water Quality

CURT SMITCH
Director

STATE OF WASHINGTON
DEPARTMENT OF WILDLIFE
600 Capitol Way North • Olympia, Washington 98501-1091 • (206) 753-5700

September 9, 1993

Mr. Phil Hilgert
Beak Consultants, Inc.
12931 N.E. 126th Place
Kirkland, WA 98034-7715

Dear Mr. Hilgert:

Re: Youngs Creek Hydroelectric Project (FERC 10359) - Resident Trout Monitoring Plan

Thank you for your letter of August 24 enclosing the draft monitoring plan. The plan, with two changes discussed below, will address our concerns for monitoring the trout population before and after construction and operation of the Youngs Creek Hydroelectric Project. I believe the plan balances risks and uncertainties reasonably between the project proponent and the fish resource, allowing appropriate mitigation and evaluation. It will provide a basis for developing future monitoring plans. It is the result of a lot of thought and discussions, including consultation with a statistician. The Executive Summary explains clearly the philosophy and objectives of the monitoring plan.

The two recommended changes are in Exhibit C of the Appendix. In the last sentence of paragraph G, I suggest adding "(for subsequent catastrophe tests)" after "baseline" for clarification. In paragraph K the time period should be Years 2-4 rather than Years 2-5.

Sincerely,

Hal A. Beecher
Hydropower Project Coordinator

HAB:pd

cc: David Mudd
Gary Engman
Bill Frymire
Brad Caldwell (WDOE)
Lynn Childers (USFWS)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
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September 29, 1993

Phil Hilgert
Beak Consultants Incorporated
12931 N.E. 126th Place
Kirkland, Washington 98034-7715

Re: Youngs Creek Hydroelectric Project, FERC No. 10359
License Article No. 408, Resident Trout Monitoring Plan

Dear Mr. Hilgert:

The U.S. Fish and Wildlife Service (Service) has reviewed the referenced draft plan developed by Snoqualmie River Hydro (SRH) and state resource agency representatives. We offer the following comments for your consideration in developing a final plan for filing with the Federal Energy Regulatory Commission (FERC), prior to hydroelectric project operation on Youngs Creek.

<u>Innovative and Detailed Plan</u>
The draft *Resident Trout Monitoring Plan* dated August 1993 is notable in its innovation and overall attention to detail for monitoring resident trout in the 2.6-mile bypass reach of the Youngs Creek hydroelectric project. We are duly impressed by the proposed method of utilizing population trend analysis to assess changes in trout abundance. We are further impressed by the level of detail provided to direct such monitoring. We find the approach and detail level acceptable, except for as noted below.

<u>Habitat Feature Mapping and Photographic Documentation</u>
We recommend locational mapping be conducted to augment the proposed field procedure for identifying and selecting pools for surveying. This would be consistent with the intent of re-surveying the same pools in succeeding years to reduce sampling variability. In addition to pools, other key habitat features such as riffles, runs, and large organic debris should also be mapped. This graphic time-lapse data of habitat feature conditions in the bypass reach over the monitoring period may be useful in assessing project-related impacts and for adjusting flows at a future date. Such mapping would be complementary in providing a three-dimensional assessment of habitat to complement the two-dimensional information provided through IFIM data.

We further recommend that photographic documentation be undertaken as a component of the monitoring plan. Photographs should be taken in successive monitoring years for the same reference points and photo view direction recorded by compass bearing.

Petitioning Does Not Ensure Mitigation

The draft plan provides for resource agencies, specifically the Service and Washington Department of Wildlife, to petition the FERC for increased instream flows should there be a statistically significant decrease or negative change in resident trout populations over a five year monitoring period. The provision to petition does not constitute mitigation since an actual instream flow increase may not be realized as an outcome of the petition process.

To rectify this situation, we recommend that the monitoring plan be modified such that a guaranteed prescribed incremental flow augmentation is tied to levels or ranges of trout population declines and to catastrophic losses.

Previously, the FERC has rejected the applicant's and resource agencies' proposal to implement a preset flow augmentation schedule if trout populations suffer catastrophic losses or declining trends after project construction. The FERC staff has indicated that no biological justification has been provided for such a schedule. The Service would offer, however, that while direct causal relationships may not be easily demonstrated between instream flow and resource productivity, basic ecological precepts support the concept that flows most identical to pre-project flows are likely to support fish populations most identical to pre-project populations. Basic biological relationships exist as a result of water quantity.

For example, flow provides the living space in which fish forage, rear, travel, and reproduce. Increased flow, up to the point of maximum weighted useable area, results in increased living space and habitat diversity, resulting in less competition among individuals of a population, more abundant and diverse prey on which fish forage, and overall greater system stability with better capacity to absorb natural or artificial perturbations and recover from the same. Consequently, individuals in a population experience less stress, are more likely to have daily life requirements met, are better able to reduce energy expenditures, are more likely to find suitable spawning grounds, and are more likely to successfully reproduce. Survival and reproductive success of individuals in a population directly affects overall fish population trends (the basis of monitoring.)

Thus, it is difficult to deny that flow augmentation would result in incremental benefits to the Youngs Creek aquatic ecosystem and resident trout population, even though those benefits may be difficult to quantify. Accordingly, in seeking mitigative measures to help offset adverse impacts manifested in sudden or longterm trout populations declines, we believe augmented flows would provide a guarantee of mitigation. Actual mitigation, which the preset schedule would provide, is more meaningful than possible mitigation, for which the plan currently provides. In our experience with the FERC process, the likelihood of augmented flow implementation as a result of petitioning is remote. Therefore, a preset schedule would guarantee mitigation, streamline the process, and reduce conflict and/or negotiation in the future. Hence, the Service recommends incorporation of a flow schedule into the final monitoring plan.

We appreciate the opportunity to review the draft monitoring plan and provide these resource recommendations. Please contact Ms. Joanne Stellini of my staff if there are questions concerning these comments.

Sincerely,

For David C. Frederick
State Supervisor

js/ssk

c: WDE, Olympia (Brad Caldwell)
WDW, Olympia (Hal Beecher)
OAG, Olympia (William Frymire)
SRH, Bellevue (Lon Covin)

APPENDIX 3

RESPONSE TO AGENCY COMMENTS

Response to Washington Department of Ecology

Thank you for your input on the Youngs Creek Hydroelectric Project Resident Trout Monitoring Plan. The plan is the result of a concerted effort by the Snoqualmie River Hydro, Washington Department of Wildlife, and Ecology to establish a monitoring program to protect fisheries resources in Youngs Creek.

Response to the Washington Department of Wildlife

Thank you for your positive input on the Youngs Creek Hydroelectric Project Resident Trout Monitoring Plan. The applicant appreciates the chance to work closely with resource agencies to develop a monitoring program that is effective at protecting fisheries resources.

Table 1. Instream flow schedule for the Youngs Creek Project with fixed incremental adjustments (if required based on fish monitoring results).

Years of Project Operation	1-5 years	6-10 years	11-15 years	16+ years
Month	Licensed Minimum Flow Schedule	Flow Adjustment Schedule (if required)		
		1st	2nd	Upper Limit
January	3	6	9	12
February	3	6	9	12
March	3	6	9	12
April	3	6	9	12
May 1-15	8	8	9	12
May 16-31	40	40	40	40
June	40	40	40	40
July 1-15	40	40	40	40
July 16-31	22	22	22	22
August	22	22	22	22
September	22	22	22	22
October	3	6	8	8
November	3	6	9	12
December	3	6	9	12

Page 1, par. 1& 2. Thank you. The Youngs Creek Resident Trout Monitoring plan represents the combined effort of Washington Department of Wildlife (WDW), the Department of Ecology, as well as Beak Consultants and Snoqualmie River Hydro (SRH).

Page 1, par. 3.
Page 2, par. 1. Habitat mapping of study pools includes maximum depth, residual depth, total length and measurement of pool width at 25, 50, and 75 percent of pool length. In addition, photographs of each pool are taken during the annual surveys.

Page 2, par. 2-4. Snoqualmie River Hydro worked closely with the WDW and Ecology to develop an instream flow schedule for Youngs Creek. An instream flow schedule with incremental adjustments had been agreed upon in the event fisheries surveys detected significant or catastrophic declines in resident trout numbers (Table 1). The Federal Energy Regulatory Commission (FERC) did not agree with the instream flow schedule with incremental adjustments and declined to include it in the May 5, 1992 Order Issuing License.

Page 2, par. 5 & 6 The Youngs Creek instream flow schedule represents several years of site specific investigations. The results of two years of snorkel surveys, habitat surveys of the project reach and tributaries were considered in determining an appropriate instream flow schedule. In addition to the biological and physical surveys, SRH used the results of an Instream Flow Incremental Methodology (IFIM) to assess habitat:flow relationships in Youngs Creek.

The IFIM, developed by the National Ecology Research Center (USFWS), permits the quantification of changes in available habitat as functions of increases or decreases in streamflow. The methodology is based on the premise that suitability of a species' habitat can be described by measuring selected physical variables in the stream. This makes it possible to quantify the changes in habitat suitability by quantifying the changes in these instream variables. Thus, the effects of any increment of change in streamflow can be displayed in terms of changes in potential habitat suitability. The methodology does not predict actual production of fish; rather, the method predicts quantitatively the potential available habitat for particular species and life stages of fish.[1]

While it may seem intuitive that an increase in stream flow will increase fish production, this is not always the case. For example, in a high gradient stream with a constrained channel like the Youngs Creek project, increasing the instream flow may lead to increased velocities with only a very small increase in total wetted stream area. Rather than an increase in habitat and presumably fish

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[1]National Ecology Research Center. 1980. The incremental approach to the study of instream flows. Western Energy and Land Use Team, Office of Biological Services, Fish and Wildlife Service, Fort Collins, Colorado. W/IFG-80/W31.

Page 2, par. 5 & 6

production, the higher flow may render areas unsuitable for use by resident fish. The net result will be a decrease in fish habitat with a higher instream flow. The National Ecology Research Team noted this relationship and stated "a larger instream flow does not necessarily mean more fish habitat" (Bovee 1982, USFWS Instream Flow Information Paper no. 12, pg 86). In addition, an instream flow that maximizes habitat for one life stage may do so at the detriment of another life stage.