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STATE OF WASHINGTON
Dixy Lee Ray
Governor

DEPARTMENT OF ECOLOGY
7272 Cleanwater Lane, Olympia, Washington 98504 206/753-2353

M E M O R A N D U M

October 31, 1977

To: Jim Krull

From: John Bernhardt

Subject: Resource Damage Assessment
Nisqually River Fish Kill, August 19, 1977

INTRODUCTION

During the early morning of Friday, August 19, 1977, the Milwaukee Railroad Company's trestle at McKenna, Washington, collapsed, dumping four hopper cars loaded with 300-400 tons of partially-processed copper ore into the Nisqually River.

The Department of Ecology and Environmental Protection Agency conducted chemical investigations to evaluate impacts on water quality and stream sediment in the river below the spill site. Biological investigations were conducted by the Washington Departments of Ecology, Game and Fisheries and U.S. Fish and Wildlife Service to assess damages caused to fish life inhabiting the stream.

This report summarizes the results of the DOE, WDF, WDG and USFWS field investigations relating to the Nisqually River ore spill and estimates the monetary value of the fishery resources damaged.

LOCATION AND DESCRIPTION

Milwaukee Railroad Company's McKenna trestle is located in Section 28 Township 17 North, Range 2 East, on the Thurston/Pierce County line near the small residential community of McKenna. The study encompassed a 19-mile section of the Nisqually River extending from the McKenna trestle downstream to the Olympia/Tacoma Highway I-5 Bridge at Nisqually Delta (Enclosures 1A to 1C).

The Nisqually River flows below the McKenna trestle averaged about 750 cfs during August 1977. Stream flow fluctuates somewhat depending upon water diversions at Centralia Diversion Dam located about 5 miles above McKenna. Stream width generally ranges from 50-150 feet with depth from 2 to over 10 feet. The lower river is composed mainly of runs and riffles with some pools.

Coho, chinook and chum salmon, steelhead and cutthroat trout, whitefish, sculpins, suckers, etc. utilize the lower Nisqually for migration and production.

CHEMICAL INVESTIGATIONS

Four investigations were conducted to identify factors that may have caused or contributed to the Nisqually River Fish Kill: (1) COMPOSITION OF THE COPPER ORE CONCENTRATE, (2) WATER QUALITY SAMPLING, (3) STREAM SEDIMENT SAMPLING and (4) STATIC BIOASSAY. The results of these investigations follow.

1. COMPOSITION OF THE COPPER ORE CONCENTRATE

According to Milwaukee Railroad Company representative, Kevin Hershey, some 300-400 tons (200 to 270 cubic yards) of copper ore concentrate were dumped into the Nisqually River when the McKenna trestle collapsed on August 19. He provided the following information concerning the general composition of the ore concentrate:

MAIN CONSTITUENTS (Percent by weight)		TRACE ELEMENTS (One percent or less)		ADDITIVES (Amounts present unknown)
Copper	26%	Aluminum	Nickel	Sodium Hydrosulfite
Sulfur	25%	Silver	Lead	Potassium Amyl Xanthate
Iron	23%	Gold	Antimony	R-23
Silica	10%	Bismuth	Tellurium	
Zinc	4%	Arsenic		
Lime	1.5%			

The ore was mainly comprised of chalcopyrite ($CuFeS_2$), a highly insoluble mineral with the consistency of black sand.

Elemental copper and zinc, two key metals in the ore, demonstrate a low solubility in water but are extremely toxic to fish in the ionized (dissolved) form. For freshwaters chemically similar to the lower Nisqually River (pH, temperature, hardness, etc.) copper can be toxic to juvenile rainbow when concentrations exceed about 0.02 mg/l (EPA, 1976). Copper appears to be more toxic to young and juvenile fish than adults. Zinc has been shown to be toxic to young rainbow trout at about 0.09 mg/l (ibid). Copper and zinc together act synergistically to increase the toxicity of each acting alone (McKee and Wolf, 1963).

In the form of sulfides ($CuFeS_2$ is a sulfide with low solubility) sulfur is highly toxic and can damage fish life at about 0.5 mg/l (ibid). Ionized iron can be toxic to fish when concentrations exceed about 1.0 mg/l (EPA, 1976). Lime is somewhat less toxic with about a 100 mg/l threshold (Hawley, 1972). Silicates are not directly toxic (EPA, 1976; McKee et al, 1963).

In the interest of brevity, toxic limits for the various trace elements are not covered due to the small amounts present.

The amounts of the three additives present in the ore are not known. Of these, Sodium Hydrosulfite is a depressing agent (assists in separating one mineral from another) with a toxic level of about 100 mg/l or less (Hawley, 1972). Potassium Amyl Xanthate is a toxic compound (floatation agent) that has been shown to kill fish at about 1.8 mg/l (ibid). R-23 is a silicone product non-toxic to fish life.

It is important to note that the lethal concentrations given for the above ore components do not consider sublethal effects, synergistic effects, (in addition to the copper and zinc) or the possibility of changes in toxicity with changing stream conditions such as pH, temperature, hardness, etc. In addition, the ore may have contained some toxic elements of which we are not aware.

2. WATER QUALITY SAMPLING

Water quality sampling was conducted mainly by the Department of Ecology with some additional samples being collected by the Environmental Protection Agency.

Methods

Samples were collected at seven stations located at intervals along the 9-mile section of the Nisqually River between the town of McKenna and the Centralia Hydroelectric Powerhouse (Enclosures 1A and 1B). Stations 1 and 2 were sampled periodically during the first two days following the spill. Daily samples were collected from six stations through August 31. One sample was collected from Station 7.

The samples were analyzed for the following chemical parameters:

1. Metals - Copper, zinc, cadmium and lead with one set of samples analyzed for 35 different metals.
2. pH.
3. Temperature (°C).
4. Specific Conductance (umhos/cm).
5. Dissolved Oxygen (mg/l).
6. Turbidity (NTU).
7. Total Hardness.
8. Sodium Hydrosulfite.
9. Potassium Amyl Xanthate.
10. R-23.

All of the parameters listed above were not measured at all stations during each survey effort. Chemical sampling was timed to coincide with biological sampling.

Results

The water quality sampling results for copper and zinc, the two key metal constituents in the ore, are summarized in Enclosure 2.

Concentrations of dissolved copper in the Nisqually River below McKenna trestle exceeded the .020 mg/l lethal threshold for about three days after the spill occurred. On August 20 (one day after the spill) copper concentrations appeared to exceed safe levels for some 19 miles of river, being .05 mg/l immediately below McKenna trestle .025 - .03 mg/l near Highway I-5 at Nisqually Delta. Copper concentrations remained at high levels in the lower Nisqually for one more day (August 21), then returned to prespill concentrations during the next two days. Only background levels of copper were detected in the lower Nisqually after August 23, except in one sample collected on August 24 immediately below McKenna trestle.

Dissolved zinc concentrations increased in the lower Nisqually following the spill and reached critical levels on August 21 (two days after the spill) when the lethal threshold of about 0.09 mg/l was exceeded in the 2 to 3 mile stretch of river immediately below the spill site. Overall, zinc appeared to exceed background levels for about 9 miles below McKenna trestle (Enclosure 2).

Chemical analyses indicated that concentrations of the other 33 metals did not reach toxic levels.

pH levels in the lower Nisqually River did not change significantly following the spill, ranging from 6.9 to 7.5 during sampling. A test conducted at the DOE analytical laboratory indicated pH in the Nisqually River may have dropped slightly immediately after the spill occurred but not enough to adversely affect fish life.

Water temperatures in the lower Nisqually River ranged from 12.5°C to 17°C during the study, well within acceptable temperature limits for salmonids. Specific conductivity was 75 to 80 umhos/cm. Dissolved oxygen content in the lower Nisqually averaged about 10 mg/l following the spill.

Turbidity in the lower Nisqually River appeared to increase somewhat as a result of excavation activities near McKenna trestle.

Total hardness of Nisqually River waters was 14 to 20 mg/l at the time of the ore spill. This is an important factor because trout are known to be much more susceptible to the toxic effects of copper in soft waters (less than about 75 mg/l) than hard waters (NAS, 1974).

Water quality analyses for the sodium hydrosulfite, Potassium Amyl Xanthate and R-23 have not been completed by EPA as of the writing of this report.

3. SEDIMENT MONITORING

Nisqually River bottom sediments were collected by Environmental Protection Agency representative, Joseph Cummins on August 19 and 29, 1977, to monitor downstream movement of the copper ore concentrate.

Methods

Sediment grab samples were collected at eleven stations located along the 19-mile stretch of the lower Nisqually River between McKenna (1/4 mile above McKenna trestle) and the Highway I-5 Bridge at Nisqually Delta (Enclosures 1A to 1C).

The samples were analyzed for metal content by the EPA analytical laboratory at Manchester, Washington. Information regarding the analytical methods can be obtained from EPA.

For the purposes of this report, total copper content in the river sediments is used as an indicator of downstream movement of the parent ore concentrate.

Results

Enclosure 3 gives the analytical results for total copper content in the Nisqually River sediment samples collected. The amounts are given in ppm dry weight (ug/g).

These data indicate some ore concentrate had moved more than one mile below the spill site as of August 19 afternoon. By August 29 the river had carried ore at least 7 1/2 miles below the spill site, and some may have been transported as much as 19 miles downstream.

4. DOE STATIC BIOASSAY

A 96-hour static bioassay was conducted by DOE to establish whether or not the copper ore concentrate contained properties toxic to fish life. The methods and results of this investigation are outlined in the DOE memorandum entitled "96-hour Static Bioassay Results on Ore from Nisqually River Spill", by Don Kjosness dated October 7, 1977 (Enclosure 4).

Briefly, the static bioassay verified that the ore contained soluble substances toxic to fish life. The lowest concentration where a mortality occurred was 10 grams ore/10 liters water or 1000 mg/l. The 10 grams ore per 10 litre water sample contained 0.07 mg/l dissolved copper and 3.81 mg/l of dissolved zinc. Concentrations of .01 mg/l copper and .04 mg/l zinc were present at the next dilution level of 1 gram ore per 10 litres water.

BIOLOGICAL INVESTIGATIONS

Four field investigations were conducted in an attempt to evaluate damages caused to fish life in the Nisqually River by the McKenna trestle failure. These included (1) USFWS STREAM SURVEYS, (2) WDF STREAM SURVEY, (3) DOE, WDG AND WDF ELECTOFISHING SURVEYS and (4) DOE 96-HOUR BIOASSAY. The results of these investigations are summarized below:

1. USFWS STREAM SURVEYS.

During August 20-September 2, stream surveys were conducted in the 17-mile section of the Nisqually River extending from one mile below

McKenna trestle downstream to the Highway I-5 Bridge at Nisqually Flats (Enclosures 1A to 1C). The methods and results of this effort are documented in the September 19, 1977, USFWS report entitled "Nisqually Copper Concentrate Spill", by Donald L. Cole (Enclosure 5).

With respect to the number of fish killed, the key portion of the USFWS report is the final paragraph which states "it seems likely that the 19,300 extrapolation from the index counts is very conservative of the kill of salmonids in the Nisqually River. Realistically, it can be assumed that the minimum magnitude of the salmonid kill was two to three-fold of the foregoing estimate." This would place the fish kill at a minimum of 50,000 to 60,000 fish.

All of the salmonids in a carcass sample collected by USFWS for biological examination were identified as rainbow trout, Salmo gairdnerii. General observations of dead and dying fish made during the USFWS surveys indicated fish mortalities may have occurred as far downstream as the Nisqually mouth, some 19 miles below the McKenna trestle (personal communication, Donald L. Cole).

2. WDF STREAM SURVEY

On August 21 WDF conducted surveys at five stations spaced along a one-mile section of the Nisqually River located about 8 miles below McKenna trestle (Enclosure 1B). The methods and results of this survey are outlined in detail in the August 31, 1977, WDF memorandum to Bill Rees and Earl Finn entitled "Nisqually River Sampling, August 21, 1977," by Grant Fiscus (Enclosure 6).

WDF estimated that 39,030 juvenile trout were killed in the 8.8-mile section of the Nisqually River between McKenna trestle and the powerhouse on August 21, two days after the trestle failed. The fact that the WDF estimate applied to only about the upper one-half of the river area affected by the ore spill and encompassed only one day of losses suggest that a realistic estimate for the overall kill would be 75,000 to 100,000 fish.

All of the salmonids observed during the WDF survey were juvenile trout.

3. DOE, WDG, WDF ELECTROFISHING SURVEY

An attempt was made to estimate the fish kill magnitude using the removal method of estimation (Zippin, 1958). However, flow in the Nisqually River was too great to effectively use this approach.

The limited electrofishing data that were obtained are summarized in Enclosure 7. These data show that good numbers of salmonids, mainly rainbow trout, inhabited Nisqually River above McKenna trestle after the spill and, most importantly, that a fair number of salmonids survived the effects of the ore spill immediately below the trestle where the maximum adverse impact would be expected.

4. DOE 96-HOUR IN-SITU BIOASSAY

On August 20 fish liveboxes each containing 25 juvenile rainbow trout were placed at six locations along the 8.8-mile section of the Nisqually River between McKenna trestle and the Centralia Hydroelectric Powerhouse (Enclosures 1A and 1B). The intent was to monitor effects following the ore spill.

The in-situ bioassay results are presented in Enclosure 8. Over 50% of the trout at the station located 1/4 and 1 1/4 mile in the Nisqually River below McKenna trestle died during the 48-hour period beginning Saturday noon, August 20. The livebox fish were not exposed to the initial impacts of the spill that occurred on Friday, August 19. Liveboxes further downstream experienced 100% survival throughout the study period.

SUMMARY AND DISCUSSION

The various chemical and biological data collected during the Nisqually River fish kill investigation indicated the kill was caused principally by toxic soluble constituents of the copper ore concentrate spilled at McKenna trestle on August 19, 1977. Several other factors also may have contributed to the problem.

A specific agent was not identified as the element in the ore that killed the fish. The kill probably occurred as a result of the combined effects (additive and synergistic) of several chemical constituents, including the heavy metals such as copper and zinc, various chemical compounds, and additives such as Potassium Amyl Xanthate.

The lowering of Nisqually River flow shortly after the ore spill occurred may have contributed to the kill, but this effect is thought to have been negligible because no dead fish (stranded) were observed above the spill site after the flow was dropped. WDF representatives Bill Rees and Earl Finn, both familiar with fish stranding problems that develop when river flows drop rapidly, felt that such losses were negligible in this case (personal communication). Drawdown was required to efficiently remove the ore from the river.

Ore cleanup operations probably contributed to the kill by increasing turbidity and ore transport downstream. Again, these activities were necessary to remove the spilled ore.

USFWS data indicated that fish mortalities occurred in the lower Nisqually River during the 3-day period of August 20 to 22, then tapered off over the next few days.

The USFWS and WDF survey data placed the fish kill magnitude at somewhere between 50,000 and 100,000 juvenile steelhead trout in the 19-mile affected area between McKenna trestle and the river mouth. Based on these data, an overall estimate of 75,000 fish would seem appropriate for this monetary assessment. This figure is conservative of the total

damages since it does not include losses of whitefish, coho salmon fingerlings, and cutthroat trout, which were known to be in the lower river in small numbers when the spill occurred. Non-game fish mortalities such as dace, sculpins, etc. also were not included.

MONETARY LOSS ESTIMATE

According to Chapter 90.48.142 RCW, the violator in fish kill cases "will pay the state damages in an amount equal to the sum of money necessary to restock such waters, replenish such resources, and otherwise restore the stream, lake or watercourse to its condition prior to injury as such condition is determined by the Department of Ecology". Under the "restock such waters" provision of this statute the violator is required to pay the cost of restocking the damaged stream with hatchery-reared fish. Restocking a stream in this manner does not actually replace the fish killed but simply amounts to moving fish from one hatchery production area to another while the fishery resource population remains static. Therefore, under the "replenish such resources" provision of the statute, the violator also must pay for the value of the fish killed had they survived to adulthood to enter the sport or commercial fisheries or return to their natal stream as spawners.

The monetary value of the estimated 75,000 juvenile steelhead trout mortality was calculated at $50,241.25 using the standard Department of Ecology Evaluation Form (Enclosure 9).

For clarification of the Fish Kill Evaluation Form, the information given in paragraphs 1 to 4 were provided by WDG in the October 20, 1977, memorandum from Jack Ayerst to John Bernhardt entitled "Nisqually River Fish Kill" (Enclosure 10).

Paragraphs 1 and 2 give estimates of the actual fish loss and adult returns to the fisheries. The WDG report provided estimated values of $41,146.00 for the Sport and Commercial Fishery Losses (paragraph 3, Fish Kill Evaluation Form) and $3,665.25 for the restocking costs (paragraph 4). The $5,430 in repropogation cost (paragraph 5) is the value of the eggs produced by the adults that would have matured and spawned, had the kill not occurred.

JB:ee

LITERATURE CITED

Hawley, John R. 1972, The Use, Characteristics and Toxicity of Mine-Mill Reagents in the Province of Ontario, Ministry of the Environment, Ontario, Canada. 244 p.

McKee, Jack Edward and Harold W. Wolfe 1963. Water Quality Criteria, The Resources Agency of California, State Water Quality Control Board, Publication No. 3-A.

National Academy of Sciences, National Academy of Engineering, 1974. Water Quality Criteria, 1972. U. S. Government Printing Office, Washington, D. C., EPA R3-73-033-March 1973.

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Zippin, Calvin. 1958. The Removal Method of Population Estimation, Journal of Wildlife Management, Vol. 22, No. 1, January 1958. 9 p.

LIST OF ENCLOSURES

1A to 1C. Map Depicting Stations Sampled by Various Agencies to Evaluate Environmental Damages Caused by Milwaukee Railroad Company's Nisqually River Copper Ore Spill, August 19, 1977.

2. Daily Concentrations of Dissolved copper and Zinc in Water Samples Collected by DOE on the Nisqually River during August 19 to 31, 1977.

3. Concentrations of Total Copper in Sediment Samples Collected by EPA from the Lower Nisqually River during August 19 and 20, 1977.

4. Memorandum from Don Kjosness to John Bernhardt entitled "96-hour Static Bioassay Results on Ore from Nisqually River Spill", October 7, 1977.

5. Memorandum from Fishery Management Biologist (Donald O. Cole) to John Bernhardt entitled "Nisqually Copper Concentrate Spill", September 19, 1977.

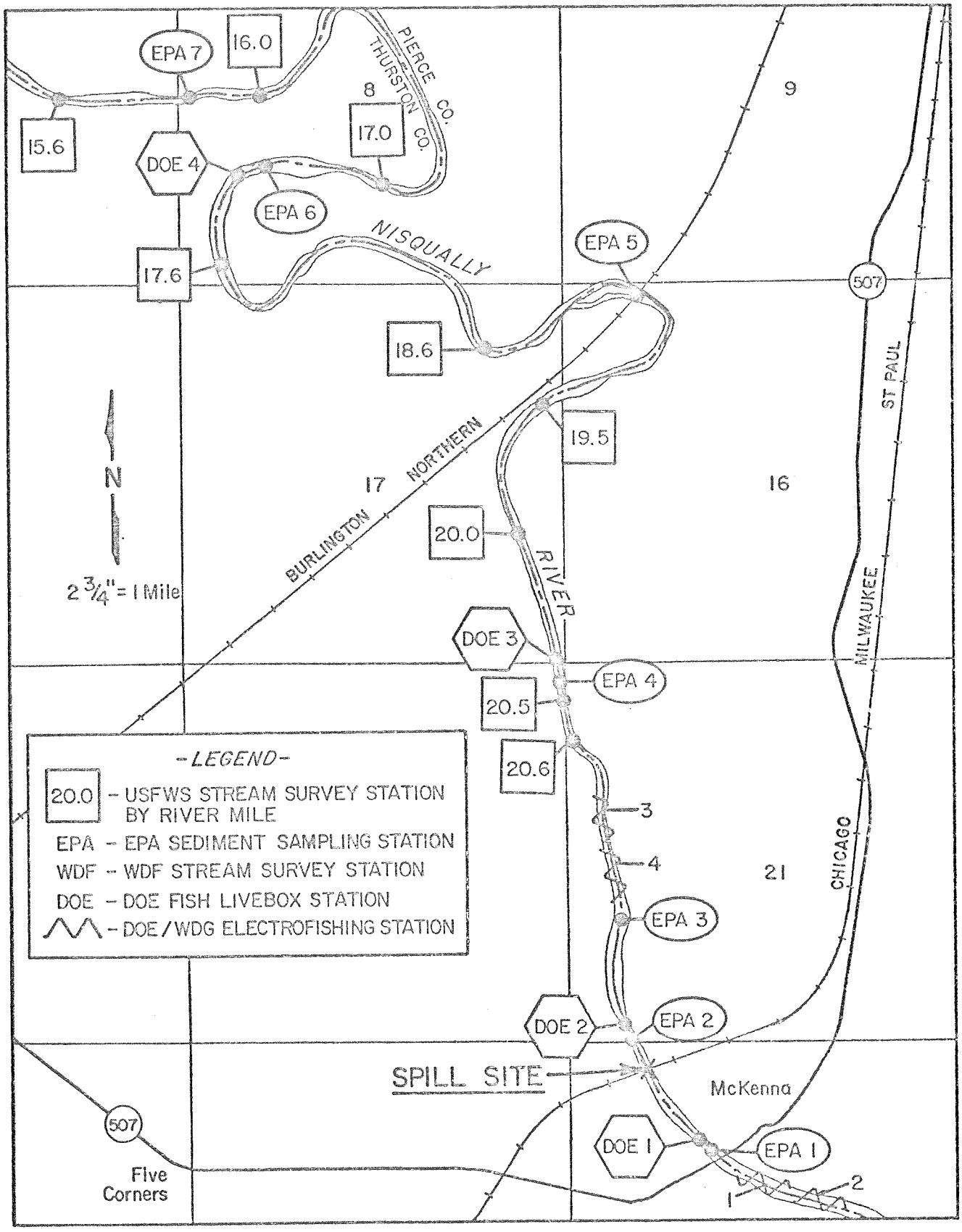
6. Memorandum from Grant Fiscus to Bill Rees and Earl Finn entitled "Nisqually River Sampling, August 21, 1977", August 31, 1977.

7. Nisqually River Copper Ore Spill, Summary of Electro-fishing Data Collected by DOE, WDG and WDF personnel during August 24, 1977.

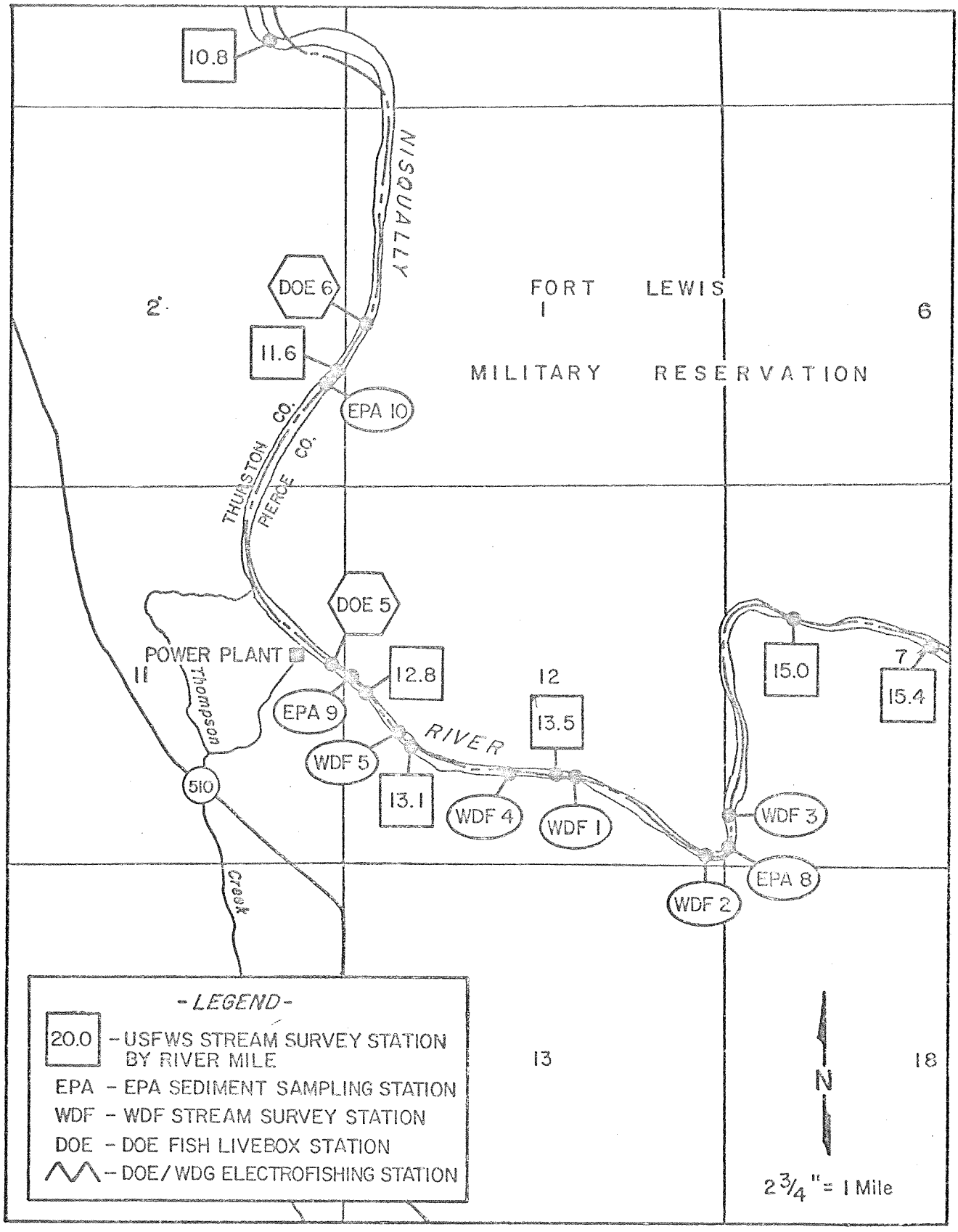
8. Summary of 96-hour In-situ Bioassay Conducted by DOE to Monitor Effects of August 19, 1977, Copper Ore Spill on Fish Life in the Nisqually River.

9. State of Washington, Department of Ecology Fish Kill Evaluation Form, Nisqually River Fish Kill, August 19, 1977.

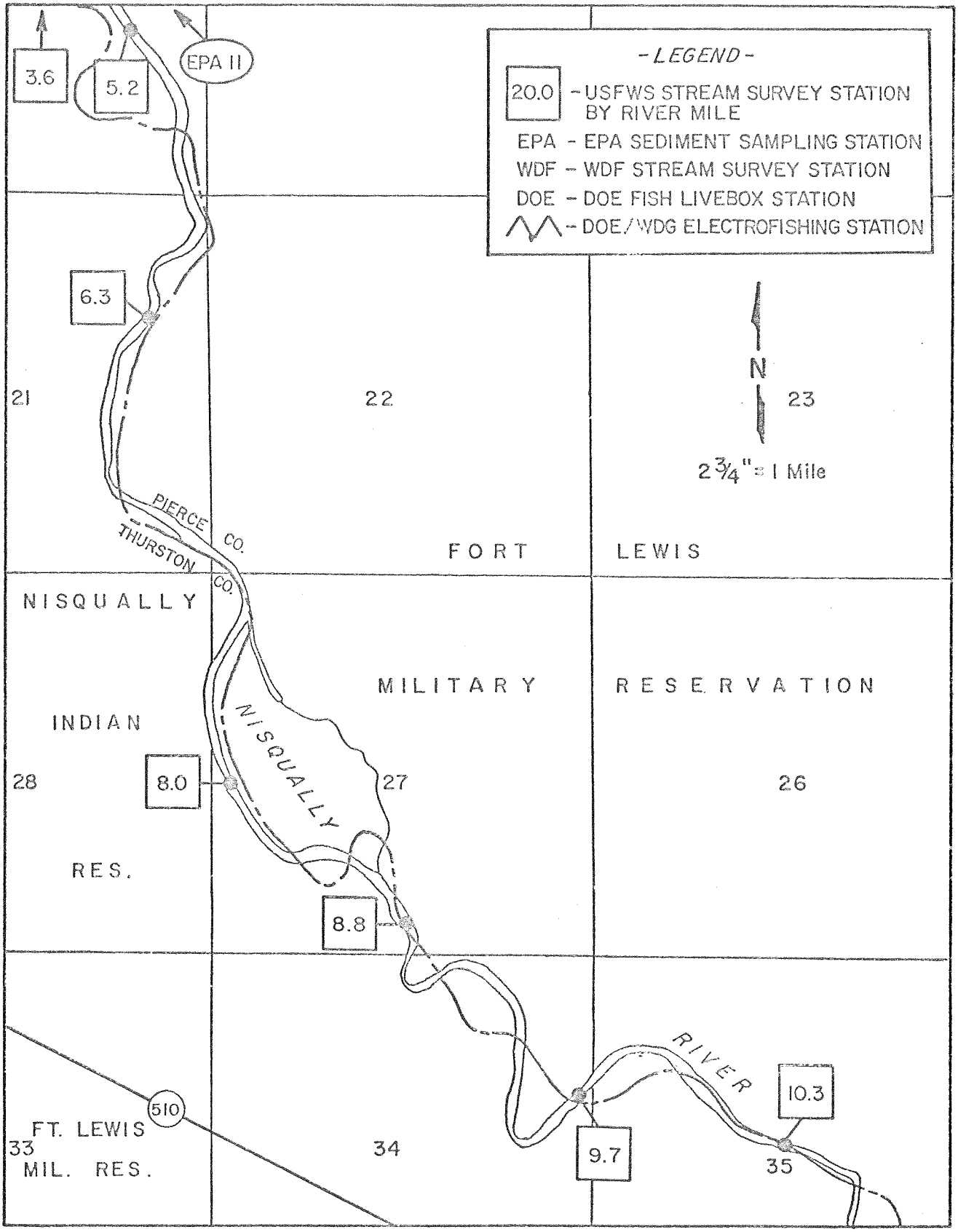
10. Memorandum from Jack Ayerst to John Bernhardt entitled "Nisqually River Fish Kill", October 20, 1977.



Enclosure 1A. MAP DEPICTING STATIONS SAMPLED BY VARIOUS AGENCIES TO EVALUATE ENVIRONMENTAL DAMAGES CAUSED BY MILWAUKEE RAILROAD COMPANY'S NISQUALLY RIVER COPPER ORE SPILL, AUGUST 19, 1977.



Enclosure 1B. MAP DEPICTING STATIONS SAMPLED BY VARIOUS AGENCIES TO EVALUATE ENVIRONMENTAL DAMAGES CAUSED BY MILWAUKEE RAILROAD COMPANY'S NISQUALLY RIVER COPPER ORE SPILL, AUGUST 19, 1977.



Enclosure IC. MAP DEPICTING STATIONS SAMPLED BY VARIOUS AGENCIES TO EVALUATE ENVIRONMENTAL DAMAGES CAUSED BY MILWAUKEE RAILROAD COMPANY'S NISQUALLY RIVER COPPER ORE SPILL, AUGUST 19, 1977.

Enclosure 2. Daily Concentrations of Dissolved Copper and Zinc in Water Samples Collected by DOE on the Nisqually River during August 19-31, 1977

TYPE ANALYSIS	STATION NUMBER	STREAM LOCATION	CONCENTRATION IN MG/L BY AUGUST DATE COLLECTED [1]												
			19	20	21	22	23	24	25	26	27	28	29	30	31
Copper (Dissolved)	1	Above RR trestle	/.01K	/.02	.01K/.02	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K
"	2	½ mile below	/.05	.05/.05	.05/.05	.01	.01	.05	.01K	.01K	.01	.01K	.01K	.01K	.01K
"	3	1½ miles below			.05/.08	.02	.03	.01	.01K	.01K	.01	.01K	- -	.01K	
"	4	4 miles below			.03/.025	.03	.02	.01	.01K	.01K	.01K	.01K	.01K	.01K	
"	5	8½ miles below			.03/.03	.02	.02	.01	.01K	.01K	.01K	.01K	.01K	.01K	
"	6	10 miles below		/.025	.01/.01	.01	.01	.01	.01K	.01K	.01K	.01K	.01K	0.1K	
"	7	19 miles below	/.01	/.03	/.01K										
Zinc (Dissolved)	1	Above RR trestle	/.01	.01	.01K/.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K	.01K
"	2	½ mile below	/.02	.03/.03	.07/.18	.02	.015	.03	.01K	.01K	.02	.01K	.01K	.01K	.01K
"	3	1½ miles below			.13/.32	.04	.02	.015	.01K	.01K	.02	.01K	- -	.01K	
"	4	4 miles below			.02/.01K	.03	.03	.015	.01K	.01K	.01	.01K	.01K	.01K	
"	5	8½ miles below			.015/.01K	.015	.025	.015	.01K	.01K	.01K	.01K	.01K	.01K	
"	6	10 miles below		.01	.01K/.01K	.015	.01K	.01	.01K	.01K	.01K	.01K	.01K	.01K	
"	7	19 miles below	/.02	.01	/.01K										

[1] A number following a slash represents the concentration in a sample collected by EPA.
K After a value = less than.

Enclosure 3. Concentrations of Total Copper in Sediment Samples Collected by EPA from the Lower Nisqually River during August 19 and 20, 1977

Station Number	Location	August 19 (ppm)	August 29 (ppm)
1.	½ mile above spill site	28 (RB)[1/]	25 (RB)
2.	At spill site [2/]	- -	16,600 (RB)
	100 yds. below spill site	- -	37,000 (RB)[3/]
	200 yds. below spill site	48,000 (RB)	1,040 (CSC)
	20 yds. above filter dam[4/]	82,000 (RB)	900 (CSC)
	20 yds. below filter dam	- -	360 (CSC)
3.	1/3 mile below spill site	22,800 (RB)	14,600 (CSC)
4.	1 mile below spill site	22,800 (RB)	8,000 (RB)
5.	2½ miles below spill site	- -	420 (LB)
6.	4½ miles below spill site	- -	420 (LB)
7.	5½ miles below spill site	- -	472 (RB)
8.	7½ miles below spill site	- -	312 (RB)
9.	9 miles below spill site	84 (LB)[5/]	54 (LB)
10.	10 miles below spill site	- -	46 (LB)
11.	19 miles below spill site	30 (RB)	52 (RB)

1/ Sample collected from river bed near right bank, looking downstream.

2/ Station 2 is a general area located immediately below spill site.

3/ Cross section composite, a mix of sediment from right bank, left bank, and midstream.

4/ Located about ½ mile below spill site.

5/ Sample collected from river bed near left bank, looking downstream.

STATE OF
WASHINGTON

Dixy Lee Ray
Governor

DEPARTMENT OF ECOLOGY

7272 Cleanwater Lane, Olympia, Washington 98504 206/753-2353

MEMORANDUM

October 7, 1977

To: John Bernhardt
Biological and Chemical Investigation

From: Don Kjosness
Olympia Enviornmental Laboratory

Subject: 96-hour Static Bioassay Results on Ore
from Nisqually River Spill

Sample Identification:

Laboratory Reference Number: 775106
Date Sample Received: 8/19/77
Sample Submitted By: Bill Purvis
Sample Description: The sample was a fine particled gray-green colored ore

Test Procedure:

The sample was tested for toxic properties in accordance with the Department of Ecology Olympia Environmental Laboratory Procedure "Static-Bioassay Techniques for the Evaluation of Industrial Effluents on Salmonid Fishes," 1974.

Test Details

Five (5) ten (10) gallon glass aquariums were placed in a fish rearing trough. Into each aquarium was added ten (10) liters of tap water from the Tumwater water system with varying amounts of ore or ore extracts.

Aquarium #1 had ten (10.0) grams of ore added to each liter of water. This equaled 100 g./10 liters.

Aquarium #2 had 100 g. of ore which was heated to boiling in one (1) liter of tap water. This was filtered and the one (1) liter of filtered extract was added to nine (9) liters of tap water.

Aquarium #3 had 10 g. of ore which was added with the same method as described for aquarium #2.

Aquarium #4 had 1 g. of ore which was added with the same method as described for aquarium #2.

Aquarium #5 had 10 liters of tap water and was used as the control aquarium.

Enclosure 4

The test organisms were coho salmon (Oncorhynchus kisutch). They averaged 59 cm in length. The longest fish used was 65 cm and the shortest 54 cm, giving a length ratio of 1:1.2. They averaged 1.12 grams each.

Ten fish were added to each aquarium, giving a flesh-to-sample ratio of 1.12 grams/liter.

The test was started on 8/22/77 at 1400 hrs. and completed on 8/26/77 at 1400 hrs.

TEST RESULTS

Aquarium #1 - 100g./10 liters

Date (hours)	Temperature °C	Dissolved Oxygen ppm	pH, 25°C	Mortalities
8/22 - 0	15.6	9.5	7.2	0
8/23 - 24	14.0	10.2	7.3	10
			TOTAL	10 (100%)

Aquarium #2 - 100g./10 liters (filtered)

8/22 - 0	16.2	9.5	7.2	0
8/23 - 24	14.2	10.1	7.4	10
			TOTAL	10 (100%)

Aquarium #3 - 10g./10 liters (filtered)

8/22 - 0	16.5	9.3	7.5	0
8/23 - 24	14.2	10.1	7.7	10
			TOTAL	10 (100%)

Aquarium #4 - 1g./10 liters (filtered)

8/22 - 0	17.0	9.3	7.7	0
8/23 - 24	14.2	10.0	7.7	0
8/24 - 48	14.0	10.2	7.7	0
8/25 - 72	14.0	10.1	7.6	0
8/26 - 96	14.2	9.8	7.5	0
			TOTAL	0 (0%)

Aquarium #5 - Control

8/22 - 0	15.6	9.5	7.6	0
8/23 - 24	14.0	8.9	7.5	0
8/24 - 48	14.0	9.6	7.6	0
8/25 - 72	14.1	10.2	7.6	0
8/26 - 96	14.2	9.9	7.6	0
			TOTAL	0 (0%)

Conclusions

The fact that fish died under the conditions of the test indicates the presence of water soluble toxic substances in the ore.

DK:ee

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Fisheries Assistance Office
2625 Parkmont Lane, Bldg. A
Olympia, Washington 98502

September 19, 1977

MEMORANDUM

To : John Bernhardt, Washington Department of Ecology, Olympia, Washington

From : Fishery Management Biologist, Fisheries Assistance Office, Olympia, Washington

Subject: Nisqually Copper Concentrate Spill

Fisheries Assistance Office (FAO) began monitoring the Nisqually River on August 20, the morning after the copper concentrate spill. Two crews floated the river, one from the spill site to river mile 13.1 and the other from river mile 13.1 to 3.7. We established indexes on the river and from within these indexes removed, to the extent possible, all dead fish. The fish were then brought back to our lab and frozen for later analysis. The indexes were monitored on a regular basis from August 20 to August 25. One survey of the lower river indexes was also made on September 2. The surveys were not continued on a regular basis after August 25 because recoveries of carcasses had declined to virtually zero and heavy rains had increased the turbidity of the lower river to the point that dead fish could not be seen even in shallow water.

The results of the index surveys are presented in Tables 1 and 2. Table 1 details the surveys which were conducted in the area from the spill to the Centralia Power House (river mile 12.7). Table 2 details the lower river index surveys.

Tables 1 and 2 indicate that dead salmonids, cottids, suckers, lampreys, and whitefish were recovered following the spill. A sample of the salmonids recovered was identified as to species. All of the salmonids in the sample were juvenile rainbow, Salmo gairdneri. Table 3 shows the average length of the salmonids recovered. In both sections of the river, the average length of the salmonid carcasses recovered increased on each successive survey; the average length approximately doubling between the first and third or fourth days following the spill.

Enclosure 5

One thing that our sampling indicated was that the fish kill did not continue for an extended length of time. In the section of the river between the spill and the Centralia Power Plant, the kill of salmonids primarily occurred within 72 hours of the spill. Below the power plant, 90% of the salmonid mortalities occurred within 96 hours of the spill.

The total number of salmonid mortalities per length of stream surveyed was determined to be one per 1.95 yards within the area from the spill to the power plant and one per 12.7 yards in the section below the power plant. A straight extrapolation of these index counts to the area from the spill to the mouth, yields an estimate of 19,320 salmonids. However, the loss of fish to scavengers and the inability of the surveyors to recover carcasses in certain situations certainly indicates that 19,320 is a conservative estimate of the magnitude of the fish kill. Taube (1974)* discusses some of the problems in estimating the size of a fish kill and indicates that such estimates are usually low. Two reports by Phinney (1974)** indicate that scavenging can be a problem in estimating the size of fish kills resulting from stranding. In one instance, 45 chinook fry were scattered along the bank of the Lewis River. One hour later, only 20 remained. On the Skagit River, 70 dead fry were scattered in an area containing an additional 50 to 100 fry. A short time later, the area was reexamined and no fry were found.

Another factor contributing to the potential low overall mortality count is that only a small fraction of the total wetted area of the stream was sampled. Generally, the surveyors could only sample a narrow band of shoreline. This was a particular problem in the area above the power plant before the river flows were reduced and throughout the surveys in the lower river. Even in the shoreline areas that could be sampled, total recovery of carcasses was very unlikely. Some juvenile fish were lodged in rocks or covered with silt and were probably not seen. Also, a significant percentage of carcasses probably drifted downstream and settled in deep pools. These areas could not be sampled during our surveys.

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* Taube, C.M. 1974. Disappearance of dead fish and assessment of mortality. Michigan Dept. of Natural Resources, Fish. Res. Dept. #1812 (DJ F-31-R), mimeo, 12 p.

** Phinney, L.A. 1974. Further observation on juvenile salmon stranding in the Skagit River, March 1973. Wash. Dept. of Fish., Progress Rpt. #26, 34 p.

** Phinney, L.A. 1974. Report on the 1972 study of the effect of river flow fluctuations below Merwin Dam on downstream migrant salmon. Wash. Dept. of Fish., 23 p.

A final indication of the lack of visibility of dead fish can be obtained from adult population studies conducted in the Nisqually River. Since 1974, FAO has been tagging adult Nisqually River chum salmon. As part of this program, extensive surveys were conducted to recover spawned out carcasses to be examined for tags. The flow conditions during the 1976-77 study were ideal for recovery of carcasses and yet only about 3,000 of an estimated 24,000 carcasses were recovered during 56 separate surveys on the river, even though many of the surveys were done on small tributary streams where visibility was good and a high percentage of the carcasses present could be recovered. Also, it should be kept in mind, that these were large fish averaging eight to ten pounds and not small fragile salmonids that could be expected to disappear quickly.

In conclusion, it seems likely that the 19,300 extrapolation from the index counts is a very conservative estimate of the kill of salmonids in the Nisqually River. Realistically, it can be assumed that the minimum magnitude of the salmonid kill was two to three-fold of the foregoing estimate.

Donald L. Cole

Donald L. Cole

DLC:am

Attachments: Tables 1, 2, and 3

cc: Steve Wilson (Nisqually Tribe)
Earl Finn (Washington Department of Fisheries)
Jack Ayerst (Washington Department of Game)
Marshall Cutsforth (Bureau of Indian Affairs)
Hardy Pierce (Department of the Interior)
Jim Stephenson (Ft. Lewis)
Area Office - Olympia (U.S. Fish and Wildlife Service)

Table 1. Recoveries of fish carcasses during surveys of index areas on the Nisqually River between river miles 20.6 and 13.1.

Approximate River Mile	Yards Surveyed	MORTALITIES OBSERVED					
		August 20	August 21	August 22	August 23	August 24	August 24
20.6	50	14 Salmonids	-	84 Cottids 1 Sucker 5 Salmonids	-	0	-
20.5	25	52 Salmonids	-	68 Cottids 1 Sucker 1 Salmonid	-	1 Sucker	-
20.0	30	4 Salmonid	-	4 Cottids 1 Salmonid	-	0	-
19.5	130	1 Whitefish 2 Cottids 217 Salmonids	-	3 Cottids 1 Sucker 1 Salmonid	-	1 Cottid	-
18.6	63	2 Cottids 14 Salmonids	-	35 Cottids 2 Salmonids	5 Cottids 2 Salmonids	1 Lamprey	2 Lampreys
17.6	120	20 Salmonids	-	-	-	-	-
17.0	499	-	1 Cottid 1 Sucker 10 Salmonid	-	2 Cottids 5 Salmonids	-	0
16.0	227	-	7 Salmonid	-	5 Salmonid	-	0
15.6	100	18 Salmonid	-	-	-	-	-
15.4	300	-	19 Salmonids	-	0	-	1 Lamprey
15.0	65	1 Whitefish 16 Salmonids	-	-	-	-	-
13.5	100	16 Salmonids	-	-	-	-	-
13.1	154	2 Whitefish 5 Salmonids	1 Cottid	0	0	1 Cottid 2 Salmonids	-

Enclosure 5 (Continued)

Table 2. Recoveries of fish carcasses during surveys of index areas on the Nisqually River between river miles 13.1 and 3.7

Approximate River Mile	Yards Surveyd	MORTALITIES OBSERVED					
		August 20	August 21	August 22	August 23	August 24	September 2
12.8	127	0	0	1 Salmonid	0	0	0
11.6	70	2 Salmonids	4 Salmonids	2 Salmonids	0	0	0
10.8	217	1 Whitefish 6 Salmonid	1 Whitefish 17 Salmonid	5 Salmonids	1 Salmonid	0	0
10.3	168	1 Cottid 8 Salmonids	1 Cottid 21 Salmonids	1Whitefish 1 Cottid 6 Salmonids	1 Cottid 3 Salmonids	0	0
9.7	90	1 Whitefish 7 Salmonids	5 Salmonid	2 Salmonid	3 Salmonid	0	0
8.8	125	1 Cottid	1 Salmonid	2 Salmonids	2 Salmonids	0	0
8.0	112	2 Salmonids	5 Salmonids	0	0	0	0
6.3	119	6 Salmonids	1 Salmonid	1 Salmonid	0	0	0
5.2	168	1 Salmonid	1 Cottid 1 Salmonid	0	0	0	0
3.6	188	0	0	0	0	0	0

Enclosure 5 (Continued)

Table 3. Average length of salmonid carcasses recovered during surveys of the Nisqually River.

Date	Upriver 2/		Lower River 3/	
	Sample Size	Average Length (mm)	Sample Size	Average Length (mm)
August 20	347	57.1	71	50.3
August 21	58	69.9	82	60.5
August 22	12	105.7 3/	30	103.8

1/ Includes recoveries from spill to Centralia Power Plant.

2/ Includes recoveries from Centralia Power Plant to river mile 3.7.

3/ Includes recoveries on August 23.

State of Washington

DEPARTMENT OF FISHERIES

August 31, 1977

N O T E

TO: Bill Rees and Earl Finn

FROM: Grant Fiscus

SUBJECT: Nisqually River Sampling, August 21, 1977

As directed, I recently sampled selected reaches of the Nisqually River above the powerhouse (RM 12.5) to assess fish impacts related to the August 19, 1977 Milwaukee Road bridge collapse and spillage of processed copper ore.

General Observations, August 21, 1977

On Sunday, at about RM 13.5, the air near the river had a definite "foul" odor, and the water had a slightly turbid appearance with an unfamiliar dark tone. I have not seen this condition at this location before, including two earlier trips to the same area this summer. River flows were extremely low, estimated at 60 cfs or so. The water appeared nearly devoid of fish life, with only occasional fry or larger fish seen, even though the existing flow would have concentrated remaining live fish.

General Observations, August 12, 1977

By contrast, I visited the same area (RM 13.5) on Friday evening, August 12, 1977, seven days prior to the spill, and found a healthy supply of trout. Surface feeding activity was intense and larger size trout were present compared to August 21, 1977. Another fisherman in the area had creeled approximately 6 trout up to approximately 15 inches in length. I released about six 6"-9"-sized trout in about 30 minutes. This size range of fish was not seen during examination of bar or pool areas on August 21, 1977.

Specific Observations, August 21, 1977.

Enroute to the survey area, 3 dead trout and 1 sculpin were observed at RM 11.6. To establish a reasonable basis for determining the number of mortalities typical of reaches throughout that part of the Nisqually River above the powerhouse, I selected 5 stations of varying shoreline characteristics and attempted to enumerate dead fish within those stations. While the dimensions of each station varied, the intent was to approximate, using the stations, the overall channel character. Nearly all fish were found at higher river elevations, such as on exposed bars, indicating a major die-off prior to the time surveyed. Also, since fish were more concentrated near the pre-drawdown water level than at the drawdown level, it appeared that die-off either peaked sometime Saturday or Saturday night. Drawdown in the area surveyed occurred sometime between Saturday evening and Sunday morning according to campers along the river. Trout were identified by anal fin examination. All station samples were retained. Photographs of stations and recovered fish are appendixed. Comments by station follow.

Station 1.

General odor and water conditions described on page 1 were noted at this station. The largest trout carcass recovered (about 6") was found in a pool below station 1, and was partially decomposed. The absence of other trout of this size, or larger, in subsequent samples might be theorized as resulting from rapid die-off of larger specimens which settled into pool areas at normal flow levels. Crayfish did not appear to be affected as severely as salmonids, and trout carcasses could have been largely obliterated by scavaging crayfish.

This station, (see photo 4.), included side channel and slack-water types. Most of the area was an exposed cobble/gravel bar. The densest number of trout were recovered at the pre-drawdown elevation. Some skinned-out carcasses were found, but most fish were fresh. The random distribution of fish indicated death occurred by some means other than stranding. Some boulders were turned at this station to verify presence or absence of salmonids under large rocks. None were found, and most sampling thereafter was simply by visual inspection from a walking position. Crow concentrations were noted downstream.

One distressed trout (4") observed in wetted part of station. Crayfish both alive and dead, with some moults. Dozens of potholed sculpins were noted, probable evidence of stranding. These fish likely survived the pollutant concentrations that killed the salmonids. Caddis fly larvae appeared normal. The wetted portion, included in the station width measurement, was also checked but only one yearling trout was found. This station contained the greatest bar exposure of the 5 stations, and subsequently contained the highest number of dead fish per area sampled.

Station 2.

This station was selected as a contrast in bottom type to station 1. The steep right bank exposed material was typical loose boulders/gravel found throughout the area, while the left bank bar had a pea gravel bottom and a small side channel. Predators had likely scavaged the pea gravel area, as most fish were on the boulder/gravel side.

Station 3.

As indicated in photo 8, this station was primarily flat boulder/cobble bar area. This type of bottom substrate is common throughout river reaches in the area. This station would have been mostly wetted under normal flow. While the bar characteristics appear to encourage stranding, recovered carcasses were found primarily at the higher elevations on the reach, namely the left bank and center of the bar. This indicated stranding was not the major cause of mortality. In fact, fish were found stuck on top of rocks, rather than in bottom of pockets. In addition, some mortalities were extremely dessicated, and in my opinion deposited prior to drawdown. Numerous wetted pockets on the exposed bar were examined and found to be devoid of salmonid fry.

Station 4.

In contrast to stations 1, 2, and 3, this station was not a full cross-section, but consisted of exposed shoreline strips adjacent to a deep pool and tailout. The right bank was generally abrupt and irregular in character with salmonid

carcasses in obscure brushy spots. The left bar was a wedge bar and carcasses were found almost exclusively under an alder overhang at the pre-drawdown water level. Six hours prior to examining this station, crows were searching nearby areas. Numerous bird tracks on mud/algae-covered rocks indicated exposed areas were heavily scavaged prior to examination.

Banks were examined for approximately 675 feet and comprise 2/3 of the total linear distance of all stations combined. Numerous crayfish moults were evident. Some fish were "rising" in the pool at mid-afternoon.

Station 5.

This station, 1/4 mile above the powerhouse, was also an exposed bank only sample, due to deep tailout waters. Exposed bank types were of contrasting types, and equal length examinations were made. The right bank had narrow sand/brush character and the left bank was a tapered rubble bar. The river character adjacent to the station was drift tailout and riffle. Both live and "near dead" crayfish were observed on the left bank bar.

Distribution of carcasses on this station was similar to station 4, with fish found either at high points of the bar or under an alder canopy. Scavenging by birds prior to the start of sampling (4:00 p.m.) likely caused a severe reduction of the carcass population on the exposed bar.

Discussion

The "estimated percent recovered" column on Table 1 indicates this observer's opinion of how effective the described sampling procedure was in recovering the number of carcasses recently deposited on the stations. As the day progressed, the impacts of carcass removal by predators became more noticeable, with carcasses on bar areas being found primarily in camouflaged locations. In addition, carcasses were more difficult to visibly find in boulder/cobble locations compared to finer textured locations. These factors, along with the effort level expended by the investigator, were used to estimate the sampling effectiveness. Projections were then made using the "percent recovered" value.

The problem of scavenging by birds on salmon fry was discussed by Phinney (1974 and 1974). He found that while the numbers of fry removed by birds was variable, complete removal has occurred in as little as 20 minutes, and commonly from half to all of test lots removed within 1 hour. Between 3-10 hours of daylight preceeded sampling at stations 1-5 in the present survey.

The bridge collapse occurred about 6 a.m. on August 19, 1977, however significant mortality near the bridge site was not reported for about 24 hours. Salmonid die-off probably occurred Saturday in sampling stations 1-5. Since mortalities found on Sunday were mostly fresh, and predator cleanup would have removed most of the Saturday die-off, it is considered that mortality on August 20 could have been at least equal to that of August 21.

Results

Visual carcass sampling was conducted at 5 stations along reaches of the Nisqually River between River Miles 12.8 and 14.1 on August 21, 1977. A total of 130 juvenile trout, mostly less than 4 inches in length, were removed from 1,008 linear feet of river, or 0.13 per foot. It was estimated that overall only

15.4% of the actual mortalities were recovered, and that 843 trout, or 0.84 trout per foot, reflected actual station mortalities on August 21, 1977.

Extrapolating the projected mortality of 0.84 trout per foot to all reaches between the powerhouse (RM 12.6) and former Milwaukee Road Bridge (RM 21.4), a standing mortality on August 21 of 39,030 juvenile trout is calculated as follows:

(8.8 mi) (5,280) (0.84) = 39,030 juvenile trout

No salmon were found in sampling described in this report.

LITERATURE CITED

Phinney, L.A.
1974. Further Observations on Juvenile Salmon Stranding in the Skagit River, 1973. Washington Department of Fisheries 34p.

Phinney, L.A.
1974. Report on the 1972 Study of the Effect of River Flow Fluctuations Below Merwin Dam on Downstream Migrant Salmon (FPC Project No. 935). Washington Department of Fisheries 23p.

APPENDIX I

(Table I)

(Page 7)

le 1. Specific Observations by Station, Nisqually River, August 21, 1977

tion ber	Time	River-mile location	Estimated dimension of areas sampled Width - Length	Description of station 1/	Number of mortalities Recovered Trout	Observed Other	Est. Percent recovered	Projected number of trout mortalities on station August 21, 19
1	0900-1115	13.5	270' - 60' (complete x-section)	Mostly exposed bar RB-backwater + side-channel w/tree canopy Center-wide cobble tail-out LB abrupt, shaded bank. Most of station exposed cobble bar.	68	1 white fish 1 brook-lamprey sculpins-dozens potholed. 7 crayfish	25%	272
2	1210-1245	14.0	180' - 60' (complete x-section)	About 1/2 exposed bar RB-boulders -steep Center- medium gravel LB - fine gravel - brood Most of station exposed fine gravel	7		30%	18
3	1300-1400	14.1	270' - 33' (complete x-section)	Mostly exposed bar RB - steep sand Center-flat broad, boulder/cobble LB steep gravel/cobble	29		15%	193
4	1430-1545	13.3	RB 10' - 665' LB 20' - 675' (bank samples only)	Mostly pool RB - 10 wide steep bank/sand center - Deep pool - not checked LB -20' flat gravel bar	16	1 sculpin 1 sucker	10%	160
5	1600-1635	12.8	RB 10'-180' LB 50'-180' (bank sample only)	Mostly tailout RB - steep sand/brush Center 0 tailout - not checked LB -flat wedging gravel bar	10	Distressed crayfish	5%	200
TALS		12.8-14.1	1,008 linear feet		130		15.4	843

RB = Right bank
LB = Left bank

Enclosure 7. Nisqually River Copper Ore Spill, Summary of Electrofishing Date Collected by DOE, WDG and WDF Personnel during August 23 and 24, 1977.

Sample Station	Description	Number of Fish Captured Rem. 1	Rem. 2	Rem. 3	Total Fish Captured	Population Estimate	Comments
1.	300' section of stream located ½ mile above McKenna trestle (Control #1)	132	115	115	362	1810[1/]	Fairly good habitat area
2.	300' section of stream located ½ mile above McKenna trestle (Control #2)	178	156	117	451	902	Habitat appeared to be representative of stream in general
3.	300' section of stream located ½ mile below McKenna trestle	34	37[2/]	- -	71	- -	Good habitat area
4.	Spot check - site located about ½ mile below McKenna trestle	121	- -	- -	121	- -	Premium habitat area

1/ The standard error exceeds the 95% confidence limit.

2/ Due to increasing river flow had to discontinue electrofishing when Rem. 2 half completed.

Enclosure 8. Summary of 96-hour In-Situ Bioassay Conducted by DOE to Monitor Effects of August 19, 1977 Copper Ore Spill on Fish Life in the Nisqually River

Date Time	Steelhead												
	Sta. #1 (Control) 1		Sta. #1 (Control) 2		Sta. #2		Sta. #3		Sta. #4		Sta. #5		Sta.
	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive
8/20/77 0 hr.	25	0	25	0	25	0	25	0	25	0	24	0	25
8/21/77 24 hr.	25	0	25	0	24	1	25	0	25	0	24	0	25
8/22/77 48 hr.	25	0	25	0	12	12	13	12	25	0	24	0	25
8/23/77 72 hr.	25	0	24	1	11	1	13	0	25	0	24	0	25
8/24/77 96 hr.	25	0	24	0	11	0	13	0	25	0	24	0	25
TOTAL	25	0	24	1	11	.14	13	12	25	0	25	0	25
% Mortality		0%		4%		56%		48%		0%		0%	

Comment: This was the first 96-hour in-situ bioassay, conducted from Saturday 8-20 through Wednesday 8-24. After 48 hours exposure a 52% mortality had occurred at Station 2, 48% mortality at Station 3.

FISH KILL EVALUATION FORM

Watercourse: Nisqually
Date of Kill: August 19, 1977
Responsible Party: Milwaukee Railroad
Date of Investigation: Aug. 19-31, 1977
Killing Agent: Copper ore
Investigator: DOE, WDF, WDG, USFWS
Kill Location: McKenna to Highway I-5
Area Affected: About 20 stream miles

1. Estimated number of fish killed:

Species	No. Dead	Estimated No. Killed	Size Range	Brood Year	Recovery Pot.( )	Recovery Pot.( )	Actual Loss
Steelhead	6,750			0-age			6,750
Steelhead	68,250			1+ age			68,250

Total Mortalities

2. Adult Returns:

Species	Actual Loss	% Survival to Smolt	% Smolt Survival to Adult Catch	Estimated No. Caught
Steelhead	6,750	100%	5%	341
Steelhead	68,250	10%	5%	338

Total Returns: 679

3. Sport and Commercial Fishery Losses:

Species	Estimated No. Caught	Sport Fishery Value	Commercial Fishery Value	Total Resource Loss Costs
Steelhead	679	$31,858.00	$9,288.00	$41,146.00

Subtotal

4. Restocking costs:

Species	Actual Loss	Replace. Loss (Act. Loss +15%)	Number/ Pound	Total Pounds	Cost/ Pound	Replace. Cost @ lb.
Steelhead	13,575		5	2715	$1.35	$3,665.25

Subtotal

5. Repropagation costs:

Species	Est. Returns	Female Escapement	Fecundity	Total Egg Losses 1/	Cost/ 1,000	Total Re-propagation Costs
Steelhead				543,000	$10.00	$5,430.00

Subtotal

6. Other costs:

7. GRAND TOTAL: $50,241.25

1/ Based on estimated number of eggs needed to produce the 75,000 fish lost.

Enclosure 9

STATE OF WASHINGTON
Dixy Lee Ray
Governor

DEPARTMENT OF GAME
600 North Capitol Way/Olympia, Washington 98504 206/753-5700

October 20, 1977

MEMORANDUM

TO: John Bernhardt,
Department of Ecology

FROM: Jack Ayerst
Department of Game

SUBJECT: Nisqually River Fish Kill

On August 19, 1977, eight railroad cars containing copper were spilled into the Nisqually River near McKenna when a railroad bridge spanning the river collapsed. An estimated 600 tons of finely ground copper ore containing copper, zinc, lead, silver and processing chemicals entered the river as a result of the accident. The Milwaukee Road train trestle had recently been weakened by an arson-caused fire and repairs had just been completed prior to the accident.

The following day large numbers of juvenile steelhead trout were observed dying along with whitefish, salmon fry, suckers, cottids and lampreys. This mortality was observed from the spill site downstream to I-5 bridge. Investigation of the river upstream from the spill site indicated no fish mortalities. This mortality continued for several days and appeared to diminish after about three days.

Various methods were used to determine the total fish kill and involved many individuals and agencies. John Bernhardt, Fishery Biologist with the Department of Ecology, evaluated the information collected and calculated that 75,000 juvenile steelhead of two age groups were killed as a result of this ore spill.

Age composition of the river population of juvenile steelhead showed approximately 91% were of the zero age group which hatched in the spring and early summer of 1977 and ranged in size from 1½ to 3 3/4 inches in length. These fish would normally rear in the river for an additional year and a half and migrate as smolts from the Nisqually River in 1979. The yearling juvenile steelhead which comprised approximately 9% of the steelhead population ranged in size from 5½ to 7 3/4 inches and would

leave the Nisqually River next spring (1978) as smolts. We expect a 5% return of adult steelhead from smolts in the Nisqually River. An evaluation of the steelhead loss is as follows:

Total Juvenile Steelhead Loss	75,000	
1) 9% yearlings (1+ age group)	6,750	
Adult return in 1979-1980 at 5%		338 adult steelhead
2) 91% 0 age group	68,250	
Of which 10% will survive to age 1+ smolts	6,825	
Adult return in 1980-1981 at 5%		341 adult steelhead

Total Adult Steelhead = 679

Harvest ratio of Nisqually steelhead	1976-1977 Season
Nisqually Indian Fishery	75.8%
Sport Fishery	24.2%

Based on the above ratios, if all steelhead are harvested, the distribution and value of the 679 adults is as follows:

Indian Harvest	76%	516 fish averaging 9 pounds each at $2.00 per pound or $18.00 each x 516 - $9,288.00
Sport Harvest	24%	163 fish-sport value of $195.45 each* 163 x $195.45 = $31,858.00
	Combined Value of Adults	$41,146.00

These figures do not include a projection of the loss of spawning potential from these fish since we desire to initiate a program immediately to replace the steelhead.

* Values based on 1980 return. Reference: A Short Form For Bio Economic Evaluations of Wildlife in Washington State, by Wendell H. Oliver, Curt Young and Duane Eldred. Bulletin #7

Restocking Costs

Existing Department of Game hatchery facilities do not have sufficient space to rear replacement steelhead since they are already programmed to full capacity.

A possible solution to rearing replacement fish may be accomplished utilizing a new inexpensive rearing concept, net pens. A net pen unit consisting of three 16 x 16 covered net pens could be located at Lake Whatcom or Lake Aberdeen utilizing existing hatchery personnel to feed and care for these fish. A three unit pen system would allow replacement rearing of the two age groups of steelhead lost. An estimated cost breakdown of replacement costs is as follows:

Perimeter floats (assembled)	*$ 8,000.00*
House Shell (Labor and Materials)	*4,500.00*
Nets	*3,700.00*
Mooring System	*500.00*
Total for Pen Complex	*$16,700.00*

Rearing Costs for 13,575 smolts to 5 fish per pound including fish food, labor, planting costs, etc., @ $1.35 per pound = 2,715 pounds times $1.35 = $3,665.25.

Total steelhead replacement costs to restock the Nisqually River with 6,750 steelhead smolts in 1978 and 6,825 smolts in 1979 is $20,365.25.

JDA:meg