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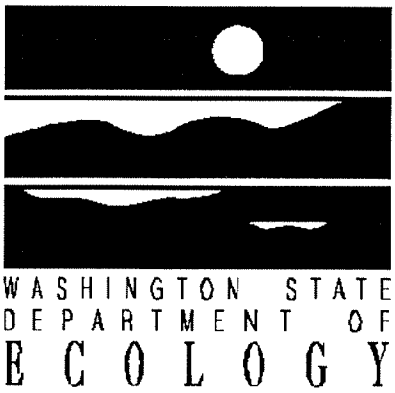


# SHELL OIL'S ANACORTES REFINERY
# CLASS II INSPECTION
# FEBRUARY 22 - 23, 1989

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by
Don Reif

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Compliance Monitoring Section
Olympia, Washington 98504

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Water Body No. WA-03-0020
(Segment No. 02-03-03)

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## INTRODUCTION

A Class II inspection was conducted at Shell Oil's Anacortes Refinery on February 22-23, 1989. Conducting the inspection was Don Reif of Ecology's Environmental Investigations Program, Compliance Monitoring Section. Assistance was provided by Keith Seiders and Carlos Ruiz of Ecology, and Ed Hsu from Shell. The inspection was requested by Kim Anderson of Ecology's Industrial Section.

Objectives of the inspection were to:

- o Collect effluent samples to check NPDES permit compliance.
- o Characterize the wastewater and sediment near the outfall to identify pollutants of concern.
- o Evaluate effluent and sediment bioassays to assess toxicity.
- o Provide data to assist in issuance of the new permit.

## LOCATION AND DESCRIPTION

Shell Oil's petroleum refinery is located on the north end of March Point, east of Anacortes (Figure 1). The plant has a refining capacity of 94,000 barrels per day. Process wastewater, ballast, water and stormwater are treated prior to discharge to Fidalgo Bay. Wastewater streams (except stormwater) are treated sequentially by oil recovery (API separators), primary clarification, secondary treatment via plug flow activated sludge, and final clarification (Figure 2). Shell's sanitary waste is treated initially in a septic tank. The septic tank effluent then joins the spent acid which acts to disinfect the sanitary effluent. This combined stream then joins the regular system. Phosphate (as phosphate fertilizer, for proper nutrient balance) is added prior to secondary treatment. Stormwater is skimmed for oil removal before joining the secondary effluent in two retention ponds prior to being pumped to the bay. Primary and waste activated sludge is thickened by belt press, then applied to a land farm on-site. Shell's 30-inch outfall pipe terminates into three 12-inch downcomers.

## METHODS

Shell normally discharges treated wastewater after midnight for a period of 4-6 hours, depending on stormwater volumes. All samples were therefore gathered during this time period (see sampling schedule, Table 1). Samples were taken at the grab sample spigot in Shell's sampling shack. The effluent sample was hand composited at the rate of one liter per 15 minutes during the 4.75 hour pumping period. Samples for bioassays (rainbow trout, Microtox, and purple sea urchin) were collected similarly. In addition, grab samples for separate analyses were collected twice during the pumping cycle. Analytical methods and references are listed in Appendix 2.

Shell's effluent flow meter performance was checked with a portable flow meter. A Polysonics doppler-type meter was attached externally to Shell's discharge pipe about 50 feet downstream from Shell's Pitot tube flow meter and sampler building. The meter was operated for the entire discharge period.

A sediment sample was collected about 100 feet east-northeast of Shell's outfall pipes in 55 feet of water. Sampling was first attempted 15 feet northeast of the diffusers and at various sites south of the ship dock, from 100-200 feet west and west-southwest of the outfall. These attempts were unsuccessful in obtaining a good sample. Shell fragments, gravel, wood debris, and very hard

sediments prevented proper closure of the 0.1 m2 Van Veen sampler. Therefore, the samples were either not taken up by the sampler or were lost (totally or partially) upon retrieval. Time constraints did not allow collection of a field reference sample. Two bioassays were run on the sediment sample: Microtox, using the saline extraction method, and the marine amphipod, *Rhepoxynius abronius*.

Collection of the sediment sample followed procedures outlined in Puget Sound Protocols (Tetra Tech, 1986). The sample consisted of four individual grabs in which the top two centimeters were removed from each grab and composited. The composite was homogenized using stainless steel spoons and beakers, then subdivided for separate analyses. All utensils were pre-cleaned by washing with non-phosphate detergent and rinsing successively with tap water, 10 percent nitric acid, then three times with deionized water, pesticide grade methylene chloride, and finally pesticide grade acetone. Collection equipment was air-dried, then wrapped in aluminum foil until used.

## RESULTS

### Flow

Ecology's portable flow meter compared well with Shell's effluent flow meter. As shown in Table 2, Ecology's reading was 10 percent higher than Shell's flow meter total. This amount of variation is easily within the combined accuracy range of both instruments. As with all effluent flow meters, Shell is encouraged to have yearly calibrations performed by a certified technician.

### General Conditions

The wastewater treatment plant grounds were neatly maintained and orderly, as was the Shell complex in general. One exception was the rock trickling filter, which, during a preliminary visit, was badly plugged and overflowed its sides in several places. The severe "ponding" of the rock media was apparently caused by thick and abundant multi-colored biological growth. This unit was being bypassed during the inspection.

From Table 3, Shell's effluent is rather unremarkable. Fecal coliforms and nutrients were very low. Also, a very small percentage of the effluent suspended solids were volatile. Therefore, treatment by biological methods was probably as complete as practicable.

### NPDES Permit Compliance

Shell was well within most permitted parameters for the inspection period and no parameter exceeded the daily maximum value (Table 4). Biochemical oxygen demand (BOD), chemical oxygen demand (COD), phenols, ammonia, total chromium, pH, and fecal coliforms were well below daily average and daily maximum limits. Hexavalent chrome exceeded the daily average but was less than the daily maximum limit. One of the two oil and grease samples equalled the daily average poundage limit, but both were well below concentration limits.

### Effluent Bioassays

No acute toxicity was noted by the suite of effluent bioassays. As shown in Table 5, no mortality occurred in juvenile rainbow trout at 65 percent effluent. In the Microtox test, toxic effects were not quantifiable due to a lack of sample toxicity.

Toxicity data generated by the echinoderm test indicated fairly substantial chronic toxicity: an NOEC of six percent effluent; an LOEC of 12.5 percent; and an $EC_{50}$ of 28.7 percent effluent. However, toxic effects due to lowered salinity were also observed in the salinity control sample at just a slightly higher concentration (NOEC of 12.5 percent) than the apparent effluent toxicity. From a statistical standpoint, this toxicity probably cannot be separated from low salinity effects for the test.

**Effluent Chemistry**

Very few priority pollutant compounds were detected in Shell's effluent sample (Table 6). Two chlorinated volatile organics and one chlorinated phenol, plus a trace of a phthalate were found. These compounds were all at very low concentrations. Total phenols, at 10.2 parts per billion, were also low.

Several metals met or slightly exceeded EPA's "Gold Book" (EPA, 1986a) values for protection of receiving waters (Table 7). Only mercury significantly exceeded the criteria: 36 times greater than the freshwater chronic and 17 times greater than the saltwater chronic values (EPA, 1986a). Even so, available dilution within Shell's effluent mixing zone would probably prevent criteria exceedences outside the mixing zone. Bioassay results indicate that mercury concentrations were not toxic to bioassay organisms under laboratory conditions.

**Sediment Bioassays**

Slight, but measurable, toxicity was noted by the amphipod test. Acute toxicity was statistically present ($P<0.05$, $F=7.04$) in the test sediment as compared to the laboratory control sediment (Table 8). Toxicity was also measured by the Microtox test, with an $EC_{50}$ of 30.9 percent.

**Sediment Chemistry**

No organics or metals detected in the sediment sample exceeded Ecology's interim sediment quality criteria (Betts, 1989). As shown in Table 9, several polynuclear aromatic hydrocarbons (PAH) were found at low levels. These concentrations, after "normalizing" to percent total organic carbon (TOC), were less and, in most cases, far less than the proposed criteria. Most of the PAHs found were relatively heavy. Since lighter weight PAHs tend to degrade faster, these traces may be indicative of historic rather than recent sources (Blumer, 1976). It also could suggest that the source (recent or historic) was crude or other heavy oils, rather than lighter, refined materials.

The metal results were similar to the organic results (Table 10). All were considerably below the interim sediment quality criteria.

Following Ecology's Interim Sediment Quality Evaluation Process (Betts, 1989), the test sediment is predicted to not cause localized adverse effects, since all chemical contaminants were less than the interim criteria. If sediments do not pass, biological tests may be conducted and, if passed, will override the chemical determination. Classification of the sediment sample is inconclusive. First, a field reference sample was not collected, but is necessary in both the amphipod and Microtox bioassays for comparing biological responses to the test sediment(s). *Rhepoxynius* must have a statistically higher mortality than the reference sample and greater than 25 percent mortality to exceed the process. This test had less than 25 percent mortality and therefore would have "passed" the evaluation process requirements. For Microtox, the test sediment must exhibit a dose-response relationship for the concentrations tested and show less than 80 percent of the light output of the reference sample. A dose-response relationship was established, but no reference sample data was available for comparison. No basis of comparison exists to evaluate the $EC_{50}$ of 31 percent extract.

### Comparison of Sample Splits

The sample splits compared very well between Ecology and Shell's labs (Table 11). Agreement was good except for phenols, where Shell found concentrations two to almost four times higher than Ecology. A further sample split for phenols is suggested for future inspections.

### Laboratory Evaluation

Shell's procedures for BOD, total suspended solids (TSS), pH, and fecal coliform analyses were evaluated during the inspection. Several departures from Standard Methods were found. Fecal coliform procedures need to be updated. A memo to this effect was sent to Shell soon after the inspection (Reif, 1989). Shell is conducting an on-going update of their lab procedures to reflect protocols in Standard Methods (APHA, 1989). Several changes were recommended for the BOD test. Information on the correct procedure for determination of the BOD of the seed material was sent in the memo. The dissolved oxygen (D.O.) depletion of the dilution water blank should not exceed 0.2 mg/L. If the depletion exceeds this, the cause should be found and corrected. Also, the D.O. meter should be calibrated before use every day. And only one bottle per dilution is needed when a D.O. meter is used for D.O. measurements.

For the TSS procedures, several recommendations are made. The oven temperature needs to be maintained at 103-105 degrees C. Filters should be pre-washed, dried, and weighed before use. Also, the entire volume of sample should always be filtered. If the filter plugs, a smaller volume should be filtered through a new filter.

## SUMMARY AND RECOMMENDATIONS

Shell's wastewater treatment system was operating well during the inspection. Shell's flow meter compared favorably with Ecology's portable flowmeter checks. Most permit parameters were well below allowable limits. Hexavalent chrome exceeded the daily average limit, but was below the daily maximum.

Very few organic contaminants were detected in Shell's effluent, and these were at low concentrations. No acute or significant chronic toxicity was noted by a suite of effluent bioassays. Several metals (antimony, copper, lead, mercury, nickel, and zinc) met or slightly exceeded EPA's criteria for protection of receiving waters. Only mercury significantly exceeded the criteria.

No sediment sample could be collected at the outfall using a Van Veen sampler. A sample was obtained 100 feet east-northeast of the outfall. It showed chemical contaminant concentrations well below Ecology's interim criteria. Slight toxicity, compared to the laboratory control sample, was noted in the amphipod bioassay. No reference sample was taken, so biological classification under Ecology's interim criteria process was not possible. However, due to the modest *Rhepoxynius* mortality, the test sample would have passed the biological evaluation.

Sample splits between the Ecology and Shell labs showed very good agreement except for total phenol. A laboratory evaluation indicated some departures from Standard Methods that have since been addressed in Shell's revised lab protocols. Further details are discussed in the Comparison of Sample Splits and Laboratory Evaluation sections.

**Recommendations include:**

- Shell's trickling filter must be repaired or modified if it is to be used. Solutions could include cleaning the existing rock media or replacing the old rock with new rock or some type of plastic media, either a random or fixed variety. If excessive growth occurs in the future, some type of control strategy (e.g. increased flow rate or chlorine dosing) should be investigated.

- Further sample splits for total phenols.

- Further sediment sampling at the outfall. Other types of sediment collection will be necessary to collect a sample near the outfall and should be investigated. Possible solutions could include a more heavily weighted clamshell-type dredge, a coring device (perhaps piston driven), or collection by a scuba diver. Another suggestion is to place sediment traps near the outfall. This idea could help clarify direction and extent of effluent particulate deposition.

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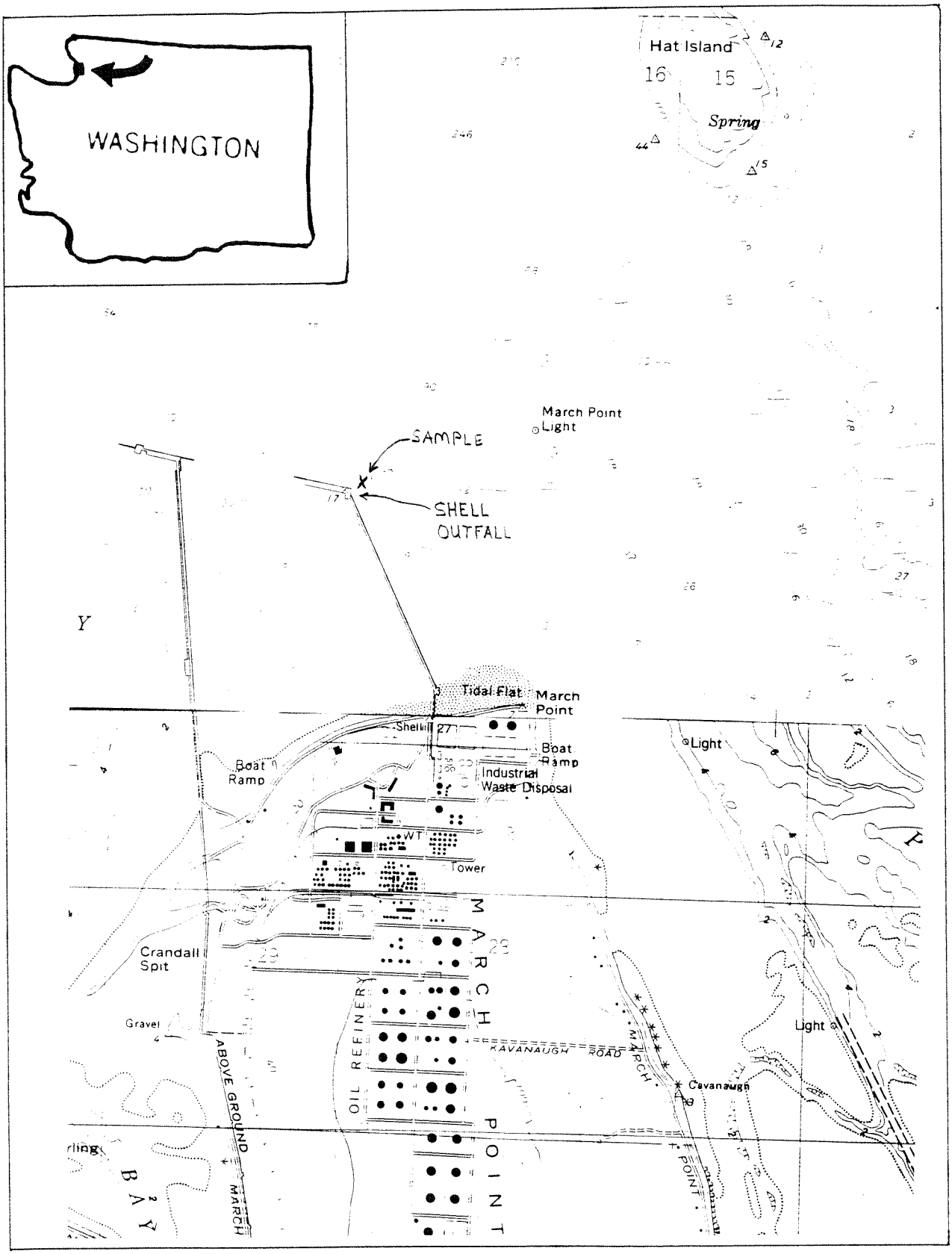


Figure 1. Plant site with sediment sampling location:
Shell Oil Class II Inspection- February 21-22, 1989.

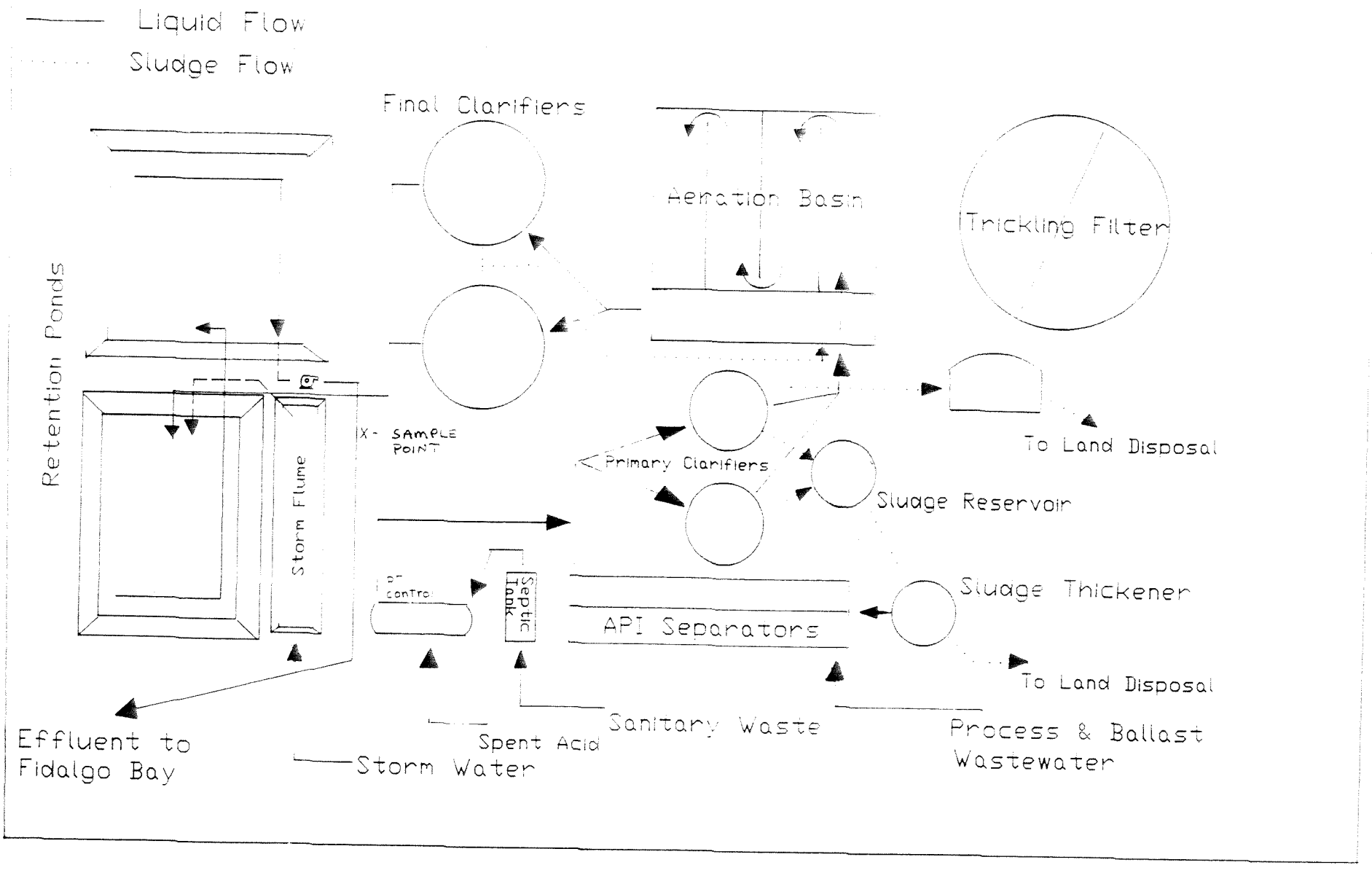


Figure 2. Treatment system schematic with sampling location; Shell Oil Class II Inspection-February 21-22, 1989.

Table 1. Sampling Schedule: Shell Oil Class II Inspection - February 21-22, 1989.

| | Water Samples | | | | Sediment |
|---|---|---|---|---|---|
| Sample: | Effluent | Effluent | Eff-Eco | Eff-Shell | Sed.#1 |
| Date: | 2/22/89 | 2/22/89 | 2/22/89 | 2/22/89 | 2/21/89 |
| Time: | 0130 | 0330 | 0045-0525 | 0045-0525 | 1550 |
| Analysis Type: | grab | grab | composite | composite | composite |
| Lab log #: | 088020 | 088021 | 088022 | 088023 | 088024 |
| **Field:** | | | | | |
| pH | X | X | X | X | |
| Conductivity | X | X | X | X | |
| Temperature | X | X | X | X | |
| Chlorine, total | X | | | | |
| Sulfide | | | | | |
| **General Chemistry:** | | | | | |
| Turbidity | X | X | X | X | |
| pH | X | X | X | X | |
| Conductivity | X | X | X | X | |
| Alkalinity | X | X | X | X | |
| Hardness | | | X | | |
| Chloride | X | X | | | |
| Solids(4) | | | X | X | |
| TSS | X | X | | | |
| $BOD_5$ | | | X | X | |
| COD | X | X | X | X | |
| $NH_3$ | X | X | X | X | |
| $NO_3$+$NO_2$ | X | X | X | X | |
| T-Phosphate | X | X | X | X | |
| Fecal Coliform | X | X | | | |
| % Solids | | | | | X |
| Grain Size | | | | | X |
| **Priority Pollutants:** | | | | | |
| pp metals | | | X | | X |
| BNA (water) | | | X | | |
| BNA (solids) | | | | | X |
| VOA (water) | | X | | | |
| VOA (solids) | | | | | X |
| Pest/PCB (water) | | | X | | |
| Pest/PCB (solids) | | | | | X |
| Phenols | X | X | X | | X |
| Grease & Oils | X | X | | | |
| TOC | | | | | X |
| **Bioassays:** | | | | | |
| Trout | | | X | | |
| Microtox | | | X | | X |
| Echinoderm | | | X | | |
| Rhep. Abr. | | | | | X |

Table 2. Flow measurement results and comparison: Shell Oil Class II inspection- February 21-22, 1989.

| Date | Time | Ecology results | Shell results |
|---|---|---|---|
| 2/22 | 0040-0524 | 3.19 MGD | 2.865 MGD |

Table 3. Summary of General Chemistry Data: Shell Oil Class II Inspection - February 21-22, 1989.

| Analysis | Sample: / Date: / Time: / Type: | Effluent 2/22/89 0130 grab | Effluent 2/22/89 0330 grab | Eff-Eco 2/22/89 0045-0525 composite | Eff-Shell 2/22/89 0045-0525 composite |
|---|---|---|---|---|---|
| **FIELD:** | | | | | |
| pH | std. units | 7.55 | 7.63 | 7.55 | 7.60 |
| Conductivity | umho/cm | 1140 | 1180 | 1150 | 1178 |
| Temperature | deg. C. | 14.5 | 15.8 | 5.4 | 12.5 |
| Chlorine, total | mg/L | <0.1 | | | |
| Sulfide | mg/L | | <0.1 | | |
| **GENERAL CHEMISTRY:** | | | | | |
| Turbidity | NTU | 10 | 10 | 10 | 10 |
| pH | std. units | 7.2 | 7.3 | 7.5 | 7.5 |
| Conductivity | umhos/cm | 1200 | 1190 | 1150 | 1210 |
| Alkalinity | mg/L $CaCO_3$ | 220 | 220 | 220 | 220 |
| Hardness | mg/L $CaCO_3$ | | | 95 | |
| Chloride | mg/L | 78.7 | 73.8 | | |
| TS | mg/L | | | 650 | 680 |
| TNVS | mg/L | | | 620 | 590 |
| TSS | mg/L | 8 | 11 | 14 | 11 |
| TNVSS | mg/L | | | 14 | 11 |
| $BOD_5$ | mg/L | | | 6 | 6 |
| COD | mg/L | 64 | 66 | 70 | 70 |
| $NH_3$ | mg/L | 0.71 | 0.71 | 0.72 | 0.70 |
| $NO_3$+$NO_2$ | mg/L | 0.11 | 0.11 | 0.11 | 0.14 |
| T-Phosphate | mg/L | 0.081 | 0.077 | 0.14 | 0.14 |
| Grease & Oils | mg/L | 6 | 5 | | |
| Fecal Coliform | #/100 mL | 9* | 3* | | |

* - Many non-fecal background organisms were noted during analysis.

Table 4. Comparison of inspection results to NPDES permit limits: Shell Oil Class II inspection-February 21-22, 1989.

| Parameter | Daily Average | Daily Maximum | Inspection Results+ |
|---|---|---|---|
| $BOD_5$: lbs/day | 540 | 970 | 160 |
| COD: lbs/day | 3800 | 7250 | 1860 |
| TSS: lbs/day | 430 | 680 | 370 |
| Oil & Grease: lbs/day | 160 | 290 | 160 & 130 |
| mg/L | 10* | 15 | 6 & 5 |
| Total Phenols: lbs/day | 3.5 | 7.3 | 0.3 |
| Ammonia: lbs/day | 290 | 650 | 19 |
| Sulfide: lbs/day | 2.8 | 6.4 | <2.7 |
| Chromium: lbs/day | | | |
| total: | 5.0 | 14.5 | 1.7 |
| hexavalent: | 0.41 | 0.92 | 0.73 |
| pH: std. units | | 6.0 to 9.0 | 7.55 & 7.63 |
| Fecal Coliform: #/100 mL | 200 | 400 | 9 & 3 |
| Bioassay: @ 65% effluent % mortality | - | 20 | 0 |

+ - Loadings based on flow of 3.19 MGD from Ecology's flowmeter.
* - Not to exceed this value more than three days per month.

Table 5. Effluent bioassay results: Shell Oil Class II Inspection - February 21-22, 1989.

96-hour rainbow trout (*Oncorhynchus mykiss*)

| | # of live test organisms: Initial | Final | Percent Mortality |
|---|---|---|---|
| 65% Effluent | 30 | 30 | 0 |
| Control | 30 | 30 | 0 |

Echinoderm Sperm Cell Bioassay (purple sea urchin)

| | NOEC | LOEC | EC50 |
|---|---|---|---|
| Effluent | 6.0% | 12.5% | 28.7% |
| Salinity Check | 12.5% | — | — |

Microtox- Effluent

"Data not suitable for reduction" - indicates a lack of sample toxicity.

$EC_{50}$ - Concentration causing the tested effect to 50 percent of the organisms.

NOEC - No Observed Effect Concentration: the highest concentration of effluent that did not cause an observable adverse effect.

LOEC - Lowest Observed Effect Concentration: the lowest concentration of effluent that caused an observable adverse effect.

Table 6. VOA and BNA compounds detected in effluent and sediment: Shell Oil Class II inspection - February 21-22, 1989.

| Sample: | Eff-Eco | Sediment |
|---|---|---|
| Type: | composite | composite |
| Date: | 02/22/89 | 02/21/89 |
| VOA Compounds | ug/L | ug/Kg dw |
| Methylene Chloride | 3.5 U | 7.0 |
| Chloroform | 2.7 | 4.3 U |
| 1,1,1-Trichloroethane | 1.7 M | 2.5 U |
| Toluene | 0.5 U | 0.5 JB |
| Phenols, Total | 10.2 | 7 |
| BNA Compounds | | |
| 2,4,6-Trichlorophenol | 3 J | 300 U |
| Phenanthrene | 1 U | 26 J |
| Fluoranthene | 1 U | 35 J |
| Pyrene | 1 U | 37 J |
| Benzo(a)Anthracene | 1 U | 35 M |
| Chrysene | 1 U | 75 |
| Bis(2-Ethylhexyl)phthalate | 1 M | 140 MB |
| Di-n-Octyl Phthalate | 1 U | 150 |
| Benzo(b&k)Fluoranthenes | 1 U | 32 M |
| Benzo(a)Pyrene | 1 U | 27 J |

U - Indicates compound was analyzed for but not detected at the given detection limit.

J - Indicates an estimated value when result is less than specified detection limit.

B - This flag is used when the analyte is found in the blank as well as the sample. Indicates possible/probable blank contamination.

M - Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

Table 7. Effluent metals results and comparison to water quality criteria: Shell Oil Class II inspection - February 21-22, 1989.

| Metal | Effluent (ug/L) | FW Acute | FW Chronic | SW Acute | SW Chronic |
|---|---|---|---|---|---|
| Antimony | 3160 | 9000 | 1600 | - | - |
| Beryllium | 1 U | 130 | 5.3 | - | - |
| Cadmium | 5 U | 3.7 | 1.1 | 43 | 9.3 |
| Chromium, total | 64 | 1700 | 200 | 10300 | - |
| Copper | 11 | 17 | 11 | 2.9 | 2.9 |
| Lead | 3.4 | 77 | 3.0 | 140 | 5.6 |
| Mercury | 0.43 | 2.4 | 0.012 | 2.1 | 0.025 |
| Nickel | 16 | 1400 | 150 | 75 | 8.3 |
| Selenium | 11 | 260 | 35 | 410 | 54 |
| Silver | 0.2 U | 3.7 | 0.12 | 2.3 | - |
| Thallium | 1 U | 1400 | 40 | 2100 | - |
| Zinc | 127 | 110 | 100 | 95 | 86 |
| Hardness | 95 | 95 | | | |

Table 8. Sediment Bioassay Results: Shell Oil Class II Inspection - February 21-22, 1989.

Microtox

| | EC50(+) |
|---|---|
| 5 min. | 64% |
| 15 min. | 31% |

+ - EC50 based on percent of saline-extracted sample.

Amphipod

| Sample | Survival(1) | Avoidance(2) | % Reburial(3) |
|---|---|---|---|
| Laboratory Control | 19.6+/-0.5 | 0.1+/-0.3 | 100.0 |
| Outfall Sediment | 17.0+/-2.1* | 0.6+/-0.8 | 98.8 |

1 - n=5: a value of 20=100%. Asterisks denote values significantly less than ($P<0.05$, $F=7.04$) the lab control, collected from West Beach, Whidbey Island.

2 - Number of amphipods on the surface per jar per day (out of a maximum of 20).

3 - At the end of the 10 day exposure, surviving individuals were transferred to fingerbowls containing 2 cm of control sediment and clean seawater, and the number able to rebury within 1 hour was recorded.

* - Indicates valve is significantly less than ($P<0.05$, $F=7.04$) the control, collected from West Beach, Whidbey Island.

Table 9. Comparison of detected sediment organics against criteria: Shell Oil Class II Inspection - February 21-22, 1989.

| Compound | Criteria* (mg/Kg TOC) | Outfall Sediment (mg/Kg TOC) | Outfall Sediment (ug/Kg dw) |
|---|---|---|---|
| LPAH(1) | 370 | 2.2 J | 26 J |
| Phenanthrene | 100 | 2.2 J | 26 J |
| HPAH(2) | 960 | 20 J | 241 J |
| Fluoranthene | 160 | 2.9 J | 35 J |
| Pyrene | 1,000 | 3.1 J | 37 J |
| Benz(a)anthracene | 110 | 2.9 M | 35 M |
| Chrysene | 110 | 6.3 | 75 |
| Total benzofluoranthenes | 230 | 2.7 M | 32 M |
| Benzo(a)pyrene | 99 | 2.3 J | 27 J |
| bis(2-ethylhexyl) phthalate | 47 | 12 MB | 140 MB |
| di-N-octyl phthalate | 58 | 13 | 150 |
| % solids - 57.9% | | | |
| % TOC, dry - 1.2% | | | |

* - From Ecology's Interim Sediment Quality Evaluation Process For Puget Sound (Betts 1989).

(1) - Low molecular weight polynuclear aromatic compounds, i.e. napthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

(2) - High molecular weight polynuclear aromatic hydrocarbons, i.e. fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranathenes, benzo(a)pyrene, indeno(1,2,3,-c,d) pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

J - Indicates an estimated value when result is less than specified detection limit.

M - Indicates an estimated value of analyte found and confirmed by analyst, but with low spectral match parameters.

B - Analyte was found in blank as well as sample, indicating possible/probable blank contamination.

Table 10. Sediment metals compared to criteria: Shell Oil Class II Inspection - February 21-22, 1989.

| Metal | Criteria* (ppm dry) | Outfall (ppm dry) |
|---|---|---|
| Antimony | 150 | 0.57 |
| Arsenic | 57 | 5.54 |
| Cadmium | 5.1 | 0.50 U |
| Chromium | 260 | 58.1 |
| Copper | 390 | 17.0 |
| Lead | 450 | 8.0 |
| Mercury | 0.41 | .012 |
| Nickel | (1) | 40.7 |
| Silver | 6.1 | .056 |
| Zinc | 410 | 79.8 |

* - Chemical criteria from Ecology's Interim Sediment Quality Evaluation Process For Puget Sound (Betts, 1989).

(1) - Criterion is not established.

Table 11. Comparison of laboratory results: Shell Oil Class II inspection: February 21-22, 1989.

| Sample | Sampler | Laboratory | $BOD_5$ (mg/L) | COD (mg/L) | TSS (mg/L) | Oil & Grease (mg/L) | Total Phenols (ug/L) | Ammonia (mg/L-N) | Fecal Coliform (#/100mL) |
|---|---|---|---|---|---|---|---|---|---|
| Effluent Composite: | Ecology | Ecology | 6 | 70 | 14 | 5 | 10.2 | 0.72 | 9 |
| | Ecology | Shell | 4.9 | 69 | - | - | 27 | - | - |
| | Shell | Ecology | 6 | 70 | 11 | - | - | 0.70 | - |
| | Shell | Shell | - | 70 | 12 | 3 | 39 | 1.0 | - |

Appendix 1. Results of VOA, BNA, Pest/PCB and metal priority pollutant scan: Shell Oil Class II Inspection - February 21-22, 1989.

| Sample: | Eff-Eco | Sediment |
|---|---|---|
| Lab Log #: | 088022 | 088024 |
| Type: | composite | composite |
| Date: | 02/22/89 | 02/21/89 |
| VOA Compounds | ug/L | ug/Kg dw |
| Chloromethane | 3.8 U | 5.0 U |
| Bromomethane | 3.1 U | 4.1 U |
| Vinyl Chloride | 2.0 U | 2.6 U |
| Chloroethane | 3.3 U | 4.4 U |
| Methylene Chloride | 3.5 U | 7.0 |
| Acetone | 10 U | 10.0 U |
| Carbon Disulfide | 1.2 U | 1.6 U |
| 1,1-Dichloroethene | 0.7 U | 0.9 U |
| 1,1-Dichloroethane | 0.6 U | 0.8 U |
| 1,2-Dichloroethene (total) | 0.8 U | 1.1 U |
| Chloroform | 2.7 | 4.3 U |
| 2-Butanone | 10.0 U | 10.0 U |
| 1,2-Dichloroethane | 0.5 U | 0.7 U |
| 1,1,1-Trichloroethane | 1.7 M | 2.5 U |
| Carbon Tetrachloride | 0.9 U | 1.2 U |
| Vinyl Acetate | 3.1 U | 4.1 U |
| Bromodichloromethane | 0.3 U | 0.4 U |
| 1,2-Dichloropropane | 0.7 U | 0.9 U |
| Trichloroethene | 0.6 U | 0.8 U |
| Benzene | 1.0 U | 1.3 U |
| Dibromochloromethane | 0.7 U | 0.9 U |
| 1,1,2-Trichloroethane | 0.7 U | 0.9 U |
| Bromoform | 2.5 U | 3.3 U |
| 4-Methyl-2-Pentanone | 3.5 U | 4.6 U |
| 2-Hexanone | 3.2 U | 4.2 U |
| 1,1,2,2-Tetrachloroethane | 2.7 U | 3.6 U |
| Tetrachloroethene | 0.5 U | 0.7 U |
| Toluene | 0.5 U | 0.5 JB |
| Chlorobenzene | 0.9 U | 1.2 U |
| trans-1,3-Dichloropropene | 1.8 U | 2.4 U |
| Ethylbenzene | 0.8 U | 1.1 U |
| cis-1,3-Dichloropropene | 1.9 U | 2.5 U |
| Styrene | 1.1 U | 1.5 U |
| Total Xylenes | 1.8 U | 2.4 U |
| 2-Chloroethylvinylether | 2.7 U | 3.6 U |
| Trichlorofluoromethane | 2.0 U | 2.7 U |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 2.0 U | 2.7 U |
| Phenols, Total | 10.2 | 7 |

Appendix 1. (Continued)

| | Sample: | Eff-Eco | Sediment |
|---|---|---|---|
| | Lab Log #: | 088022 | 088024 |
| | Type: | composite | composite |
| | Date: | 02/22/89 | 02/21/89 |
| BNA Compounds | | ug/L | ug/Kg dw |
| Phenol | | 1 U | 60 U |
| Bis(2-Chloroethyl)Ether | | 1 U | 60 U |
| 2-Chlorophenol | | 1 U | 60 U |
| 1,3-Dichlorobenzene | | 1 U | 60 U |
| 1,4-Dichlorobenzene | | 1 U | 60 U |
| Benzyl Alcohol | | 5 U | 300 U |
| 1,2-Dichlorobenzene | | 1 U | 60 U |
| 2-Methylphenol | | 1 U | 60 U |
| Bis(2-chloroisopropyl)ether | | 1 U | 60 U |
| 4-Methylphenol | | 1 U | 60 U |
| N-Nitroso-Di-n-Propylamine | | 1 U | 60 U |
| Hexachloroethane | | 2 U | 120 U |
| Nitrobenzene | | 1 U | 60 U |
| Isophorone | | 1 U | 60 U |
| 2-Nitrophenol | | 5 U | 300 U |
| 2,4-Dimethylphenol | | 2 U | 120 U |
| Benzoic Acid | | 10 U | 600 U |
| Bis(2-Chloroethoxy)Methane | | 1 U | 60 U |
| 2,4-Dichlorophenol | | 3 U | 180 U |
| 1,2,4-Trichlorobenzene | | 1 U | 60 U |
| Naphthalene | | 1 U | 60 U |
| 4-Chloroaniline | | 3 U | 180 U |
| Hexachlorobutadiene | | 2 U | 120 U |
| 4-Chloro-3-Methylphenol | | 2 U | 120 U |
| 2-Methylnaphthalene | | 1 U | 60 U |
| Hexachlorocyclopentadiene | | 5 U | 300 U |
| 2,4,6-Trichlorophenol | | 3 J | 300 U |
| 2,4,5-Trichlorophenol | | 5 U | 300 U |
| 2-Chloronaphthalene | | 1 U | 60 U |
| 2-Nitroaniline | | 5 U | 300 U |
| Dimethyl Phthalate | | 1 U | 60 U |
| Acenaphthylene | | 1 U | 60 U |
| 3-Nitroaniline | | 5 U | 300 U |
| Acenaphthene | | 1 U | 60 U |
| 2,4-Dinitrophenol | | 10 U | 600 U |
| 4-Nitrophenol | | 5 U | 300 U |
| Dibenzofuran | | 1 U | 60 U |
| 2,4-Dinitrotoluene | | 5 U | 300 U |
| 2,6-Dinitrotoluene | | 5 U | 300 U |
| Diethyl Phthalate | | 1 U | 60 U |
| 4-Chlorophenyl-Phenylether | | 1 U | 60 U |

Appendix 1. (Continued)

| | Sample: | Eff-Eco | Sediment |
|---|---|---|---|
| | Lab Log #: | 088022 | 088024 |
| | Type: | composite | composite |
| | Date: | 02/22/89 | 02/21/89 |
| BNA Compounds | | ug/L | ug/Kg dw |
| Fluorene | | 1 U | 60 U |
| 4-Nitroaniline | | 5 U | 300 U |
| 4,6-Dinitro-2-Methylphenol | | 10 U | 600 U |
| N-Nitrosodiphenylamine | | 1 U | 60 U |
| 4-Bromophenyl-Phenylether | | 1 U | 60 U |
| Hexachlorobenzene | | 1 U | 60 U |
| Pentachlorophenol | | 5 U | 300 U |
| Phenanthrene | | 1 U | 26 J |
| Anthracene | | 1 U | 60 U |
| Di-n-Butyl Phthalate | | 1 U | 60 U |
| Fluoranthene | | 1 U | 35 J |
| Pyrene | | 1 U | 37 J |
| Butylbenzylpthalate | | 2 U | 60 U |
| 3,3'-Dichlorobenzidine | | 5 U | 300 U |
| Benzo(a)Anthracene | | 1 U | 35 M |
| Chrysene | | 1 U | 75 |
| Bis(2-Ethylhexyl)phthalate | | 1 M | 140 MB |
| Di-n-Octyl Phthalate | | 1 U | 150 |
| Benzo(b&k)Fluoranthenes | | 1 U | 32 M |
| Benzo(a)Pyrene | | 1 U | 27 J |
| Indeno(1,2,3-cd)Pyrene | | 1 U | 60 U |
| Dibenzo(a,h)Anthracene | | 1 U | 60 U |
| Benzo(g,h,i)Perylene | | 1 U | 60 U |
| Pest/PCB Compounds | | ug/L | ug/Kg dw |
| alpha-BHC | | 0.05 U | 2.5 U |
| beta-BHC | | 0.05 U | 2.5 U |
| delta-BHC | | 0.05 U | 2.5 U |
| gamma-BHC (Lindane) | | 0.05 U | 2.5 U |
| Heptachlor | | 0.05 U | 2.5 U |
| Aldrin | | 0.05 U | 2.5 U |
| Heptachlor Epoxide | | 0.05 U | 2.5 U |
| Endosulfan I | | 0.05 U | 2.5 U |
| Dieldrin | | 0.08 U | 4.0 U |
| 4,4'-DDE | | 0.08 U | 4.0 U |
| Endrin | | 0.08 U | 4.0 U |
| Endosulfan II | | 0.08 U | 4.0 U |
| 4,4'-DDD | | 0.15 U | 7.5 U |
| Endosulfan Sulfate | | 0.15 U | 7.5 U |
| 4,4'-DDT | | 0.10 U | 5.0 U |
| Methoxychlor | | 0.20 U | 10 U |

Appendix 1. (Continued)

| Sample: | Eff-Eco | Sediment |
|---|---|---|
| Lab Log #: | 088022 | 088024 |
| Type: | composite | composite |
| Date: | 02/22/89 | 02/21/89 |
| Pest/PCB Compounds | ug/L | ug/Kg dw |
| Endrin Ketone | 0.08 U | 4.0 U |
| alpha-Chlordane | 0.05 U | 2.5 U |
| gamma-Chlordane | 0.05 U | 2.5 U |
| Toxaphene | 7.5 U | 375 U |
| Aroclor-1016 and 1242 | 1.0 U | 50 U |
| Aroclor-1248 | 1.0 U | 50 U |
| Aroclor-1254 | 1.0 U | 50 U |
| Aroclor-1260 | 1.0 U | 50 U |
| Priority pollutant metals | ug/L | mg/Kg dw |
| Antimony | 3160 | 0.57 |
| Arsenic | 5.6 | 5.54 |
| Beryllium | 1.0 U | 0.43 |
| Cadmium | 5.0 U | 0.50 U |
| Chromium, total | 64 | 58.1 |
| Chromium, hexavalent | 27.52 | - |
| Copper | 11 | 17.0 |
| Lead | 3.4 | 8.0 |
| Mercury | 0.43 | 0.012 |
| Nickel | 16 | 40.7 |
| Selenium | 11 | 0.26 |
| Silver | 0.2 U | 0.056 |
| Thallium | 1.0 U | 0.10 |
| Zinc | 127 | 79.8 |

U - Indicates compound was analyzed for but not detected at the given detection limit.

J - Indicates an estimated value when result is less than specified detection limit.

B - This flag is used when the analyte is found in the blank as well as the sample. Indicates possible/probable blank contamination.

M - Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

Appendix 2. Analytical methods and references- Shell Oil Class II Inspection: February 21-22, 1989.

| Analysis | Method | Laboratory |
|---|---|---|
| TOC (solids) | APHA, 1985: #505 | Laucks Testing Labs; Seattle, Wa. |
| Grain Size | Tetra Tech, 1986 | Laucks Testing Labs; Seattle, Wa. |
| % Solids | APHA, 1985: #209F | Laucks Testing Labs; Seattle, Wa. |
| VOA (water) | EPA, 1984: #624 | ARI; Seattle, Wa. |
| VOA (solids) | EPA, 1986: #8240 | ARI; Seattle, Wa. |
| BNA (water) | EPA, 1984: #625 | ARI; Seattle, Wa. |
| BNA (solids) | EPA, 1986: #8270 | ARI; Seattle, Wa. |
| Pest/PCB (water) | EPA, 1984: #608 | ARI; Seattle, Wa. |
| Pest/PCB (solids) | EPA, 1986: #8080 | ARI; Seattle, Wa. |
| Metals (water) | EPA, 1983: #200 series | Ecology; Manchester, Wa. |
| Metals (solids) | EPA, 1983: #200 series | Ecology; Manchester, Wa. |
| Total phenolics | EPA, 1983: #420.2 | Ecology; Manchester, Wa. |
| Trout 96-hour | Ecology, 1981 | Ecology; Manchester, Wa. |
| Microtox | Beckman Oper. Manual | ECOVA Lab; Redmond, Wa. |
| Echinoderm Sperm Cell | Dinnel, et al., 1987 | E.V.S. Consultants; Seattle, Wa. |
| Rhepoxinius | Tetra Tech, 1986 | E.V.S. Consultants; Seattle, Wa. |