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Case history

PCB TRANSFORMER SPILL SEATTLE, WASHINGTON

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Summary

On September 13, 1974, an electrical transformer fell during loading operations and caused a spill of 265 gallons of PCB into the Duwamish River in Seattle, Washington. The heavier than water material remained on the river bottom in the general vicinity of the spill thus providing the opportunity to conduct a unique removal operation during an eighteen month period. Several removal alternatives were investigated and are discussed. The initial method used SCUBA divers operating hand guided pumps to remove visible pockets of PCB and then pump them, along with bottom muds and water, to a physical/chemical treatment unit for safe separation of water and sludge. The second stage recovery utilized a special high solids dredge, discharging the pollutant and dredge spoil in large earthen ponds, and treating the effluent before returning to the Duwamish Waterway. Treatment and PCB pollutant recovery data is discussed.

The Accident

On September 13, 1974, an electrical transformer was dropped while being loaded upon a commercial barge resulting in 265 gallons of Aroclor 1242 polychlorinated biphenyl (PCB) being spilled into the Duwamish Waterway.

The Duwamish Waterway is an important navigational channel within the City of Seattle. The Lower Duwamish River is affected by tides of up to 13 feet and regularly flows at approximately 4 knots. The spill site, near River Mile 1.5, is predominately a mud/silt bottom, has fresh water overlaying a salt water wedge, and is approximately 45 ft. deep and 500 ft. wide. The Duwamish River empties into Elliott Bay and supports one of the many anadromous fish runs in the Puget Sound area (Fig. 1).

The 75 KVA transformer involved was made by Westinghouse and has an internal coolant liquid capacity of 283 total gallons. According to the manufacturers specifications tag, the PCB coolant was Enerteen, a mixture of 70% PCB (Aroclor 1254) and 30% trichloralbenzene. However, laboratory examination disclosed the coolant had been changed to 100% PCB (Aroclor 1242), Specific Gravity 1.4, probably because it would perform better in the extreme climate of the Arctic.

The transformer was created in plywood and bolted to "*skids*" on the crate bottom. On the exterior of the crate there appeared the directions "*lift*

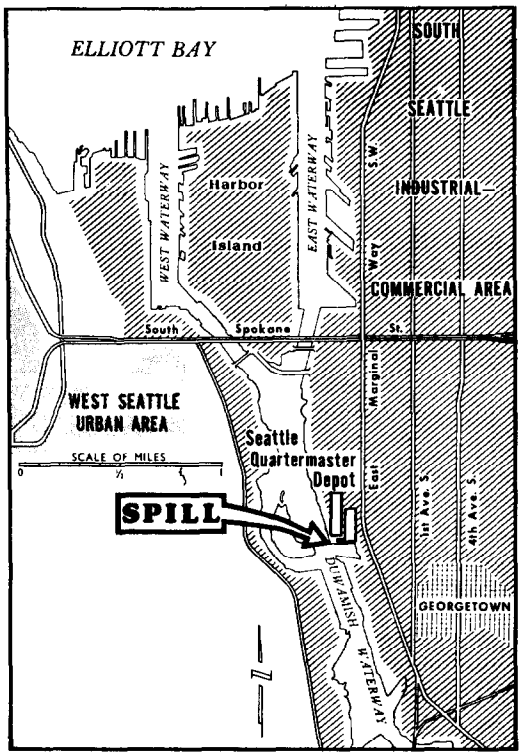

Fig. 1. PCB spill location, Duwamish Waterway, September 13, 1974.

by base only" and the center of balance was designated. There were no markings indicating the potential hazards of the transformer coolant. The upper corners of the crate were fully enclosed and were not cut off to expose the corner metal lifting "*ears*" on the metal transformer case. In previous instances transformers shipment, the packing crates had the upper corners cut off, thereby exposing the metal ears on the top of the transformer cases which were utilized to hoist the transformers. However, as this was to be a water shipment, the unit was sealed.

The spill was reported to the U.S. Coast Guard (USCG) in Seattle as a minor oil spill. A Seattle oil cleanup contractor, Marine Oil Pickup Service (MOPS), was then contracted, responded and removed some 4 gallons of floating material. The initial spill report did not reveal the involvement of PCB. On September 16—17, a followup investigation by both the Washington State Department of Ecology (DOE) and USCG determined that the transformer coolant was PCB and not an oil spill. DOE requested U.S. Environmental Protection Agency (EPA) assistance to locate and quantify the spill in the waterway. EPA also initiated investigations into alternatives for possible removal and disposal of the spilled material.

Assessing the magnitude

On September 18, an EPA Region X, laboratory team collected and analyzed some 29 bottom samples in the vicinity of the accident (Fig. 2). The analytical results indicated the material had remained in two general areas, one immediately adjacent to the dock where the spill occurred and the second

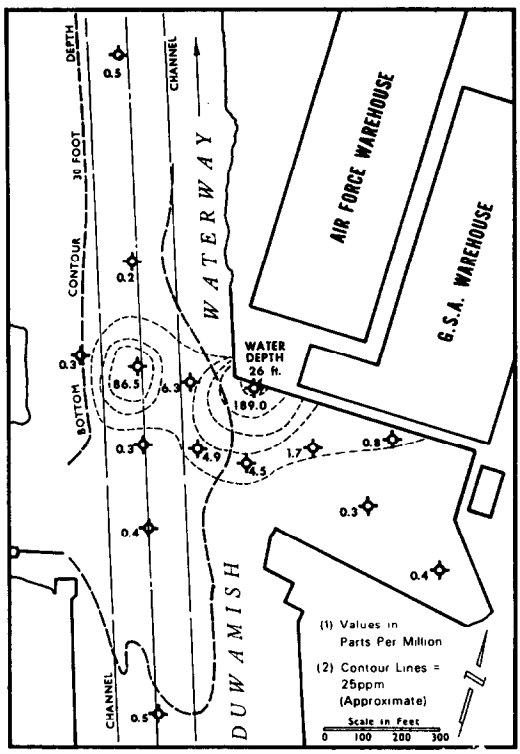

Fig. 2. Pre-cleanup (Sept. 18, 1974) PCB sediment concentration.

further out in the Duwamish River. After reviewing data on September 23, EPA representatives met with Seattle USCG and Department of Defense (DOD) representatives involved in the incident and requested DOD or the shipper to assume responsibility for the incident and initiate cleanup. Responsibility was refused whereupon EPA assumed On-Scene-Coordinator (OSC) role, as prescribed by the Regional Oil and Hazardous Material Contingency Plan, for cleanup of the pollutant.

Cleanup potential

EPA divers deployed on September 26 observed pools of free PCB material on the bottom. They concluded that a dredging program to remove the con-

taminated material could be successfully carried out.

Several alternative actions were outlined, including those below:

1. Utilize hard hat divers pumping water and contaminated sludge into a Navy 100,000 barge. This operation would require additional facilities to offload the barge, treat the effluent and dispose of the sludge.

2. Utilize a 22" pipeline dredge to remove some 8,000,000 gallons of water and PCB contaminated mud onto Kellogg Island, which is immediately across the waterway from the site, owned by the Port of Seattle and presently used as a dredge spoil disposal site by the COE. This operation would require constructing several large ponds by moving some 30,000 yards of material. It would also be necessary to construct impervious liners for the ponds for complete retention of all fluids. It was estimated that the dredging operation could be performed in one day, assuming all site preparation had been completed.

3. Utilize divers with small hand held dredges pumping water and spill material through pre-settling tanks and using EPA's transportable physical/chemical treatment unit located in Edison, New Jersey, to treat the return water.

Evaluation of the three alternates resulted in the initial selection of the second approach. The first alternative was eliminated because of the lack of adequate barge holding capacity in the area together with the lack of subsequent sludge disposal site for the contaminated mud. Logistics problems associated with the third approach resulted in its initial rejection.

On October 2, after an on-site visit by a team of geologists from U.S. Environmental Protection Agency, U.S. Corps of Engineers and Washington State Department of Ecology, it was decided that the necessary holding ponds could not be economically constructed due to poor soil characteristics. The need to retain all effluent and sludge made it necessary to completely seal the ponds in order to prevent any seepage or runoff. It was estimated that 30 days or more would be required to construct the ponds and cost more than existing funds would allow. Logistic problems such as access to the island, construction, etc., were reviewed with military personnel from the 6th Army, Ft. Lewis and 13th Naval District and the use of the island was then eliminated. Based on this data, this alternate was eliminated and Alternate 3 was selected.

During the investigation period discussions were also being held with the technical staff at the EPA Edison, N.J. Industrial Environmental Research Laboratory regarding use of the transportable physical/chemical treatment unit. The unit is a mobile waste water treatment plan utilizing primary settling, mixed media pressure filters and activated carbon columns [1]. It was hoped its use would reduce PCB in the return water from the settling of the dredged material sufficiently to permit immediate discharge back to the waterway. Because this unit was used successfully in a spill incident involving pesticides on the East Coast [2] it was decided to utilize the system in the Duwamish Spill.

Cleanup — Phase I

On October 3, the unit was activated and on October 4 it departed Edison, New Jersey, arriving in Seattle October 9. Dredging began on October 12. The State of Washington, Department of Ecology, conducted tests using alum, ferric chloride, lime and Nalco 634, a polyelectrolyte to determine the most satisfactory settling rates of contaminated sludge. Nalco 634, a polyelectrolyte, at 20 mg/l provided the best settling of any of the material tested. On October 31, after containing the inital treated effluent in holding tanks pending favorable laboratory results, the first operational discharge was approved as the final effluent contained only 0.075 μg/l PCB (Table 1, Fig. 3).

TABLE 1

Initial treatment plant results

Sampling location	PCB concentration (μg/l)
First settling tank	400
Second settling tank (swimming pool)	400
After sand filter	3.5
Final effluent after carbon columns	0.085
Sludge concentrations	
Low — 4 parts per thousand	
High — 30 parts per thousand	
Average: 1—2% PCB in barreled sludge	

The dredging operation lasted some 20 days resulting in the processing of approximately 600,000 gallons of water and the collection of 215 drums of PCB contaminated mud which were stored temporarily in the Air Force warehouse. Ultimate disposal of the drums was carried out by DOD in the Spring of 1975 at a Federally recognized hazardous waste disposal site near Twin Falls, Idaho. This site uses an abandoned Titan missile silos for secure containment.

The highest concentration level of PCB recovered was found in the initial spill area. However, there was evidence that the river current and tidal action had caused pockets of PCB to move about. Divers observed pools of PCB moving as much as 50 ft. with the tide from one day to the next.

Concentrations of PCB in the recovered mud indicated that approximately 70—90 gallons of the material were removed during the operation. While visual observations of the material on the bottom surface indicated most of the free PCB had been removed, it was evident, based on bottom sampling, that concentrations of PCB remained high in the sediments within the spill impact area.

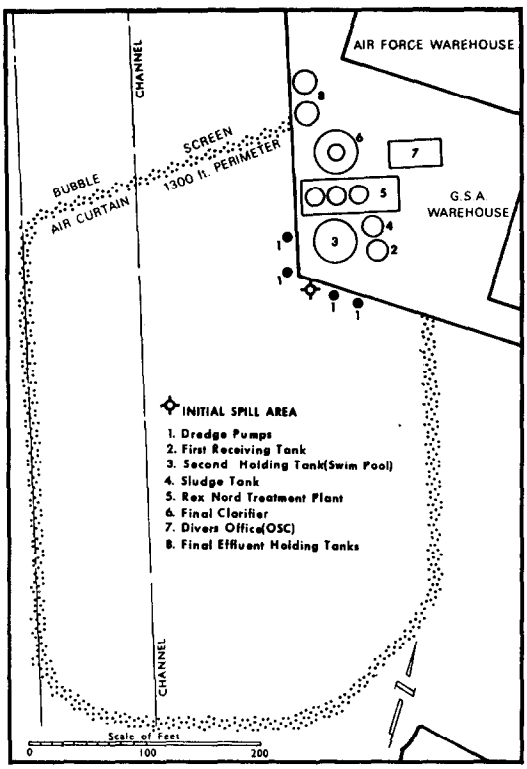

Fig. 3. Disposition of spill recovery equipment.

On October 31, the project was terminated as it was determined that the operation had changed from one in which handheld dredging was effective to one which would require a substantially larger effort, ultimately requiring the removal of some 40,000 yards of bottom material from the barge slip area in which the spill occurred. In some cases the divers had dredged in the bottom muds up to 20 in. deep and continued to note droplets of PCB in the sediments. A sampling program conducted during the latter part of the removal operation revealed that substantial quantities of PCB remained tied up in the bottom sediments. Concentrations substantially higher than background were also noted out to mid-channel. It was estimated the contaminated area was about 200 × 500 ft (Figs. 4 and 5).

Cleanup — Phase II

Pursuant to EPA's Headquarters efforts, the U.S. Department of Defense assumed responsibility for the spill incident in February 1975 and subsequently delegated further removal efforts to the Seattle District Corps of Engineers. Funding for the cleanup project was the responsibility of the

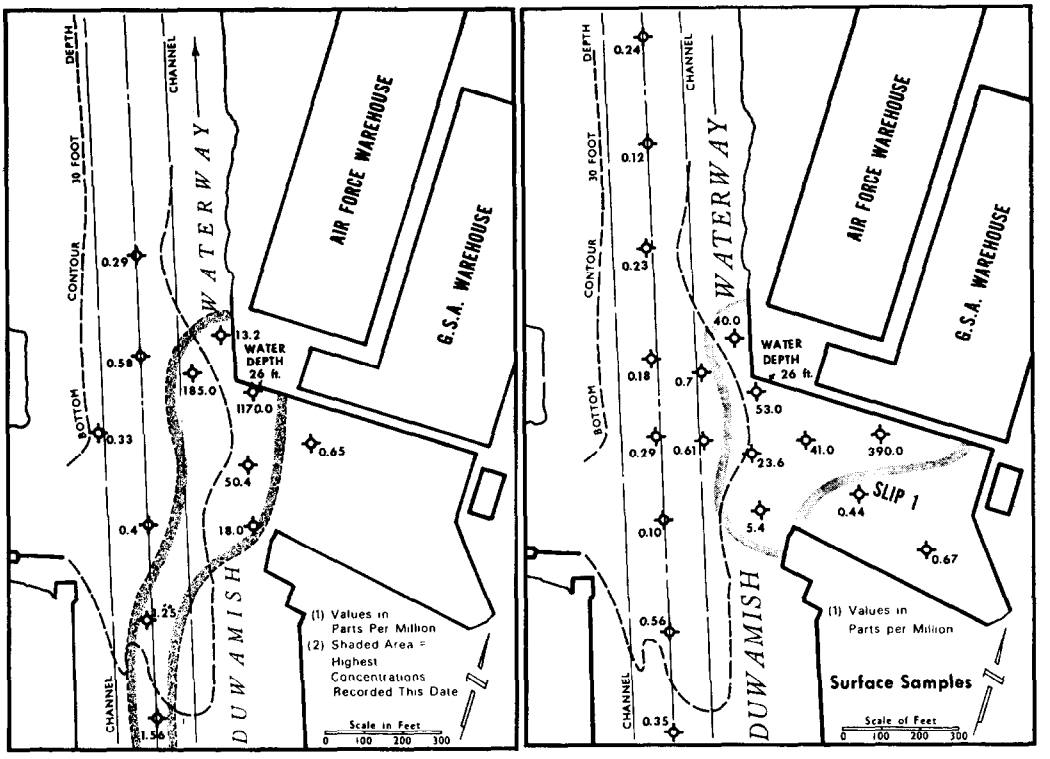

Fig. 4. Post-cleanup (Nov. 4, 1974) PCB sediment concentration.

Fig. 5. PCB sediment concentrations (June 2, 1975).

Army Material Supply Command, Tooele, Utah.

EPA Region X laboratory staff carried out a continuing monitoring program from September 18, 1974, five days after the spill, through 1975 to April 1976. Although most of the material remained in the spill area, it was shown that PCB's were slowly migrating throughout the slip.

Environmental concerns centered around pending dredging operation required that the project commence after November and be completed no later than April to minimize any effect on fish resources of the area. This year, however, a 100 year flood during the month of December dispersed a small pocket of the PCB pollutant in mid-channel out into Elliott Bay (Fig. 6). This area was believed to contain approximately 5 gallons of the PCB pollutant.

The Corps of Engineers tentatively selected Kellogg Island as the disposal site for the PCB contaminated sediment. However, objections raised by the Port of Seattle ultimately resulted in the rejection of this site. Next, the Corps discussed possibly using the old treatment plant site immediately north of the Federal Center South Complex with the present owners, Chiyoda Industries. Initially, there was no response to the Corps request and it was

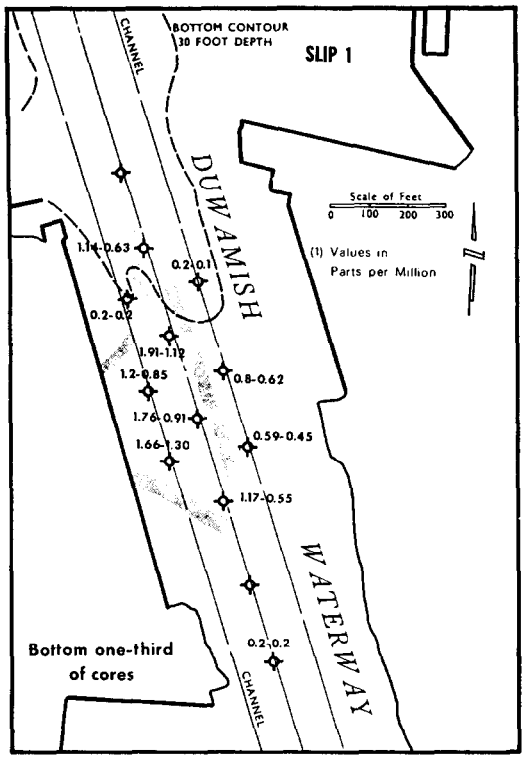

Fig. 6. PCB sediment concentrations (June 18, 1975).

assumed that there was little interest on the part of Chiyoda to negotiate for the disposal of dredge spoil at this location.

As a result of the apparent rejection, serious discussions were held with Manson Construction Company for the use of their South Parks Court property some two miles upstream from the spill site. Discussions were held simultaneously with the City of Everett authorities regarding placement of the PCB contaminated material in the current spoil disposal site within the City of Everett. This area was being used in conjunction with a 180,000 yard maintenance dredging project by the Corps of Engineers for the Port of Everett. Use of this site was denied by the Port of Everett authorities who expressed concern over disposal of toxic Seattle spoils within the confines of the city limits of Everett.

Negotiations then focused on the use of the Manson property. This property is approximately 24 acres and would require extensive access preparation in order to allow the barged contaminated material to be offloaded at the site. If this site was used, the dredged spoil would have been placed in a water tight barge, hauled upriver, and offloaded by pipeline into a large earth pit. The pit then would subsequently be filled with the contaminated material and covered with 3 ft. of clean material. During final negotiations in late

December, Chiyoda Industries expressed an interest to allowing the material to be disposed on their property. Use of this site would simplify the project by permitting the spoil material to be transported to the site by approximately 2500 ft. of 10 in. pipeline. Negotiations were completed in February thus allowing the project to commence on March 1, 1976.

In order to proceed with the project the Corps had to apply for the necessary 404 dredging permit and complete an Environmental Impact Assessment (EIA). As sites were selected and subsequently rejected this permit and EIA had to be amended and Public Notice reissued.

The proposed dredging project would be carried out with the use of a Chicago based Pneuma Dredge system. This patented dredge is a high capacity (2—3000 gpm) high solids dredge capable of removing spoils containing up to 80% solids by volume with minimum disturbance to the bottom sediment. It was originally estimated that some 30—40,000 cubic yards of material would be removed from the slip area. This would require an average 2 ft. cut throughout the slip with an additional 3—4 ft. cut at the spill site. The spoil material would be hydraulically pumped 2500 ft. to the disposal site.

During the month of February the Corps of Engineers constructed two large 20—25,000 yard capacity holding ponds along the north side of the 25 acre Chiyoda property. The 15 ft. deep pits would ultimately hold the PCB spoil material. In order to use the property, State and Federal assurance were given that would allow for future construction on the site. It was agreed that back filling would be at the specifications outlined by the owners so as to provide a suitable base for future constructions. The Washington State DOE and the EPA required that none of the contaminated spoil would ever leave the site, and would remain under 3 ft. of clean undisturbed material. The first pond was located some 200 ft. back from the shoreline so as to prohibit any migration of the contaminated spoil back in the Duwamish.

To aid the treatment process, NALCO 7134 was injected in the pipeline about 200 ft. before the spoil entered Pond 1. It was found that by adding this cationic polyelectrolyte at 20 mg/l the solids settled near the influent resulting in very little turbidity entering Pond 2. Tests showed that water entering Pond 2 had a turbidity of about 17 JTU.

The water pumped periodically from Pond 2 through a "*Filtrite*" cartridge filter system at 1000 gpm into a small 10,000 gallon plastic line holding pond. Various tests were conducted with the "*Filtrite*" unit and it was found that the 100 micron size cartridges provided the best overall removal of algae and suspended solids. This smaller pond served as a surge pond to allow for continuous use of the final treatment unit, an EPA physical/chemical treatment truck from Edison, New Jersey.

The Edison physical/chemical treatment unit [3], which also assisted in the first PCB cleanup operation in October 1974 consists of 3 mixed media pressure sand filters followed by three activated carbon columns. While the truck was designed for a flow rate of 200 gpm utilizing all the system in

series, it was found that the turbidity and PCB concentrations were sufficiently low to permit bypassing the sand filters and using the three carbon columns in parallel. This permitted running 600 gpm through the unit rather than the 200 gpm for which it was designed. The effluent was pumped 70 ft. to an abandoned 30 in. sewer line which discharged into the Duwamish River.

An extensive monitoring program was carried out during the operation to insure (*1*) that the PCB contaminated sediment was removed from the waterway and (*2*) that the contaminant did not return to the Duwamish through the treatment process. Both pre-dredge sediments and sediments taken during the dredging operation were analyzed for PCB in order to establish the degree of PCB contamination remaining in the slip. Generally, the dredged area was found to be free of PCB after about a foot of sediment was removed. However, at the spill site where it was originally thought that a 4 ft. of dredging would be required to reduce the 2,000 mg/l concentration, it was found that the bottom still contained about 200 mg/l after 6 ft. of material had been removed. Additional dredging to a depth of about 10—12 ft. to hardpan in this area resulted in the PCB concentrations of about 10 mg/l.

PCB concentrations entering Pond 1 were about 8—10 mg/l. After centrifuge, 40 μg/l remained in the water column. The concentration of PCB was drastically reduced during the treatment period. Less than 0.05 μg/l were entering the EPA treatment unit and a negligible amount leaving.

Discussion

The EPA treatment unit arrived in Seattle on March 1 and dredging began March 6. It is estimated that 12—15,000 yards of material was removed during the 30 days operation. It is also estimated that no more than 25% solid removal was accomplished during this period. This may be attributed to skimming of the top layer of bottom sediment with the exception of that dredged at the spill site. Numerous breakdowns and delays were encountered due to bottom debris, relocation of the dredge, and other more minor problems. During the month approximately 9.5 million gallons of water were treated and returned to the Duwamish Waterway.

On March 31, the dredging terminated and on April 12 after treating most of the remaining water in the ponds, the EPA treatment unit departed Seattle for Edison, New Jersey. Based on sampling conducted during the final phase of the operation it is estimated that approximately 140—150 gallons of PCB were removed during this operation (Fig. 7). Added to the 70—90 gallons removed during the initial phase, it is estimated that 210—240 gallons of the original 250 gallons of PCB spilled were removed. While final costs have not been tabulated, it is estimated the project cost about $ 370,000 (See Table 2). This, together with the initial cost of $ 120,000, brings the total expenditure to about $ 500,000 to removed the 240 gallons of Aroclor 1242.

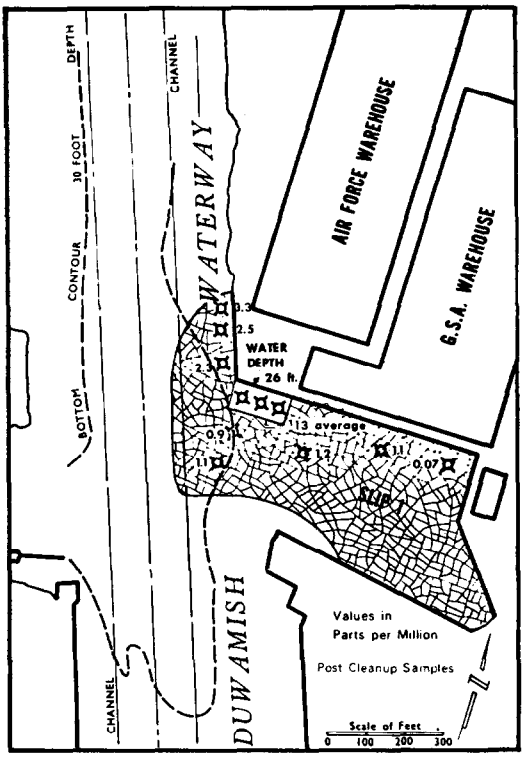

Fig. 7. PCB sediment concentrations (post-cleanup samples).

Conclusion

(1) The overall project was a success in that a vast majority of the PCB was removed.

(2) It also indicated that bottom sinker toxic substances spilled, under similar circumstances, tend to remain in the area and can successfully be removed even after a significant period of time.

(3) While the expenditures appear high, it can be shown that future operations could be modified so as to considerably reduce the cost in removing these toxic materials.

(4) PCB has a strong affinity for particulate matter and once these sediments are removed and dewatered, can be disposed of in a satisfactory landfill operation.

(5) To achieve even a higher success, immediate response actions are required to remove these pollutants from the spill site.

(6) Dredging methods must be evaluated as to the type of sedimate removed and potential pollutant dispersion through the water environment.

TABLE 2

Phase II, operational costs (material removed: 15—20,000 yds, 30% solids)

Dredging	
Pneuma dredge	$ 80,688
C/E barge plus tug	13,000
Misc. pipings, fittings, etc.	15,000
Water treatment	
EPA physical/chemical truck (includes transportation, operator, contingency) Figure not to exceed $ 123,000.	$ 64,000
Monitoring	
PCB removal	$ 34,600
EPA study, WES supported	17,012
EPA study, EPA supported	9,430
Disposal site	
Disposal site rontal	$ 35,000
Site preparation	60,000
Back cover ponds	50,000
Misc. expense (includes ship movement, fittings, etc.)	40,000
Total	$ 418,730

References

1 J.C. Willmann, J. Blazevich and H.J. Snyder, PCB Spill in the Duwamish Seattle, Washington, Proceedings of 1976 National Conference on Control of Hazardous Material Spills, New Orleans, Louisiana, April 1976, p. 351.

2 R.W. Fullner and H. Crump-Wiesner, Use of EPA's Environmental Emergency Response Unit in a Pesticide Spill, Proceedings of the 1976 National Conference on Control of Hazardous Material Spills, New Orleans, Louisiana, April 1976, p. 345.

3 D.G. Manson, M.K. Grupta and R.G. Scholtz, A Mobile Multi-Purpose Treatment System for Processing Hazardous Material Contaminated Waters, Proceedings of the 1972 National Conference on Control of Hazardous Material Spills, EPA, Houston, Texas, March 1972, p. 153.