was a significant motivation in the remedy selection. Selecting both soil and groundwater treatment was estimated to cost eight times as much as the soil cover. The ROD said alternative treatment remedies for both contaminated soil and groundwater were rejected because "they are more costly while achieving the same desired results" as the selected remedy. Only by using a narrow, short-term objective of limiting exposure to the hazardous waste are there comparable environmental results of soil treatment and a soil cover.

For the soils problem, the rejection of the solidification/stabilization alternative is inconsistent with generally understood capabilities of the technology. Indeed, having soil contaminated with only two toxic metals, lead and chromium, offers a textbook example of when chemical fixation works best. None of the arguments given in the ROD against using this soil treatment describe especially unique or difficult problems. For example, the presence of large buried objects is faced routinely; they can be washed and reburied. Regarding implementation risks, wetting excavated materials for dust suppression is routine and, in exceptional cases, inflatable domes have been used. The technology has been selected for Superfund sites posing much more challenging kinds and levels of contamination for which solidification is unproven.

The argument that stabilization technology needs to be verified for a site is an argument for conducting a treatability study, preferably during the RIFS, not for rejecting the alternative. If, as the ROD acknowledged to be the case, the soil is contaminated enough to pose a true environmental risk, then the selected remedy of a soil cover is not permanently effective. The absence of land use restrictions is particularly worrisome.

The rejection of groundwater treatment does not consider several factors: 1) values for chromium contamination very close to the MCL; 2) the hot spot of high chromium contamination apparently just outside the site boundary; and 3) the exact environmental and health effects, which might not be eliminated by dilution, resulting from likely continued leaching and migration of contaminants into Lake Winnebago, even if water intrusion is curtailed through the surface of the site. The problem is that groundwater movement will still occur beneath the surface where the contaminated soils reside. At the Liquid Disposal Superfund site in Michigan, a RCRA hazardous waste cap and a containment wall will be built around chemically stabilized material, landfilled onsite, to prevent just this type of leaching and movement of contaminated groundwater.

Moreover, in the Schmalz ROD, no specific criteria were given for groundwater monitoring or for triggering a decision that a groundwater remedy and a better soils remedy are needed. This site highlights a problem found by recent EPA research: "many [Superfund] investigations are not producing sufficient data to adequately characterize ground water conditions near these sites." (R.H. Plumb, Jr., "A Comparison of Ground Water Monitoring Data From CERCLA and RCRA Sites," ***Ground Water Monitoring Research,*** fall 1987, pp. 94-100.)

Case Study 10
Tacoma Tar Pits, Tacoma, Washington, EPA Region 10

Capsule OTA findings:–No treatability study results supported the selection of chemical stabilization. Significant amounts of untreated contaminants as well as the treated materials will be left onsite. The effectiveness of the treatment is uncertain. Incineration was said to offer no better protection and was rejected because of its higher cost.

Key dates:

- Entered Superfund system: 2/1/82
- Preliminary Assessment: 4/1/82
- Site Inspection: 3/1/83
- National Priorities List
  –proposed date: 10/81
  –final date: 9/83
  —site rank: #347 out of 770
- RIFS start and completion: 11/84 to 9/87
- public comment period before Record of Decision: 11/6/87 to 12/6/87

- Signing of ROD: 12/30/87
- Estimated complete remediation: Assume 2 years after ROD

Total time.—7 years

Brief description of site.-The site is approximately 30 acres and "within a heavily industrialized area . , . [the] site is part of the Commencement Bay-Nearshore/Tideflats Superfund site located within the Tacoma Tideflats industrial area near Commencement Bay." (The ROD does not describe this action as an operable unit, but that is what it appears to be. However, Tacoma Tar Pits is listed as a separate site in CERCLIS, three years after the large Commencement Bay site entered the system.) "A coal gasification plant was in operation on site from 1924 through 1956. The study area currently contains a metal recycling facility . . . a natural gas transfer station . . . a rail freight loading yard . . . a meat packing plant . . . and a railroad switching yard . . . "

Major contamination/environmental threat.—"The site currently contains two ponds, a small tar pit, and various surface-water drainage ditches. The study area is located near several major surface water bodies [waterways]. . . the Puyallup River, and Commencement Bay. Although none of these water bodies are used for water supply, the bay and river do support extensive fish and shellfish populations. Several portions of Commencement Bay have been identified as being severely contaminated, resulting in adverse biological effects . . . contamination of the local groundwater resource is also of concern. Many local industries use groundwater from on-site wells . . . "

With regard to site contaminants, first found in 1981: "Many of these organic compounds are toxic and several are considered to be carcinogenic. These compounds include aromatic hydrocarbons (i.e., benzene, toluene), polynuclear aromatic hydrocarbons collectively known as PAHs (i.e., napthalene, benzo(a)pyrene), as well as numerous other classes of hydrocarbons and cyanide. Heavy metals . . . include arsenic, mercury, and lead." The automobile recycling facility has also caused lead and PCB contamination. The estimated volume of tar is 5,000 cubic yards; it is mostly in three areas at depths of several feet and more. PCBs are found up to 204 parts per million (ppm), and lead in soil in the 2,000 to 8,000 ppm range. Three shallow aquifers have varying degrees of contamination, and the ROD noted the "current lack of understanding of local groundwater hydrology."

Four indicator compounds were used to estimate risks and establish cleanup goals: benzo(a)pyrene, PCBs, benzene, and lead. For the most part, the cleanup levels are consistent with a 1 in 1 million cancer risk level, except for lead in soil which seems high relative to the MCL value. The major emphasis was correctly put on exposure of onsite workers over short periods.

HRS scores.—groundwater 6.12; surface water 10.91; air 71.92; total 42.20

Removal actions.—None indicated.

Cleanup remedy selected.–This ROD apparently is for an operable unit of the larger Superfund site of which it is a part, even though it did not use the term. Besides the selected remedy, cleanup alternatives examined included containment and landfilling, incineration, in situ vitrification, and groundwater treatment.

"The preferred remedial alternative . . . is a combination of source control measures, measures to control contaminant release, and also measures to reduce human exposure to contaminants. This alternative consists of the excavation of the most severely contaminated soils, stabilization of these soils using a technique which immobilizes contaminants, capping of the stabilized material [with asphalt], treatment of the surface water, continued groundwater monitoring, regulatory controls on water usage for both surface and groundwater, and restrictions on site access. " Thoroughly mixed excavated materials will be "fed to a mixing vessel where silicate polymers, cement, and water from the site ponds is added."

However, in site areas that are not severely contaminated with PAHs, soils and sediments "will be excavated to a depth not to exceed 3 feet." This requirement means that significant amounts of contaminants may not be excavated

and treated. Exactly what amount will not be excavated cannot be judged from the information given in the ROD, but the site's history and complex contamination suggests that this may bean important limitation to the selected remedy. Many of the contaminants have been present long enough to have migrated downward a significant distance. "The total estimated volume of material to be excavated is **45,000** cubic yards." The total cost for the selected remedy is $3.4 million. This cost implies a rather low cost for the stabilization part of the cleanup of about $50 per cubic yard.

Satisfaction of SARA statutory requirements:

1) ***Selection of permanent cleanup.—The*** ROD said: "This remedy satisfies the preference expressed in SARA for treatment that reduces toxicity, mobility, and volume. . . . it is determined that this remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable."

The uncertainty about contaminants left untreated onsite means the selected remedy may not be permanent. The intent to comply with SARA's requirement for 5-year review confirms that the selected remedy is not assuredly permanent. This situation raises questions about future land use. Further uncertainty about permanence is indicated by the ROD's comment: "If as a result of this frequent reassessment, the remedial action is shown to have decreased performance, the nature and extent of additional actions will be considered."

An important issue for Tacoma Tar Pits concerns the cleanup of contaminated groundwater. Although the ROD contained cleanup standards for groundwater, "the remedial action does not currently provide for groundwater extraction and treatment." The basis for this lack of cleanup was that the selected remedy will reduce surface water intrusion and contaminant flow into the water, that existing contamination will be swept away and into its ultimate discharge, and that "Action levels of contaminants in groundwater have not been consistently exceeded at off-site locations. " A claim of permanence at this time is premature because the ROD said that it may become necessary to evaluate and implement an alternative remedial action that includes groundwater extraction. A commitment to groundwater monitoring was made, but given the acknowledged complexity of local hydrogeology and given EPA's interest in minimizing cost, it necessitates a major, carefully planned effort.

With regard to the selected stabilization treatment technology: "No bench or pilot studies have been performed to date, these being left until the Remedial Design is commenced . . . " The diverse and highly concentrated contaminants pose a major challenge for a chemical stabilization technology. The current state of knowledge and experience does not support an assumption of effectiveness for the Tacoma Tar Pits site. The ROD noted: "Laboratory experiments will be performed to ensure that the stabilization process effectively immobilizes contaminants. Following this activity, a larger scale 'pilot study' will stabilize a larger volume of contaminated material from the site. This pilot study will determine the effectiveness of the stabilization process." The uncertainty about effectiveness means that the selected remedy did not merit the high (maximum possible) rankings it received for effectiveness in the ROD's analysis of cleanup alternatives. Moreover, there is no basis for saying: "The chemical stabilization process should significantly reduce the toxicity and leachability of site soils," The ability of any chemical stabilization technology to reduce toxicity of a wide range of organic and inorganic contaminants has not been proven nor is it generally accepted in the technical community, But it is reasonable to claim that the mobility of the contaminants might be reduced through stabilization; to claim more than that would require actual test data on site materials, Elsewhere the ROD said: "Permanent treatment can be provided through the immobilization of contaminants." This statement is, however, overly emphatic at the current stage of knowledge about the site.

An important statement on the selected stabilization technology was in the responsiveness summary, given in response to a concern about its effectiveness: ***"Although the cement/ polymer stabilization process is a proven tech-***

nique for immobilization of heavy metals, this technique has not been conclusively proven to be effective in immobilizing organic contaminants in coal tars, Therefore, both laboratory and bench scale treatability studies will be performed during the design phase of the remedial action to ensure the process will be effective and permanent. . . . the soils/tars containing the highest tar content . . . may be considered for an alternate type of treatment/ disposal (i.e., incineration) if the stabilization process is found to be ineffective for the waste matrix" (emphasis added). Also: "Criteria to be used to evaluate the effectiveness of the stabilization process during laboratory and bench scale studies . . . " will be addressed in the design phase.

The FS for the Re-Solve site in Massachusetts rejected stabilization for organic contamination because "there has been limited success in chemically fixing organic contaminants such as solvents and PCBs," The ROD for the Liquid Disposal site in Michigan, which also selected stabilization for soil contaminated with organic chemicals, said that the hazardous substances "will not be permanently destroyed." And the FS for Liquid Disposal said: "Considerable research data exists demonstrating the effectiveness of this technology in immobilizing a wide range of contaminants, primarily inorganic. A substantial amount of data does not exist, however, to accurately judge the long-term reliability of the process."

The ROD for the Tower Chemical Superfund site in Florida said the following about chemical stabilization processes, which it rejected: "This technology would also require long-term (30 years) monitoring which is less favorable than technologies which provide permanent destruction of wastes." The inference is that the technology does not provide permanent destruction of wastes.

Another EPA document, used to teach people about waste treatment said: "Solidification technologies are designed to be used for final waste treatment. This means the technology should be applied only after other treatment techniques have been applied, i.e., incineration, chemical treatment or other. " (U.S. Environmental Protection Agency, "RCRA/CERCLA Treatment Alternatives for Hazardous Wastes," October 1987.)

A recent EPA study found "large losses of organics during the mixing process." (L. Weitzman et al., "Evaluation of Solidification/Stabilization As A Best Demonstrated Available Technology," paper presented at EPA's ***Fourteenth Annual Research Symposium,*** May **1988.]** Another EPA study showed that stabilization was not competitive with thermal and chemical treatment technologies and soil washing for organic contamination. (R.C. Thurnau and M.P. Esposito, "TCLP As A Measure of Treatment Effectiveness: Results of TCLP Work Completed on Different Treatment Technologies for CERCLA Soils," paper presented at EPA's ***Fourteenth Annual Research Symposium,*** **May 1988.) A demonstration of a stabilization technology** under EPA auspices concluded that "for the organics, the leachate concentrations were approximately equal for the treated and untreated soils." (P.R. de Percin and S. Sawyer, "SITE Demonstration of Hazcon Solidification/Stabilization Process," paper presented at EPA's ***Fourteenth Annual Research Symposium,*** May **1988.)**

The rejection of other treatment technologies for Tacoma Tar Pits did not have much technical analysis behind it. The analysis in the ROD rests mainly on a very simple rating system. For example, all 10 alternatives, including capping the waste and incinerating it, received the same rating of high for technical feasibility (including effectiveness, useful life, operation and maintenance requirements, possible failure modes, constructability, implementation time, worker safety, and neighborhood safety). All but the two no action or nearly no action options received the same high rating for public health impacts (including minimization of chemical releases, exposures during remedial action, and exposures after remedial action). But sound technical bases exist for finer distinctions among such abroad range of alternatives. For example, the incineration options offered substantially greater effectiveness, reliability, permanency, and certainty of destruc-

tion of toxic substances than capping the waste or the selected remedy.

The estimated costs of the alternatives probably weighed heavily: two incineration options (including stabilization of residue) had total costs of *$17* million (only surface soils) and $243 million (all soil with contamination with a risk greater than 1 in *1* million cancer risk); both options included groundwater pumping and treatment. In comparison, the selected remedy (stabilization) would cost $8 million if groundwater treatment is included in the calculation. The cost will be only $3.4 million, however, because groundwater treatment was excluded.

2) ***Accurate assessment of land disposal and containment alternatives.—There*** is a statement on future land use: "Land use restrictions will be imposed to prevent or require stringent control of future excavation on the site, to prevent future use of surface water and shallow groundwater, and to prevent site access by personnel other than site workers. " However, there is no detailed analysis of possible future failures of the landfill in which the contaminated materials will be re-buried after stabilization.

The ROD for the Tower Chemical site made a good point about concrete or asphalt caps (as selected for Tacoma Tar Pits): "The risk of failure . . . is high due to the potential for fracture formation." The FS for the Pristine site says: "Asphalt is photosensitive, and subject to cracking due to settling, chemical action, and vegetation. Frequent inspections are required to ensure cap integrity. " The asphalt cap option was rejected at both of these sites.

RIFS contractor. –The studies were paid for by responsible parties. The ROD noted that, although EPA and the State found the documents acceptable, "EPA has prepared an addendum for each document addressing issues that the studies have inadequately or incompletely addressed." Geotechnology, Inc., performed the RI; Envirosphere Company (Ebasco) performed the FS. For the entire Commencement Bay/ Nearshor/Tideflats site, the SCAP indicates three different RIFSs with the last one labeled Tar Pits started on 9/23/83 and then taken over by the PRPs on *11/1/84.* It is not clear what actions resulted from the two earlier RIFSs and no completion dates for them are indicated; $2.5 million was spent by the government on the first one in 1982 and *1983.*

State concurrence.—" The State of Washington has been consulted and has verbally concurred with the selected remedy." Verbal concurrence may indicate a rushed ROD at the end of the fiscal year quarter.

Community acceptance.—The ROD noted that community interest "has not been actively demonstrated." The reasons given for the lack of community interest are the site's location within the larger Commencement Bay Superfund site, the lack of private residences nearby, and a number of cleanup actions already taken in the area.

Special comments.—Although there are statements about restricting future land use, there are also statements that suggest that those restrictions may be applied only in the short term, For example: "The [stabilization] reagent composition is formulated to provide a high-strength surface capable of supporting trucks and other vehicles. "

Cleanup goals were set for indicator contaminants. While these goals make risk assessment more manageable, there can be problems with using them for analysis of the effectiveness of a cleanup technology that is chemical specific, such as chemical stabilization. Moreover, the cleanup very much depends on data that reveal areas of high tar concentration, where there is no excavation depth limit. However, there may be other areas that have high concentrations of other contaminants and that may be either overlooked or fall under the provision of the excavation depth limit. Compounding the problem is the relatively small amount of soil sampling that has been reported, averaging only about 1.5 locations per acre.

The administrative record indicated a large number of contractors have performed studies on the site. It is not clear whether EPA had independent work done to verify work done for the responsible parties. There is also some confusion about the relationship between Tacoma

Tar Pits and the larger Commencement Bay site because the former is listed separately in CERCLIS and the ROD does not use the term operable unit.

General conclusions.—The technical information obtained prior to and used in the ROD did not support claims that the selected remedy is permanent nor even that it will be effective. Delaying testing of the chosen stabilization technology and setting of criteria for its effectiveness until after the ROD undercuts the claim that a permanent remedy has already been selected. The scope and depth of analysis of alternative cleanup technologies was less than seen in any other ROD examined in this report. This shortcoming directly affected technology selection; it maybe related to the strong involvement of the responsible parties, particularly in conducting the RIFS. (An experienced attorney advises responsible parties: "Participation in the IRIFS] study provides an opportunity to generate information that can sway EPA decision makers on important issues. We all know that one can interpret the same data a number of ways. Differing conclusions can be made and supported from the same data. A company that uses its experts to argue convincingly in favor of one conclusion often can influence the ultimate decision." [P. H. Hailer, ***Hazardous Materials,*** January-February 1988.])

While the ROD's interest in alternative treatment technology is commendable, the chief driving force for selecting the remedy appears to be cost: "The final selected remedy meets the requirement of cost-effectiveness as this alternative provides for permanent treatment, and contaminant release minimization for a cost significantly less than other alternatives exhibiting a similar level of protection. Additional cost of these [other alternatives] is the result of the use of more costly technologies such as incineration . . , or the excavation of larger volumes of soils coupled with off-site landfilling." But no data support the contention of similar or equal levels of protection for stabilization and incineration; therefore, the claim that the selected remedy is cost-effective is unsupported.

However, incineration for a comparable volume of contaminated soil definitely would be much more expensive ($242 million) and, therefore, this site, like many others, shows how important it is to examine the issue of comparable environmental protection for a cost-effectiveness decision. Moreover, Tacoma Tar Pits illustrates the need to consider a broader range of treatment technologies to reduce cleanup costs. Biological treatment for such a site deserves attention. The case for its consideration at Tacoma Tar Pits, for example, was as good, if not better, than for the Renora site where it was chosen without treatability test data to support the decision. A research program on developing biotechnology for cleaning up old manufactured gas plant sites such as Tacoma Tar Pits is underway at the University of Tennessee with support from the Gas Research Institute, The choice at Tacoma Tar Pits could have included postponing the remedial action or conducting treatability studies for biological treatment.

Moreover, the cost of the selected remedy may have been significantly under estimated. Data from a vendor of the stabilization technology most likely to be effective on this site suggests a cost of about $150 per cubic yard instead of the $50 indicated in the ROD. If major costs for treatability studies are added in, the cost of the selected remedy could be about $5 million more than the $3.4 million estimated in the ROD for a total of $8.4 million. The higher cost matches the low range of the ROD's incineration options without groundwater treatment.

The lack of a commitment to groundwater cleanup may be linked to the location of the site in a highly contaminated area, including contaminated major water bodies. This is a situation where analyzing the cleanup in isolation may be misleading and ultimately inefficient.